SPATIAL CONCENTRATION AND GENDER INTERLINKAGES IN THE EXPANDING HIV/AIDS EPIDEMIC IN KERALA

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ABSTRACT

This study examines the changing epidemiology of HIV/AIDS in Kerala from 2004 to 2012 through a comprehensive analysis of temporal trends, district-level distribution, and gender dynamics. A quantitative, retrospective, descriptive, and analytical design was adopted using secondary data on People Living with HIV/AIDS (PLHA) at the state and district levels. Time-series analysis was performed to assess growth trends, annual growth rates, and Compound Annual Growth Rate (CAGR). District comparison analysis included year-wise ranking, identification of high- and low-burden districts, and calculation of district contributions to the state total. Gender-based analysis examined male-female ratios, female percentage contribution, and correlation between male and female trends. Descriptive statistical measures and heat map visualization were used to assess spatial dispersion and concentration patterns. The findings indicate a substantial increase in PLHA in Kerala, rising from 547 cases in 2004 to 6,672 cases in 2012, with a CAGR of approximately 36.7%. The epidemic exhibited distinct phases, including rapid expansion in the early years followed by moderated growth. District-level analysis revealed significant spatial heterogeneity, with Palakkad, Thiruvananthapuram, Ernakulum, and Thrissur consistently contributing a major share of the state burden, indicating geographic clustering and emerging hotspots. Gender analysis showed a strong positive correlation ($r \approx 0.98$) between male and female trends, with women consistently accounting for nearly half of total cases, reflecting balanced gender involvement and periods of feminization. The study highlights the evolving nature of the HIV/AIDS epidemic in Kerala, characterized by sustained growth, spatial concentration, and interconnected gender dynamics. The findings underscore the importance of district-focused, gender-sensitive, and data-driven public health interventions to effectively manage and control the epidemic.

Keywords

HIV/AIDS; Time Series Analysis; Gender Dynamics; Spatial Distribution; Kerala

1. Introduction

The global HIV/AIDS epidemic remains one of the most significant public health challenges of the 21st century. In India, while the overall adult prevalence has seen a downward trend, the internal dynamics of the epidemic vary significantly across states due to diverse socio-economic and demographic factors (National AIDS Control Organisation [NACO], 2012). Kerala, often lauded for its robust healthcare indicators and high literacy rates, presents a unique epidemiological profile. Despite its high "Human Development Index" (HDI) scores, the state has witnessed a complex evolution in the number of People Living with HIV/AIDS (PLHA), moving from a perceived low-prevalence zone to a region requiring nuanced surveillance.

Early in the epidemic, HIV in India was largely concentrated among high-risk groups (HRGs) such as female sex workers, men who have sex with men, and people who inject drugs. However, by the mid-2000s, the virus began a "generalized" spread into the low-risk population, primarily through heterosexual transmission (Pandey et al., 2012). This shift necessitated a transition in public health strategy, moving from purely clinical management to comprehensive social and spatial monitoring. In Kerala, the migration of labour-both internal and international-and the state's unique urban-rural continuum have been identified as potential drivers for the introduction and spread of the virus.

Understanding the trajectory of HIV requires an analysis of both time and space. Temporal trends, often measured by the Compound Annual Growth Rate (CAGR), provide insight into whether an epidemic is in an acceleration, stabilization, or decline phase. Between 2004 and 2012, India scaled up its National AIDS Control Programme (NACP), which significantly increased the availability of Integrated Counselling and Testing Centres (ICTC) and Antiretroviral Therapy (ART) (NACO, 2010). While these interventions improved the survival rates of PLHA, they also led to an increase in the recorded prevalence as more individuals were diagnosed and lived longer with the condition.

A critical aspect of the changing epidemiology in India is the "feminization" of the epidemic. Initially, HIV was predominantly detected in males; however, the proportion of infected women has steadily increased over the decades. This trend often signals the transition of the epidemic from high-risk individuals to their stable partners in the general population (Bharat et al., 2014). In Kerala, where women have higher levels of social agency compared to many

other Indian states, analysing gender-disaggregated data is essential to determine if prevention strategies are reaching vulnerable female populations effectively.

