ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000926
Article Type:	Research
Date Submitted by the Author:	09-Feb-2012
Complete List of Authors:	Pandey, Arvind; National Institute of Medical Statistics, Sahu, Damodar; National Institute of Medical Statistics, ICMR Bakkali, TaoufiK; UNAIDS, India Country Office Reddy, DCS; WHO India Office, Kant, Shashi; All India Institute of Medical Sciences, Community Medicine Bhattacharya, M.; Natinal Institute of Health and family welfare, Raj, Yujwal; National AIDS Control Organization, Haldar, Partha; WHO India Office, Bhardwaj, Deepak; National Institute of Medical Statistics, ICMR Chandra, Nalini; UNAIDS, India Country Office
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Infectious diseases, Public health
Keywords:	HIV & AIDS < INFECTIOUS DISEASES, HIV prevalence, PLHIV

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Corresponding author: Dr. Arvind Pandey, Director
Postal address: National Institute of Medical Statistics,
Indian Council of Medical Research (ICMR)
Ansari Nagar, New Delhi – 110 029, India
E-mail: arvindp.nims@gmail.com
Telephone: Office - 91-11-26588803
FAX : 91-11-26589635

Dr. Damodar Sahu, National Institute of Medical Statistics, ICMR, New Delhi, India
Mr. Taoufik Bakkali , UNAIDS, India Country Office, New Delhi, India
Dr. DCS Reddy, WHO India Office, New Delhi, India
Dr. Shashi Kant, All India Institute of Medical Statistics, New Delhi, India

Dr. Madhulekha Bhattacharya, National Institute of Health and Family Welfare, New Delhi, India

Dr. Yujwal Raj, [6]National AIDS Control Organization, New Delhi, India
Dr. Partha Haldar, WHO India Office, New Delhi, India

Mr. Deepak Bhardwaj, [1]National Institute of Medical Statistics, ICMR, New Delhi, India
Ms. Nalini Chandra, UNAIDS, India Country Office, New Delhi, India

Short Title: Estimate of HIV India 2008-09

Key words: HIV prevalence, HIV burden, HIV Sentinel Surveillance, India

Word count- 2974

Abstract:

Objectives: To update the estimation of the adult HIV prevalence and number of people living with HIV in India for the year 2008/2009 with the combination of improved data and methods.

Design: Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived.

Setting: HIV Sentinel sites spread over all the States of India.

Participants: Secondary data from HIV Sentinel Surveillance sites which includes attendees of Antenatal Clinics and sites under targeted interventions of high risk groups, namely, female sex workers (FSW), intravenous drug users (IDU) and men having sex with men (MSM).

Primary and secondary outcome measures: Estimates of adult HIV prevalence and people living with HIV in India and its States.

Results: The adult HIV prevalence in India has been estimated as 0.31% in 2009 against 0.41% in 2000. Among the high prevalence states, the HIV prevalence has declined in Tamil Nadu to 0.33% in 2009 and other states show either a plateau or a slightly declining trend over the time period 2006 – 2009. There are states in the low prevalence states where the adult HIV prevalence has risen over the last four years. The estimated number of people living with HIV in India is 2.4 million (1.93 – 3.04 million) in 2009. Of which, 39 percent are women, children under 15 years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections.

Conclusion: The adult HIV prevalence in India has declined to of level 0.31 percent and estimated number of PLHIV 2.4 million in 2009. The estimated adult prevalence has declined in few states, a plateau or a slightly declining trend over the time. In future, efforts may be made to examine the implications of the emerging trend of the HIV prevalence on the recent infections in the study population.

Article Focus – Modelling exercise to estimate the adult prevalence and burden of HIV in India using the HIV Sentinel Surveillance data.

Key Messages –

- Estimates indicate a slow down trend in the epidemic with current adult HIV prevalence at 0.31% in 2009.
- In 2009, 2.39 million people were estimated to be living with HIV with uncertainty bounds 1.93-3.04 millions.
- Among PLHIV, 61% are male and 39% are female and by age the percent distribution of HIV infection is estimated at 4% are children below the age of 15 years, 83% are adults aged 15–49 years and rest 13% are over 50 years of age.

Strengths and Limitations- Epidemiological assumptions used in Modeling based on evidence on limited studies in other countries, not on Indian population.

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Background:

Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived every year since 1998. The process is consultative amongst the national and international experts in the field of biostatistics and epidemiology. Technical supports are received from UN organizations particularly experts from the WHO and UNAIDS. Efforts are made to improve data both in terms of quality and representativeness as well as the methodology matching to epidemics. For instance, in 2006 with the expansion of sentinel surveillance to all districts [1] and sero-survey as a part of third round of National Family Health Survey (NFHS-3) [2] many of the assumptions are replaced with evidence based information. The latter provided an opportunity to calibrate the surveillance data [3, 4] particularly the data from ANC attendees used in the estimation process as a proxy to general population. In addition, globally used method for similar epidemic, e.g. WHO/UNAIDS workbook [5] along with Spectrum software [6] was used in 2006 and 2007 rounds of estimation. The WHO/UNAIDS Workbook having assimilated the average prevalence for each risk group, namely, FSW, IDU, MSM and ANC fitted a logistic model to get the trend of the epidemic. The calibration factors derived in 2006 were used in the 2007 round of estimation in view of non-availability of community based survey data to calibrate every year [7]. Also, it forwarded a limitation of curve fitting over the average HIV prevalence in the population within the Workbook. The

issue was deliberated in the UNAIDS Global Reference group on Estimates, Modelling and Projections (www.epidem.org) and it was suggested to adopt the combination of Estimation and Projection Package (EPP) and Spectrum [8]. The present paper aims to update the HIV estimation with the above combination. Specifically, it describes the data and methods used for the 2008 & 2009 HIV burden estimates for India and compares the resulting estimates with those of earlier years.

Method and Material

The Estimation Projection Package (EPP) [9] and Spectrum AEM modules [6] have been used for the estimation of prevalence and burden of HIV.

The EPP estimates the trends over time of HIV prevalence by fitting an epidemiological model to the surveillance data provided by HIV sentinel surveillance systems. The basic principle underlying EPP is to develop epidemic curves separately for different sub-populations and then combine to produce a single epidemic curve estimating HIV prevalence at the national level. For adult HIV prevalence epidemic curve generated for each sub-population group, initial guesses were made using four parameters, namely t_0 (start year of the HIV epidemic), *r (t*he force of infection), f_0 (the initial fraction of the adult population at risk of infection used to determine the peak level of the epidemic curve, ϕ (the behaviour adjustment parameter which determines how the proportion of new entrants in the adult population who are at risk of HIV infections changes over time). The 2009 version of has also included the provision of antiretroviral therapy,

which increases survival of people living with HIV, hence increasing prevalence and impacting the process of fitting an epidemiological model to the HIV epidemic.

Data

The data sets inputted to EPP includes firstly, the population size of higher risk groups, i.e., FSW. MSM and IDU; Secondly, the population size of lower risk groups which was the general population; thirdly, sentinel surveillance data from 1998 to 2009 on HIV prevalence among higher risk group populations and antenatal care clinic attendees for lower risk groups representing general population.

The size of the higher risk and lower risk population: The size estimates—as detailed out in the NACP-III policy document—for FSW, MSM and IDU has been considered. They are updated with the mapping exercise conducted in 2009 in certain states by NACO and State AIDS Control Societies (SACs). In states where the mapping exercise was not concluded, the higher risk group population was estimated as a proportion of people with higher risk behaviour as reported under the NACP-III document [10]. The lower risk group category is determined through a simple calculation of the total adult population minus the population size of the higher risk groups. The population size for people aged 15–49 years in 2009 has been derived through Demproj in the Spectrum Package. The data used in Demproj for calculating the population size included the Census population data of 1981, 1991 and 2001 and the Expert Group Population Estimates and Projections of India [11, 12, 13, 14]. The breakdown by sex for the IDU population assumes that 90% of the IDU population is male and 10% is female [10, 15].

Programme Coverage: As antiretroviral therapy (ART) programme coverage influences the trend of HIV prevalence, the current ART coverage is extrapolated for the years beyond 2009—which is consistent with the NACP-III planned target of 500,000 by 2015—and distributed among all risk group based on last year proportions in respective risk groups [16].

Demographic input and epidemiological assumptions: The demographic inputs to EPP include the proportion of male population, adult birth rate (15+), survival to age 15 (ℓ_{15}), adult mortality in 15+ (μ) and adult population growth rate. The data source for the above mentioned demographic indicators included Sample Registration System 2002 to 2008 [17]. The following two primary epidemiological assumptions were considered: (1) The criteria for reassigning higher risk groups to the general population category: Based on the second round of Behaviour Surveillance Survey conducted in 2006 [15], it was determined that IDU and MSM after a 15 year duration would be reassigned to the general population category whereas for FSW the timeframe for being reassigned to the general population was reduced to 8 years and (2) AIDS mortality: AIDS mortality was assumed to be higher by as much as 7% for injecting drug users vis-à-vis non- injecting drug users.

Defining the characteristics of the Epidemic - The HIV epidemic in India, at national level, is concentrated amongst female sex workers (FSW), men who have sex with men (MSM) and injecting drug users (IDU). Amongst the 34 Indian States/Union Territories—the epidemic is a defined as a concentrated non-IDU epidemic for all the states with the

exception of Manipur and Nagaland where the epidemic is a defined as a concentrated IDU epidemic.

Generating State-specific prevalence curves: The States/Union Territory specific epidemic, for which first time States/Union Territory specific prevalence curves was generated under the 2008/2009 HIV estimates. Using the Bayesian melding approach, 1000 iterations were used for fitting the initial guesses for ANC sites and 3000 iterations for higher risk group sites. The best fitting curves for all sub-population categories were subsequently combined for producing state prevalence curves.

Calibrating ANC prevalence curves in EPP Model: Estimates of HIV prevalence is primarily based on times series prevalence data amongst ANC attendees. Due to the difference in sero-prevalence between the ANC attendees and those from population based surveys, the calibration of the prevalence curves based on the former is required. The key source of information used for calibrating HIV prevalence curves has the 2006 National Family Health Survey (NFHS-3) [2] where state-specific information on HIV prevalence is determined.

In EPP, when a calibration factor is used, the overall curve determined on the basis of ANC HSS trend data which is scaled according to the calibration constant. Differences in the prevalence level are modelled on the probit scale. The probit scale is chosen in such a way that the differences between prevalence levels do not depend on the level itself. The calibration factor was derived for individual states in five high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur and Tamil Nadu, based on

calculations from NFHS-3 while for Nagaland the calibration factor was determined from a specific study undertaken by NACO [19]. For the remainder of the moderate and low prevalence states, the common constant calibration factor was derived from the NFHS-3 on the basis of the rest of the (excluding aforesaid 6 high prevalence states) national comparison between general population prevalence and ANC prevalence.

Estimation of PLHIV for all age groups using Spectrum

Spectrum under its AIDS Impact Model (AIM) requires a number of inputs and parameters to process estimates and projections of HIV related parameters that will allow fitting of the trend of epidemic as initially determined in EPP. The first input into Spectrum is the projection of HIV incidence determined in EPP. It is combined with the population projection and the other programme coverage indicators and parameters to determine the indicators related to the impact of the epidemic. The parameters included into Spectrum include the ART, PPTCT programme coverage data, age and sex distribution of prevalence. For each of the 34 States/Union Territories, adult and children ART treatment coverage—from 2004 to 2009 and the projected coverage till 2015—along with duration of breastfeeding were used in AIM. An estimated 300,000 adults and 17,000 children utilized ART as on December 2009. Approximately 13,000 mothers had utilized PPTCT in India as by December 2009. Assumptions over other state-specific HIV characteristics included age and sex distribution of new infections, proportion of those newly infected, progressing need for treatment by time since infection, proportion of adults in need of treatment, proportion of adults dying due to AIDS related causes without treatment by time in need, annual mortality among children in need of treatment but not receiving treatment by age, annual survival of adults and children on ART, probability of transmission of HIV from

mother-to-child etc. After finalizing the input of all these parameters, Spectrum re-processed the estimation and projection of the HIV epidemic.

Uncertainty Analysis: The point estimates are associated with uncertainty due to the prevalence/incidence curve produced by EPP and the input assumptions that are based on studies from population samples in selected countries. For addressing this associated uncertainty, a special programme in Spectrum [18] was used for producing uncertainty bounds around the usual point estimates for each indicator and for each year. A logistic curve is fitted to the resulting points, i.e., the 1000 different logistic curve generated is fitted for the prevalence data by varying the data before each fit with the ranges indicated next to the quality categories.

Results and discussion

National / States/Union Territory estimates of HIV Adult Prevalence: While the adult HIV prevalence for each state and Union Territory was directly projected through EPP and Spectrum, the national adult HIV prevalence is determined through application of the simple aggregation number of PLHIV from all states divided by the total adult population and calculated as a multiple of hundred to determined a percentage.

The adult HIV prevalence (males and females together) in India in 2008 is estimated as 0.32% with uncertainty bounds 0.26%–0.41%, and 31% in 2009 with uncertainty bounds 0.25%–0.39%; the decline in HIV prevalence is by 0.02% during the previous two years. The adult HIV prevalence was estimated at 0.25% for women and 0.36% for men in 2009. It was estimated at 0.26% for women and 0.38% for men in 2008 (Table 1). The results of 2008/2009 round of HIV estimates—in terms of trend and levels—are derived

from a methodology that allows for readjustment of the prevalence curves on the basis of additional HSS data. Accordingly, the estimated HIV prevalence came out 0.36% for the year 2006 and 0.34% for the year 2007. As these are exactly the same value derived under the 2006 and 2007 round of HIV estimates, the consistency in results are indicative that the process adopted by the Working Group on Estimates and the results derived therein are valid and a sound base for analysis (Figure 1).

Table 1 : Adult HIV prevalence by sex and number of HIV infections for all ages with uncertainty bounds for the years 2008 and 2009, India

	2008	2009
Adult 15-49 HIV prevalence		
Persons	0.32% (0.26 – 0.41)	0.31% (0.25 - 0.39)
Female	0.26%	0.25%
Male	0.38%	0.36%
Number of HIV infections (All ages)		
Persons (in Lakh)	24.42 (19.74 – 30.89)	23.95 (19.34 – 30.42)
Percent distribution of HIV infection by sex		
Female	38.5%	38.7%
Male	61.5%	61.3%
Percent distribution of HIV infections by age group		
< 15	4.2%	4.4%
15-49	83.3%	82.4%
50+	12.5%	13.2%

State-wise HIV Adult Prevalence: States/Union Territory wise estimates of adult HIV prevalence were the basis for estimating national adult HIV prevalence as detailed in earlier sections of the report. Over and above this process, an uncertainty analysis was conducted independently for each state in Spectrum. The state level data on adult HIV prevalence is provided in Map 1 and an analysis of central emerging trends is recapitulated therein.

The adult HIV prevalence trend line in the six high epidemic states (see technical report), i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur, Nagaland and Tamil Nadu, and Mizoram. Mizoram is added to this group on the basis of the actual estimation derived from the Spectrum. As reflective from the graph, HIV prevalence is on the decline in all states over the four year period of 2006 to 2009; although the degree in decline varies slightly. For instance, the HIV prevalence trend in Karnataka, Mizoram and Nagaland appears more stable (Figure 2). As evident, in all three moderate prevalence states- Goa, Gujarat and Pondicherry, adult HIV prevalence trends is declining from 2006 to 2009.

Regarding the low prevalence States/Union Territories, figure 2 highlights those where the trend for HIV prevalence is stable to increasing between 2006 and 2009. These include the seven States/Union Territories of Arunachal Pradesh, Assam, Chandigarh, Jharkhand, Kerala, Meghalaya and Orissa.

The relatively greater increase in HIV prevalence is noted in Assam, Jharkhand and Orissa vis-à-vis Arunachal Pradesh, Kerala and Meghalaya. The estimated HIV prevalence for Chandigarh—as reflected in figure-2—is not considered a true reflection of the nature of the epidemic in the Union Territory. Whilst noting the increase in the estimated HIV prevalence, it must be considered that the trend is attributable to the services Chandigarh provides to PLHIV from the neighbouring states of Punjab, Haryana and even Himachal Pradesh. As ART information is included as one of the parameters for the projection, the resulted trend is showing an increase, independent of the trend

observed in HSS. A separate analysis of the HIV epidemic in Chandigarh is thus required to take into consideration the evidence and the trends of neighbouring states.

