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An Analysis of Levels and Trends in HIV Prevalence Among Pregnant Women Attending Antenatal Clinics in Karnataka, South India, 2003-2019

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ABSTRACT

Background and Objective: Periodic tracking of the trends and the levels of HIV prevalence at regional and district levels helps to strengthen a state's HIV/AIDS response. HIV prevalence among pregnant women is crucial for the HIV prevalence estimation of the general population. Karnataka is one of the high HIV prevalence states in India. Probing regional and district levels and trends of HIV prevalence provides critical insights into district-level epidemic patterns. This paper analyzes the region- and district-wise levels and trends of HIV prevalence among pregnant women attending the antenatal clinics (ANC) from 2003 to 2019 in Karnataka, South India.

Methods: HIV prevalence data collected from pregnant women in Karnataka during HIV Sentinel Surveillance (HSS) between 2003 and 2019 was used for trend analysis. The consistent sites were grouped into four zones (Bangalore, Belgaum, Gulbarga and Mysore regions), totaling 60 sites, including 30 urban and 30 rural sites. Regional and district-level HIV prevalence was calculated; trend analysis using Chi-square trend test and spatial analysis using QGIS software was done. For the last three HSS rounds, HIV prevalence based on sociodemographic variables was calculated to understand the factors contributing to HIV positivity in each region.

Results: In total, 254,563 pregnant women were recruited. HIV prevalence in Karnataka was 0.22 (OR: 0.15 95% CI: 0.16 - 0.28) in 2019. The prevalence was 0.24, 0.32, 0.17 and 0.14 in Bangalore, Belgaum, Gulbarga, and Mysore regions, respectively. HIV prevalence had significantly ($P < 0.05$) declined in 26 districts.

Conclusion and Global Health Implications: HIV prevalence among pregnant women was comparatively higher in Bangalore and Belgaum regions. Analysis of contextual factors associated with the transmission risk and evidence-based targeted interventions will strengthen HIV management in Karnataka. Regionalized, disaggregated, sub-national analyses will help identify emerging pockets of infections, concentrated epidemic zones and contextual factors driving the disease transmission.

Keywords: • HIV/AIDS • HIV Sentinel Surveillance • Pregnant Women • Prevalence • Trend • Karnataka

I. Introduction

I.1. Background of the Study

Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS) has been a global public health concern since the 1980s. Globally, the estimated population of people with HIV (PWH) is about 37.7 million in 2020.¹ India has the third-largest estimated PWH (2,348,860), of which 42% are females aged above 15 years.^{2,3} In India, estimations indicate 69,220 new infections and 58,960 AIDS-related deaths in 2019.⁴ Within India, HIV is highly concentrated in the southern and north-eastern states, and reports suggest that about 85% of HIV infections in South India occur through heterosexual transmission.⁵ Pregnant women are considered a proxy for the general population, and hence HIV prevalence among pregnant women is a key indicator of adult HIV prevalence.⁶

Karnataka has been one of the high-prevalent states in India, with the third-highest estimated PWH population of 269,470 and an incidence range of 0.01-0.05 per 1000 uninfected population. The adult HIV prevalence in Karnataka was 0.47% (0.37–0.59) in 2019, while the national average was 0.22% (0.17–0.29%) in 2019.⁴ On a positive note, Karnataka is the only state in India to achieve the targeted 75% reduction in new HIV infections between 2010 and 2019.⁴ HIV in Karnataka is heterogeneous and highly concentrated in specific regions and districts.⁷ Belgaum and Bangalore regions have consistently reported high HIV prevalence among antenatal clinic (ANC) attendees and the general population surveillance.^{7,8} India's HIV Sentinel Surveillance (HSS) facilitates periodic monitoring of HIV prevalence at national and state levels. Besides HIV prevalence estimations, HSS serves as a preliminary indicator of sociodemographic factors associated with HIV risk. An analysis of recent HSS data reports a significant association of age, education, spouse occupation, and marital status with higher HIV prevalence among pregnant mothers and indicated that regions of high ANC-HIV prevalence were potentially those with high FSW-HIV prevalence.⁸ A previous study that analyzed the sociodemographic characteristics of HIV-positive pregnant women in Karnataka indicated

that HIV was concentrated among pregnant women who were young and less educated, in their first gravida, residing in rural regions.⁹ While the levels and trends of HIV prevalence at the national and state level are available, probing further into the region and district-wise levels and trends of HIV prevalence will provide critical insights on district-level epidemic patterns for region-specific tailor-made interventions. Hence, this paper analyzes the HSS data of pregnant women to derive the district-wise levels and trends of HIV prevalence in Karnataka.

As one of the largest and robust surveillance systems, India's HIV Sentinel Surveillance (HSS) facilitates periodic monitoring of HIV prevalence at national and state levels.¹⁰ Probing further into the region and district-wise levels and trends of HIV prevalence will provide critical insights on district-level epidemic patterns.