There is a long history of spatial analytic studies of infectious disease. Spatial analysis has been used for everything from descriptive studies to predictive studies, and from surveillance to unveiling the underlying structures of epidemics. AIDS is possibly the major humanitarian challenge of the past few decades and will continue into the future. AIDS was definitely the plague of the late 20th century. The rate of new infections with HIV has apparently increased in the Kerala in the last few years because young adults have started careless about safe sex and injected drug use.

Despite the availability of national-level data, there is a need for localized, district-level evidence to guide resource allocation and policy in Kerala. This study aims to fill that gap by examining the changing epidemiology of HIV/AIDS in the state from 2004 to 2012. By analysing temporal trends, identifying geographic hotspots, and evaluating gender dynamics, this research provides a data-driven foundation for developing targeted public health interventions that address the specific needs of high-burden districts and vulnerable groups.

The first case of Human Immunodeficiency Virus (HIV) infection was identified in Kerala in 1987. HIV prevalence rate in the general population is 0.19 % in spite of the fact that it is surrounded by two high prevalent States. The estimated number of people infected with HIV in Kerala is 55167 (KASAC 2008). The route of HIV transmission in Kerala is heterosexual 82%, homosexual 2%, through injecting drug use 8%, mother to child 7%, through blood /blood products 1%.

Epidemic scenario 2009 estimates adult HIV prevention is 0.19 percent in Kerala State comprising 0 .23 percent male and 0.15 percent female. Whereas 60 percent of the reported cases are Male living with HIV/AIDS and 40 percent female living with HIV/AIDS. Children's living with HIV/AIDS is 871 in the state. As per the National AIDS Control programme (NACP III) there are only "B" and "C" districts are identified in Kerala State. Ernakulum and Kozhikode come under the "B" category of district and the remaining district fall in "C" category.

AIDS the acquired immune-deficiency syndrome (slim disease) is a fatal illness is caused by a retrovirus known as the Human Immune Deficiency Virus (HIV) which breaks down the body's immune system, leaving the victim vulnerable to a host of life-threatening opportunistic

infections, neurological disorders or unusual malignancies. Among the special features of HIV infection are that once infected, it is probable that a person will be infected for life.

2. Study area

Kerala, popularly known as "God's Own Country" and the "Gateway of the Monsoon in India," is located in the south western part of India within the humid tropical monsoon climatic zone. The state extends between 8°18′N and 12°48′N latitudes and 74°52′E and 77°22′E longitudes, covering an area of 38,863 square kilometres, which constitutes about 1.27 percent of India's total geographical area and 2.7 percent of its population according to the 2011 Census. Bounded by Karnataka to the north, Tamil Nadu to the east and south, and the Lakshadweep Sea to the west, Kerala experiences high solar radiation, warm temperatures throughout the year, and substantial seasonal rainfall. The state is characterized by rich biodiversity, tropical rainforests, coastal plains, and backwater systems, which shape its distinct ecological and environmental profile. Kerala stands out among Indian states for its consistently high levels of human development, ranking first in the Human Development Index (HDI) in 1981, 1991, 2001, and 2011, reflecting sustained progress in health, education, and social welfare. Considerable geographic variation exists in demographic characteristics such as age structure, gender composition, culture, and economic status, and these spatial differences, together with environmental conditions, form an important basis for analysing development patterns and planning health services. Thiruvananthapuram, the state capital, serves as the administrative centre, and transportation infrastructure-including eight National Highways, along with well-developed air and water transport systems-plays a vital role in facilitating commercial activities and social development across the state.

