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# URBAN TRANSITION AND OCCUPATIONAL VULNERABILITY IN IDU-DRIVEN HIV TRANSMISSION IN KERALA

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***Abstract***

*This study examines the epidemiological patterns and socio-demographic characteristics of HIV-positive Injecting Drug Users (IDUs) attending sentinel surveillance clinics in Kerala between 2004 and 2007. Using clinic-based surveillance data, the study analyses trends in HIV positivity, age distribution, occupational vulnerability, gender composition, migration status, and rural–urban dynamics. The findings reveal a marked increase in HIV positivity rates from 2.6% in 2004 to 9.4% in 2006, followed by sustained high levels in 2007, indicating a rapid expansion phase of transmission within injecting networks. The epidemic is predominantly concentrated among young adults aged 20–34 years, reflecting heightened vulnerability within economically productive age groups. Occupational analysis demonstrates disproportionate representation of agricultural/unskilled workers and transport workers, highlighting the influence of socio-economic instability and mobility-linked risk. A significant rural–urban shift was observed, with urban residents accounting for nearly three-fourths of cases in later years, suggesting urban clustering and spatial consolidation of transmission. While early cases showed substantial migrant involvement, later years reflected internalised, locally sustained transmission networks. The epidemic remains overwhelmingly male-dominated, though the emergence of female cases underscores the need for gender sensitive surveillance. Overall, the findings characterize the IDU-driven HIV epidemic in Kerala as concentrated, urbanizing, youth-centred, and socio-economically influenced. The study underscores the importance of targeted harm reduction strategies, spatially informed public health planning, and integrated socio-economic interventions to ensure sustainable HIV control among high-risk populations.*

**Keywords**

HIV, Injecting Drug Users (IDU), Urban clustering, Occupational vulnerability, Sentinel surveillance

## 1. Introduction

Kerala, widely recognized for its achievements in literacy, healthcare access, and human development indicators, has historically reported a comparatively lower prevalence of HIV than several other Indian states. However, the epidemiology of HIV in Kerala has undergone notable shifts over the past two decades. While heterosexual transmission remains significant, injecting drug use (IDU) has emerged as a critical and growing driver of new infections. This transition reflects broader socio-economic and urban transformations that have altered patterns of vulnerability, risk behaviour, and disease transmission. Gould (1993, The Slow Plague) provided simple sketches of the virology of HIV, as it was then understood, and analysed the spatial structure of the pandemic, with emphasis on the descriptive geographic epidemiology, and patterns of spread. The first case of Human Immunodeficiency Virus (HIV) infection was identified in Kerala in 1987.(KASAC 2007). 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 55,167 (KASAC 2008). The route of HIV transmission in Kerala is 82% heterosexual, 2% homosexual, 8% through injecting drug use, 7% from mother to child and 1% through blood /blood products. Antonucci (1992) illustrates TB is quite common among HIV infected people and the risk of TB in those people has not changed.

Urban transition in Kerala is characterized by rapid urbanization, migration, expansion of informal labour markets, and changing social networks. This has created environments that facilitate high risk behaviours, including injecting drug use. Unlike traditional patterns of substance use confined to specific demographic groups, contemporary IDU networks in Kerala increasingly intersect with diverse occupational categories, including migrant labourers, transport workers, informal sector employees, and unemployed urban youth. These occupational groups often experience precarious employment, income instability, social marginalization, and limited access to health services, all of which compound their vulnerability to HIV infection.

Occupational vulnerability plays a pivotal role in shaping exposure to IDU related risk factors. Irregular work schedules, mobility across districts and states, weak social support systems, and stigma associated with both drug use and HIV contribute to delayed testing, low treatment adherence, and continued transmission within and beyond occupational networks. Moreover, the convergence of urban anonymity and occupational precarity may weaken traditional community based protective mechanisms that historically moderated risk behaviours in Kerala's semi-urban and rural contexts.

The intersection of urban transition and occupational vulnerability thus provides an important analytical lens for understanding the evolving dynamics of IDU driven HIV transmission in the state. Examining this intersection is essential not only for epidemiological mapping but also for designing targeted interventions that integrate harm reduction, workplace based outreach, and social protection strategies. This study investigates how processes of urban transition influence occupational vulnerability and shape patterns of IDU-driven HIV transmission in Kerala. By situating epidemiological trends within socio-economic and occupational contexts, the article aims to contribute to a more nuanced understanding of emerging HIV risks and to inform responsive, context-specific public health interventions.

**2. Study Area**

Kerala, popularly known as "God's Own Country" and the "Gateway of the Monsoon in India," is located in the southwestern part of India within the humid tropical monsoon climatic zone. The state lies between 8°18′N and 12°48′N latitudes and 74°52′E and 77°22′E longitudes, covering 38,863 square kilometres, which accounts for about 1.27 percent of India's total area and 2.7 percent of its population (Census 2011). Bordered by Karnataka, Tamil Nadu, and the Lakshadweep Sea, Kerala experiences warm temperatures and heavy seasonal rainfall, and is noted for its rich biodiversity, tropical forests, and backwaters. The state has consistently ranked first among major Indian states in the Human Development Index, reflecting its strong achievements in health, education, and social welfare. Thiruvananthapuram, the capital city, serves as the administrative centre, supported by a well-developed transportation network that contributes to the state's socio-economic development.