Figure-2 highlights the low prevalence states of Delhi, Haryana, Punjab, Rajasthan, Uttar Pradesh, and West Bengal where HIV prevalence is either stable or declining. Evidently, the degree for decline in HIV prevalence is not uniform between these states which may be on account of the programmatic impact of ART coverage, and the strength of the prevention interventions etc. The decline in HIV prevalence is lower in Haryana and Punjab vis-à-vis Delhi, Rajasthan, Uttar Pradesh, and West Bengal.

National and State estimates of number of people living with HIV

In 2009, the total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) while in 2008; it was 2.44 million people were living with HIV within the uncertainty bounds of 1.97-3.09 millions. Among PLHIV, by sex approximately 61% are male and 39% are female and by age the percent distribution of HIV infection is estimated at 4% are children below the age of 15 years, 83% are adults aged 15–49 years and rest 13% are over 50 years of age (Table 1).

The four high prevalence states of South India account for 57% of all HIV infections in the country. Whilst Andhra Pradesh accounts for 500,000 cases; Maharashtra accounts for 420,000 cases, Karnataka accounts for 250,000 cases and Tamil Nadu accounts for 150,000 cases. Over 100,000 PLHIVs are reported in West Bengal, Gujarat, Bihar and Uttar Pradesh and together these states account for 22% of HIV infections in India. The number of PLHIVs in Punjab, Orissa, Rajasthan and Madhya Pradesh range from 50,000

to 100,000 and these states collectively account for 12% of HIV infections. Thus whilst the states noted above are with low HIV prevalence; a large number of PLHIVs are reported due to the states' overall large population size (Map 1).

The percent distribution of HIV burden amongst high prevalence states vis-à-vis the remaining states in India is 57% and 43% respectively. Amongst the high prevalence states, Andhra Pradesh accounts for the greatest proportion of cases at 21% vis-à-vis the other states. Following Andhra Pradesh, Maharashtra accounts for approximately 18% of HIV infection, Karnataka and Tamil Nadu reportedly account for 10% and 7% of all cases whereas Manipur and Nagaland account for 1% of the estimated total.

Conclusions

The India HIV estimates 2008/2009 confirms a slow down in the AIDS epidemic. National adult HIV prevalence, or the number of adults living with HIV as a proportion of the total population, has declined by 0.10% points from 0.41% in 2000 to 0.31% in 2009. Adult HIV prevalence is either stable or declining in the high prevalence states whereas the trend is varying across the low to moderate prevalence states. Among the high prevalence states, the HIV prevalence has declined in Tamil Nadu between 2006 and 2009 to reach levels of 0.37% in 2008 and 0.33% in 2009. Manipur shows a declining trend over the past four years. Andhra Pradesh, Karnataka, Maharashtra and Nagaland show either a plateau or a slightly declining trend over the time period 2006 – 2009.

In the low prevalence states of Chandigarh, Orissa, Kerala, Jharkhand, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh and Meghalaya; adult HIV prevalence has risen

over the last four years which warrants the need for strengthening the trend of the HIV epidemic.

In descending order, states with the highest adult HIV prevalence in 2009 included Manipur (1.4%); followed by Andhra Pradesh (0.90%), Mizoram (0.81%), Nagaland (0.78%), Karnataka (0.63%) and Maharashtra (0.55%). Besides these, the states of Goa, Chandigarh, Gujarat, Punjab and Tamil Nadu have an estimated adult HIV prevalence greater than national prevalence (0.31%). Delhi, Orissa, West Bengal, Chhattisgarh and Pondicherry have an estimated adult HIV prevalence of 0.28-0.30%. Other states have lower levels of HIV.

The total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) in 2009. Children under 15 years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections. Thirty-nine percent of all HIV infections are estimated to be among women. This amounts to 0.93 million women with HIV in India.

References:

1. National Institute of Health & Family Welfare, 2007, Country Report on Annual HIV Sentinel Surveillence, 2006, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

2. International Institute for Population Sciences (IIPS) and Macro International, 2007, National Family Health Survey, 2005-06 (NFHS-3): India, IIPS, Mumbai.

3. Pandey A., Reddy D.C.S., Ghys P., et al. Improved estimate of India's HIV burden in 2006, *Indian Journal of Medical Research*, 2009, 129, 50-58.

4. Pandey A., Reddy D.C.S., Thomas M. What lies behind the fall in the HIV population in India? *Economic & Political Weekly*, December 2008, 27: pp-15-17.

5. Lyerla R, Gouws E, Garcia-Calleja JM, et al. The 2005 Workbook: an improved tool for estimating HIV prevalence in countries with low level and concentrated epidemics. *Sex Transm Infect* 2006;82(Suppl III):iii41–iii44.

6. Stover J, Walker N, Grassly NC, at al. Projecting the demographic impact of AIDS and the number of people in need of treatment: updates to the Spectrum projection package. *Sex Transm Infect* 2006;82(Suppl III):iii45–iii50.

7. Pandey A., Reddy D.C.S., Thomas M., et al. Prevalence and burden of HIV in India 2007 - An Update of Estimates, *Demography India*, 2010, 39(2).

8. UNAIDS Global Reference group on Estimates, Modelling and Projections (www.epidem.org)

9. UNAIDS, 2010, http://www.unaids.org/en/dataanalysis/tools/estimation projection package epp/

10. *National AIDS Control Organization, National AIDS Control Programme – III*, Ministry of Health & Family Welfare, India.

11. *Census of India 1981*, Office of the Registrar General India, New Delhi,

12. *Census of India 1991*, Office of the Registrar General India, New Delhi,

13. *Census of India 2001*, Office of the Registrar General India, New Delhi,

14. *Population Projections for India and States 2001-2026, Report of the Technical Group on Population Projections*, May 2006, National Commission on Population, Ministry of Health & Family Welfare, New Delhi.

15. *Behavioural Surveillance Survey, 2006 – Female sex Workers (FSW) & their clients*, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

16. *National AIDS Control Organization, National AIDS Control Programme CMS*, Ministry of Health & Family Welfare, India.

17. *Sample Registration System*, Statistical reports, Office of the Registrar General India, New Delhi, 2010.

18. Grassly N.C., Morgan M., Walker N., et al. Uncertainty in estimates of HIV/AIDS: the estimation and application of plausibility bounds, *Sex. Transm. Inf.* 2004; 80; 31-38.

19. Bachani D., Sogarwal R., Rao K.S. A population based survey on HIV prevention in Nagaland, India, *SAARC Journal of Tuberculosis*, Lung Diseases and HIV/AIDS, vol. 6(1), 2009, pp1-11.

Contributorship

AP contributed to conception, analysis and drafting of article. DS contributed to data analysis, interpretation and draft of the article. TB contributed to the implementation of the models, analysis and interpretation of data. DCSR contributed to the design, analysis and interpretation of data.SK contributed to the interpretation of data. MB contributed to the design, acquisition and analysis of data. YR contributed to the planning, acquisition and analysis of data. PH contributed to the analysis and interpretation of data. Deepak Bharadwaj contributed to the data analysis. NC contributed interpretation. All the authors read and approved the final manuscript.

Data Sharing

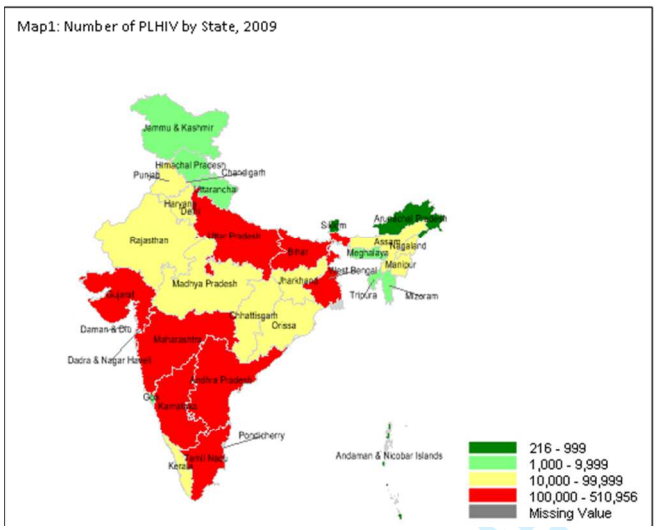
We have used all published data.

Funding

No specific funding.

Competing Interests

The authors declare that they have no competing interests.



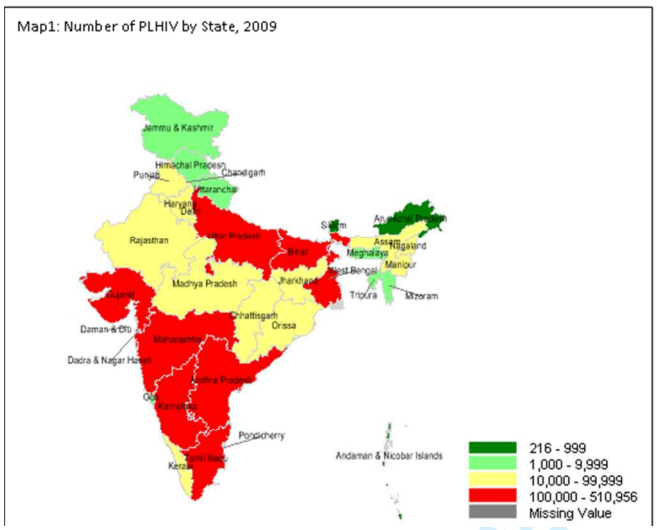
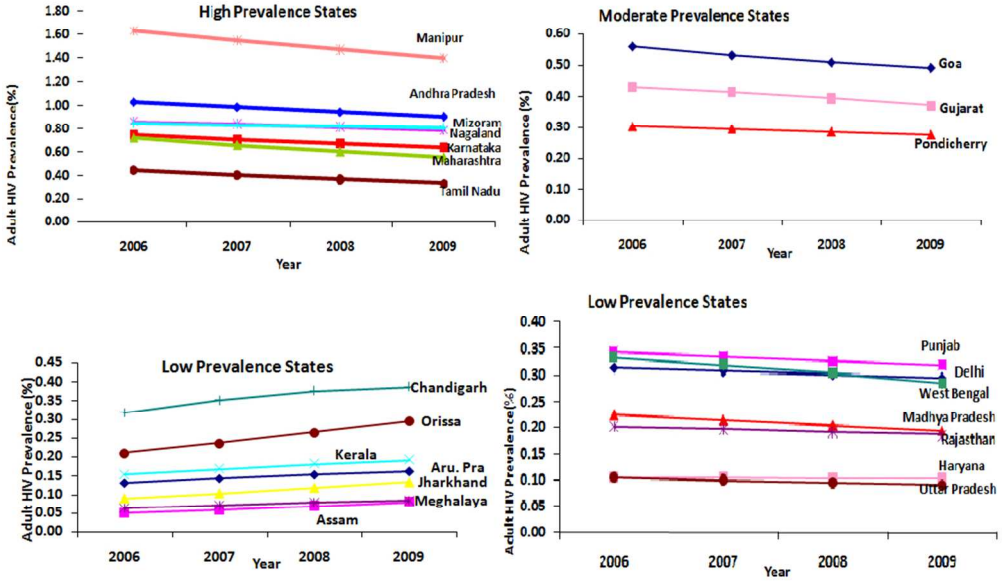


Figure 2: Adult HIV Prevalence Trends from 2006 to 2009, India States



ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000926.R1
Article Type:	Research
Date Submitted by the Author:	05-Jul-2012
Complete List of Authors:	Pandey, Arvind; National Institute of Medical Statistics, Sahu, Damodar; National Institute of Medical Statistics, ICMR Bakkali, TaoufiK; UNAIDS, India Country Office Reddy, DCS; WHO India Office, Kant, Shashi; All India Institute of Medical Sciences, Community Medicine Bhattacharya, M.; Natinal Institute of Health and family welfare, Raj, Yujwal; National AIDS Control Organization, Haldar, Partha; WHO India Office, Bhardwaj, Deepak; National Institute of Medical Statistics, ICMR Chandra, Nalini; UNAIDS, India Country Office
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Infectious diseases, Public health
Keywords:	HIV & AIDS < INFECTIOUS DISEASES, HIV prevalence, PLHIV

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Background:

Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived every year since 1998. The process is consultative amongst the national and international experts in the field of biostatistics and epidemiology. Technical supports are received from UN organizations particularly experts from the WHO and UNAIDS. Efforts are made to improve data both in terms of quality and representativeness as well as the methodology matching to epidemics. For instance, in 2006 with the expansion of sentinel surveillance to all districts [1], sero-survey as a part of third round of National Family Health Survey (NFHS-3) [2] and the observation that there is a common practice of referral of HIV-positive/suspected cases to public hospitals and a preferential use of public hospitals by people in the lower socio-economic strata causing overestimation of the HIV burden in India [3, 4], many of the assumptions are replaced with evidence based information.

In fact, the NFHS-3 provided an opportunity to calibrate the surveillance data [5, 6] particularly the data from ANC attendees used in the estimation process as a proxy to general population. In addition, globally used method for similar epidemic, e.g. WHO/UNAIDS workbook [7] along with Spectrum software [8] was used in 2006 and 2007 rounds of estimation. The WHO/UNAIDS Workbook having assimilated the average prevalence for each risk group, namely, FSW, IDU, MSM and ANC fitted a logistic model to get the trend of the epidemic. The calibration factors derived in 2006 were used in the 2007 round of estimation in view of non-availability of community based survey data to calibrate every year [9]. Also, it forwarded a limitation of curve

fitting over the average HIV prevalence in the population within the Workbook. The issue was deliberated in the UNAIDS Global Reference group on Estimates, Modelling and Projections and it was suggested to adopt the combination of Estimation and Projection Package (EPP) and Spectrum [10]. The present paper aims to update the HIV estimation with the above combination. Specifically, it describes the data and methods used for the 2008 & 2009 HIV burden estimates for India and compares the resulting estimates with those of earlier years.

Method and Material

The Estimation Projection Package (EPP) [11] and Spectrum DemProj and AIM modules [8] was used for the estimating prevalence and burden of HIV.

Data

The Working Group reviewed and used four sets of data available from various sources for the estimation process.

Surveillance: The following surveillance data available from 1998 to 2009 was used in EPP for producing state and national curves. These represent HIV prevalence data from HIV sentinel surveillance that was conducted amongst pregnant women attending antenatal clinics and the key population groups of Female Sex Workers (FSW), Men having Sex with Men (MSM) and Injecting Drug Users (IDUs). Through the scale up in number of HIV Sentinel Surveillance (HSS) sites and increased focus on key population sites, a wider geographical and population group coverage was achieved leading to more

accurate results. The following table reflects the scale up in numbers of surveillance sites per year for the populations groups that are used in the HIV estimates process.

Table 1: Scale up of HIV Sentinel Sites in India, 1998-2009

Site Type	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009
ANC	92	93	111	172	200	476	390	391	636	654	668
IDU	5	6	10	10	13	18	24	30	51	52	61
MSM	-	-	3	3	3	9	15	18	31	40	67
FSW	1	1	2	2	2	32	42	83	138	137	194
Total	98	100	126	187	218	535	471	522	856	883	990

Also, the working group used the estimated prevalence from the National Family and Health Survey (NFHS) conducted throughout the country with state level representation in the high prevalence states. The adult HIV prevalence from the NFHS-3 was used for calibration of the fitted curves.

Population sizes (the size of the higher risk and lower risk population): Secondly, for determining specific demographic parameters of key population groups, the size estimates for FSW, MSM and IDU provided under the NACP III document [12] was considered. This was updated with data from the 2009 mapping exercise conducted among key population in 2009 in specific states by NACO and State AIDS Control Societies (SACs). In states where the mapping exercise was not concluded, the higher risk group population was estimated as a proportion of people with higher risk behaviour as reported under the NACP-III document [13].