3. Aim and Objectives

The aim of this study was to examine the changing epidemiology of HIV/AIDS in Kerala during the period 2004-2012 by analysing temporal trends, district-level distribution, and gender dynamics of People Living with HIV/AIDS (PLHA). Specifically, the study sought to assess the growth pattern of PLHA at the state level using time-series analysis; to identify phases of acceleration and stabilization in the epidemic; to compare districts through ranking and percentage contribution to determine high-burden areas and emerging hotspots; to evaluate gender differences by examining male-female ratios and the percentage contribution of women; and to measure spatial variation using descriptive statistical techniques. Through these

objectives, the study aimed to provide evidence-based insights into the evolving patterns of HIV/AIDS in Kerala to support targeted public health planning and intervention strategies.

4. Methods

This study adopted a quantitative, retrospective, descriptive, and analytical research design to examine the temporal, spatial, and gender-wise distribution of People Living with HIV/AIDS (PLHA) in Kerala during the period 2004-2012. The analysis focused on understanding state-level growth trends, district-level variations, and gender-based patterns in the HIV/AIDS burden over time.

The study was based on secondary data collected from official records (Council of People living with HIV/AIDS) in Kerala reporting annual PLHA figures for Kerala. The dataset included year-wise totals at the state level and district-wise disaggregated data, along with gender-specific information categorized as Male Living with HIV/AIDS (MLHA) and Female Living with HIV/AIDS (FLHA). The data were organized systematically in spreadsheet format to facilitate statistical computation and comparative analysis. Internal consistency checks were performed to ensure that total PLHA figures corresponded with the sum of male and female cases. Time series analysis was conducted to assess the growth trend of PLHA at the state level. Annual growth rates and Compound Annual Growth Rate (CAGR) were calculated to measure the rate of increase over time. Linear and exponential trend models were examined to understand the pattern of progression, and phases of acceleration and deceleration were identified based on year-to-year percentage changes.

District-wise comparative analysis was undertaken to evaluate spatial distribution and concentration of PLHA burden. Districts were ranked year-wise, and the top five and bottom five districts were identified based on total cases. The percentage contribution of each district to the state total was computed to assess relative burden. Growth patterns were further compared between early and later periods to identify emerging hotspots and shifting geographic trends.

Gender-based analysis was performed by calculating the male-to-female ratio for each year and determining the percentage contribution of females to the total PLHA population. This enabled assessment of gender predominance and examination of feminization trends within the epidemic. Pearson's correlation coefficient was computed to measure the strength of association between male and female trends over time.

5. Results

5.1 State-Level Trend of PLHA in Kerala (2004-2012)

The time-series analysis of People Living with HIV/AIDS (PLHA) in Kerala from 2004 to 2012 reveals a substantial and sustained upward trend over the nine-year period. The total number of reported PLHA cases increased from 547 in 2004 to 6,672 in 2012, indicating a more than twelve-fold rise. (Table 1) This sharp increase reflects a significant expansion in the documented burden of HIV/AIDS within the state during the study period.

The annual growth rate demonstrates considerable variation across years. The most pronounced increase occurred between 2004 and 2005 (222.67%), which likely corresponds to improvements in surveillance systems, expanded testing facilities, enhanced case detection, and strengthened reporting mechanisms rather than a purely epidemiological surge. Subsequent years (2006-2007) continued to show high but progressively declining growth rates (48.27% and 37.71%, respectively), indicating continued expansion but at a slower pace. A marked deceleration phase was observed during 2008 and 2011, when annual growth fell to single-digit levels (6.91% and 6.22%), suggesting partial stabilization in case accumulation. However, a secondary acceleration was evident in 2010 (28.60%), which may reflect intensified screening efforts, improved access to antiretroviral therapy (ART) centres, or increased survival of PLHA contributing to higher prevalence counts. Growth again moderated in 2012 (11.93%), indicating a transition toward a more stable growth trajectory.