2. Methods

2.1. Study Design and Setting

India's HIV Sentinel Surveillance (HSS) is a cross-sectional survey conducted across 30 sentinel sites from urban and rural regions, comprising 60 sites in total, for the uniform representation of pregnant women (Figure 1). In this study, the HIV prevalence recorded at consistent sites in the last 11 rounds of HSS was considered to calculate the regional and district level HIV prevalence. Consistent sites were functional in at least four HSS rounds between 2003 and 2019 and were grouped into four regions: Bangalore, Belgaum, Gulbarga, and Mysore regions. The districts were grouped based on the four administrative divisions of Karnataka. All sites were functioning under a government healthcare facility.

Pregnant women aged 15-49 years and attending the ANC site for the first time during the surveillance period were included in the study. The sample size was 400 for each sentinel site.^{11,12} For each round of HSS, the study was conducted for three months or until the sample size was reached, whichever was earlier. In each site, participants were restricted to 20 per day to ensure data quality. A consecutive sampling method was followed to

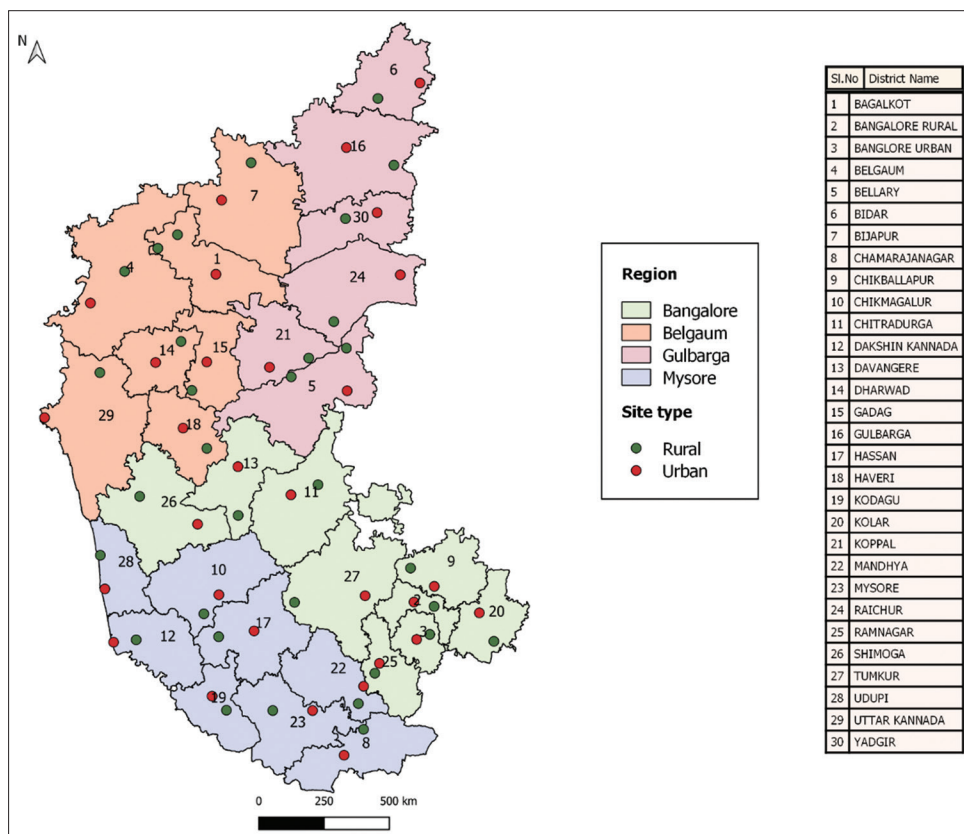


Figure 1: Distribution of HIV sentinel surveillance sites in Karnataka – 2019

reduce sampling bias. The unlinked anonymous testing (UAT) strategy was followed until 2015 and was changed to the linked anonymous testing (LAT) strategy in 2017. Unlinked anonymous testing ensures the confidentiality of participants and minimizes participation bias. No personal identifiers are collected in this method, and a unique HSS code is assigned to the data forms and the test samples. However, to facilitate ART linkage and treatment management, the surveillance code is linked with the ANC registration number in a separate HSS register and maintained confidentially at the HSS sites.¹⁰ The standard two-test protocol was followed for HIV testing. The samples were tested through two ELISA or rapid tests or a combination of both at designated laboratories identified by NACO.¹¹ The online data management software, Strategic Information Management System (SIMS), was used

for data entry.¹³ The complete methodology of HSS and all standard operating procedures (SOP) were followed in all sites throughout the HSS as per the operational guidelines.^{10,11}

2.2. Statistical Analysis

For each round of HSS, the state, regional, and district-level seroprevalence was calculated based on the formula, $P = y/n$, where 'y' denotes the number of HIV-positive pregnant women, and 'n' denotes the total number of pregnant women recruited. 95% CI (confidence interval) was calculated based on binomial and normal theory methods.¹⁴ Prevalence trends were identified by the Chi-square trend test, using the CDC software Epi Info 7.2. Then, the spatial variation of HIV prevalence through the years was analyzed using the QGIS software (version 3.83, 2019). For the last three HSS rounds (2015, 2017, 2019), HIV prevalence based

on key sociodemographic variables was calculated. Districts reporting at least one HIV-positive case in two of the three rounds were identified against each sociodemographic variable to understand further the region-specific factors contributing to HIV positivity in each region.