In addition, data inputs used for determining the size of the general population at lower risk for HIV were number of births, number of deaths, adult population growth rate and population size for people aged over 15 years across and in 34 states/Union Territories from the vital registration system [14]. National population estimates were obtained from

population projection for India and states from the period 2001 to 2026. The size of the general population at lower risk for HIV were calculated as the total adult population minus the population size of the higher risk groups. The population size for people aged 15–49 years in 2009 has been derived through Demproj in the Spectrum Package. The data used in Demproj for calculating the population size included the Census population data of 1981, 1991 and 2001 and the Expert Group Population Estimates and Projections of India [15, 16, 17, 18]. The breakdown by sex for the IDU population assumes that 90% of the IDU population is male and 10% is female [12, 19].

Programme Coverage: As antiretroviral therapy (ART) programme coverage influences the trend of HIV prevalence, the current ART coverage is extrapolated for the years beyond 2009—which is consistent with the NACP-III planned target of 500,000 by 2015—and distributed among all risk group based on last year proportions in respective risk groups [20].

Methods:

The EPP estimates the trends over time of HIV prevalence by fitting an epidemiological model to the surveillance data provided by HIV sentinel surveillance systems. The basic principle underlying EPP is to develop epidemic curves separately for different sub-populations and then combine to produce a single epidemic curve estimating HIV prevalence at the national level. For adult HIV prevalence epidemic curve generated for each sub-population group, initial guesses were made using four parameters, namely t_0 (start year of the HIV epidemic), *r (t*he force of infection), f_0 (the initial fraction of the adult population at risk of infection used to determine the peak level of the epidemic

curve, φ (the behaviour adjustment parameter which determines how the proportion of new entrants in the adult population who are at risk of HIV infections changes over time). The 2009 version of has also included the provision of antiretroviral therapy, which increases survival of people living with HIV, hence increasing prevalence and impacting the process of fitting an epidemiological model to the HIV epidemic. Data from the above sources were entered to EPP to produce curves of adult HIV prevalence among different population groups including antenatal clinic attendees — as proxy for general population — and key population groups.

The following two primary epidemiological assumptions were considered whilst analyzing data under the 2009 version of EPP: (1) a specific criterion was considered for reassigning higher risk groups to the general population category. Based on the second round of Behaviour Surveillance Survey conducted in 2006 [19], it was determined that IDU and MSM after a 15 year duration would be reassigned to the general population category whereas for FSW the timeframe for being reassigned to the general population was reduced to 8 years and (2) AIDS mortality was assumed to be higher by as much as 7% for injecting drug users vis-à-vis non- injecting drug users.

Defining the characteristics of the Epidemic - The HIV epidemic in India, at national level, is concentrated amongst female sex workers (FSW), men who have sex with men (MSM) and injecting drug users (IDU). Amongst the 34 Indian States/Union Territories—the epidemic is a defined as a concentrated non-IDU epidemic for all the states with the exception of Manipur and Nagaland where the epidemic is a defined as a concentrated IDU epidemic.

Generating State-specific prevalence curves: The States/Union Territory specific epidemic, for which first time States/Union Territory specific prevalence curves was generated under the 2008/2009 HIV estimates. Using the Bayesian melding approach, 1000 iterations were used for fitting the initial guesses for ANC sites and 3000 iterations for higher risk group sites. The best fitting curves for all sub-population categories were subsequently combined for producing state prevalence curves.

Calibrating ANC prevalence curves in EPP Model: Estimates of HIV prevalence is primarily based on times series prevalence data amongst ANC attendees in HSS. Due to the difference in sero-prevalence between the ANC attendees and those from population based surveys, the calibration of the prevalence curves based on the former is required. The key source of information used for calibrating HIV prevalence curves has the 2006 National Family Health Survey (NFHS-3) [2] where state-specific information on HIV prevalence is determined. The curve for antenatal clinic attendees was calibrated from National Family Health Survey (NFHS-3) 2005-06 for general population. In order to have an appropriate calibration of the HIV prevalence trends determined in spectrum, the point values of prevalence determined from the NFHS-3 in 2006 as a reference for calibrating the prevalence trend for general population, initially determined through ANC.

In EPP, when a calibration factor is used, the overall curve determined on the basis of ANC HSS trend data which is scaled according to the calibration constant. Differences in the prevalence level are modeled on the probit scale. The probit scale is chosen in such a way that the differences between prevalence levels do not depend on the level itself. The calibration factor was derived for individual states in five high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur and Tamil Nadu, based on

calculations from NFHS-3 while for Nagaland the calibration factor was determined from a specific study undertaken by NACO [21]. For the remainder of the moderate and low prevalence states, the common constant calibration factor of 0.69 was derived from the NFHS-3 on the basis of the rest of the states (excluding aforesaid 6 high prevalence states) national comparison between general population prevalence and ANC prevalence.

Estimation of PLHIV for all age groups using Spectrum In order to estimate the number of people living with HIV and HIV prevalence for all ages, the projected adult HIV prevalence for each state was fed into Spectrum along with programme data on Antiretroviral (ART) programme coverage, percent of mothers and children given nevirapine prophylaxis and certain demographic and epidemiological parameters.

Spectrum under its AIDS Impact Model (AIM) requires a number of inputs and parameters to process estimates and projections of HIV related parameters that will allow fitting of the trend of epidemic as initially determined in EPP. The first input into Spectrum is the projection of HIV incidence determined in EPP. It is combined with the population projection and the other programme coverage indicators and parameters to determine the indicators related to the impact of the epidemic. The parameters included into Spectrum include the ART, PPTCT programme coverage data, age and sex distribution of prevalence. For each of the 34 States/Union Territories, adult and children ART treatment coverage—from 2004 to 2009 and the projected coverage till 2015—along with duration of breastfeeding were used in AIM. An estimated 300,000 adults and 17,000 children utilized ART as on December 2009. Approximately 13,000 mothers had utilized PPTCT in India as by December 2009. Assumptions over other state-specific HIV characteristics included age and sex distribution of new infections, proportion of those newly infected, progressing need for treatment by time since infection, proportion of adults in need of treatment, proportion of adults dying due to AIDS related causes without treatment by time in need, annual

mortality among children in need of treatment but not receiving treatment by age, annual survival of adults and children on ART, probability of transmission of HIV from mother-to-child etc. After finalizing the input of all these parameters, Spectrum re-processed the estimation and projection of the HIV epidemic.

Uncertainty Analysis: The point estimates are associated with uncertainty due to the prevalence/incidence curve produced by EPP and the input assumptions that are based on studies from population samples in selected countries. For addressing this associated uncertainty, a special programme in Spectrum [22] was used for producing uncertainty bounds around the usual point estimates for each indicator and for each year. A logistic curve is fitted to the resulting points, i.e., the 1000 different logistic curve generated is fitted for the prevalence data by varying the data before each fit with the ranges indicated next to the quality categories.

Results and discussion

The tools used for generating HIV estimates and the data used as mentioned above allows for production of estimated HIV prevalence and incidence trends from the beginning of the epidemic to the current year and projection for the future.

National / States/Union Territory estimates of HIV Adult Prevalence: While the adult HIV prevalence for each state and Union Territory was directly projected through EPP and Spectrum, the national adult HIV prevalence is determined through application of the simple aggregation number of PLHIV from all states divided by the total adult population and calculated as a multiple of hundred to determined a percentage.

The adult HIV prevalence (males and females together) in India in 2008 is estimated as 0.32% with uncertainty bounds 0.26%–0.41%, and 0.31% in 2009 with uncertainty bounds 0.25%–0.39. The adult HIV prevalence was estimated at 0.25% for women and 0.36% for men in 2009. It was estimated at 0.26% for women and 0.38% for men in 2008

(Table 2). The results of 2008/2009 round of HIV estimates—in terms of trend and levels—are derived from a methodology that allows for readjustment of the prevalence curves on the basis of additional HSS data. Accordingly, the estimated HIV prevalence came out 0.36% for the year 2006 and 0.34% for the year 2007. As these are exactly the same value derived under the 2006 and 2007 round of HIV estimates, the consistency in results are indicative that the process adopted by the Working Group on Estimates and the results derived therein are valid and a sound base for analysis (Figure 1).

Table 2 : Adult HIV prevalence by sex and number of HIV infections for all ages with uncertainty bounds for the years 2008 and 2009, India

	2008	2009
Adult 15-49 HIV prevalence		
Persons	0.32% (0.26 – 0.41)	0.31% (0.25 - 0.39)
Female	0.26%	0.25%
Male	0.38%	0.36%
Number of HIV infections (All ages)		
Persons (in Lakh)	24.42 (19.74 – 30.89)	23.95 (19.34 – 30.42)
Percent distribution of HIV infection by sex		
Female	38.5%	38.7%
Male	61.5%	61.3%
Percent distribution of HIV infections by age group		
< 15	4.2%	4.4%
15-49	83.3%	82.4%
50+	12.5%	13.2%

State-wise HIV Adult Prevalence: States/Union Territory wise estimates of adult HIV prevalence were the basis for estimating national adult HIV prevalence as detailed in earlier sections of the report. Over and above this process, an uncertainty analysis was conducted independently for each state in Spectrum. The state level estimates on adult HIV prevalence is provided in Map 1 and an analysis of central emerging trends is recapitulated therein.

As reflective from Figure 2, the HIV prevalence is on the decline in all states over the past four year period of 2006 to 2009; although the degree in decline varies slightly. For instance, the HIV prevalence trend appears stable in six high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur, Nagaland and Tamil Nadu and Mizoram (which is added to this group on the basis of consistently reporting HIV prevalence among ANC clinic attendees >1% in past four years in HSS). Further, , in all three moderate prevalence states- Goa, Gujarat and Pondicherry, adult HIV prevalence trends is declining from 2006 to 2009.

Regarding the low prevalence States/Union Territories, figure 2 highlights those where the trend for HIV prevalence is stable to increasing between 2006 and 2009. These include the seven States/Union Territories of Arunachal Pradesh, Assam, Chandigarh, Jharkhand, Kerala, Meghalaya and Orissa.

The relatively greater increase in HIV prevalence is noted in Assam, Jharkhand and Orissa vis-à-vis Arunachal Pradesh, Kerala and Meghalaya. The estimated HIV prevalence for Chandigarh—as reflected in figure-2—is not considered a true reflection of the nature of the epidemic in the Union Territory. Whilst noting the increase in the estimated HIV prevalence, it must be considered that the trend is attributable to the services Chandigarh provides to PLHIV from the neighbouring states of Punjab, Haryana and even Himachal Pradesh. As ART information is included as one of the parameters for the projection, the resulted trend is showing an increase, independent of the trend observed in HSS. A separate analysis of the HIV epidemic in Chandigarh is thus required to take into consideration the evidence and the trends of neighbouring states.

Figure-2 highlights the low prevalence states of Delhi, Haryana, Punjab, Rajasthan, Uttar Pradesh, and West Bengal where HIV prevalence is either stable or declining. Evidently, the degree for decline in HIV prevalence is not uniform between these states which may be on account of the programmatic impact of ART coverage, and the strength of the prevention interventions etc. The decline in HIV prevalence is lower in Haryana and Punjab vis-à-vis Delhi, Rajasthan, Uttar Pradesh, and West Bengal.

National and State estimates of number of people living with HIV

In 2009, the total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) while in 2008; it was 2.44 million people were living with HIV within the uncertainty bounds of 1.97-3.09 millions. Among PLHIV, by sex approximately 61% are male and 39% are female and by age the percent distribution of HIV infection is estimated at 4% are children below the age of 15 years, 83% are adults aged 15–49 years and rest 13% are over 50 years of age (Table 1).

The four high prevalence states of South India account for 57% of all HIV infections in the country. Whilst Andhra Pradesh accounts for 500,000 cases; Maharashtra accounts for 420,000 cases, Karnataka accounts for 250,000 cases and Tamil Nadu accounts for 150,000 cases. Over 100,000 PLHIVs are reported in West Bengal, Gujarat, Bihar and Uttar Pradesh and together these states account for 22% of HIV infections in India. The number of PLHIVs in Punjab, Orissa, Rajasthan and Madhya Pradesh range from 50,000 to 100,000 and these states collectively account for 12% of HIV infections. Thus whilst the states noted above are with low HIV prevalence; a large number of PLHIVs are reported due to the states' overall large population size (Map 1).

The percent distribution of HIV burden amongst high prevalence states vis-à-vis the remaining states in India is 57% and 43% respectively. Amongst the high prevalence states, Andhra Pradesh accounts for the greatest proportion of cases at 21% vis-à-vis the other states. Following Andhra Pradesh, Maharashtra accounts for approximately 18% of HIV infection, Karnataka and Tamil Nadu reportedly account for 10% and 7% of all cases whereas Manipur and Nagaland account for 1% of the estimated total.

Conclusions

The India HIV estimates 2008/2009 indicate a slowdown in the AIDS epidemic. National adult HIV prevalence, or the number of adults living with HIV as a proportion of the total population, has declined by 0.05% points from 0.36% (0.29% - 0.45%) in 2006 to 0.31% (0.25% - 0.39%) in 2009. The results of 2008-09 round of estimates match perfectly with previously announced estimates. The estimation of 2008-09 has utilized EPP against UNAIDS/WHO workbook in 2006. . Results from the 2008/09 estimate replace the previously announced numbers; however, they should not be directly compared with the previous years. This is because the method of estimation and projection took in consideration old data and additional new information generated from new rounds of surveillance. The assumptions, methodologies and data used to produce the estimates have gradually changed as a result of ongoing enhancement of knowledge on the epidemic. Hence a comparison between the latest estimates with those published in previous years may yield misleading conclusions.

Adult HIV prevalence is either stable or declining in the high prevalence states whereas the trend is varying across the low to moderate prevalence states. Among the high

prevalence states, the HIV prevalence has declined in Tamil Nadu between 2006 and 2009 to reach levels of 0.37% in 2008 and 0.33% in 2009. Manipur shows a declining trend over the past four years. Andhra Pradesh, Karnataka, Maharashtra and Nagaland show either a plateau or a slightly declining trend over the time period 2006 – 2009.

In the low prevalence states of Chandigarh, Orissa, Kerala, Jharkhand, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh and Meghalaya; adult HIV prevalence has risen over the last four years which warrants the need for strengthening the trend of the HIV epidemic.

In descending order, states with the highest adult HIV prevalence in 2009 included Manipur (1.4%); followed by Andhra Pradesh (0.90%), Mizoram (0.81%), Nagaland (0.78%), Karnataka (0.63%) and Maharashtra (0.55%). Besides these, the states of Goa, Chandigarh, Gujarat, Punjab and Tamil Nadu have an estimated adult HIV prevalence greater than national prevalence (0.31%). Delhi, Orissa, West Bengal, Chhattisgarh and Pondicherry have an estimated adult HIV prevalence of 0.28-0.30%. Other states have lower levels of HIV.

The total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) in 2009. Children under 15 years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections. Thirty-nine percent of all HIV infections are estimated to be among women. This amounts to 0.93 million women with HIV in India.

References:

1. National Institute of Health & Family Welfare, 2007, Country Report on Annual HIV Sentinel Surveillence, 2006, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

2. International Institute for Population Sciences (IIPS) and Macro International, 2007, National Family Health Survey, 2005-06 (NFHS-3): India, IIPS, Mumbai.

3. Dandona L, Lakshmi V, Sudha T, Kumar GA, Dandona R. A population based study of human immunodeficiency virus in south India reveals major differences from sentinel surveillance-based estimates. *BMC Med* 2006; *4* : 31-49.

4. Dandona L, Lakshmi V, Kumar GA, Dandona R. Is the HIV burden in India being over estimated? *BMC Public Health* 2006; *6* : 308-17.

5. Pandey A., Reddy D.C.S., Ghys P., et al. Improved estimate of India's HIV burden in 2006, *Indian Journal of Medical Research*, 2009, 129, 50-58.

6. Pandey A., Reddy D.C.S., Thomas M. What lies behind the fall in the HIV population in India? *Economic & Political Weekly*, December 2008, 27: pp-15-17.

7. Lyerla R, Gouws E, Garcia-Calleja JM, et al. The 2005 Workbook: an improved tool for estimating HIV prevalence in countries with low level and concentrated epidemics. *Sex Transm Infect* 2006;82(Suppl III):iii41–iii44.

8. Stover J, Walker N, Grassly NC, at al. Projecting the demographic impact of AIDS and the number of people in need of treatment: updates to the Spectrum projection package. *Sex Transm Infect* 2006;82(Suppl III):iii45–iii50.