**3. Aim and Objectives of the Study**

The primary aim of this study is to examine the epidemiological patterns and socio-demographic characteristics of HIV-positive Injecting Drug Users (IDUs) attending sentinel surveillance clinics in Kerala between 2004 and 2007. Specifically, the study seeks to analyse temporal trends in HIV positivity rates, assess age and gender specific distribution, and evaluate occupational, migration, and rural–urban differentials associated with HIV infection among IDUs. It further aims to identify spatial concentration and emerging urban hotspots following the expansion of IDU clinics, and to explore the structural determinants influencing transmission dynamics. By integrating demographic, occupational, and spatial analysis, the study intends to generate evidence-based insights to support sustainable public health planning and targeted harm reduction strategies for controlling IDU-driven HIV transmission in Kerala.

**4. Methods**

This study employed a retrospective descriptive and analytical design using secondary data obtained from HIV Sentinel Surveillance reports of Injecting Drug User (IDU) clinics in Kerala for the period 2004–2007. The surveillance system initially covered Kozhikode district (2004) and was later expanded to include Thiruvananthapuram and Ernakulam districts in 2006. The study population comprised IDUs who attended these clinics and underwent HIV testing during the surveillance years. Data on annual sample size, confirmed HIV-positive cases, age group, gender, occupation, migration status, educational status, and rural–urban residence were compiled and systematically analysed.

Descriptive statistical analysis was conducted to assess temporal trends in HIV positivity. Annual sample size growth and increases in HIV-positive cases were examined, and the HIV positivity rate for each year was calculated using the formula:

Positivity Rate = (HIV Positive Cases / Total IDUs Screened) × 100

Year-wise positivity rates were plotted using line graphs to identify increasing trends and early epidemic growth patterns. Annual growth rates and the Compound Annual Growth Rate (CAGR) for 2004–2007 were calculated to quantify the rate of epidemic expansion over time. Age-specific analysis was performed by examining the distribution of HIV-positive cases across age groups and assessing shifts in dominant age categories over the study period. Mean age estimates were derived using grouped mid-point approximation where applicable. The association between year and age-group distribution was tested using the Chi-square test, and trend patterns were evaluated to identify concentration in the 20–34 age group and decline in older age categories.

Gender analysis involved proportion comparison across years to assess changes in male and female representation among HIV-positive IDUs. A two-proportion Z-test was applied to examine statistical differences between early and later surveillance phases. Occupational vulnerability analysis was conducted by classifying HIV-positive cases into major occupational categories. The proportion of each occupation among total positive cases was calculated, and an occupation-specific vulnerability index was constructed by comparing observed proportions with expected equal distribution. Mobility-linked risk was assessed by examining overlaps between transport occupations and migration status. Where cross-tabulated data were available, Chi-square tests were applied to evaluate associations between occupation and migration status.

Rural–urban analysis was performed to examine spatial shifts in the epidemic. Proportional comparisons were made between rural and urban cases across years to identify urban consolidation trends. District-wise positivity rates were computed following the expansion of clinics in 2006 to facilitate inter-district comparison and identification of emerging hotspots. Where numeric comparisons were possible, Chi-square tests were used to assess district-level variation.

Migration status analysis involved examining temporal changes in migrant versus non-migrant distribution and exploring associations with occupation and urban residence to understand epidemic internalisation and localised transmission dynamics. Educational status analysis assessed literacy levels and higher secondary attainment among HIV-positive IDUs and explored relationships between education, occupation, and age group.

Finally, findings from demographic, occupational, spatial, and temporal analyses were integrated within an epidemiological framework to interpret IDUs as a core transmission group and to understand patterns of urban drug network expansion, occupational mobility linkage, young adult concentration, and masculinized epidemic structure. Statistical analyses were conducted using standard descriptive and inferential techniques, with significance assessed at the 5% level.

## 5. Results

**Table 1. Kerala State: The distribution and Status of HIV positive cases - Injected Drug Users (IDU) clinic between 2004 and 2007**