2.3. Ethical Approval

The study was approved by the Ministry of Health and Family Welfare, Government of India. In HSS among pregnant women, HIV testing was anonymous, and the results were not used to determine the HIV status of a person. Hence, the written informed consent was waived, as endorsed in Item No. 6 under Chapter III, India HIV Act 2017.¹⁵ However, the pregnant mothers recruited for HSS were informed about the study purpose before data and sample collection.

3. Results

In total, 254,563 pregnant women were recruited for HSS from 2003 to 2019 in Karnataka. The state-, and regional trends and levels of HIV prevalence among pregnant women in Karnataka are represented in Table 1. The result indicates a significant decline ($P < 0.001$) in HIV prevalence among pregnant women in Karnataka; 1.43 % (OR: 1.00 95% CI: 1.27 - 1.59) in 2003, to 0.69% (OR: 0.48 95% CI: 0.59 - 0.80) in 2011 and further to 0.22% (OR: 0.15 95% CI: 0.16 - 0.28) in 2019 (Figure 2).

3.1. HIV Prevalence at the Regional Level

In all four regions of Karnataka, the HIV prevalence trend indicated a significant decline ($P < 0.001$) as presented in Table 1. In Bangalore region, the prevalence declined from 1.13 % (95% CI: 0.87% - 1.40%) in 2003 to 0.24% (95% CI: 0.12 - 0.35) in 2019; in Belgaum region from 2.15% (95% CI: 1.77% - 2.53%) to 0.32 % (95% CI: 0.18 % - 0.46 %); in Gulbarga region from 2.08 % (95% CI: 1.64% - 2.52 %) to 0.17 % (95% CI: 0.06 % - 0.29 %), and in Mysore region from 0.67 % (95% CI: 0.47 %- 0.87 %) to 0.14% (95% CI: 0.05% - 0.23%).

3.2. HIV Prevalence at the District Level

Most districts in Karnataka indicated a significant decline in HIV prevalence but had inter-district variations. Spatial variation of the HIV prevalence in the districts of Karnataka (Table 2) is shown in

Figure 3. Significant decline ($P < 0.05$) was observed in 26 districts in Belgaum, Gulbarga and Mysore regions. Four districts (Bangalore Urban, Bangalore Rural, Chikballapur and Chitradurga) recorded a declining trend, which, however, was not statistically significant ($P > 0.05$). Bangalore, Davangere, Tumkur, Bagalkot, Belgaum, Bijapur, Chamrajnagar, and Hassan

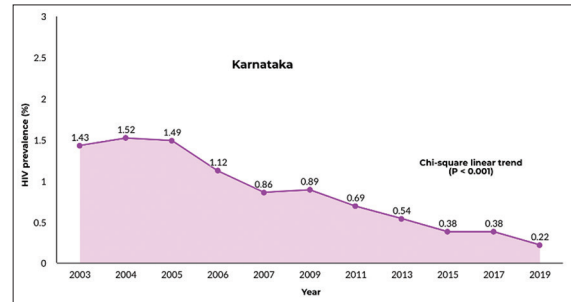


Figure 2: Trend of HIV prevalence (%) among pregnant women attending ANC clinics in Karnataka (2003 -2019) Figure shows yearly surveillance until 2007 and biennial surveillance henceforth.

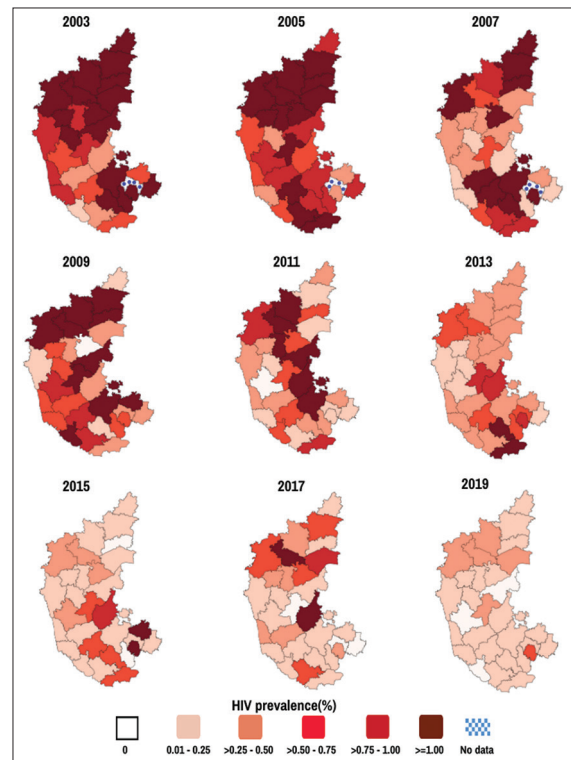


Figure 3: Geographical variation of HIV Prevalence (%) among pregnant women across the districts in Karnataka (2003-2019)