9. Pandey A., Reddy D.C.S., Thomas M., et al. Prevalence and burden of HIV in India 2007 - An Update of Estimates, *Demography India*, 2010, 39(2).

10. UNAIDS Global Reference group on Estimates, Modelling and Projections (www.epidem.org)

11. UNAIDS, 2010, http://www.unaids.org/en/dataanalysis/tools/estimation projection package epp/

12. *National AIDS Control Organization, National AIDS Control Programme – III*, Ministry of Health & Family Welfare, India.

13. Technical Report India HIV Estimates 2008-2009 National Institute of Medical Statistics, ICMR, De*lhi and National AIDS Control* Organization, , Ministry of Health & Family Welfare, India (2010).

14. *Sample Registration System*, Statistical reports, Office of the Registrar General India, New Delhi, 2010.

15. *Census of India 1981*, Office of the Registrar General India, New Delhi,

16. *Census of India 1991*, Office of the Registrar General India, New Delhi,

17. *Census of India 2001*, Office of the Registrar General India, New Delhi,

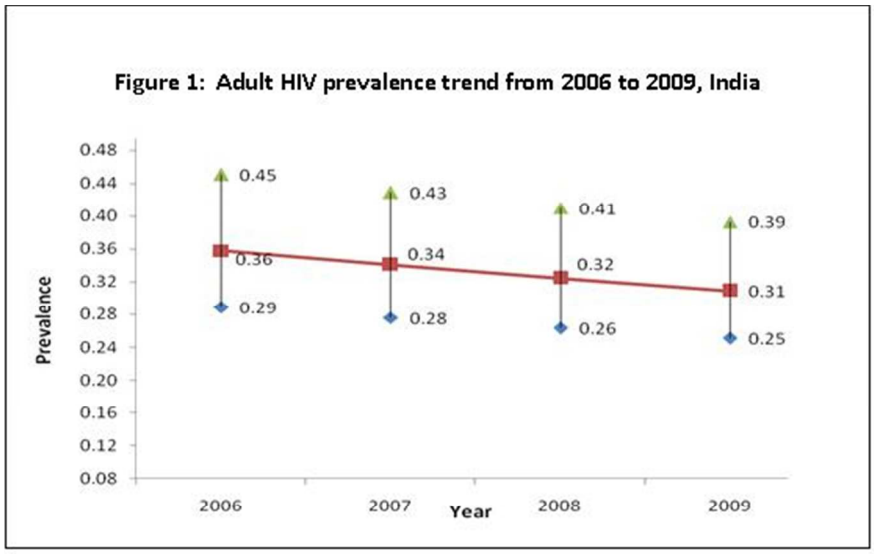
18. *Population Projections for India and States 2001-2026, Report of the Technical Group on Population Projections*, May 2006, National Commission on Population, Ministry of Health & Family Welfare, New Delhi.

19. *Behavioural Surveillance Survey, 2006 – Female sex Workers (FSW) & their clients*, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

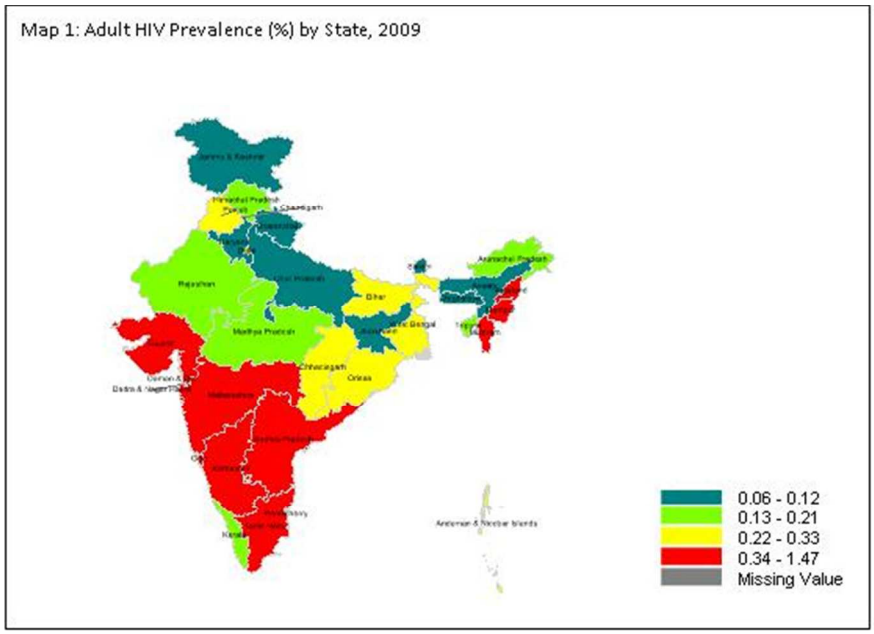
20. *National AIDS Control Organization, National AIDS Control Programme CMS*, Ministry of Health & Family Welfare, India.

21. Bachani D., Sogarwal R., Rao K.S. A population based survey on HIV prevention in Nagaland, India, *SAARC Journal of Tuberculosis*, Lung Diseases and HIV/AIDS, vol. 6(1), 2009, pp1-11.

22. Grassly N.C., Morgan M., Walker N., et al. Uncertainty in estimates of HIV/AIDS: the estimation and application of plausibility bounds, *Sex. Transm. Inf.* 2004; 80; 31-38.

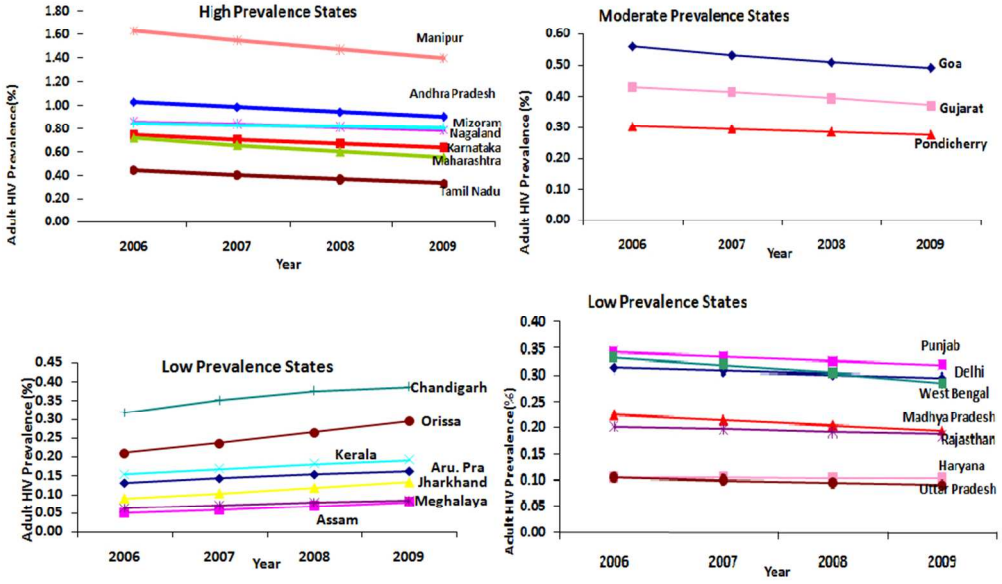


225x180mm (72 x 72 DPI)



225x180mm (72 x 72 DPI)

Figure 2: Adult HIV Prevalence Trends from 2006 to 2009, India States



Research check list: Estimates of HIV Prevalence and Number of People Living With HIV in India 2008-09

Sr. No.	Item	Remarks
1.	CONSORT statement	**Not required**
2.	PRISMA statement	**Not required**
3.	EVEREST statement	**Not required**
4.	STARD statement	**Not required**
5.	STROBE statement	**Not required**
6.	MOOSE statement	**Not required**
7.	ANY OTHER statement	**The study is secondary data analysis**

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Background:

Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived every year since 1998. The process is consultative amongst the national and international experts in the field of biostatistics and epidemiology. Technical supports are received from UN organizations particularly experts from the WHO and UNAIDS. Efforts are made to improve data both in terms of quality and representativeness as well as the methodology matching to epidemics. For instance, in 2006 with the expansion of sentinel surveillance to all districts [1], sero-survey as a part of third round of National Family Health Survey (NFHS-3) [2] and the observation that there is a common practice of referral of HIV-positive/suspected cases to public hospitals and a preferential use of public hospitals by people in the lower socio-economic strata causing overestimation of the HIV burden in India [3, 4], many of the assumptions are replaced with evidence based information.

In fact, the NFHS-3 provided an opportunity to calibrate the surveillance data [5, 6] particularly the data from ANC attendees used in the estimation process as a proxy to general population. In addition, globally used method for similar epidemic, e.g. WHO/UNAIDS workbook [7] along with Spectrum software [8] was used in 2006 and 2007 rounds of estimation. The WHO/UNAIDS Workbook having assimilated the average prevalence for each risk group, namely, FSW, IDU, MSM and ANC fitted a logistic model to get the trend of the epidemic. The calibration factors derived in 2006 were used in the 2007 round of estimation in view of non-availability of community based survey data to calibrate every year [9]. Also, it forwarded a limitation of curve

fitting over the average HIV prevalence in the population within the Workbook. The issue was deliberated in the UNAIDS Global Reference group on Estimates, Modelling and Projections and it was suggested to adopt the combination of Estimation and Projection Package (EPP) and Spectrum [10]. The present paper aims to update the HIV estimation with the above combination. Specifically, it describes the data and methods used for the 2008 & 2009 HIV burden estimates for India and compares the resulting estimates with those of earlier years.

Method and Material

The Estimation Projection Package (EPP) [11] and Spectrum DemProj and AIM modules [8] was used for the estimating prevalence and burden of HIV.

Data

The Working Group reviewed and used four sets of data available from various sources for the estimation process.

Surveillance: The following surveillance data available from 1998 to 2009 was used in EPP for producing state and national curves. These represent HIV prevalence data from HIV sentinel surveillance that was conducted amongst pregnant women attending antenatal clinics and the key population groups of Female Sex Workers (FSW), Men having Sex with Men (MSM) and Injecting Drug Users (IDUs). Through the scale up in number of HIV Sentinel Surveillance (HSS) sites and increased focus on key population sites, a wider geographical and population group coverage was achieved leading to more

accurate results. The following table reflects the scale up in numbers of surveillance sites per year for the populations groups that are used in the HIV estimates process.

Table 1: Scale up of HIV Sentinel Sites in India, 1998-2009

Site Type	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009
ANC	92	93	111	172	200	476	390	391	636	654	668
IDU	5	6	10	10	13	18	24	30	51	52	61
MSM	-	-	3	3	3	9	15	18	31	40	67
FSW	1	1	2	2	2	32	42	83	138	137	194
Total	98	100	126	187	218	535	471	522	856	883	990

Also, the working group used the estimated prevalence from the National Family and Health Survey (NFHS) conducted throughout the country with state level representation in the high prevalence states. The adult HIV prevalence from the NFHS-3 was used for calibration of the fitted curves.

Population sizes (the size of the higher risk and lower risk population): Secondly, for determining specific demographic parameters of key population groups, the size estimates for FSW, MSM and IDU provided under the NACP III document [12] was considered. This was updated with data from the 2009 mapping exercise conducted among key population in 2009 in specific states by NACO and State AIDS Control Societies (SACs). In states where the mapping exercise was not concluded, the higher risk group population was estimated as a proportion of people with higher risk behaviour as reported under the NACP-III document [13].

In addition, data inputs used for determining the size of the general population at lower risk for HIV were number of births, number of deaths, adult population growth rate and population size for people aged over 15 years across and in 34 states/Union Territories from the vital registration system [14]. National population estimates were obtained from

population projection for India and states from the period 2001 to 2026. The size of the general population at lower risk for HIV were calculated as the total adult population minus the population size of the higher risk groups. The population size for people aged 15–49 years in 2009 has been derived through Demproj in the Spectrum Package. The data used in Demproj for calculating the population size included the Census population data of 1981, 1991 and 2001 and the Expert Group Population Estimates and Projections of India [15, 16, 17, 18]. The breakdown by sex for the IDU population assumes that 90% of the IDU population is male and 10% is female [12, 19].

Programme Coverage: As antiretroviral therapy (ART) programme coverage influences the trend of HIV prevalence, the current ART coverage is extrapolated for the years beyond 2009—which is consistent with the NACP-III planned target of 500,000 by 2015—and distributed among all risk group based on last year proportions in respective risk groups [20].

Methods:

The EPP estimates the trends over time of HIV prevalence by fitting an epidemiological model to the surveillance data provided by HIV sentinel surveillance systems. The basic principle underlying EPP is to develop epidemic curves separately for different sub-populations and then combine to produce a single epidemic curve estimating HIV prevalence at the national level. For adult HIV prevalence epidemic curve generated for each sub-population group, initial guesses were made using four parameters, namely t_0 (start year of the HIV epidemic), *r (t*he force of infection), f_0 (the initial fraction of the adult population at risk of infection used to determine the peak level of the epidemic

curve, φ (the behaviour adjustment parameter which determines how the proportion of new entrants in the adult population who are at risk of HIV infections changes over time). The 2009 version of has also included the provision of antiretroviral therapy, which increases survival of people living with HIV, hence increasing prevalence and impacting the process of fitting an epidemiological model to the HIV epidemic. Data from the above sources were entered to EPP to produce curves of adult HIV prevalence among different population groups including antenatal clinic attendees — as proxy for general population — and key population groups.

The following two primary epidemiological assumptions were considered whilst analyzing data under the 2009 version of EPP: (1) a specific criterion was considered for reassigning higher risk groups to the general population category. Based on the second round of Behaviour Surveillance Survey conducted in 2006 [19], it was determined that IDU and MSM after a 15 year duration would be reassigned to the general population category whereas for FSW the timeframe for being reassigned to the general population was reduced to 8 years and (2) AIDS mortality was assumed to be higher by as much as 7% for injecting drug users vis-à-vis non- injecting drug users.

Defining the characteristics of the Epidemic - The HIV epidemic in India, at national level, is concentrated amongst female sex workers (FSW), men who have sex with men (MSM) and injecting drug users (IDU). Amongst the 34 Indian States/Union Territories—the epidemic is a defined as a concentrated non-IDU epidemic for all the states with the exception of Manipur and Nagaland where the epidemic is a defined as a concentrated IDU epidemic.

Generating State-specific prevalence curves: The States/Union Territory specific epidemic, for which first time States/Union Territory specific prevalence curves was generated under the 2008/2009 HIV estimates. Using the Bayesian melding approach, 1000 iterations were used for fitting the initial guesses for ANC sites and 3000 iterations for higher risk group sites. The best fitting curves for all sub-population categories were subsequently combined for producing state prevalence curves.

Calibrating ANC prevalence curves in EPP Model: Estimates of HIV prevalence is primarily based on times series prevalence data amongst ANC attendees in HSS. Due to the difference in sero-prevalence between the ANC attendees and those from population based surveys, the calibration of the prevalence curves based on the former is required. The key source of information used for calibrating HIV prevalence curves has the 2006 National Family Health Survey (NFHS-3) [2] where state-specific information on HIV prevalence is determined. The curve for antenatal clinic attendees was calibrated from National Family Health Survey (NFHS-3) 2005-06 for general population. In order to have an appropriate calibration of the HIV prevalence trends determined in spectrum, the point values of prevalence determined from the NFHS-3 in 2006 as a reference for calibrating the prevalence trend for general population, initially determined through ANC.

In EPP, when a calibration factor is used, the overall curve determined on the basis of ANC HSS trend data which is scaled according to the calibration constant. Differences in the prevalence level are modeled on the probit scale. The probit scale is chosen in such a way that the differences between prevalence levels do not depend on the level itself. The calibration factor was derived for individual states in five high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur and Tamil Nadu, based on

calculations from NFHS-3 while for Nagaland the calibration factor was determined from a specific study undertaken by NACO [21]. For the remainder of the moderate and low prevalence states, the common constant calibration factor of 0.69 was derived from the NFHS-3 on the basis of the rest of the states (excluding aforesaid 6 high prevalence states) national comparison between general population prevalence and ANC prevalence.

Estimation of PLHIV for all age groups using Spectrum In order to estimate the number of people living with HIV and HIV prevalence for all ages, the projected adult HIV prevalence for each state was fed into Spectrum along with programme data on Antiretroviral (ART) programme coverage, percent of mothers and children given nevirapine prophylaxis and certain demographic and epidemiological parameters.