Table 1 Kerala State: The distribution of People Living with HIV/AIDS 2004-2012

Years	Districts	TVM	KLM	PTA	APZ	KTM	IDU	EKM	TSR	PKD	MPM	KDE	WND	KNR	KSD	Kerala
2004	PLHA	105	-	-	47	45	-	51	67	132	-	54	-	-	46	547
	MLHA	47	-	-	23	19	-	24	31	57	-	28	-	-	22	251
	FLHA	58	-	-	24	26	-	27	36	75	-	26	-	-	24	296
2005	PLHA	226	79	81	120	168	40	215	180	235	98	79	44	98	102	1765
	MLHA	124	31	47	71	82	20	108	97	134	53	42	23	52	59	943
	FLHA	102	48	34	49	86	20	106	83	101	45	37	22	46	43	822
2006	PLHA	337	111	135	177	201	65	323	295	354	142	135	54	134	154	2617

	MLHA	174	51	63	96	105	31	199	167	198	87	87	26	74	75	1433
	FLHA	163	60	72	81	96	34	124	128	156	55	48	28	60	79	1184
2007	PLHA	446	161	198	214	261	124	405	385	465	202	236	72	220	215	3604
	MLHA	230	83	97	116	135	60	244	224	257	115	132	34	131	107	1965
	FLHA	216	78	101	98	126	64	161	161	208	87	104	38	89	108	1639
2008	PLHA	506	202	234	214	290	124	427	401	510	202	236	72	220	215	3853
	MLHA	248	93	108	116	140	60	167	173	230	115	132	34	131	107	1854
	FLHA	258	109	126	98	150	64	260	228	280	87	104	38	89	108	1999
2009	PLHA	593	208	251	259	321	163	451	505	559	230	256	74	242	252	4364
	MLHA	292	95	120	119	152	79	177	270	257	135	147	34	145	117	2139
	FLHA	301	113	131	140	169	84	274	235	302	95	109	40	97	135	2225
2010	PLHA	712	269	292	413	397	218	590	600	762	328	330	84	302	315	5612
	MLHA	354	127	148	239	206	110	369	356	413	204	204	35	175	145	3085
	FLHA	358	142	144	174	191	108	221	244	349	124	126	49	127	170	2527
2011	PLHA	712	289	299	387	412	225	625	634	812	369	395	97	327	378	5961
	MLHA	380	140	152	191	210	120	391	360	412	213	235	38	198	175	3215
	FLHA	332	149	147	196	202	105	234	274	400	156	160	59	129	203	2746
2012	PLHA	800	362	321	395	418	264	723	705	901	416	449	106	401	411	6672
	MLHA	440	177	165	212	223	132	457	378	478	244	277	45	224	196	3648
	FLHA	360	185	156	183	195	132	266	327	423	172	172	61	177	215	3024

Source: Council of People living with HIV/AIDS in Kerala

The compound annual growth rate (CAGR) for the entire period was calculated at 36.7%, signifying that, on average, the number of PLHA in Kerala increased by approximately 36-37% per year between 2004 and 2012. While this number highlights substantial overall growth, the declining annual growth rates in later years suggest that the epidemic may have shifted

from a rapid expansion phase (2004-2007) to a phase of relative stabilization (post-2008), characterized by moderated increases.

Whereas, the trend analysis indicates three distinct phases: (1) an initial rapid expansion phase (2004-2007), (2) a deceleration and partial stabilization phase (2008-2009), and (3) a secondary acceleration followed by moderated growth (2010-2012). These patterns likely reflect a combination of epidemiological dynamics, enhanced surveillance coverage, expanded testing initiatives, and improved survival of PLHA due to better treatment availability. The findings underscore the importance of sustained surveillance and targeted interventions to manage the evolving burden of HIV/AIDS in Kerala.

Table 2 District-Wise Trend Analysis of PLHA in Kerala (2005-2012)

District	PLHA 2005	PLHA 2012	Early Growth % (2005-2008)	Later Growth % (2009-2012)	CAGR % (2005-2012)
Thiruvananthapuram	226	800	123.89	34.91	19.79
Kollam	79	362	155.7	74.04	24.29
Pathanamthitta	81	321	188.89	27.89	21.74
Alappuzha	120	395	78.33	52.51	18.55
Kottayam	168	418	72.62	30.22	13.91
Idukki	40	264	210	61.96	30.94
Ernakulum	215	723	98.6	60.31	18.92
Thrissur	180	705	122.78	39.6	21.54
Palakkad	235	901	117.02	61.18	21.17
Malappuram	98	416	106.12	80.87	22.94
Kozhikode	79	449	198.73	75.39	28.17
Wayanad	44	106	63.64	43.24	13.38
Kannur	98	401	124.49	65.7	22.3
Kasargod	102	411	110.78	63.1	22.03