Table 1: Prevalence trends of state and regional level HIV prevalence (%) among pregnant women in Karnataka, 2003-2019

Year	2003	2004	2005	2006	2007	2009	2011	2013	2015	2017	2019	P value
Karnataka												
Tested	21955	21534	21599	21627	21602	23192	23996	24767	24745	24800	24746	< 0.001*
HIV Positive %	1.43	1.52	1.49	1.12	0.86	0.89	0.69	0.54	0.38	0.38	0.22	
(95% CI)	(1.27-1.59)	(1.36-1.68)	(1.33-1.65)	(0.98-1.26)	(0.74-0.98)	(0.77-1.01)	(0.59-0.80)	(0.45-0.63)	(0.31-0.46)	(0.30-0.46)	(0.16-0.28)	
OR	1.00	1.06	1.04	0.78	0.60	0.62	0.48	0.37	0.27	0.26	0.15	
Bangalore												
Tested	5998	5600	5599	5600	5600	7199	7197	7195	7200	7200	7183	< 0.001*
HIV Positive %	1.13	1.25	0.86	0.79	0.61	0.90	0.56	0.63	0.61	0.28	0.24	
(95% CI)	(0.87-1.40)	(0.96-1.54)	(0.62-1.10)	(0.55-1.02)	(0.40-0.81)	(0.68-1.12)	(0.38-0.73)	(0.44-0.81)	(0.43-0.79)	(0.16-0.40)	(0.12-0.35)	
OR	1	1.1	0.75	0.69	0.53	0.79	0.49	0.55	0.54	0.24	0.21	
Belgaum												
Tested	5579	5600	5600	5627	5600	5599	5599	5988	6000	6000	5981	< 0.001*
HIV Positive %	2.15	2.04	2.52	1.46	0.75	1.07	1.18	0.40	0.28	0.53	0.32	
(95% CI)	(1.77-2.53)	(1.67-2.41)	(2.11-2.93)	(1.14-1.77)	(0.52-0.98)	(0.80-1.34)	(0.90-1.46)	(0.24-0.56)	(0.15-0.42)	(0.35-0.72)	(0.18-0.46)	
OR	1	0.95	1.18	0.67	0.34	0.49	0.54	0.18	0.13	0.24	0.14	
Gulbarga												
Tested	3988	4000	4000	4000	4002	3998	4800	5191	5200	5200	5191	< 0.001*
HIV Positive %	2.08	1.68	1.78	1.23	1.20	0.60	0.58	0.42	0.25	0.44	0.17	
(95% CI)	(1.64-2.52)	(1.28-2.07)	(1.37-2.18)	(0.88-1.57)	(0.86-1.54)	(0.36-0.84)	(0.37-0.80)	(0.25-0.60)	(0.11-0.39)	(0.26-0.62)	(0.06-0.29)	
OR	1.00	0.80	0.85	0.58	0.57	0.28	0.28	0.20	0.12	0.21	0.08	
Mysore												
Tested	6390	6334	6400	6400	6400	6396	6400	6393	6345	6400	6391	< 0.001*
HIV Positive %	0.67	1.20	0.97	1.06	0.97	0.89	0.50	0.66	0.33	0.30	0.14	
(95% CI)	(0.47-0.87)	(0.93-1.47)	(0.73-1.21)	(0.81-1.31)	(0.73-1.21)	(0.66-1.12)	(0.33-0.67)	(0.46-0.86)	(0.19-0.47)	(0.16-0.43)	(0.05-0.23)	
OR	1	1.79	1.44	1.59	1.44	1.33	0.74	0.98	0.49	0.44	0.21	

* Chi-square liner trend: significant at 0.1% (p<0.001) level; OR: Odds Ratio

Table 2: Prevalence trend of district level HIV prevalence (%) among pregnant women in Karnataka, 2003-2019