Spectrum under its AIDS Impact Model (AIM) requires a number of inputs and parameters to process estimates and projections of HIV related parameters that will allow fitting of the trend of epidemic as initially determined in EPP. The first input into Spectrum is the projection of HIV incidence determined in EPP. It is combined with the population projection and the other programme coverage indicators and parameters to determine the indicators related to the impact of the epidemic. The parameters included into Spectrum include the ART, PPTCT programme coverage data, age and sex distribution of prevalence. For each of the 34 States/Union Territories, adult and children ART treatment coverage—from 2004 to 2009 and the projected coverage till 2015—along with duration of breastfeeding were used in AIM. An estimated 300,000 adults and 17,000 children utilized ART as on December 2009. Approximately 13,000 mothers had utilized PPTCT in India as by December 2009. Assumptions over other state-specific HIV characteristics included age and sex distribution of new infections, proportion of those newly infected, progressing need for treatment by time since infection, proportion of adults in need of treatment, proportion of adults dying due to AIDS related causes without treatment by time in need, annual

mortality among children in need of treatment but not receiving treatment by age, annual survival of adults and children on ART, probability of transmission of HIV from mother-to-child etc. After finalizing the input of all these parameters, Spectrum re-processed the estimation and projection of the HIV epidemic.

Uncertainty Analysis: The point estimates are associated with uncertainty due to the prevalence/incidence curve produced by EPP and the input assumptions that are based on studies from population samples in selected countries. For addressing this associated uncertainty, a special programme in Spectrum [22] was used for producing uncertainty bounds around the usual point estimates for each indicator and for each year. A logistic curve is fitted to the resulting points, i.e., the 1000 different logistic curve generated is fitted for the prevalence data by varying the data before each fit with the ranges indicated next to the quality categories.

Results and discussion

The tools used for generating HIV estimates and the data used as mentioned above allows for production of estimated HIV prevalence and incidence trends from the beginning of the epidemic to the current year and projection for the future.

National / States/Union Territory estimates of HIV Adult Prevalence: While the adult HIV prevalence for each state and Union Territory was directly projected through EPP and Spectrum, the national adult HIV prevalence is determined through application of the simple aggregation number of PLHIV from all states divided by the total adult population and calculated as a multiple of hundred to determined a percentage.

The adult HIV prevalence (males and females together) in India in 2008 is estimated as 0.32% with uncertainty bounds 0.26%–0.41%, and 0.31% in 2009 with uncertainty bounds 0.25%–0.39. The adult HIV prevalence was estimated at 0.25% for women and 0.36% for men in 2009. It was estimated at 0.26% for women and 0.38% for men in 2008

(Table 2). The results of 2008/2009 round of HIV estimates—in terms of trend and levels—are derived from a methodology that allows for readjustment of the prevalence curves on the basis of additional HSS data. Accordingly, the estimated HIV prevalence came out 0.36% for the year 2006 and 0.34% for the year 2007. As these are exactly the same value derived under the 2006 and 2007 round of HIV estimates, the consistency in results are indicative that the process adopted by the Working Group on Estimates and the results derived therein are valid and a sound base for analysis (Figure 1).

Table 2 : Adult HIV prevalence by sex and number of HIV infections for all ages with uncertainty bounds for the years 2008 and 2009, India

	2008	2009
Adult 15-49 HIV prevalence		
Persons	0.32% (0.26 – 0.41)	0.31% (0.25 - 0.39)
Female	0.26%	0.25%
Male	0.38%	0.36%
Number of HIV infections (All ages)		
Persons (in Lakh)	24.42 (19.74 – 30.89)	23.95 (19.34 – 30.42)
Percent distribution of HIV infection by sex		
Female	38.5%	38.7%
Male	61.5%	61.3%
Percent distribution of HIV infections by age group		
< 15	4.2%	4.4%
15-49	83.3%	82.4%
50+	12.5%	13.2%

State-wise HIV Adult Prevalence: States/Union Territory wise estimates of adult HIV prevalence were the basis for estimating national adult HIV prevalence as detailed in earlier sections of the report. Over and above this process, an uncertainty analysis was conducted independently for each state in Spectrum. The state level estimates on adult HIV prevalence is provided in Map 1 and an analysis of central emerging trends is recapitulated therein.

As reflective from Figure 2, the HIV prevalence is on the decline in all states over the past four year period of 2006 to 2009; although the degree in decline varies slightly. For instance, the HIV prevalence trend appears stable in six high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur, Nagaland and Tamil Nadu and Mizoram (which is added to this group on the basis of consistently reporting HIV prevalence among ANC clinic attendees >1% in past four years in HSS). Further, , in all three moderate prevalence states- Goa, Gujarat and Pondicherry, adult HIV prevalence trends is declining from 2006 to 2009.

Regarding the low prevalence States/Union Territories, figure 2 highlights those where the trend for HIV prevalence is stable to increasing between 2006 and 2009. These include the seven States/Union Territories of Arunachal Pradesh, Assam, Chandigarh, Jharkhand, Kerala, Meghalaya and Orissa.

The relatively greater increase in HIV prevalence is noted in Assam, Jharkhand and Orissa vis-à-vis Arunachal Pradesh, Kerala and Meghalaya. The estimated HIV prevalence for Chandigarh—as reflected in figure-2—is not considered a true reflection of the nature of the epidemic in the Union Territory. Whilst noting the increase in the estimated HIV prevalence, it must be considered that the trend is attributable to the services Chandigarh provides to PLHIV from the neighbouring states of Punjab, Haryana and even Himachal Pradesh. As ART information is included as one of the parameters for the projection, the resulted trend is showing an increase, independent of the trend observed in HSS. A separate analysis of the HIV epidemic in Chandigarh is thus required to take into consideration the evidence and the trends of neighbouring states.

Figure-2 highlights the low prevalence states of Delhi, Haryana, Punjab, Rajasthan, Uttar Pradesh, and West Bengal where HIV prevalence is either stable or declining. Evidently, the degree for decline in HIV prevalence is not uniform between these states which may be on account of the programmatic impact of ART coverage, and the strength of the prevention interventions etc. The decline in HIV prevalence is lower in Haryana and Punjab vis-à-vis Delhi, Rajasthan, Uttar Pradesh, and West Bengal.

National and State estimates of number of people living with HIV

In 2009, the total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) while in 2008; it was 2.44 million people were living with HIV within the uncertainty bounds of 1.97-3.09 millions. Among PLHIV, by sex approximately 61% are male and 39% are female and by age the percent distribution of HIV infection is estimated at 4% are children below the age of 15 years, 83% are adults aged 15–49 years and rest 13% are over 50 years of age (Table2).

The four high prevalence states of South India account for 57% of all HIV infections in the country. Whilst Andhra Pradesh accounts for 500,000 cases; Maharashtra accounts for 420,000 cases, Karnataka accounts for 250,000 cases and Tamil Nadu accounts for 150,000 cases. Over 100,000 PLHIVs are reported in West Bengal, Gujarat, Bihar and Uttar Pradesh and together these states account for 22% of HIV infections in India. The number of PLHIVs in Punjab, Orissa, Rajasthan and Madhya Pradesh range from 50,000 to 100,000 and these states collectively account for 12% of HIV infections. Thus whilst the states noted above are with low HIV prevalence; a large number of PLHIVs are reported due to the states' overall large population size (Map 1).

The percent distribution of HIV burden amongst high prevalence states vis-à-vis the remaining states in India is 57% and 43% respectively. Amongst the high prevalence states, Andhra Pradesh accounts for the greatest proportion of cases at 21% vis-à-vis the other states. Following Andhra Pradesh, Maharashtra accounts for approximately 18% of HIV infection, Karnataka and Tamil Nadu reportedly account for 10% and 7% of all cases whereas Manipur and Nagaland account for 1% of the estimated total.

Conclusions

The India HIV estimates 2008/2009 indicate a slowdown in the AIDS epidemic. National adult HIV prevalence, or the number of adults living with HIV as a proportion of the total population, has declined by 0.05% points from 0.36% (0.29% - 0.45%) in 2006 to 0.31% (0.25% - 0.39%) in 2009. Though the estimation of 2008/09 has utilized EPP and Spectrum tool against UNAIDS/WHO workbook and Spectrum in 2006, the results of 2008-09 round of estimates match perfectly with previously announced estimates. However the results of 2008-09 round of estimates cannot be directly compared with the previous yearsbecause the methodology and data used to produce the estimates have gradually changed as a result of ongoing enhancement of knowledge on the epidemic.

Adult HIV prevalence is either stable or declining in the high prevalence states whereas the trend is varying across the low to moderate prevalence states. Among the high prevalence states, the HIV prevalence has declined in Tamil Nadu between 2006 and 2009 to reach levels of 0.37% in 2008 and 0.33% in 2009. Manipur shows a declining trend over the past four years. Andhra Pradesh, Karnataka, Maharashtra and Nagaland show either a plateau or a slightly declining trend over the time period 2006 – 2009.

In the low prevalence states of Chandigarh, Orissa, Kerala, Jharkhand, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh and Meghalaya; adult HIV prevalence has risen over the last four years which warrants the need for strengthening the trend of the HIV epidemic.

In descending order, states with the highest adult HIV prevalence in 2009 included Manipur (1.4%); followed by Andhra Pradesh (0.90%), Mizoram (0.81%), Nagaland (0.78%), Karnataka (0.63%) and Maharashtra (0.55%). Besides these, the states of Goa, Chandigarh, Gujarat, Punjab and Tamil Nadu have an estimated adult HIV prevalence greater than national prevalence (0.31%). Delhi, Orissa, West Bengal, Chhattisgarh and Pondicherry have an estimated adult HIV prevalence of 0.28-0.30%. Other states have lower levels of HIV.

The total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) in 2009. Children under 15 years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections. Thirty-nine percent of all HIV infections are estimated to be among women. This amounts to 0.93 million women with HIV in India.

References:

1. National Institute of Health & Family Welfare, 2007, Country Report on Annual HIV Sentinel Surveillence, 2006, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

2. International Institute for Population Sciences (IIPS) and Macro International, 2007, National Family Health Survey, 2005-06 (NFHS-3): India, IIPS, Mumbai.

3. Dandona L, Lakshmi V, Sudha T, Kumar GA, Dandona R. A population based study of human immunodeficiency virus in south India reveals major differences from sentinel surveillance-based estimates. *BMC Med* 2006; *4* : 31-49.

4. Dandona L, Lakshmi V, Kumar GA, Dandona R. Is the HIV burden in India being over estimated? *BMC Public Health* 2006; *6* : 308-17.

5. Pandey A., Reddy D.C.S., Ghys P., et al. Improved estimate of India's HIV burden in 2006, *Indian Journal of Medical Research*, 2009, 129, 50-58.

6. Pandey A., Reddy D.C.S., Thomas M. What lies behind the fall in the HIV population in India? *Economic & Political Weekly*, December 2008, 27: pp-15-17.

7. Lyerla R, Gouws E, Garcia-Calleja JM, et al. The 2005 Workbook: an improved tool for estimating HIV prevalence in countries with low level and concentrated epidemics. *Sex Transm Infect* 2006;82(Suppl III):iii41–iii44.

8. Stover J, Walker N, Grassly NC, at al. Projecting the demographic impact of AIDS and the number of people in need of treatment: updates to the Spectrum projection package. *Sex Transm Infect* 2006;82(Suppl III):iii45–iii50.

9. Pandey A., Reddy D.C.S., Thomas M., et al. Prevalence and burden of HIV in India 2007 - An Update of Estimates, *Demography India*, 2010, 39(2).

10. UNAIDS Global Reference group on Estimates, Modelling and Projections (www.epidem.org)

11. UNAIDS, 2010, http://www.unaids.org/en/dataanalysis/tools/estimation projection package epp/

12. *National AIDS Control Organization, National AIDS Control Programme – III*, Ministry of Health & Family Welfare, India.

13. Technical Report India HIV Estimates 2008-2009 National Institute of Medical Statistics, ICMR, De*lhi and National AIDS Control* Organization, , Ministry of Health & Family Welfare, India (2010).

14. *Sample Registration System*, Statistical reports, Office of the Registrar General India, New Delhi, 2010.

15. *Census of India 1981*, Office of the Registrar General India, New Delhi,

16. *Census of India 1991*, Office of the Registrar General India, New Delhi,

17. *Census of India 2001*, Office of the Registrar General India, New Delhi,

18. *Population Projections for India and States 2001-2026, Report of the Technical Group on Population Projections*, May 2006, National Commission on Population, Ministry of Health & Family Welfare, New Delhi.

19. *Behavioural Surveillance Survey, 2006 – Female sex Workers (FSW) & their clients*, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

20. *National AIDS Control Organization, National AIDS Control Programme CMS*, Ministry of Health & Family Welfare, India.

21. Bachani D., Sogarwal R., Rao K.S. A population based survey on HIV prevention in Nagaland, India, *SAARC Journal of Tuberculosis*, Lung Diseases and HIV/AIDS, vol. 6(1), 2009, pp1-11.

22. Grassly N.C., Morgan M., Walker N., et al. Uncertainty in estimates of HIV/AIDS: the estimation and application of plausibility bounds, *Sex. Transm. Inf.* 2004; 80; 31-38.

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000926.R2
Article Type:	Research
Date Submitted by the Author:	11-Aug-2012
Complete List of Authors:	Pandey, Arvind; National Institute of Medical Statistics, Sahu, Damodar; National Institute of Medical Statistics, ICMR Bakkali, TaoufiK; UNAIDS, India Country Office Reddy, DCS; WHO India Office, Venkatesh, S; National AIDS Control Organization, Kant, Shashi; All India Institute of Medical Sciences, Community Medicine Bhattacharya, M.; Natinal Institute of Health and family welfare, Raj, Yujwal; National AIDS Control Organization, Haldar, Partha; WHO India Office, Bhardwaj, Deepak; National Institute of Medical Statistics, ICMR Chandra, Nalini; UNAIDS, India Country Office
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Infectious diseases, Public health, Sexual health
Keywords:	HIV & AIDS < INFECTIOUS DISEASES, HIV prevalence, PLHIV

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Abstract:

Objectives: To update the estimation of the adult HIV prevalence and number of people living with HIV in India for the year 2008/2009 with the combination of improved data and methods.

Design: Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived.

Setting: HSS sites spread over all the States of India.

Participants: Secondary data from HIV Sentinel Surveillance sites which includes attendees of Antenatal Clinics and sites under targeted interventions of high risk groups, namely, female sex workers (FSW), intravenous drug users (IDU) and men having sex with men (MSM).

Primary and secondary outcome measures: Estimates of adult HIV prevalence and people living with HIV in India and its States.

Results: The adult HIV prevalence in India has declined to an estimated 0.31% (0.25%–0.39%) in 2009 against 0.36% (0.29%-0.45%) in 2006. Among the high prevalence states, the HIV prevalence has declined in Tamil Nadu to 0.33% in 2009 and other states show either a plateau or a slightly declining trend over the time period 2006 – 2009. There are states in the low prevalence states where the adult HIV prevalence has risen over the last four years. The estimated number of people living with HIV in India is 2.4 million (1.93 – 3.04 million) in 2009. Of which, 39 percent are women, children under 15

years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections.

Conclusion: The estimated adult prevalence has declined in few states, a plateau or a slightly declining trend over the time. In future, efforts may be made to examine the implications of the emerging trend of the HIV prevalence on the recent infections in the study population.

Article Summary

1) Article Focus – Modelling exercise to estimate the adult prevalence and burden of HIV in India using the HIV Sentinel Surveillance data.

2) Key Messages - up to three bullet points outlining the key messages and significance of the study

• Estimates indicate a slow down trend in the epidemic with current adult HIV prevalence at 0.31% in 2009.

• In 2009, 2.39 million people were estimated to be living with HIV with uncertainty bounds 1.93-3.04 millions.

• Males account for a greater proportion of the epidemic's burden vis-à-vis females at 61% and 39% respectively. The percent distribution of HIV infection by age is estimated

at 4% among children below the age of 15 years, 83% among adults and 13% among those aged over 50 years.

3) Strengths and Limitations.

Epidemiological assumptions used in Modeling based on evidence on limited studies in other countries, not on Indian population.