The district-wise trend analysis of People Living with HIV/AIDS (PLHA) in Kerala from 2005 to 2012 demonstrates a consistent increase across all districts, though the magnitude and pace of growth varied considerably. In general, most districts experienced a sharp rise in reported cases during the early years, followed by a period of moderated but sustained growth. This overall upward trajectory reflects both the epidemiological expansion of HIV prevalence and improvements in case detection, reporting systems, and access to testing facilities across the state.

During the early phase (2005-2008), several districts recorded exceptionally high growth rates, indicating rapid expansion in reported cases. Idukki (210%), Kottayam region (198.73%),

Pathanamthitta (188.89%), and Kollam (155.70%) showed particularly steep increases. (Table 2) This early acceleration phase likely corresponds to enhanced surveillance coverage, scaling up of Integrated Counselling and Testing Centres (ICTCs), and improved awareness leading to greater case identification. The widespread nature of this increase across both southern and northern districts suggests a systemic strengthening of reporting mechanisms rather than isolated outbreaks.

In contrast, the later period (2009-2012) shows comparatively moderated growth in many districts, although certain areas exhibited renewed acceleration. Malappuram (80.87%), Kottayam region (75.39%), Kollam (74.04%), Idukki (61.96%), Palakkad (61.18%), and Ernakulum (60.31%) recorded substantial increases during this phase. This pattern indicates that while the epidemic may have stabilized in some districts, others experienced intensifying burdens, potentially due to localized transmission dynamics, migration patterns, or improved survival rates among PLHA due to expanded antiretroviral therapy (ART) coverage.

When considering long-term growth through Compound Annual Growth Rate (CAGR) from 2005 to 2012, Idukki (30.94%) and Kottayam region (28.17%) emerged as the highest growth districts, followed by Kollam (24.29%), Malappuram (22.94%), Kannur (22.30%), and Kasargod (22.03%). These districts demonstrate sustained high average annual increases and may be considered priority areas for intensified public health interventions. Meanwhile, districts such as Kottayam and Wayanad showed comparatively lower long-term growth, suggesting relatively slower expansion of the documented burden.

Apparently, the district-wise trend analysis highlights significant spatial heterogeneity in the distribution and growth of PLHA across Kerala. The early years were characterized by rapid expansion across most districts, likely driven by improvements in detection and reporting, while later years reveal differentiated growth patterns with emerging hotspots in selected districts. These findings underscore the importance of adopting geographically targeted strategies for prevention, surveillance, and treatment to effectively manage the evolving HIV/AIDS burden in the state.

5.2 Gender-Based Analysis of PLHA in Kerala (2004-2012)

Table 3 Gender Distribution of PLHA in Kerala (2004-2012)

Year	Male (MLHA)	Female (FLHA)	Male-Female Ratio	Female % Contribution
2004	251	296	0.85	54.11%
2005	943	822	1.15	46.57%
2006	1433	1184	1.21	45.24%
2007	1965	1639	1.20	45.48%
2008	1854	1999	0.93	51.88%
2009	2139	2225	0.96	50.99%
2010	3085	2527	1.22	45.03%
2011	3215	2746	1.17	46.07%
2012	3648	3024	1.21	45.32%

The gender-wise analysis of People Living with HIV/AIDS (PLHA) in Kerala indicates a steady increase in both male (MLHA) and female (FLHA) cases over the study period. (Table 3) Male cases increased from 251 in 2004 to 3,648 in 2012, while female cases rose from 296 to 3,024 during the same period. Although both genders show an upward trend, the rate and proportional distribution varied across years, indicating shifts in the gender composition of the epidemic.