Region	District	2003	2004	2005	2006	2007	2009	2011	2013	2015	2017	2019	P value
Bangalore	Bangalore Urban	1.17	0.63	0.50	1.38	1.25	0.75	0.25	0.88	1.13	0.50	0.63	0.223
Bangalore	Bangalore Rural	ND	ND	ND	ND	ND	0.38	0.13	0.75	0.25	0.00	0.25	0.348
Bangalore	Chikballapur	0.75	0.25	0.50	0.00	0.50	1.25	0.38	0.50	1.75	0.25	0.13	0.957
Bangalore	Chitradurga	0.38	0.75	0.63	0.25	0.25	0.50	1.25	0.88	1.00	1.13	0.13	0.221
Bangalore	Davangere	0.88	2.13	1.38	1.38	0.75	2.00	0.75	0.88	0.63	0.00	0.50	<0.001*
Bangalore	Kolar	1.25	1.25	1.00	1.50	0.25	0.50	0.25	0.25	0.13	0.00	0.13	<0.001*
Bangalore	Ramnagaram	1.88	2.50	0.88	0.50	0.13	0.63	0.50	0.75	0.00	0.25	0.13	<0.001*
Bangalore	Shimoga	0.75	0.50	0.88	0.50	0.38	1.00	0.00	0.25	0.38	0.13	0.00	0.001*
Bangalore	Tumkur	1.88	1.50	1.00	0.75	1.13	1.13	1.50	0.50	0.25	0.25	0.25	<0.001*
Belgaum	Bagalkot	2.75	2.63	2.88	2.13	0.63	2.13	3.50	0.58	0.50	1.17	0.42	<0.001*
Belgaum	Belgaum	4.43	4.25	3.63	3.13	2.00	1.50	0.88	0.75	0.50	0.63	0.50	<0.001*
Belgaum	Bijapur	1.63	1.38	2.13	1.23	1.00	2.00	1.75	0.50	0.13	0.38	0.50	<0.001*
Belgaum	Dharwad	3.00	2.88	6.75	0.88	0.38	0.63	0.50	0.13	0.13	0.38	0.25	<0.001*
Belgaum	Gadag	0.88	1.13	1.13	0.88	0.50	0.50	1.13	0.38	0.25	0.38	0.13	<0.001*
Belgaum	Haveri	1.39	0.63	0.38	0.63	0.25	0.63	0.13	0.13	0.13	0.25	0.25	<0.001*
Belgaum	Uttara Kannada	1.00	1.38	0.75	1.35	0.50	0.13	0.38	0.25	0.25	0.25	0.13	<0.001*
Gulbarga	Bellary	1.63	1.13	0.88	1.38	0.38	1.13	1.25	0.50	0.25	0.25	0.00	<0.001*
Gulbarga	Bidar	1.39	0.88	0.88	0.88	1.13	0.13	0.50	0.38	0.25	0.13	0.13	<0.001*
Gulbarga	Gulbarga@	1.63	2.25	2.63	0.88	2.74	1.25	0.25	0.38	0.25	0.75	0.25	<0.001*
Gulbarga	Koppal	4.13	3.00	2.88	1.63	1.25	0.00	0.63	0.38	0.50	0.63	0.13	<0.001*
Gulbarga	Raichur	1.63	1.13	1.63	1.38	0.50	0.50	0.25	0.50	0.25	0.88	0.38	<0.001*
Gulbarga	Yadgir^	1.63	2.25	2.63	0.88	2.74	1.25	0.63	0.38	0.00	0.13	0.25	<0.001*
Mysore	Chamrajnagar	0.51	1.00	1.63	1.38	1.00	0.50	0.88	1.25	0.63	0.25	0.25	0.012*
Mysore	Chikmagalur	0.50	0.95	0.88	1.50	2.38	0.75	0.38	0.38	0.25	0.38	0.13	<0.001*
Mysore	Dakshina Kannada	0.88	1.38	0.38	0.75	0.13	0.75	0.25	0.50	0.13	0.13	0.13	<0.001*
Mysore	Hassan	0.75	1.00	1.38	2.38	1.25	0.88	0.75	0.63	0.63	0.13	0.13	<0.001*
Mysore	Kodagu	0.25	0.75	0.75	0.50	0.75	2.63	0.63	0.50	0.25	0.25	0.00	0.025*
Mysore	Mandya	1.13	1.13	1.00	0.25	1.25	0.13	0.50	1.13	0.54	0.13	0.13	0.002*
Mysore	Mysore	0.50	2.38	1.13	1.00	0.88	0.88	0.13	0.50	0.13	0.63	0.13	<0.001*
Mysore	Udupi	0.88	1.00	0.63	0.75	0.13	0.63	0.50	0.38	0.13	0.50	0.25	0.015*

*Significantly declining trend ($P<0.05$); ND- No data.

^Newly bifurcated districts: Sites initiated in 2010; @Parent district's HIV prevalence is given up to the year 2009

recorded a prevalence of 0.5 and above in at least 8 of the 11 HSS.

4. Discussion

Karnataka has been among India's high HIV prevalence states, with a prevalence of 1.43% among pregnant women in 2003. The prevalence significantly decreased ($P<0.001$) to 0.38% in 2019, which was still higher than the national average of

0.28%.⁴ In the general population, HIV prevalence of $\geq 1\%$ indicates a high prevalence, 0.5-0.99 indicates moderate prevalence, and prevalence < 0.5 indicates a low prevalence.¹⁶ In 2003, Karnataka recorded high HIV prevalence among pregnant women in 18 districts, moderate prevalence in 10 and low prevalence in 2 of its 30 districts. In 2019, the state recorded moderate prevalence in 4 districts and low prevalence in all the remaining districts (Table 2).

The trend significantly declined or stabilized in most districts since 2011, while it was fluctuating in Chikballapur and Chitradurga districts in the Bangalore region. (Table 2).