Background:

Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived every year since 1998. The process is consultative amongst the national and international experts in the field of biostatistics and epidemiology. Technical supports are received from UN organizations particularly experts from the WHO and UNAIDS. Efforts are made to improve data both in terms of quality and representativeness as well as the methodology matching to epidemics. For instance, in 2006 with the expansion of sentinel surveillance to all districts [1], sero-survey as a part of third round of National Family Health Survey (NFHS-3) [2] and the observation that there is a common practice of referral of HIV-positive/suspected cases to public hospitals and a preferential use of public hospitals by people in the lower socio-economic strata causing overestimation of the HIV burden in India [3, 4], many of the assumptions are replaced with evidence based information.

In fact, the NFHS-3 provided an opportunity to calibrate the surveillance data [5, 6] particularly the data from ANC attendees used in the estimation process as a proxy to

general population. In addition, globally used method for similar epidemic, e.g. WHO/UNAIDS workbook [7] along with Spectrum software [8] was used in 2006 and 2007 rounds of estimation. The WHO/UNAIDS Workbook having assimilated the average prevalence for each risk group, namely, FSW, IDU, MSM and ANC fitted a logistic model to get the trend of the epidemic. The calibration factors derived in 2006 were used in the 2007 round of estimation in view of non-availability of community based survey data to calibrate every year [9]. Also, it forwarded a limitation of curve fitting over the average HIV prevalence in the population within the Workbook. The issue was deliberated in the UNAIDS Global Reference group on Estimates, Modelling and Projections and it was suggested to adopt the combination of Estimation and Projection Package (EPP) and Spectrum [10]. The present paper aims to update the HIV estimation with the above combination. Specifically, it describes the data and methods used for the 2008 & 2009 HIV burden estimates for India and compares the resulting estimates with those of earlier years.

Method and Material

The Estimation Projection Package (EPP) [11] and Spectrum DemProj and AIM modules [12] was used for the estimating prevalence and burden of HIV.

Data

The Working Group reviewed and used four sets of data available from various sources for the estimation process.

Surveillance: The following surveillance data available from 1998 to 2009 was used in EPP for producing state and national curves. These represent HIV prevalence data from HIV sentinel surveillance that was conducted amongst pregnant women attending antenatal clinics and the key population groups of Female Sex Workers (FSW), Men having Sex with Men (MSM) and Injecting Drug Users (IDUs). Through the scale up in number of HIV Sentinel Surveillance (HSS) sites and increased focus on key population sites, a wider geographical and population group coverage was achieved leading to more accurate results. The following table reflects the scale up in numbers of surveillance sites per year for the populations groups that are used in the HIV estimates process.

Table 1: Scale up of HIV Sentinel Sites in India, 1998-2009

Site Type	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009
ANC	92	93	111	172	200	476	390	391	636	654	668
IDU	5	6	10	10	13	18	24	30	51	52	61
MSM	-	-	3	3	3	9	15	18	31	40	67
FSW	1	1	2	2	2	32	42	83	138	137	194
Total	98	100	126	187	218	535	471	522	856	883	990

Also, the working group used the estimated prevalence from the National Family and Health Survey (NFHS) conducted throughout the country with state level representation in the high prevalence states. The adult HIV prevalence from the NFHS-3 was used for calibration of the fitted curves.

Population sizes (the size of the higher risk and lower risk population): Secondly, for determining specific demographic parameters of key population groups, the size estimates for FSW, MSM and IDU provided under the NACP III document [13] was considered. This was updated with data from the 2009 mapping exercise conducted among key population in 2009 in specific states by NACO and State AIDS Control Societies (SACs). In states where the mapping exercise was not concluded, the higher

risk group population was estimated as a proportion of people with higher risk behaviour as reported under the NACP-III document [14].

In addition, data inputs used for determining the size of the general population at lower risk for HIV were number of births, number of deaths, adult population growth rate and population size for people aged over 15 years across and in 34 states/Union Territories from the vital registration system [15]. National population estimates were obtained from population projection for India and states from the period 2001 to 2026. The size of the general population at lower risk for HIV were calculated as the total adult population minus the population size of the higher risk groups. The population size for people aged 15–49 years in 2009 has been derived through Demproj in the Spectrum Package. The data used in Demproj for calculating the population size included the Census population data of 1981, 1991 and 2001 and the Expert Group Population Estimates and Projections of India [16, 17, 18, 19]. The breakdown by sex for the IDU population assumes that 90% of the IDU population is male and 10% is female [13, 20].

Programme Coverage: As antiretroviral therapy (ART) programme coverage influences the trend of HIV prevalence, the current ART coverage is extrapolated for the years beyond 2009—which is consistent with the NACP-III planned target of 500,000 by 2015—and distributed among all risk group based on last year proportions in respective risk groups [21].

Methods:

The EPP estimates the trends over time of HIV prevalence by fitting an epidemiological model to the surveillance data provided by HIV sentinel surveillance systems. The basic principle underlying EPP is to develop epidemic curves separately for different sub-populations and then combine to produce a single epidemic curve estimating HIV prevalence at the national level. For adult HIV prevalence epidemic curve generated for each sub-population group, initial guesses were made using four parameters, namely t_0 (start year of the HIV epidemic), *r (t*he force of infection), f_0 (the initial fraction of the adult population at risk of infection used to determine the peak level of the epidemic curve, φ (the behaviour adjustment parameter which determines how the proportion of new entrants in the adult population who are at risk of HIV infections changes over time). The 2009 version of has also included the provision of antiretroviral therapy, which increases survival of people living with HIV, hence increasing prevalence and impacting the process of fitting an epidemiological model to the HIV epidemic. Data from the above sources were entered to EPP to produce curves of adult HIV prevalence among different population groups including antenatal clinic attendees — as proxy for general population — and key population groups.

The following two primary epidemiological assumptions were considered whilst analyzing data under the 2009 version of EPP: (1) a specific criterion was considered for reassigning higher risk groups to the general population category. Based on the second round of Behaviour Surveillance Survey conducted in 2006 [20], it was determined that IDU and MSM after a 15 year duration would be reassigned to the general population category whereas for FSW the timeframe for being reassigned to the general population was reduced to 8 years and (2) non-AIDS mortality was assumed to be higher by as much

as 7% for injecting drug users vis-à-vis non- injecting drug users meant to account for the higher risk of mortality experienced by all IDU regardless of HIV status.

Defining the characteristics of the Epidemic - The HIV epidemic in India, at national level, is concentrated amongst female sex workers (FSW), men who have sex with men (MSM) and injecting drug users (IDU). Amongst the 34 Indian States/Union Territories—the epidemic is a defined as a concentrated non-IDU epidemic for all the states with the exception of Manipur and Nagaland where the epidemic is a defined as a concentrated IDU epidemic.

Generating State-specific prevalence curves: The States/Union Territory specific epidemic, for which first time States/Union Territory specific prevalence curves was generated under the 2008/2009 HIV estimates. Using the Bayesian melding approach, 1000 iterations were used for fitting the initial guesses for ANC sites and 3000 iterations for higher risk group sites. The best fitting curves for all sub-population categories were subsequently combined for producing state prevalence curves.

Calibrating ANC prevalence curves in EPP Model: Estimates of HIV prevalence is primarily based on times series prevalence data amongst ANC attendees in HSS. Due to the difference in sero-prevalence between the ANC attendees and those from population based surveys, the calibration of the prevalence curves based on the former is required. The key source of information used for calibrating HIV prevalence curves has the 2006 National Family Health Survey (NFHS-3) [2] where state-specific information on HIV prevalence is determined. The curve for antenatal clinic attendees was calibrated from National Family Health Survey (NFHS-3) 2005-06 for general population. In order to have an appropriate

calibration of the HIV prevalence trends determined in spectrum, the point values of prevalence determined from the NFHS-3 in 2006 as a reference for calibrating the prevalence trend for general population, initially determined through ANC.

In EPP, when a calibration factor is used, the overall curve determined on the basis of ANC HSS trend data which is scaled according to the calibration constant. Differences in the prevalence level are modeled on the probit scale. The probit scale is chosen in such a way that the differences between prevalence levels do not depend on the level itself. The calibration factor was derived for individual states in five high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur and Tamil Nadu, based on calculations from NFHS-3 while for Nagaland the calibration factor was determined from a specific study undertaken by NACO [22]. For the remainder of the moderate and low prevalence states, the common constant calibration factor of 0.69 was derived from the NFHS-3 on the basis of the rest of the states (excluding aforesaid 6 high prevalence states) national comparison between general population prevalence and ANC prevalence.

Estimation of PLHIV for all age groups using Spectrum In order to estimate the number of people living with HIV and HIV prevalence for all ages, the projected adult HIV prevalence for each state was fed into Spectrum along with programme data on Antiretroviral (ART) programme coverage, percent of mothers and children given nevirapine prophylaxis and certain demographic and epidemiological parameters.

Spectrum under its AIDS Impact Model (AIM) requires a number of inputs and parameters to process estimates and projections of HIV related parameters that will allow fitting of the trend of epidemic as initially determined in EPP. The first input into Spectrum is the projection of HIV incidence determined in EPP. It is combined with the population

projection and the other programme coverage indicators and parameters to determine the indicators related to the impact of the epidemic. The parameters included into Spectrum include the ART, PPTCT programme coverage data, age and sex distribution of prevalence. For each of the 34 States/Union Territories, adult and children ART treatment coverage—from 2004 to 2009 and the projected coverage till 2015—along with duration of breastfeeding were used in AIM. An estimated 300,000 adults and 17,000 children utilized ART as on December 2009. Approximately 13,000 mothers had utilized PPTCT in India as by December 2009. Assumptions over other state-specific HIV characteristics included age and sex distribution of new infections, proportion of those newly infected progressing need for treatment by time since infection, proportion of adults in need of treatment, proportion of adults dying due to AIDS related causes without treatment by time in need, annual mortality among children in need of treatment but not receiving treatment by age, annual survival of adults and children on ART, probability of transmission of HIV from mother-to-child etc. [12,23] After finalizing the input of all these parameters, Spectrum re-processed the estimation and projection of the HIV epidemic.

Uncertainty Analysis: The point estimates are associated with uncertainty due to the prevalence/incidence curve produced by EPP and the input assumptions that are based on studies from population samples in selected countries. For addressing this associated uncertainty, a special programme in Spectrum [24] was used for producing uncertainty bounds around the usual point estimates for each indicator and for each year. A logistic curve is fitted to the resulting points, i.e., the 1000 different logistic curve generated is fitted for the prevalence data by varying the data before each fit with the ranges indicated next to the quality categories.

Results and discussion

The tools used for generating HIV estimates and the data used as mentioned above allows for production of estimated HIV prevalence and incidence trends from the beginning of the epidemic to the current year and projection for the future.

National / States/Union Territory estimates of HIV Adult Prevalence: While the adult HIV prevalence for each state and Union Territory was directly projected through EPP and Spectrum, the national adult HIV prevalence is determined through application of the simple aggregation number of PLHIV from all states divided by the total adult population and calculated as a multiple of hundred to determined a percentage.

The adult HIV prevalence (males and females together) in India in 2008 is estimated as 0.32% with uncertainty bounds 0.26%–0.41%, and 0.31% in 2009 with uncertainty bounds 0.25%–0.39. The adult HIV prevalence was estimated at 0.25% for women and 0.36% for men in 2009. It was estimated at 0.26% for women and 0.38% for men in 2008 (Table 2). The results of 2008/2009 round of HIV estimates—in terms of trend and levels—are derived from a methodology that allows for readjustment of the prevalence curves on the basis of additional HSS data. Accordingly, the estimated HIV prevalence came out 0.36% for the year 2006 and 0.34% for the year 2007. As these are exactly the same value derived under the 2006 and 2007 round of HIV estimates, the consistency in results are indicative that the process adopted by the Working Group on Estimates and the results derived therein are valid and a sound base for analysis (Figure 1).

Table 2 : Adult HIV prevalence by sex and number of HIV infections for all ages with uncertainty bounds for the years 2008 and 2009, India

	2008	2009
Adult 15-49 HIV prevalence		
Persons	0.32% (0.26 – 0.41)	0.31% (0.25 - 0.39)
Female	0.26%	0.25%
Male	0.38%	0.36%

Number of HIV infections (All ages)		
Persons (in million)	2.44 (1.97-3.09)	2.40 (1.93-3.04)
Percent distribution of HIV infection by sex		
Female	38.5%	38.7%
Male	61.5%	61.3%
Percent distribution of HIV infections by age group		
< 15	4.2%	4.4%
15-49	83.3%	82.4%
50+	12.5%	13.2%

State-wise HIV Adult Prevalence: States/Union Territory wise estimates of adult HIV prevalence were the basis for estimating national adult HIV prevalence as detailed in earlier sections of the report. Over and above this process, an uncertainty analysis was conducted independently for each state in Spectrum. The state level estimates on adult HIV prevalence is provided in Map 1 and an analysis of central emerging trends is recapitulated therein.

As reflective from Figure 2, the HIV prevalence is on the decline in all states over the past four year period of 2006 to 2009; although the degree in decline varies slightly. For instance, the HIV prevalence trend appears stable in six high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur, Nagaland and Tamil Nadu and Mizoram (which is added to this group on the basis of consistently reporting HIV prevalence among ANC clinic attendees >1% in past four years in HSS). Further, , in all three moderate prevalence states- Goa, Gujarat and Pondicherry, adult HIV prevalence trends is declining from 2006 to 2009.

Regarding the low prevalence States/Union Territories, figure 2 highlights those where the trend for HIV prevalence is stable to increasing between 2006 and 2009. These

include the seven States/Union Territories of Arunachal Pradesh, Assam, Chandigarh, Jharkhand, Kerala, Meghalaya and Orissa.

The relatively greater increase in HIV prevalence is noted in Assam, Jharkhand and Orissa vis-à-vis Arunachal Pradesh, Kerala and Meghalaya. The estimated HIV prevalence for Chandigarh—as reflected in figure-2—is not considered a true reflection of the nature of the epidemic in the Union Territory. Whilst noting the increase in the estimated HIV prevalence, it must be considered that the trend is attributable to the services Chandigarh provides to PLHIV from the neighbouring states of Punjab, Haryana and even Himachal Pradesh. As ART information is included as one of the parameters for the projection, the resulted trend is showing an increase, independent of the trend observed in HSS. A separate analysis of the HIV epidemic in Chandigarh is thus required to take into consideration the evidence and the trends of neighbouring states.

Figure-2 highlights the low prevalence states of Delhi, Haryana, Punjab, Rajasthan, Uttar Pradesh, and West Bengal where HIV prevalence is either stable or declining. Evidently, the degree for decline in HIV prevalence is not uniform between these states which may be on account of the programmatic impact of ART coverage, and the strength of the prevention interventions etc. The decline in HIV prevalence is lower in Haryana and Punjab vis-à-vis Delhi, Rajasthan, Uttar Pradesh, and West Bengal.

National and State estimates of number of people living with HIV

In 2009, the total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) while in 2008; it was 2.44 million

people were living with HIV within the uncertainty bounds of 1.97-3.09 millions. Among PLHIV, by sex approximately 61% are male and 39% are female and by age the percent distribution of HIV infection is estimated at 4% are children below the age of 15 years, 83% are adults aged 15–49 years and rest 13% are over 50 years of age (Table2).

The four high prevalence states of South India account for 57% of all HIV infections in the country. Whilst Andhra Pradesh accounts for 500,000 cases; Maharashtra accounts for 420,000 cases, Karnataka accounts for 250,000 cases and Tamil Nadu accounts for 150,000 cases. Over 100,000 PLHIVs are reported in West Bengal, Gujarat, Bihar and Uttar Pradesh and together these states account for 22% of HIV infections in India. The number of PLHIVs in Punjab, Orissa, Rajasthan and Madhya Pradesh range from 50,000 to 100,000 and these states collectively account for 12% of HIV infections. Thus whilst the states noted above are with low HIV prevalence; a large number of PLHIVs are reported due to the states' overall large population size (Map 1).

The percent distribution of HIV burden amongst high prevalence states vis-à-vis the remaining states in India is 57% and 43% respectively. Amongst the high prevalence states, Andhra Pradesh accounts for the greatest proportion of cases at 21% vis-à-vis the other states. Following Andhra Pradesh, Maharashtra accounts for approximately 18% of HIV infection, Karnataka and Tamil Nadu reportedly account for 10% and 7% of all cases whereas Manipur and Nagaland account for 1% of the estimated total.