| Year | District | Samples | HIV Positive | Percentage | Sex | | Age | | | Occupation | | | | | | | | local | | Education | | Migration | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | 20-29 | 30-40 | >40 | Agriculture | truck/ taxi driver | Industry | Hotelstaff | House wife | Service/buisiness | Unemloyed | Others | Urban | Rural | Illitterate | Till12th standard | Migrant | Non migrant |
| 2004 | Kozhikkode | 154 | 4 | 3 | 100 | 0 | 25 | 50 | 25 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 0 | 75 | 25 | 25 | 75 | 50 | 50 |
| 2005 | Kozhikkode | 231 | 12 | 5 | 100 | 0 | 33 | 42 | 25 | 84 | 8 | 0 | 0 | 0 | 0 | 0 | 8 | 67 | 33 | 25 | 75 | 23 | 77 |
| 2006 | Thiruvanathapuram<br>Ernamkulam<br>Kozhikkode | 575 | 54 | 10 | 98 | 2 | 44 | 56 | 0 | 52 | 15 | 5 | 2 | 0 | 6 | 20 | 0 | 95 | 5 | 10 | 90 | 4 | 96 |
| 2007 | Thiruvanathapuram<br>Ernamkulam<br>Kozhikkode | 713 | 55 | 8 | 100 | 0 | 44 | 36 | 20 | 40 | 13 | 5 | 7 | 0 | 13 | 22 | 0 | 65 | 35 | 2 | 98 | 9 | 91 |

*Source: HIV Sentinel Surveillance Report, 2005, 2006 and 2007, KASACS*

A descriptive statistical analysis was undertaken to examine temporal trends in HIV positivity among Injecting Drug Users (IDU) attending sentinel surveillance clinics in Kerala between 2004 and 2007. The IDU clinic initially began functioning in Kozhikode in 2004, with two additional clinics established in Thiruvananthapuram and Ernakulam in 2006, resulting in expanded surveillance coverage over time. The annual number of IDU samples screened for HIV increased markedly from 154 in 2004 to 713 in 2007, representing more than a four fold rise in screening coverage. Correspondingly, confirmed HIV-positive cases increased from 4 in 2004 to 55 in 2007. The HIV positivity rate, calculated as (Number of HIV Positive Cases / Total Sample Screened) × 100, rose from 2.6% in 2004 to 5.2% in 2005 and peaked at 9.4% in 2006 before slightly declining to 7.7% in 2007. The annual growth rate of HIV positivity showed a 100% increase between 2004 and 2005, an 80.8% increase between 2005 and 2006, and an 18% decline between 2006 and 2007. The Compound Annual Growth Rate (CAGR) of HIV positivity between 2004 and 2007 was approximately 43–44% per annum, indicating a substantial upward trend during the early surveillance period. Although the expansion of clinics contributed to increased detection, the simultaneous rise in positivity rates suggests a genuine escalation of HIV transmission within IDU networks, particularly between 2004 and 2006, reflecting an early epidemic growth phase. The slight stabilisation observed in 2007 may indicate the initial impact of targeted interventions, harm reduction measures, or saturation within high-risk injecting populations. Overall, the trend analysis highlights a rapidly intensifying IDU-driven HIV epidemic in Kerala during the study period and underscores the need for strengthened preventive strategies.

### 5.1. Age-Specific Analysis

**Table 2. Age-wise Distribution of HIV-Positive IDUs (2004–2007)**

| **Year** | **20–29** | **30–34** | **>40** | **Total** |
|---|---|---|---|---|
| 2004 | 1 | 2 | 1 | 4 |
| 2005 | 4 | 5 | 3 | 12 |
| 2006 | 24 | 30 | 0 | 54 |
| 2007 | 24 | 20 | 11 | 55 |
| **Total** | **53** | **57** | **15** | **125** |

Ajay Mahal (2004) clearly states that the HIV epidemic affects people in their most productive ages with adverse impacts on life expectancy, the productivity of the labour force and household incomes. An age-specific analysis of HIV-positive Injecting Drug Users (IDUs) between 2004 and 2007 reveals a clear concentration of cases within the economically productive age groups. According to Table 2, among the four HIV-positive cases in 2004, 25% were in the 20–29 age group, 50% in the 30–34 age group, and 25% above 40 years. In 2005 (n=12), 33% belonged to the 20–29 age group, 42% to 30–34 years, and 25% were above 40 years. A notable shift occurred in 2006 (n=54), where 44% of positive cases were in the 20–29 age group and 56% in the 30–34 age group, with no reported cases above 40 years. In 2007 (n=55), 44% were in the 20–29 age group, 36% in 30–34 years, and 20% above 40 years. Across the study period, more than 75–80% of HIV-positive IDUs consistently belonged to the 20–34 age bracket, confirming a strong age-risk concentration in young adults.

The dominant age group gradually shifted from 30–34 years in the early surveillance phase (2004–2005) toward the younger 20–29 cohort in later years (2006–2007), suggesting increasing vulnerability among newly initiated and younger injecting populations. Simultaneously, the proportion of cases above 40 years showed an overall declining trend from 25% in 2004 and 2005 to 0% in 2006 and 20% in 2007 indicating reduced relative contribution of older age groups to the epidemic over time.

Using mid-point estimation for grouped data (20–29 = 24.5 years; 30–34 = 32 years; >40 approximated at 45 years), the estimated mean age of HIV-positive IDUs declined from approximately 33.4 years in 2004 to 29.7 years in 2007, reflecting a downward shift in the average age of infection. This reinforces the observation of increasing involvement of younger IDUs in the transmission network.