Karnataka's first HIV case was reported in 1988 in Belgaum.¹⁷ The National AIDS Control Organization (NACO), Karnataka State AIDS Prevention Society (KSAPS), the District AIDS Control and Prevention units (DAPCUs), and private partners implemented and monitored various HIV interventions in Karnataka. From 2003, a consistent decline in HIV prevalence among pregnant women was predominantly observed in Karnataka, owing to various interventions. Reports show that a higher prevalence among the high-risk groups (HRGs) reflects on the HIV prevalence of pregnant women.¹⁸ Hence the early stages of the interventions were predominantly focused on HRGs, and had a measurable impact on HIV prevention in the general population.¹⁹ Some of the notable interventions that had a potential impact on HRG behavior and HIV prevalence and the subsequent impact on ANC prevalence are discussed here.

Initially, India-Canada Collaborative HIV/AIDS Project (ICHAP) was implemented in collaboration between the University of Manitoba and KSAPS to carry out HIV prevention and control programs in rural Karnataka in 2001.²⁰ The Karnataka Health Promotion Trust (KHPT) was formed in 2003 as a collaborative partnership between the University of Manitoba and KSAPS to deliver HIV/AIDS services in Karnataka.^{21,22} KHPT implemented and supported various initiatives such as Sankalp, Corridors and Samastha for HIV prevention and management.²² In 2003, Avahan, an India AIDS Initiative that aimed to scale up the HIV prevention services, was implemented in six high-prevalent states in India. As a part of the Avahan initiative, the 'Sankalp' was launched in 18 districts in Karnataka for HIV prevention services to HRGs and the bridge population.²² In 2005, 'Corridors' was launched in Northern Karnataka for HIV services among HRGs who live and migrate across the border districts of North Karnataka and South Maharashtra.²³ During 2006-2011, the Samastha project was implemented in 13 high-prevalence districts in Karnataka.²³ It

was an enhanced care model and used a district-based approach to strengthen and coordinate the existing HIV healthcare services.^{24,25} Implementation of behavioral interventions and advocacy for safer sex was the primary idea of Avahan initiatives. The prevention services included commodity distribution (free condoms, needles and syringes), extensive peer-outreach, community mobilization, dedicated health services to FSWs and their clients, creating an enabling environment and other psychological support programs.²¹ Further, in 2004, antiretroviral therapy (ART) was initiated in Karnataka, which subsequently increased the ART enrollment.²⁶

Avahan scaled up the prevention services during Phase I (2003-2008) and transitioned the services to NACO in Phase II (2008-2013).²⁷ A series of assessments conducted between 2004-2012 at selected districts in Karnataka showed that the prevalence of HIV and STI declined considerably and reported significantly high rates of condom usage with regular clients.^{28,29} A modeling study indicates that under certain conditions in a concentrated epidemic, a significant decline in ANC prevalence is achievable through effective interventions among FSW.³⁰ The study also reports evidence of localized interventions in certain districts of Karnataka even before 2003.³⁰ The overall declining trend in the HIV prevalence among pregnant women since 2011 is most likely a synergized impact of the interventions implemented in Karnataka. Nevertheless, the recent years' prevalence trends reached stabilization and require targeted measures to achieve the global agenda of 'Eliminating AIDS by 2030'.

To understand the recent trends, HIV prevalence and the districts with a minimum of one HIV-positive pregnant woman in the last three rounds of HSS (2015, 2017, 2019) were categorized under key sociodemographic factors often associated with infection risk (Table 3). Based on this disaggregated data, the prevalence was higher among pregnant women aged 25-49 years, illiterates, residing in rural regions and those whose spouse was laborers or transport workers. HIV positivity in recent HSS rounds was constantly reported in districts of Bangalore, Chikballapur, Chitradurga, Davanagere, Tumkur, Bagalkot, Belgaum, Bijapur, Gadag, Dharwad,

Table 3: HIV prevalence and districts reporting at least one HIV-positive pregnant woman in any 2 of the last three rounds of HIV Sentinel Surveillance based on the sociodemographic variables