Conclusions

The India HIV estimates 2008/2009 indicate a slowdown in the AIDS epidemic. National adult HIV prevalence, or the number of adults living with HIV as a proportion of the total

population, has declined by 0.05% points from 0.36% (0.29% - 0.45%) in 2006 to 0.31% (0.25% - 0.39%) in 2009. Though the estimation of 2008/09 has utilized EPP and Spectrum tool against UNAIDS/WHO workbook and Spectrum in 2006, the results of 2008-09 round of estimates match perfectly with previously announced estimates. However the results of 2008-09 round of estimates cannot be directly compared with the previous years because the methodology and data used to produce the estimates have gradually changed as a result of ongoing enhancement of knowledge on the epidemic.

Adult HIV prevalence is either stable or declining in the high prevalence states whereas the trend is varying across the low to moderate prevalence states. Among the high prevalence states, the HIV prevalence has declined in Tamil Nadu between 2006 and 2009 to reach levels of 0.37% in 2008 and 0.33% in 2009. Manipur shows a declining trend over the past four years. Andhra Pradesh, Karnataka, Maharashtra and Nagaland show either a plateau or a slightly declining trend over the time period 2006 – 2009.

In the low prevalence states of Chandigarh, Orissa, Kerala, Jharkhand, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh and Meghalaya; adult HIV prevalence has risen over the last four years which warrants the need for strengthening the trend of the HIV epidemic.

In descending order, states with the highest adult HIV prevalence in 2009 included Manipur (1.4%); followed by Andhra Pradesh (0.90%), Mizoram (0.81%), Nagaland (0.78%), Karnataka (0.63%) and Maharashtra (0.55%). Besides these, the states of Goa, Chandigarh, Gujarat, Punjab and Tamil Nadu have an estimated adult HIV prevalence greater than national prevalence (0.31%). Delhi, Orissa, West Bengal, Chhattisgarh and

Pondicherry have an estimated adult HIV prevalence of 0.28-0.30%. Other states have lower levels of HIV.

The total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) in 2009. Children under 15 years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections. Thirty-nine percent of all HIV infections are estimated to be among women. This amounts to 0.93 million women with HIV in India.

Competing Interests Statement

There are no competing interests.

Contributorship Statement

The authors are the member of the working group on India's HIV estimation and have contributed equally in the design, analysis, interpretation and critical review of the paper.

Data Sharing Statement

We have used all published data.

Funding Statement

This research received no specific funding.

References:

1. National Institute of Health & Family Welfare, 2007, Country Report on Annual HIV Sentinel Surveillence, 2006, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

2. International Institute for Population Sciences (IIPS) and Macro International, 2007, National Family Health Survey, 2005-06 (NFHS-3): India, IIPS, Mumbai.

3. Dandona L, Lakshmi V, Sudha T, Kumar GA, Dandona R. A population based study of human immunodeficiency virus in south India reveals major differences from sentinel surveillance-based estimates. *BMC Med* 2006; *4* : 31-49.

4. Dandona L, Lakshmi V, Kumar GA, Dandona R. Is the HIV burden in India being over estimated? *BMC Public Health* 2006; *6* : 308-17.

5. Pandey A., Reddy D.C.S., Ghys P., et al. Improved estimate of India's HIV burden in 2006, *Indian Journal of Medical Research*, 2009, 129, 50-58.

6. Pandey A., Reddy D.C.S., Thomas M. What lies behind the fall in the HIV population in India? *Economic & Political Weekly*, December 2008, 27: pp-15-17.

7. Lyerla R, Gouws E, Garcia-Calleja JM, et al. The 2005 Workbook: an improved tool for estimating HIV prevalence in countries with low level and concentrated epidemics. *Sex Transm Infect* 2006;82(Suppl III):iii41–iii44.

8. Stover J, Walker N, Grassly NC, at al. Projecting the demographic impact of AIDS and the number of people in need of treatment: updates to the Spectrum projection package. *Sex Transm Infect* 2006;82(Suppl III):iii45–iii50.

9. Pandey A., Reddy D.C.S., Thomas M., et al. Prevalence and burden of HIV in India 2007 - An Update of Estimates, *Demography India*, 2010, 39(2).

10. UNAIDS Global Reference group on Estimates, Modelling and Projections (www.epidem.org)

11. UNAIDS, 2010, http://www.unaids.org/en/dataanalysis/tools/estimation projection package epp/
12. Stover J, Johnson P, Zaba B, Zwhalen M, Dabis F, Ekpini R. The Spectrum projection package: improvements in estimating mortality, ART needs, PMTCT impact and uncertainty bounds. *Sex. Transm. Infect.* 2008;84:i24-i30.

13. *National AIDS Control Organization, National AIDS Control Programme – III*, Ministry of Health & Family Welfare, India.

14. Technical Report India HIV Estimates 2008-2009 National Institute of Medical Statistics, ICMR, De*lhi and National AIDS Control* Organization, , Ministry of Health & Family Welfare, India (2010).

15. *Sample Registration System*, Statistical reports, Office of the Registrar General India, New Delhi, 2010.

16. *Census of India 1981*, Office of the Registrar General India, New Delhi,

17. *Census of India 1991*, Office of the Registrar General India, New Delhi,

18. *Census of India 2001*, Office of the Registrar General India, New Delhi,

19. *Population Projections for India and States 2001-2026, Report of the Technical Group on Population Projections*, May 2006, National Commission on Population, Ministry of Health & Family Welfare, New Delhi.

20. *Behavioural Surveillance Survey, 2006 – Female sex Workers (FSW) & their clients*, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

21. *National AIDS Control Organization, National AIDS Control Programme CMS*, Ministry of Health & Family Welfare, India.

22. Bachani D., Sogarwal R., Rao K.S. A population based survey on HIV prevention in Nagaland, India, *SAARC Journal of Tuberculosis*, Lung Diseases and HIV/AIDS, vol. 6(1), 2009, pp1-11.

23. Stover J., Johnson P., Hallett T., Marston M., Becquet R., Timaeus I.M., The Spectrum projection package: improvements in estimating incidence by age and sex, mother-to-child transmission, HIV progression in children and double orphans. *Sex Transm Infect* 2010;86:ii16-ii21

24. Grassly N.C., Morgan M., Walker N., et al. Uncertainty in estimates of HIV/AIDS: the estimation and application of plausibility bounds, *Sex. Transm. Inf.* 2004; 80; 31-38.

ESTIMATE OF HIV PREVALENCE AND NUMBER OF PEOPLE LIVING WITH HIV IN INDIA 2008-09

Background:

Based on HIV sentinel surveillance (HSS) data and a set of epidemiological assumptions, estimates of HIV prevalence and burden in India have been derived every year since 1998. The process is consultative amongst the national and international experts in the field of biostatistics and epidemiology. Technical supports are received from UN organizations particularly experts from the WHO and UNAIDS. Efforts are made to improve data both in terms of quality and representativeness as well as the methodology matching to epidemics. For instance, in 2006 with the expansion of sentinel surveillance to all districts [1], sero-survey as a part of third round of National Family Health Survey (NFHS-3) [2] and the observation that there is a common practice of referral of HIV-positive/suspected cases to public hospitals and a preferential use of public hospitals by people in the lower socio-economic strata causing overestimation of the HIV burden in India [3, 4], many of the assumptions are replaced with evidence based information.

In fact, the NFHS-3 provided an opportunity to calibrate the surveillance data [5, 6] particularly the data from ANC attendees used in the estimation process as a proxy to general population. In addition, globally used method for similar epidemic, e.g. WHO/UNAIDS workbook [7] along with Spectrum software [8] was used in 2006 and 2007 rounds of estimation. The WHO/UNAIDS Workbook having assimilated the average prevalence for each risk group, namely, FSW, IDU, MSM and ANC fitted a logistic model to get the trend of the epidemic. The calibration factors derived in 2006 were used in the 2007 round of estimation in view of non-availability of community based survey data to calibrate every year [9]. Also, it forwarded a limitation of curve

fitting over the average HIV prevalence in the population within the Workbook. The issue was deliberated in the UNAIDS Global Reference group on Estimates, Modelling and Projections and it was suggested to adopt the combination of Estimation and Projection Package (EPP) and Spectrum [10]. The present paper aims to update the HIV estimation with the above combination. Specifically, it describes the data and methods used for the 2008 & 2009 HIV burden estimates for India and compares the resulting estimates with those of earlier years.

Method and Material

The Estimation Projection Package (EPP) [11] and Spectrum DemProj and AIM modules [8] was used for the estimating prevalence and burden of HIV.

Data

The Working Group reviewed and used four sets of data available from various sources for the estimation process.

Surveillance: The following surveillance data available from 1998 to 2009 was used in EPP for producing state and national curves. These represent HIV prevalence data from HIV sentinel surveillance that was conducted amongst pregnant women attending antenatal clinics and the key population groups of Female Sex Workers (FSW), Men having Sex with Men (MSM) and Injecting Drug Users (IDUs). Through the scale up in number of HIV Sentinel Surveillance (HSS) sites and increased focus on key population sites, a wider geographical and population group coverage was achieved leading to more

accurate results. The following table reflects the scale up in numbers of surveillance sites per year for the populations groups that are used in the HIV estimates process.

Table 1: Scale up of HIV Sentinel Sites in India, 1998-2009

Site Type	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2009
ANC	92	93	111	172	200	476	390	391	636	654	668
IDU	5	6	10	10	13	18	24	30	51	52	61
MSM	-	-	3	3	3	9	15	18	31	40	67
FSW	1	1	2	2	2	32	42	83	138	137	194
Total	98	100	126	187	218	535	471	522	856	883	990

Also, the working group used the estimated prevalence from the National Family and Health Survey (NFHS) conducted throughout the country with state level representation in the high prevalence states. The adult HIV prevalence from the NFHS-3 was used for calibration of the fitted curves.

Population sizes (the size of the higher risk and lower risk population): Secondly, for determining specific demographic parameters of key population groups, the size estimates for FSW, MSM and IDU provided under the NACP III document [12] was considered. This was updated with data from the 2009 mapping exercise conducted among key population in 2009 in specific states by NACO and State AIDS Control Societies (SACs). In states where the mapping exercise was not concluded, the higher risk group population was estimated as a proportion of people with higher risk behaviour as reported under the NACP-III document [13].

In addition, data inputs used for determining the size of the general population at lower risk for HIV were number of births, number of deaths, adult population growth rate and population size for people aged over 15 years across and in 34 states/Union Territories from the vital registration system [14]. National population estimates were obtained from

population projection for India and states from the period 2001 to 2026. The size of the general population at lower risk for HIV were calculated as the total adult population minus the population size of the higher risk groups. The population size for people aged 15–49 years in 2009 has been derived through Demproj in the Spectrum Package. The data used in Demproj for calculating the population size included the Census population data of 1981, 1991 and 2001 and the Expert Group Population Estimates and Projections of India [15, 16, 17, 18]. The breakdown by sex for the IDU population assumes that 90% of the IDU population is male and 10% is female [12, 19].

Programme Coverage: As antiretroviral therapy (ART) programme coverage influences the trend of HIV prevalence, the current ART coverage is extrapolated for the years beyond 2009—which is consistent with the NACP-III planned target of 500,000 by 2015—and distributed among all risk group based on last year proportions in respective risk groups [20].

Methods:

The EPP estimates the trends over time of HIV prevalence by fitting an epidemiological model to the surveillance data provided by HIV sentinel surveillance systems. The basic principle underlying EPP is to develop epidemic curves separately for different sub-populations and then combine to produce a single epidemic curve estimating HIV prevalence at the national level. For adult HIV prevalence epidemic curve generated for each sub-population group, initial guesses were made using four parameters, namely t_0 (start year of the HIV epidemic), *r (t*he force of infection), f_0 (the initial fraction of the adult population at risk of infection used to determine the peak level of the epidemic

curve, φ (the behaviour adjustment parameter which determines how the proportion of new entrants in the adult population who are at risk of HIV infections changes over time). The 2009 version of has also included the provision of antiretroviral therapy, which increases survival of people living with HIV, hence increasing prevalence and impacting the process of fitting an epidemiological model to the HIV epidemic. Data from the above sources were entered to EPP to produce curves of adult HIV prevalence among different population groups including antenatal clinic attendees — as proxy for general population — and key population groups.

The following two primary epidemiological assumptions were considered whilst analyzing data under the 2009 version of EPP: (1) a specific criterion was considered for reassigning higher risk groups to the general population category. Based on the second round of Behaviour Surveillance Survey conducted in 2006 [19], it was determined that IDU and MSM after a 15 year duration would be reassigned to the general population category whereas for FSW the timeframe for being reassigned to the general population was reduced to 8 years and (2) AIDS mortality was assumed to be higher by as much as 7% for injecting drug users vis-à-vis non- injecting drug users.

Defining the characteristics of the Epidemic - The HIV epidemic in India, at national level, is concentrated amongst female sex workers (FSW), men who have sex with men (MSM) and injecting drug users (IDU). Amongst the 34 Indian States/Union Territories—the epidemic is a defined as a concentrated non-IDU epidemic for all the states with the exception of Manipur and Nagaland where the epidemic is a defined as a concentrated IDU epidemic.

Generating State-specific prevalence curves: The States/Union Territory specific epidemic, for which first time States/Union Territory specific prevalence curves was generated under the 2008/2009 HIV estimates. Using the Bayesian melding approach, 1000 iterations were used for fitting the initial guesses for ANC sites and 3000 iterations for higher risk group sites. The best fitting curves for all sub-population categories were subsequently combined for producing state prevalence curves.

Calibrating ANC prevalence curves in EPP Model: Estimates of HIV prevalence is primarily based on times series prevalence data amongst ANC attendees in HSS. Due to the difference in sero-prevalence between the ANC attendees and those from population based surveys, the calibration of the prevalence curves based on the former is required. The key source of information used for calibrating HIV prevalence curves has the 2006 National Family Health Survey (NFHS-3) [2] where state-specific information on HIV prevalence is determined. The curve for antenatal clinic attendees was calibrated from National Family Health Survey (NFHS-3) 2005-06 for general population. In order to have an appropriate calibration of the HIV prevalence trends determined in spectrum, the point values of prevalence determined from the NFHS-3 in 2006 as a reference for calibrating the prevalence trend for general population, initially determined through ANC.

In EPP, when a calibration factor is used, the overall curve determined on the basis of ANC HSS trend data which is scaled according to the calibration constant. Differences in the prevalence level are modeled on the probit scale. The probit scale is chosen in such a way that the differences between prevalence levels do not depend on the level itself. The calibration factor was derived for individual states in five high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur and Tamil Nadu, based on

calculations from NFHS-3 while for Nagaland the calibration factor was determined from a specific study undertaken by NACO [21]. For the remainder of the moderate and low prevalence states, the common constant calibration factor of 0.69 was derived from the NFHS-3 on the basis of the rest of the states (excluding aforesaid 6 high prevalence states) national comparison between general population prevalence and ANC prevalence.

Estimation of PLHIV for all age groups using Spectrum In order to estimate the number of people living with HIV and HIV prevalence for all ages, the projected adult HIV prevalence for each state was fed into Spectrum along with programme data on Antiretroviral (ART) programme coverage, percent of mothers and children given nevirapine prophylaxis and certain demographic and epidemiological parameters.

Spectrum under its AIDS Impact Model (AIM) requires a number of inputs and parameters to process estimates and projections of HIV related parameters that will allow fitting of the trend of epidemic as initially determined in EPP. The first input into Spectrum is the projection of HIV incidence determined in EPP. It is combined with the population projection and the other programme coverage indicators and parameters to determine the indicators related to the impact of the epidemic. The parameters included into Spectrum include the ART, PPTCT programme coverage data, age and sex distribution of prevalence. For each of the 34 States/Union Territories, adult and children ART treatment coverage—from 2004 to 2009 and the projected coverage till 2015—along with duration of breastfeeding were used in AIM. An estimated 300,000 adults and 17,000 children utilized ART as on December 2009. Approximately 13,000 mothers had utilized PPTCT in India as by December 2009. Assumptions over other state-specific HIV characteristics included age and sex distribution of new infections, proportion of those newly infected, progressing need for treatment by time since infection, proportion of adults in need of treatment, proportion of adults dying due to AIDS related causes without treatment by time in need, annual

mortality among children in need of treatment but not receiving treatment by age, annual survival of adults and children on ART, probability of transmission of HIV from mother-to-child etc. After finalizing the input of all these parameters, Spectrum re-processed the estimation and projection of the HIV epidemic.