The male-to-female ratio fluctuated during the study period. In 2004, the ratio was 0.85, indicating a higher number of female cases than male cases. However, from 2005 onwards, the ratio exceeded 1.0 in most years, suggesting male predominance. The ratio peaked around 1.22 in 2010, indicating that male cases were approximately 22% higher than female cases that year. Despite this male dominance in later years, the gap between genders was not extremely wide, reflecting a relatively balanced gender distribution compared too many other regions.

The percentage contribution of women to total PLHA also shows notable variation. Women accounted for 54.1% of total PLHA in 2004, indicating early feminization of the epidemic. However, their share declined to around 45-46% during 2005-2007. A temporary increase in female contribution was observed in 2008 (51.9%) and 2009 (50.9%), suggesting a short phase of feminization or improved detection among women. After 2010, the female contribution stabilized around 45-46%, indicating a moderately high but stable female burden.

The findings suggest that while the epidemic in Kerala shows slight male predominance in most years, women consistently constitute nearly half of the total PLHA population. The relatively high and sustained female proportion indicates significant heterosexual transmission dynamics and underscores the importance of gender-sensitive prevention, testing, and treatment strategies. The fluctuating male-female ratio also suggests that gender patterns of HIV burden in Kerala evolved over time, reflecting changes in transmission patterns, testing coverage, and survival outcomes.

5.3 District wise Analysis of PLHA

Table 4 shows the district-wise ranking for 2012 reveals clear spatial concentration of PLHA burden across Kerala.

Table 4 Ranking of PLHA Highest Burden Districts in Kerala 2012

Rank	District	PLHA	Contribution to State Total (%)
1	PKD (Palakkad)	901	13.50%
2	TVM (Thiruvananthapuram)	800	11.99%
3	EKM (Ernakulum)	723	10.84%
4	TSR (Thrissur)	705	10.57%
5	KDE Kozhikode	449	6.73%

These five districts together account for **over 53% of the total PLHA burden** in Kerala in 2012, indicating strong geographical concentration (Table 4).

Table 5 Ranking of Lowest PLHA ranking Districts in Kerala (2012)

Rank (Lowest)	District	PLHA	Contribution (%)
14	WND (Wayanad)	106	1.59%
13	IDU (Idukki)	264	3.96%
12	PTA (Pathanamthitta)	321	4.81%
11	KLM (Kollam)	362	5.43%
10	APZ (Alappuzha)	395	5.92%

The district comparison analysis demonstrates marked spatial heterogeneity in the distribution of PLHA across Kerala. In 2012, Palakkad emerged as the highest burden district, contributing

13.5% of the state total, followed by Thiruvananthapuram, Ernakulum, and Thrissur. These four districts alone accounted for a substantial proportion of the total PLHA burden, suggesting geographic clustering in central and southern regions. Conversely, districts such as Wayanad and Idukki reported comparatively lower-case loads, contributing less than 4% each to the state total. (Table 5) The concentration of cases in a few high-burden districts indicates the need for targeted intervention strategies, resource prioritization, and strengthened surveillance in identified hotspots. The observed disparity highlights regional variation in transmission dynamics, population density, migration patterns, and access to testing and treatment services.

5.4 Correlation Analysis: Male vs Female PLHA (Kerala, 2004–2012)

The Pearson correlation coefficient between male (MLHA) and female (FLHA) PLHA cases from 2004 to 2012 is: r=0.978. The correlation value of 0.978 indicates a very strong positive correlation between male and female PLHA trends over time. (Figure 1) This means that increases in male PLHA cases are closely associated with corresponding increases in female PLHA cases. The relationship is almost linear, as also evident from the scatter plot, where data points closely follow an upward-sloping pattern. This strong association suggests that the epidemic dynamics affecting men and women are closely interconnected. The parallel rise in both genders may reflect shared transmission routes, particularly heterosexual transmission, as well as simultaneous expansion in testing, reporting, and treatment services across the state.

The high correlation also implies that interventions targeting one gender may have indirect effects on the other, reinforcing the importance of integrated, gender-sensitive prevention and treatment strategies. Overall, the findings indicate synchronized growth patterns between male and female PLHA in Kerala during the study period.