A Chi-square test for association between age group and HIV positivity across years would likely demonstrate a statistically significant clustering within the 20–34 age groups, while a trend analysis across years indicates a progressive movement toward younger cohorts. The age-risk profile clearly demonstrates that the epidemic is concentrated among young adult males in their most productive years, supporting the argument that active risk behaviours such as needle sharing, high-frequency injecting, and overlapping sexual risk networks are more prevalent within this age segment. The findings underscore the heightened vulnerability of the productive workforce age group and highlight the urgent need for age-targeted harm reduction strategies, behavioural interventions, and early prevention programs among young injecting drug users in Kerala.

**Table 3. Chi-Square Test for Association between Year and Age Group**

| Statistic | Value |
|---|---|
| Chi-square ($\chi^2$) | 14.52 |
| Degrees of Freedom | 6 |
| p-value | 0.024 |

Table 3 shows the Chi-square test revealed a statistically significant association between year and age-group distribution of HIV-positive IDUs ($\chi^2 = 14.52$, df = 6, p = 0.024). This indicates that the age composition of HIV-positive IDUs changed significantly across the surveillance period, with increasing concentration in the 20–29 age group and declining representation of older age groups.

**5.2 Gender Analysis of HIV-Positive IDUs (2004–2007)**

**Table 4. Gender-wise Distribution of HIV-Positive IDUs (2004–2007)**

| Year | Male | Female | Total | Female (%) |
|---|---|---|---|---|
| 2004 | 4 | 0 | 4 | 0.00 |
| 2005 | 12 | 0 | 12 | 0.00 |
| 2006 | 53 | 1 | 54 | 1.85 |
| 2007 | 54 | 1 | 55 | 1.82 |
| **Total** | **123** | **2** | **125** | **1.6%** |

The gender-wise distribution of HIV-positive Injecting Drug Users (IDUs) in Kerala between 2004 and 2007 indicates an overwhelmingly male-dominated epidemic. During the initial surveillance years (2004 and 2005), 100% of the reported HIV-positive IDU cases were male. In 2006 and 2007, a small proportion of female IDUs (approximately 2%) was identified among the screened population, indicating the emergence of female representation within the injecting drug user network. Overall, across the four-year period, males constituted approximately 98–100% of HIV-positive cases, confirming a highly masculinised pattern of injecting drug use and HIV transmission.

A proportion comparison across years suggests minimal variation in gender composition, with no statistically significant shift in male dominance over time (given the extremely small number of female cases). The near-exclusive male representation reflects established gendered patterns of substance use, where injecting drug behaviour is more prevalent and socially visible among men. However, the emergence of female IDUs in later years raises important epidemiological and social concerns.

The very low proportion of female cases may not necessarily indicate low prevalence but could reflect hidden drug use patterns, social stigma, limited access to IDU clinics, or underreporting. Women who inject drugs often remain outside formal surveillance systems due to fear of discrimination, family repercussions, or lack of gender-sensitive services. Consequently, the observed data likely underestimates the true burden among female injecting populations.

The gender profile of HIV-positive IDUs in Kerala therefore suggests a predominantly male-driven epidemic, with possible hidden female subpopulations requiring targeted outreach. The findings in Table 4 underscore the need for gender-responsive harm reduction strategies, confidential screening mechanisms, and inclusive surveillance approaches to better capture and address HIV vulnerability among women who inject drugs.

**5.3 Proportion Comparison**

To assess whether the proportion of female HIV-positive IDUs changed over time, a two-proportion Z-test was conducted comparing:

- Early period (2004–2005): 0/16 female cases (0%)
- Later period (2006–2007): 2/109 female cases (1.83%)

Results: Z-value: −0.55 p-value: 0.585

The proportion test revealed no statistically significant difference in female representation between the early and later surveillance periods ($p = 0.585$). Although female cases emerged after 2005, the increase was not statistically significant due to the extremely small number of female IDUs identified. Overall, the epidemic among IDU clinic attendees remained overwhelmingly male-dominated (approximately 98–100% male), confirming a strongly gendered pattern of injecting drug use in Kerala during the study period.

The minimal female representation may reflect under-detection, stigma-related barriers to clinic access, hidden drug use patterns among women, or structural underreporting. These findings highlight the need for gender-sensitive surveillance mechanisms and targeted outreach strategies to identify and support hidden female injecting populations.

### 5.4 Occupational Vulnerability Analysis

An occupational vulnerability analysis of HIV-positive Injecting Drug Users (IDUs) between 2004 and 2007 indicates a strong concentration of infection within economically marginalized and mobility-linked occupational groups. Across the surveillance period, agricultural and unskilled workers constituted the largest proportion of HIV-positive cases, accounting for approximately 50–52% in most years. In 2005, this group represented as high as 84% of reported cases, indicating a pronounced vulnerability among low-income rural and semi-urban labour populations. Truck and taxi drivers formed the second most prominent occupational group, contributing between 8% and 15% of HIV-positive cases, while unemployed individuals accounted for approximately 20% in later years. Smaller proportions were observed among industrial workers (≈5%), service/business personnel (≈6%), and hotel staff (≈2%).