Uncertainty Analysis: The point estimates are associated with uncertainty due to the prevalence/incidence curve produced by EPP and the input assumptions that are based on studies from population samples in selected countries. For addressing this associated uncertainty, a special programme in Spectrum [22] was used for producing uncertainty bounds around the usual point estimates for each indicator and for each year. A logistic curve is fitted to the resulting points, i.e., the 1000 different logistic curve generated is fitted for the prevalence data by varying the data before each fit with the ranges indicated next to the quality categories.

Results and discussion

The tools used for generating HIV estimates and the data used as mentioned above allows for production of estimated HIV prevalence and incidence trends from the beginning of the epidemic to the current year and projection for the future.

National / States/Union Territory estimates of HIV Adult Prevalence: While the adult HIV prevalence for each state and Union Territory was directly projected through EPP and Spectrum, the national adult HIV prevalence is determined through application of the simple aggregation number of PLHIV from all states divided by the total adult population and calculated as a multiple of hundred to determined a percentage.

The adult HIV prevalence (males and females together) in India in 2008 is estimated as 0.32% with uncertainty bounds 0.26%–0.41%, and 0.31% in 2009 with uncertainty bounds 0.25%–0.39. The adult HIV prevalence was estimated at 0.25% for women and 0.36% for men in 2009. It was estimated at 0.26% for women and 0.38% for men in 2008

(Table 2). The results of 2008/2009 round of HIV estimates—in terms of trend and levels—are derived from a methodology that allows for readjustment of the prevalence curves on the basis of additional HSS data. Accordingly, the estimated HIV prevalence came out 0.36% for the year 2006 and 0.34% for the year 2007. As these are exactly the same value derived under the 2006 and 2007 round of HIV estimates, the consistency in results are indicative that the process adopted by the Working Group on Estimates and the results derived therein are valid and a sound base for analysis (Figure 1).

Table 2 : Adult HIV prevalence by sex and number of HIV infections for all ages with uncertainty bounds for the years 2008 and 2009, India

	2008	2009
Adult 15-49 HIV prevalence		
Persons	0.32% (0.26 – 0.41)	0.31% (0.25 - 0.39)
Female	0.26%	0.25%
Male	0.38%	0.36%
Number of HIV infections (All ages)		
Persons (in Lakh)	24.42 (19.74 – 30.89)	23.95 (19.34 – 30.42)
Percent distribution of HIV infection by sex		
Female	38.5%	38.7%
Male	61.5%	61.3%
Percent distribution of HIV infections by age group		
< 15	4.2%	4.4%
15-49	83.3%	82.4%
50+	12.5%	13.2%

State-wise HIV Adult Prevalence: States/Union Territory wise estimates of adult HIV prevalence were the basis for estimating national adult HIV prevalence as detailed in earlier sections of the report. Over and above this process, an uncertainty analysis was conducted independently for each state in Spectrum. The state level estimates on adult HIV prevalence is provided in Map 1 and an analysis of central emerging trends is recapitulated therein.

As reflective from Figure 2, the HIV prevalence is on the decline in all states over the past four year period of 2006 to 2009; although the degree in decline varies slightly. For instance, the HIV prevalence trend appears stable in six high prevalence states, i.e., Andhra Pradesh, Karnataka, Maharashtra, Manipur, Nagaland and Tamil Nadu and Mizoram (which is added to this group on the basis of consistently reporting HIV prevalence among ANC clinic attendees >1% in past four years in HSS). Further, , in all three moderate prevalence states- Goa, Gujarat and Pondicherry, adult HIV prevalence trends is declining from 2006 to 2009.

Regarding the low prevalence States/Union Territories, figure 2 highlights those where the trend for HIV prevalence is stable to increasing between 2006 and 2009. These include the seven States/Union Territories of Arunachal Pradesh, Assam, Chandigarh, Jharkhand, Kerala, Meghalaya and Orissa.

The relatively greater increase in HIV prevalence is noted in Assam, Jharkhand and Orissa vis-à-vis Arunachal Pradesh, Kerala and Meghalaya. The estimated HIV prevalence for Chandigarh—as reflected in figure-2—is not considered a true reflection of the nature of the epidemic in the Union Territory. Whilst noting the increase in the estimated HIV prevalence, it must be considered that the trend is attributable to the services Chandigarh provides to PLHIV from the neighbouring states of Punjab, Haryana and even Himachal Pradesh. As ART information is included as one of the parameters for the projection, the resulted trend is showing an increase, independent of the trend observed in HSS. A separate analysis of the HIV epidemic in Chandigarh is thus required to take into consideration the evidence and the trends of neighbouring states.

Figure-2 highlights the low prevalence states of Delhi, Haryana, Punjab, Rajasthan, Uttar Pradesh, and West Bengal where HIV prevalence is either stable or declining. Evidently, the degree for decline in HIV prevalence is not uniform between these states which may be on account of the programmatic impact of ART coverage, and the strength of the prevention interventions etc. The decline in HIV prevalence is lower in Haryana and Punjab vis-à-vis Delhi, Rajasthan, Uttar Pradesh, and West Bengal.

National and State estimates of number of people living with HIV

In 2009, the total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) while in 2008; it was 2.44 million people were living with HIV within the uncertainty bounds of 1.97-3.09 millions. Among PLHIV, by sex approximately 61% are male and 39% are female and by age the percent distribution of HIV infection is estimated at 4% are children below the age of 15 years, 83% are adults aged 15–49 years and rest 13% are over 50 years of age (Table2).

The four high prevalence states of South India account for 57% of all HIV infections in the country. Whilst Andhra Pradesh accounts for 500,000 cases; Maharashtra accounts for 420,000 cases, Karnataka accounts for 250,000 cases and Tamil Nadu accounts for 150,000 cases. Over 100,000 PLHIVs are reported in West Bengal, Gujarat, Bihar and Uttar Pradesh and together these states account for 22% of HIV infections in India. The number of PLHIVs in Punjab, Orissa, Rajasthan and Madhya Pradesh range from 50,000 to 100,000 and these states collectively account for 12% of HIV infections. Thus whilst the states noted above are with low HIV prevalence; a large number of PLHIVs are reported due to the states' overall large population size (Map 1).

The percent distribution of HIV burden amongst high prevalence states vis-à-vis the remaining states in India is 57% and 43% respectively. Amongst the high prevalence states, Andhra Pradesh accounts for the greatest proportion of cases at 21% vis-à-vis the other states. Following Andhra Pradesh, Maharashtra accounts for approximately 18% of HIV infection, Karnataka and Tamil Nadu reportedly account for 10% and 7% of all cases whereas Manipur and Nagaland account for 1% of the estimated total.

Conclusions

The India HIV estimates 2008/2009 indicate a slowdown in the AIDS epidemic. National adult HIV prevalence, or the number of adults living with HIV as a proportion of the total population, has declined by 0.05% points from 0.36% (0.29% - 0.45%) in 2006 to 0.31% (0.25% - 0.39%) in 2009. Though the estimation of 2008/09 has utilized EPP and Spectrum tool against UNAIDS/WHO workbook and Spectrum in 2006, the results of 2008-09 round of estimates match perfectly with previously announced estimates. However the results of 2008-09 round of estimates cannot be directly compared with the previous yearsbecause the methodology and data used to produce the estimates have gradually changed as a result of ongoing enhancement of knowledge on the epidemic.

Adult HIV prevalence is either stable or declining in the high prevalence states whereas the trend is varying across the low to moderate prevalence states. Among the high prevalence states, the HIV prevalence has declined in Tamil Nadu between 2006 and 2009 to reach levels of 0.37% in 2008 and 0.33% in 2009. Manipur shows a declining trend over the past four years. Andhra Pradesh, Karnataka, Maharashtra and Nagaland show either a plateau or a slightly declining trend over the time period 2006 – 2009.

In the low prevalence states of Chandigarh, Orissa, Kerala, Jharkhand, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh and Meghalaya; adult HIV prevalence has risen over the last four years which warrants the need for strengthening the trend of the HIV epidemic.

In descending order, states with the highest adult HIV prevalence in 2009 included Manipur (1.4%); followed by Andhra Pradesh (0.90%), Mizoram (0.81%), Nagaland (0.78%), Karnataka (0.63%) and Maharashtra (0.55%). Besides these, the states of Goa, Chandigarh, Gujarat, Punjab and Tamil Nadu have an estimated adult HIV prevalence greater than national prevalence (0.31%). Delhi, Orissa, West Bengal, Chhattisgarh and Pondicherry have an estimated adult HIV prevalence of 0.28-0.30%. Other states have lower levels of HIV.

The total number of people living with HIV (PLHIV) in India is estimated at 2.4 million (uncertainty bounds of 1.93 – 3.04 million) in 2009. Children under 15 years of age account for 4.4% of all infections, whilst people aged 15 – 49 years account for 82.4% of all infections. Thirty-nine percent of all HIV infections are estimated to be among women. This amounts to 0.93 million women with HIV in India.

References:

1. National Institute of Health & Family Welfare, 2007, Country Report on Annual HIV Sentinel Surveillence, 2006, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

2. International Institute for Population Sciences (IIPS) and Macro International, 2007, National Family Health Survey, 2005-06 (NFHS-3): India, IIPS, Mumbai.

3. Dandona L, Lakshmi V, Sudha T, Kumar GA, Dandona R. A population based study of human immunodeficiency virus in south India reveals major differences from sentinel surveillance-based estimates. *BMC Med* 2006; *4* : 31-49.

4. Dandona L, Lakshmi V, Kumar GA, Dandona R. Is the HIV burden in India being over estimated? *BMC Public Health* 2006; *6* : 308-17.

5. Pandey A., Reddy D.C.S., Ghys P., et al. Improved estimate of India's HIV burden in 2006, *Indian Journal of Medical Research*, 2009, 129, 50-58.

6. Pandey A., Reddy D.C.S., Thomas M. What lies behind the fall in the HIV population in India? *Economic & Political Weekly*, December 2008, 27: pp-15-17.

7. Lyerla R, Gouws E, Garcia-Calleja JM, et al. The 2005 Workbook: an improved tool for estimating HIV prevalence in countries with low level and concentrated epidemics. *Sex Transm Infect* 2006;82(Suppl III):iii41–iii44.

8. Stover J, Walker N, Grassly NC, at al. Projecting the demographic impact of AIDS and the number of people in need of treatment: updates to the Spectrum projection package. *Sex Transm Infect* 2006;82(Suppl III):iii45–iii50.

9. Pandey A., Reddy D.C.S., Thomas M., et al. Prevalence and burden of HIV in India 2007 - An Update of Estimates, *Demography India*, 2010, 39(2).

10. UNAIDS Global Reference group on Estimates, Modelling and Projections (www.epidem.org)

11. UNAIDS, 2010, http://www.unaids.org/en/dataanalysis/tools/estimation projection package epp/

12. *National AIDS Control Organization, National AIDS Control Programme – III*, Ministry of Health & Family Welfare, India.

13. Technical Report India HIV Estimates 2008-2009 National Institute of Medical Statistics, ICMR, De*lhi and National AIDS Control* Organization, , Ministry of Health & Family Welfare, India (2010).

14. *Sample Registration System*, Statistical reports, Office of the Registrar General India, New Delhi, 2010.

15. *Census of India 1981*, Office of the Registrar General India, New Delhi,

16. *Census of India 1991*, Office of the Registrar General India, New Delhi,

17. *Census of India 2001*, Office of the Registrar General India, New Delhi,

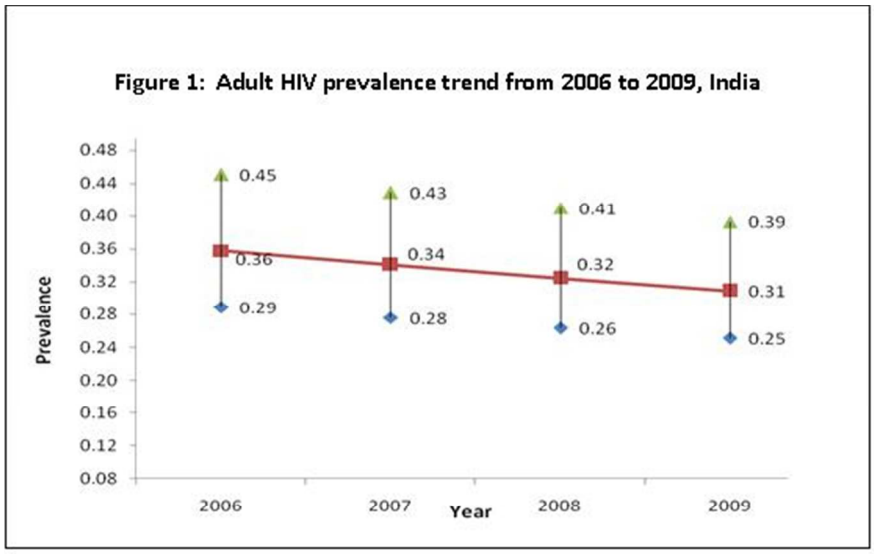
18. *Population Projections for India and States 2001-2026, Report of the Technical Group on Population Projections*, May 2006, National Commission on Population, Ministry of Health & Family Welfare, New Delhi.

19. *Behavioural Surveillance Survey, 2006 – Female sex Workers (FSW) & their clients*, National AIDS Control Organization (NACO), Ministry of Health & Family Welfare, New Delhi.

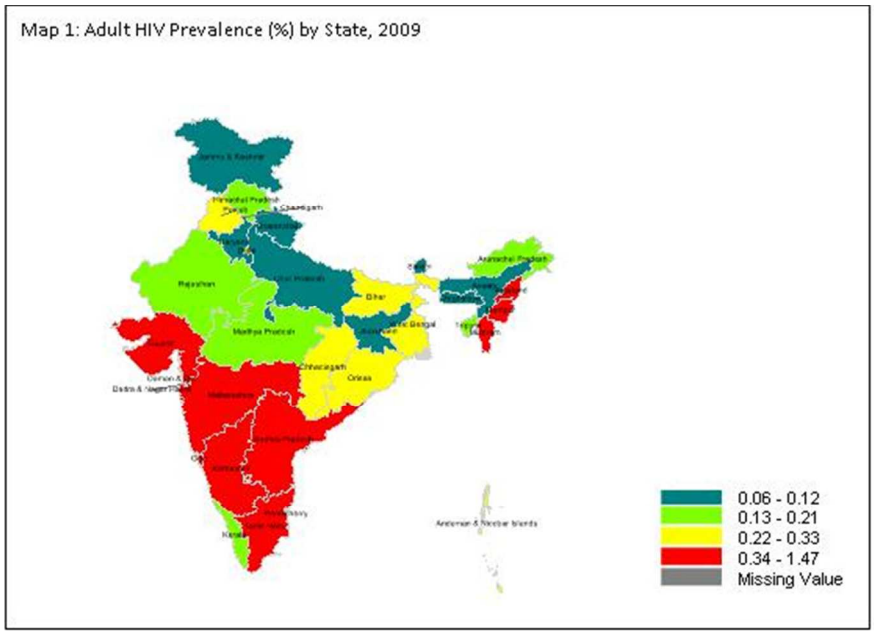
20. *National AIDS Control Organization, National AIDS Control Programme CMS*, Ministry of Health & Family Welfare, India.

21. Bachani D., Sogarwal R., Rao K.S. A population based survey on HIV prevention in Nagaland, India, *SAARC Journal of Tuberculosis*, Lung Diseases and HIV/AIDS, vol. 6(1), 2009, pp1-11.

22. Grassly N.C., Morgan M., Walker N., et al. Uncertainty in estimates of HIV/AIDS: the estimation and application of plausibility bounds, *Sex. Transm. Inf.* 2004; 80; 31-38.



225x180mm (72 x 72 DPI)



225x180mm (72 x 72 DPI)

Figure 2: Adult HIV Prevalence Trends from 2006 to 2009, India States