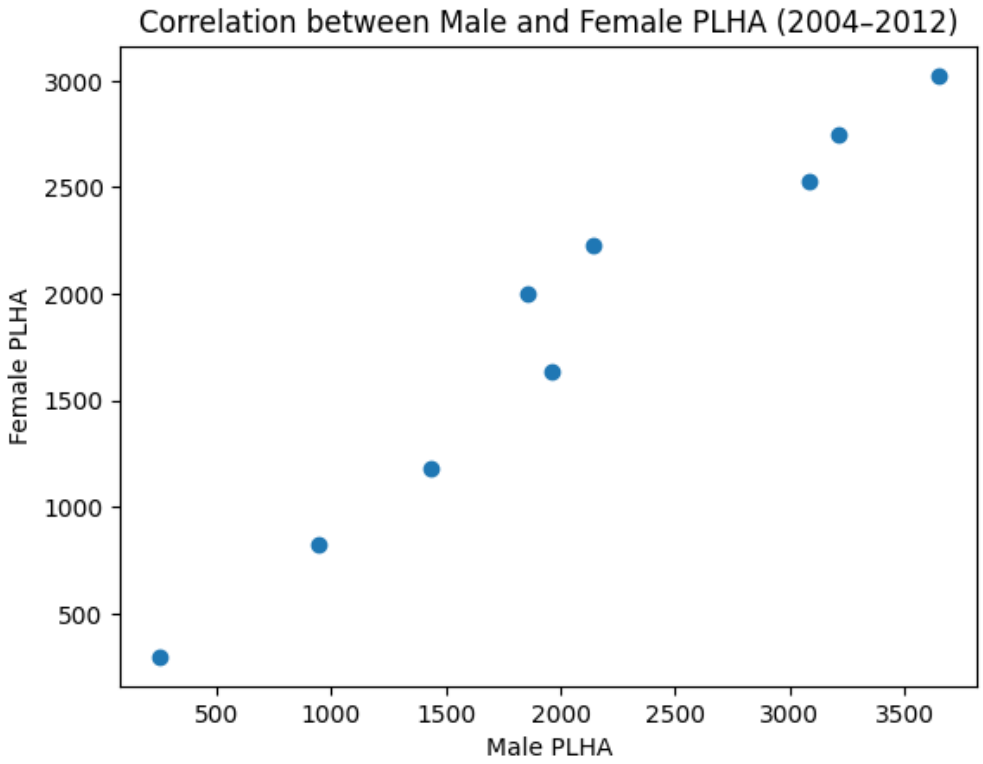

Figure 1 Correlation between Male and Female PLHA (Kerala, 2004–2012)

6. Discussion

The time-series analysis revealed a substantial and continuous increase in People Living with HIV/AIDS (PLHA) in Kerala from 2004 to 2012. The high Compound Annual Growth Rate (CAGR) indicates rapid expansion during the early years, followed by moderated growth in later years. This pattern suggests that the observed rise may be partly attributed to expand testing, improved surveillance systems, and increased survival due to antiretroviral therapy (ART), in addition to ongoing transmission dynamics. Research from this period indicates that the scale-up of ART programs significantly influenced prevalence trends by extending the life expectancy of those infected, thereby increasing the total pool of PLHA even as new infections might have slowed (Pandey et al., 2012).

The study identified distinct phases in the epidemic trajectory: an early acceleration phase (2004-2007), a stabilization phase (2008-2009), and a secondary rise around 2010 followed by moderated growth. These shifts may reflect the impact of public health interventions, changes in awareness levels, and the scaling up of Integrated Counselling and Testing Centres (ICTC) and ART services. National reports during this timeframe noted that sustained program interventions under the National AIDS Control Programme (NACP) were beginning to show signs of stabilizing the epidemic across various Indian states, including those in the south (Department of AIDS Control - NACO, 2010). The deceleration in later years suggests the potential effectiveness of these control measures.