Sociodemographic Variables	HIV Prevalence (%)			Districts reporting at least one HIV positive pregnant mother in any 2 of the last 3 HSS			
	2015	2017	2019	Regions			
				Bangalore	Belgaum	Gulbarga	Mysore
Age (Yrs.)							
15-24	0.28	0.33	0.19	Bangalore Urban, Chikballapur, Chitradurga, Davanagere, Kolar, Ramanagaram, Tumkur	Bagalkot, Belgaum, Bijapur, Gadag, Dharwad, Haveri, Uttara Kannada	Bellary, Gulbarga, Koppal, Yadgir	Chamrajnagar, Chikmagalur, Hassan, Kodagu, Mandya, Mysore
25-49	0.51	0.47	0.25	Bangalore Urban, Bangalore Rural, Chitradurga, Davanagere, Tumkur	Bagalkot, Belgaum, Bijapur, Dharwad, Gadag, Uttara Kannada	Bellary, Bidar, Gulbarga, Koppal, Raichur	Chamrajnagar, Chikmagalur, Dakshina Kannada, Hassan, Udupi, Kodagu, Mandya, Mysore
Education							
Illiterate	0.60	0.46	0.45	Chikballapur, Tumkur	Bagalkot, Belgaum	Bellary, Koppal, Raichur, Yadgir	-
Literate & till 5 th standard	0.32	0.37	0.29	Chitradurga, Davanagere	Bagalkot	-	Hassan, Udupi
6 th to 10 th standard	0.38	0.33	0.22	Bangalore Urban, Bangalore Rural, Chikballapur, Chitradurga, Davanagere, Ramanagaram, Tumkur	Bagalkot, Belgaum, Bijapur, Gadag, Haveri, Dharwad, Uttara Kannada	Gulbarga, Koppal	Chamrajnagar, Mandya, Mysore, Chikmagalur, Dakshina Kannada, Hassan, Kodagu
11 th to Graduation	0.16	0.43	0.14	Chitradurga	Bagalkot, Belgaum, Bijapur, Uttara Kannada	-	Chikmagalur, Udupi
Post-Graduation	0.43	0.47	0.14	-	-	-	-
Gravida Status							
First	0.33	0.43	0.24	Bangalore Urban, Chikballapur, Chitradurga, Davanagere, Shimoga	Bagalkot, Belgaum, Bijapur, Gadag, Haveri, Uttara Kannada	Bidar, Gulbarga, Koppal, Raichur	Chamrajnagar, Chikmagalur, Hassan, Udupi
Second	0.45	0.32	0.19	Bangalore Urban, Bangalore Rural, Chitradurga, Davanagere, Tumkur	Bagalkot, Belgaum, Bijapur, Gadag, Uttara Kannada	Gulbarga, Koppal, Raichur	Mandya, Mysore, Chamrajnagar, Chikmagalur, Dakshina Kannada, Hassan, Udupi
Third	0.28	0.36	0.23		Bagalkot, Belgaum, Dharwad	Gulbarga	Kodagu
Fourth/More	0.26	0.43	0.20	-	-	-	-
Spouse Occupation							
Agricultural Laborer	0.46	0.31	0.22	Chikballapur	Bagalkot, Gadag	Koppal, Raichur	Chikmagalur, Hassan, Kodagu

(Contd...)

Table 3: (Continued)

Sociodemographic Variables	HIV Prevalence (%)			Districts reporting at least one HIV positive pregnant mother in any 2 of the last 3 HSS			
	2015	2017	2019	Regions			
				Bangalore	Belgaum	Gulbarga	Mysore
Non-Agricultural Laborer [@]	0.23	0.39	0.24	Bangalore Urban, Bangalore Rural, Chitradurga, Kolar, Ramanagaram, Tumkur	Bagalkot, Belgaum, Dharwad, Uttara Kannada	Bellary	Chamrajnagar, Hassan, Mandya
Skilled/Semiskilled worker [#]	0.35	0.17	0.15	Bangalore Urban	Belgaum	Raichur	Dakshina Kannada
Truck Driver/ helper	1.16	0.91	0.00	Bangalore Urban	-	-	-
Local transport worker [§]	0.43	0.62	0.22	Davanagere	Bagalkot, Bijapur	Bidar, Koppal	Mysore
Current residence							
Urban	0.30	0.36	0.15	Bangalore Urban, Bangalore Rural, Chikballapur, Chitradurga, Davanagere	Bagalkot, Bijapur, Dharwad, Gadag, Haveri, Uttara Kannada	Bellary, Bidar, Gulbarga, Koppal	Mandya, Mysore
Rural	0.41	0.38	0.26	Chikballapur, Chitradurga, Davanagere, Shimoga, Tumkur	Bagalkot, Belgaum, Bijapur, Dharwad, Gadag, Haveri, Uttara Kannada	Bellary, Gulbarga, Koppal, Raichur, Yadgir	Chikmagalur, Dakshina Kannada, Hassan, Udupi, Kodagu, Mysore

[@]Workers at construction sites, quarries, stone crushers, road or canal works, brick-kilns, etc.

[#]Workers in small-scale or cottage industries; industrial/factory workers; technicians such as electricians, masons, plumbers, carpenters, goldsmiths, iron-smiths, those involved in automobile repair works etc.; artisans such as weavers, potters, painters, cobblers, shoe-makers, tailors etc.