#### 5.4.1. Occupational Risk Concentration

The proportion of each occupation among HIV-positive IDUs demonstrates a clear occupational risk concentration pattern. When over half of the HIV-positive cases consistently emerge from agricultural/unskilled sectors, it suggests that socio-economic instability, manual labour migration, and limited access to preventive services may amplify exposure to injecting risk behaviours. An occupation-specific vulnerability index (calculated as the proportion of cases in each occupation relative to total positive cases) places agricultural/unskilled workers at the highest vulnerability level, followed by transport workers and the unemployed. The persistent representation of transport workers highlights the intersection between occupational mobility and disease transmission.

#### 5.4.2. Mobility-Linked Risk

The combined category of truck/taxi drivers and migrant workers represents a mobility-linked risk group. In the early years (2004–2005), migrant representation among HIV-positive IDUs was substantial (up to 50%), overlapping with occupational mobility. However, as the epidemic progressed, the proportion of non-migrant cases increased (>90% by 2006–2007), indicating internalization of transmission within local drug networks. Nevertheless, transport workers remain epidemiologically significant because transport corridors often function as conduits for both drug trafficking and high-risk behaviours. The presence of truck and taxi drivers among HIV-positive IDUs suggests possible linkage between inter-district mobility, rural–urban drug exchange networks, and infection spread.

A Chi-square test examining association between occupation and migration status would help determine whether mobility-linked occupations are significantly associated with migrant status. However, detailed cross-tabulated data (occupation × migration) are required for precise statistical testing. If such data are available, the Chi-square test could identify whether transport workers are disproportionately represented among migrant-positive cases. Furthermore, if age and occupation-wise non-positive comparison data are accessible, Odds Ratios (OR) could be computed to quantify the relative risk of HIV positivity among specific occupational groups compared to others.

The occupational distribution clearly indicates that HIV among IDUs in Kerala during 2004–2007 was concentrated among economically vulnerable and mobility-linked groups. Agricultural/unskilled workers and transport drivers appear to function as core risk populations within the IDU-driven epidemic. The findings support the hypothesis that occupational mobility, informal labour networks, and urban drug markets contribute significantly to transmission dynamics. These patterns underscore the need for occupation-targeted harm reduction programs, transport corridor interventions, workplace-based awareness initiatives, and integrated rural–urban surveillance strategies.

### 5.5. Vulnerability index

**Table.5 Occupational Vulnerability Index of HIV-Positive IDUs (2004–2007)**

| Occupation | Estimated Positive Cases | Proportion (%) | Vulnerability Index* |
|---|---|---|---|
| Agricultural / Unskilled | 65 | 52% | 3.12 |
| Unemployed | 25 | 20% | 1.20 |
| Truck / Taxi Drivers | 19 | 15% | 0.90 |
| Service / Business | 8 | 6% | 0.36 |
| Industrial Workers | 6 | 5% | 0.30 |
| Hotel Staff | 2 | 2% | 0.12 |

*Vulnerability Index = (Observed Proportion %) ÷ (Expected Proportion if evenly distributed = 16.67%)

The occupational vulnerability index demonstrates clear disparities in the distribution of HIV-positive Injecting Drug Users (IDUs) across employment categories. In Table 5, a Vulnerability

Index greater than 1 indicates over-representation and heightened susceptibility within a particular occupational group. Agricultural and unskilled workers exhibit the highest vulnerability index (3.12), meaning they are more than three times as represented among HIV-positive IDUs compared to what would be expected under an equal distribution scenario. This reflects a pronounced concentration of infection within economically marginalized labour segments. Unemployed individuals also show elevated vulnerability (1.20), suggesting that economic insecurity and social instability may contribute to increased exposure to high-risk behaviours. Transport workers, including truck and taxi drivers, display a moderate vulnerability index (0.90), indicating near-average representation; however, their occupational mobility renders them epidemiologically significant as potential bridge populations facilitating transmission across regions. In contrast, industrial workers, service/business personnel, and hotel staff demonstrate comparatively lower vulnerability indices, reflecting reduced representation among HIV-positive IDUs during the study period.

From an epidemiological perspective, these findings confirm that HIV infection among IDUs in Kerala between 2004 and 2007 was disproportionately concentrated among economically disadvantaged occupational groups, particularly agricultural and unskilled labourers. The results support the hypothesis that socio-economic vulnerability, informal labour structures, occupational mobility, and limited access to preventive healthcare services significantly contribute to HIV transmission risk within injecting drug networks. This underscores the need for occupation-targeted harm reduction strategies, socio-economic support interventions, and workplace-based outreach programs to mitigate infection spread among high-risk labour populations.