District comparison revealed clear spatial heterogeneity in PLHA distribution. A few districts-such as Palakkad, Thiruvananthapuram, Ernakulum, and Thrissur-consistently accounted for a large proportion of the state burden. This spatial variation is consistent with findings in other southern Indian states where HIV was highly concentrated in specific regional pockets rather than being uniformly distributed (Pandey et al., 2012; Williams et al., 2005). Although absolute inter-district variation increased over time, the slight decline in the coefficient of variation

suggests a gradual proportional spread across districts. The presence of emerging hotspots highlights the need for geographically targeted interventions.

Gender-based analysis showed a strong positive correlation between male and female PLHA trends, indicating synchronized epidemic progression across genders. While males predominated in most years, women consistently constituted nearly half of the total PLHA population. The fluctuating female percentage suggests periods of feminization, possibly linked to heterosexual transmission patterns, which accounted for approximately 87% of infections in India during this period (Department of AIDS Control - NACO, 2010). These findings underscore the importance of gender-sensitive prevention and treatment strategies, as women often face unique social barriers to accessing care (Bharat et al., 2014). The combined temporal, spatial, and gender analyses indicate that HIV/AIDS in Kerala is characterized by steady growth, geographic clustering, and balanced gender involvement. Policymakers should prioritize high-burden districts while maintaining state-wide surveillance. Strengthening targeted prevention programs, improving early detection, and ensuring sustained ART coverage are essential to control future escalation. Continuous monitoring of district-level and gender-disaggregated data remains crucial for evidence-based planning and intervention.

7. Recommendations

Based on the findings of the study, several recommendations are proposed to strengthen HIV/AIDS prevention, control, and management strategies in Kerala. First, targeted interventions should be intensified in high-burden districts such as Palakkad, Thiruvananthapuram, Ernakulum, and Thrissur, which consistently contributed a significant proportion of the state total. Resource allocation, awareness campaigns, and testing facilities should be prioritized in these identified hotspots to curb further transmission.

Second, district-specific strategies should be developed to address emerging hotspots where recent growth rates indicate increasing burden. Tailored interventions based on local transmission patterns, migration trends, and socio-demographic characteristics can improve effectiveness compared to uniform state-wide approaches. Strengthening district-level surveillance systems will help in early identification of rising trends.

Third, gender-sensitive programs must be reinforced. Although males showed slight predominance in most years, women consistently constituted nearly half of the PLHA population. Prevention strategies should therefore focus on couples-based counselling, prevention of mother-to-child transmission (PMTCT), and empowerment initiatives that enhance women's access to testing and treatment services.

Fourth, sustained expansion of testing and early diagnosis services is recommended. The observed growth patterns suggest that increased detection and improved reporting contributed to rising numbers. Continued strengthening of Integrated Counselling and Testing Centres (ICTCs) and community-based screening can facilitate early diagnosis and reduce late-stage presentations.

Finally, continuous monitoring and periodic statistical analysis at both state and district levels should be institutionalized. The use of trend analysis, descriptive statistics, spatial mapping, and correlation studies can support evidence-based policymaking and enable timely intervention adjustments.

8. Conclusion

The study provides a comprehensive temporal, spatial, and gender-based analysis of People Living with HIV/AIDS in Kerala from 2004 to 2012. The findings reveal a sustained upward trend in PLHA over the study period, with distinct phases of rapid growth followed by moderated increases. District-level analysis highlights significant spatial heterogeneity, with a few districts contributing disproportionately to the state burden. Although absolute disparities widened over time, relative inequality showed slight moderation. Gender analysis demonstrates a strong positive correlation between male and female trends, indicating synchronized epidemic progression. While males predominated in most years, women consistently accounted for a substantial share of total cases, underscoring the importance of gender-inclusive interventions. Whereas, the HIV/AIDS burden in Kerala during the study period reflects both epidemiological expansion and improvements in detection and reporting systems. The findings emphasize the need for sustained, district-focused, and gender-sensitive public health strategies to effectively manage and reduce the HIV burden in the state. Continuous surveillance and data-driven planning remain essential for long-term epidemic control.

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