[§]Auto/taxi driver, handcart pullers, and rickshaw puller

Gulbarga, Bellary, Koppal, Raichur, Chikmagalur, Hassan and Mysore. Belgaum region, known for the traditional sex trade,³¹ consistently recorded the highest HIV prevalence. In our analysis, Belgaum had a prevalence of 0.5 and above in all HSS since 2003, the highest being 4.43 in 2003 (Table 2). Bangalore Urban and Davangere districts in the Bangalore region also recorded a higher prevalence. Previous studies show that HIV among pregnant women in Karnataka is highly concentrated in the northern (Belgaum region) and southern districts (Bangalore region), particularly those with high HIV prevalence among HRGs.^{7,8} While spouse occupation being laborers, seasonal migration and commercial sex trade were associated with infection risks in North Karnataka, spouse occupation being truckers and transport workers were associated with infection risks in South Karnataka.^{8,9} It is noteworthy that although no significant variation was observed in the overall urban-rural prevalence in Karnataka, HIV

positivity in the recent rounds was comparatively higher in the rural areas (Table 3). In 2019, HIV prevalence in the rural sites ranged between 0.00% - 2.13%, and the rural sites in Bangalore Rural (2.13%), Bijapur (0.77%), Belgaum (0.68%), Raichur (0.63%) Bagalkot (0.62%) and Davanagere (0.57%) recorded higher prevalence. HIV prevalence in the urban sites ranged between 0.00% - 0.53%, with the highest prevalence in Bangalore Urban (0.53%).³² Further disaggregated analysis of the region-specific factors associated with infection risk may indicate the regional variations, the rising pockets of infection and the possibilities of intervention optimizations.

The study provides preliminary evidence of regional and district-level HIV prevalence trends in Karnataka and gives insights to focus areas for prevention services among pregnant women. Alongside prevention services, HIV treatment and management play a significant role in ensuring the

prevention of neonatal transmission. Antiretroviral therapy (ART) and prevention of parent to child transmission (PPTCT) programs are being implemented at the national and state levels.³³ Universal HIV testing, early access and adherence to ART, follow-up and periodic viral load assessments are essential to prevent neonatal HIV transmission, for which awareness on HIV management is essential.³⁴ As per the National Family Health Survey (NFHS) data, about 24.5% of females aged between 15 - 49 years in Karnataka had a comprehensive knowledge of HIV in 2020, while it was 9.5% in 2016.³⁵ Counseling and integration of HIV treatment services with antenatal care are shown to positively impact voluntary HIV testing and ART adherence, whereas follow-up was a major barrier in PPTCT services.^{34,36} A recent meta-analysis on community-based HIV initiatives that effectively achieved UNAIDS 90-90-90 targets shows that various strategies include deployment of community workers/peers, combined test and treat strategies, educational methods, mobile testing, campaigns and technology. The results suggested that the deployment of community healthcare workers/peer workers significantly improved viral suppression and encouraged innovative interventions for HIV management.³⁷ Reports on the efficiency of innovative methods such as digital platforms, distribution of self-test kits that encourage voluntary testing and subsequent ART linkage among pregnant mothers are emerging.^{38,39} The feasibility and accessibility of such novel strategies will fast-track further decline in HIV prevalence among pregnant women in Karnataka.

4.1. Strengths and Limitations of the study

HSS is a cross-sectional survey which is having its limitation in predicting the temporal relationship. HSS in Karnataka predominantly included pregnant women attending the government ANC. Hence, this analysis does not consider the HIV prevalence of those attending private ANC. The paper is limited to trend analysis and does not analyze the structural and behavioral factors associated with infection trends because such contextual data for pregnant women is scarce.

5. Conclusion and Global Health Implications

The current analysis indicates a significant decrease in almost all districts in Karnataka since 2003. However, inter-district variations were observed, with the prevalence reaching stabilizing levels in the last few years. Our findings will be instrumental in facilitating targeted interventions at regions of high prevalence.

The global agenda of 'End of AIDS by 2030' necessitates regionalized and disaggregated analysis at sub-national levels. Such an approach will help identify the emerging pockets of new HIV infections, zones of concentrated epidemic and contextual factors driving the disease transmission. This paper identifies regions of a concentrated epidemic, with further scope to identify and intervene on the underlying region-specific factors affecting disease transmission.

Compliance With Ethical Standards

Conflicts of Interest: The authors declare no competing interests. **Financial Disclosure:** Nothing to declare. **Funding/Support:** Funding was received from the National AIDS Control Organization (NACO) (Government of India) for conducting the HIV Sentinel Surveillance (HSS) in the states, Andhra Pradesh, Telangana, Karnataka, Kerala, Odisha, Puducherry, and Tamil Nadu. NACO Grant No. T-11020/02/2015-NACO (Surveillance). **Acknowledgments:** The authors wish to thank the National AIDS Control Organization, Karnataka State AIDS Control Society, National and State Reference Laboratories, State Surveillance Team members, District AIDS Prevention Control Units, and sentinel site personnel for their support in completing the surveillance activities on time. The authors also express their gratitude to Dr. Sanjay Mehendale, former Additional Director General, Indian Council of Medical Research, New Delhi, and Dr. Manoj V Murhekar, Director, ICMR-National Institute of Epidemiology, Chennai, for their support and technical inputs towards conducting the surveillance. **Disclaimer:** None

Key Messages

- ▶ HIV Prevalence among pregnant women in Karnataka has significantly declined since 2003.
- ▶ Based on the recent trends, the prevalence was higher among pregnant women aged 25-49 years, illiterates and those whose spouse was laborers or transport workers.
- ▶ HIV prevalence was comparatively higher in Bangalore and Belgaum regions.

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