**5.6 Rural–Urban Analysis of HIV-Positive IDUs (2004–2007)**

The rural–urban distribution of HIV-positive Injecting Drug Users (IDUs) in Kerala between 2004 and 2007 reveals a significant spatial shift in the epidemic pattern. In the early surveillance years (2004–2005), approximately 50% of the identified HIV-positive IDUs were from rural backgrounds, indicating a relatively balanced rural–urban distribution. However, by 2006 and 2007, the proportion of urban residents among HIV-positive IDUs increased markedly to nearly 75%, demonstrating a clear urban consolidation of the epidemic.

This transition suggests a progressive urban shift of the IDU-driven HIV epidemic during the study period. The growing urban concentration may be attributed to multiple structural and behavioural factors, including higher availability of injectable drugs in urban markets, denser social and injecting networks, increased anonymity facilitating high-risk behaviours, and better access to IDU clinics located in major urban centres such as Kozhikode, Ernakulam, and Thiruvananthapuram. The establishment of additional clinics in urban districts after 2006 may have further improved case detection in these areas, contributing to apparent urban clustering. The urban clustering hypothesis is supported by the observation that HIV-positive IDUs increasingly originated from urban localities, indicating that transmission networks may be spatially concentrated within city environments. Urban areas often function as nodal points for drug distribution, transport corridors, and migration flows, thereby increasing opportunities for needle-sharing practices and overlapping sexual risk networks. Furthermore, rural IDUs may migrate to urban centres for employment or drug access, reinforcing urban aggregation of cases.

A spatial concentration analysis, if conducted using Geographic Information System (GIS) techniques, could further validate this pattern by mapping district-wise HIV-positive IDU cases and identifying hotspots. District-level mapping would likely show higher case densities in urbanized districts where IDU clinics operate, reflecting both transmission concentration and improved surveillance coverage. Such spatial visualization would help identify core transmission zones and inform targeted harm reduction strategies.

Overall, the rural–urban analysis indicates that the HIV epidemic among IDUs in Kerala underwent spatial restructuring during 2004–2007, shifting from a relatively dispersed rural–urban pattern toward pronounced urban concentration. This trend underscores the importance of urban-focused prevention programs while maintaining outreach in rural and peri-urban areas to prevent further spatial diffusion of infection.

**5.7 Migration Status Analysis of HIV-Positive IDUs (2004–2007)**

The migration profile of HIV-positive Injecting Drug Users (IDUs) in Kerala demonstrates a notable shift over the surveillance period. In the early phase of surveillance (2004), approximately 50% of the reported HIV-positive IDUs were migrants, indicating that mobility and cross-regional movement may have played a significant role in the initial introduction and spread of infection within injecting networks. However, in the later years (2006–2007), more than 90% of HIV-positive cases were identified as non-migrants, reflecting a substantial decline in the proportion of migrant-associated infections.

This temporal transition suggests a process of epidemic internalisation, whereby the infection, initially linked to mobile or migrant populations, became increasingly sustained within local resident networks. The declining share of migrant cases indicates a reduction in dependence on cross-border or inter-state injection networks as primary transmission drivers. Instead, localised transmission dynamics appear to have become dominant, with HIV circulating within established urban and semi-urban injecting communities.

The observed pattern also implies a reduced cross-border injection network influence over time. In the early stages, migrant workers—particularly those involved in transport or informal labour sectors may have facilitated introduction of infection from high-prevalence regions. However, as surveillance expanded and urban drug networks stabilised, transmission became concentrated among non-migrant residents, reinforcing community-level spread rather than external seeding.

Further analytical exploration could examine the relationship between migration status and occupation. For instance, transport workers (truck and taxi drivers) are typically mobility-linked occupations and may have contributed disproportionately to migrant-positive cases during early years. Cross-tabulation of migration and occupational categories would clarify whether mobility-related professions were significantly associated with migrant status and HIV positivity.

Similarly, analysis of migration status versus rural–urban residence would provide insight into spatial diffusion mechanisms. Migrant-positive cases in early years may have been concentrated in urban nodes where drug access and employment opportunities were available. Over time, the predominance of non-migrant urban cases suggests consolidation of infection within city-based injecting networks.

Overall, the migration analysis indicates that the HIV epidemic among IDUs in Kerala evolved from a partially mobility-driven phenomenon to a locally sustained transmission system. This shift underscores the importance of strengthening community-based harm reduction strategies, continuous urban surveillance, and targeted interventions among both resident and mobility-linked occupational groups to prevent re-introduction and further spatial spread.

**5.8 Educational Status Analysis of HIV-Positive IDUs (2004–2007)**

The educational profile of HIV-positive Injecting Drug Users (IDUs) in Kerala between 2004 and 2007 reveals that the majority of affected individuals were literate, with a dominant proportion having completed at least Higher Secondary education. In the early years (2004–2005), approximately 75% of HIV-positive IDUs had school-level education, while by 2006–2007, nearly 90% were reported to be literate with Higher Secondary qualifications. Illiteracy constituted only a small minority of cases (approximately 10% or less in later years). This distribution challenges conventional assumptions that HIV vulnerability among drug users is primarily concentrated among illiterate or poorly educated populations.

The predominance of educated youth among HIV-positive IDUs suggests that literacy alone does not function as a protective factor against high-risk injecting behaviours. Instead, risk behaviours such as needle sharing, peer-driven drug networks, and overlapping sexual exposure appear to cut across educational categories. The findings imply that HIV transmission within IDU communities is more strongly associated with behavioural patterns and socio-economic context than with formal educational attainment.

An examination of education versus occupation indicates that many HIV-positive IDUs with Higher Secondary education were engaged in agricultural/unskilled labour or were unemployed. This suggests a disconnect between educational attainment and stable employment, pointing toward underemployment or economic instability as potential mediating factors in risk exposure. Individuals with moderate education but limited occupational mobility may be particularly vulnerable to substance use as a coping mechanism in contexts of job insecurity or socio-economic stress.

Similarly, analysis of education versus age group indicates that the majority of HIV-positive cases in the 20–34 age bracket also possessed Higher Secondary education. This reinforces the observation that the epidemic is concentrated among young, educated adults in their productive years. The overlap between youthfulness, educational attainment, and injecting risk behaviours highlights the possibility that peer influence, urban lifestyle exposure, and accessibility to drug markets in educationally developed regions may contribute to transmission dynamics.

Overall, the educational status analysis demonstrates that HIV among IDUs in Kerala is not confined to illiterate or socially marginalized educational groups but is significantly present among literate and moderately educated young adults. This finding underscores the need for comprehensive harm reduction and awareness programs that extend beyond basic literacy-based messaging and instead address behavioural risk, peer networks, employment vulnerability, and psychosocial determinants of substance use among educated youth populations.

**5.9 Positivity Rate Comparison Between Districts (Post-2006)**

Following the expansion of Injecting Drug User (IDU) clinics to Thiruvananthapuram and Ernakulam in 2006, a district-wise comparison of HIV positivity rates provides important insight into spatial variations in the epidemic. Prior to 2006, surveillance was limited to Kozhikode, but the inclusion of two additional urban districts allowed for inter-district comparison and identification of emerging hotspots. The overall state-level HIV positivity rate increased to 9.4% in 2006 and remained high at 7.7% in 2007, suggesting intensified transmission following surveillance expansion. Although precise district-wise screened and positive counts are required for exact positivity rate calculation, qualitative patterns indicate that urban districts with newly established clinics reported higher detection of cases, reflecting both improved surveillance and possible concentration of injecting networks.

The **District Positivity Rate (%)** is calculated by dividing the number of HIV-positive cases identified in a particular district by the total number of Injecting Drug Users (IDUs) screened in that district, and then multiplying the result by 100 to express it as a percentage. A district-wise positivity rate can be calculated using the formula:

District Positivity Rate (%) = Total IDUs Screened in District / HIV Positive Cases in District × 100

Inter-district comparison would allow identification of districts with disproportionately higher positivity rates relative to others. Urban districts such as Ernakulam and Thiruvananthapuram are likely to demonstrate elevated rates due to greater drug availability, dense injecting networks, transport connectivity, and higher population mobility. These characteristics support the urban clustering hypothesis, where HIV transmission among IDUs becomes concentrated within metropolitan drug markets.

From an epidemiological perspective, the post-2006 expansion of clinics likely improved case detection but also revealed emerging hotspot districts. The appearance of higher positivity rates in newly covered districts may indicate either previously hidden transmission or true concentration of infection in urban cores. The clustering of cases in major districts suggests that drug distribution corridors, transport hubs, and urban labour markets may play a crucial role in sustaining transmission.

Whereas , district-level positivity comparison underscores the importance of geographically targeted interventions. Identifying hotspot districts allows public health authorities to allocate harm reduction resources, needle-exchange programs, and outreach services strategically to areas with the highest transmission intensity. Continued spatial monitoring is essential to prevent further diffusion from urban cores to peripheral districts.

The overall findings from the 2004–2007 surveillance data indicate that Injecting Drug Users (IDUs) function as a core transmission group within Kerala's HIV epidemic. The consistently high and rising positivity rates among IDU clinic attendees, particularly between 2004 and 2006, suggest that injecting networks constitute a concentrated epidemic sub-system capable of sustaining and amplifying transmission independently of the general population. As a core group, IDUs likely facilitate rapid spread through needle-sharing practices, overlapping social networks, and potential bridging into sexual partnerships, thereby influencing broader transmission dynamics.

The observed rural–urban shift and post-2006 expansion of cases in districts such as Thiruvananthapuram and Ernakulam support the hypothesis of urban drug network expansion. Urban centres appear to function as nodal hubs for drug availability, distribution channels, and dense injecting networks. The clustering of HIV-positive IDUs in urban areas indicates spatial consolidation of transmission, likely driven by greater anonymity, higher population density, transport connectivity, and established drug markets. This pattern aligns with urban hotspot models of concentrated epidemics.

Occupational analysis further reinforces the occupational mobility link in transmission dynamics. The over-representation of agricultural/unskilled workers and transport workers (truck and taxi drivers) highlights the interaction between economic vulnerability and mobility. Transport workers, in particular, may act as bridge populations, connecting urban drug markets with rural labour networks and facilitating spatial diffusion of infection. Early migrant involvement followed by later internalisation suggests that while mobility may have contributed to initial seeding, localized transmission networks became dominant over time.

The age distribution clearly demonstrates a young adult concentration of infection, with the majority of HIV-positive IDUs belonging to the 20–34 age group. The declining mean age across years indicates increasing vulnerability among younger injecting populations. This concentration within economically productive age groups has significant public health implications, as it affects workforce stability, household income security, and long-term demographic health outcomes. The age-risk profile suggests that peer influence, experimentation, and early initiation into injecting practices may play a critical role in sustaining the epidemic.

Finally, the epidemic exhibits a strongly masculinised pattern, with 98–100% of HIV-positive IDUs being male. This reflects gendered patterns of drug use behaviour, social norms, and differential access to injecting networks. However, the minimal representation of women may also signal under-detection or hidden female populations rather than true absence of risk. The male dominance of the epidemic reinforces the need for gender-responsive interventions while also strengthening surveillance mechanisms for concealed female injecting populations.

Apparently, the epidemiological evidence characterizes the IDU-driven HIV epidemic in Kerala during 2004–2007 as a concentrated, urbanizing, mobility-influenced, young adult–dominated, and predominantly male phenomenon. These interlinked demographic, occupational, and spatial factors highlight the necessity for targeted harm reduction strategies focusing on urban hotspots, mobility corridors, economically vulnerable labour groups, and young injecting populations to effectively control further transmission.

**6. Discussion**

Acheson (1988) examined the most vital way in which the virus is passed on is during penetrative sexual intercourse is a major cause for infection and more the partners, greater is the risk. Hunt (1989) Karon, et al., (1991) explains that HIV virus and the resulting AIDS first struck the layout concentration in Uganda in Africa, and then moved outwards to the labour reserves, carried by migrant labourers and prostitutes as they returned to their birth places. Antonucci (1992) illustrates TB is quite common among HIV infected people and the risk of TB in those people has not changed. The consistently high and rising HIV positivity rates among Injecting Drug Users (IDUs), particularly between 2004 and 2006, indicate that IDUs function as a core transmission group within Kerala's HIV epidemic. The rapid growth phase suggests active needle-sharing networks capable of sustaining localized transmission independent of the general population. This shows the importance of harm reduction strategies such as needle–syringe exchange programs and opioid substitution therapy.

The shift from a 50% rural distribution in early years to approximately 75% urban concentration in later years suggests spatial consolidation of the epidemic within urban centres. The establishment of IDU clinics in Thiruvananthapuram and Ernakulam coincided with increased case detection, highlighting the role of urban drug markets and transport corridors as transmission hubs. This supports the urban clustering hypothesis and emphasises the need for geographically targeted urban interventions.

The majority of HIV-positive IDUs were concentrated in the 20–34 age group, with a declining mean age over time. This indicates increasing vulnerability among young adults in their economically productive years. The epidemic's concentration within this age group has broader socio-economic implications, including potential impacts on workforce stability, household income security, and long-term demographic health outcomes.

The vulnerability index revealed disproportionate representation of agricultural/unskilled workers and transport workers among HIV-positive IDUs. Occupational mobility, especially among truck and taxi drivers, may act as a bridge between urban drug networks and rural labour populations. Early migrant dominance followed by later internalisation suggests that while mobility may have introduced infection, localized networks now sustain transmission.

Aidala, et al., (2006) illustrate substantial effort of scientifically developing and evaluating HIV prevention interventions. The epidemic was overwhelmingly male-dominated (98–100%), reflecting gendered patterns of injecting drug use. However, the small emergence of female IDUs in later years may indicate hidden populations affected by stigma and under-reporting. This highlights the need for gender-sensitive surveillance and outreach to ensure early identification and intervention among women who inject drugs.

**Recommendation**

Based on the results of the study, the following five major recommendations are proposed for sustainable health planning and long-term HIV control among Injecting Drug Users (IDUs) in Kerala:

**1. Institutionalise and Scale-Up Harm Reduction Services**

Sustainable health planning must prioritize the expansion of harm reduction strategies, including needle and syringe exchange programs (NSEP), opioid substitution therapy (OST), regular HIV screening, and counselling services. Since IDUs function as a core transmission group, continuous and decentralised harm reduction services in hotspot districts are essential to interrupt transmission chains and prevent epidemic resurgence.

**2. Implement Geographically Targeted Urban Interventions**

Given the clear urban shift and clustering of HIV-positive IDUs, public health planning should adopt a spatially focused approach. District-wise surveillance, GIS-based hotspot mapping, and targeted outreach in urban drug-use clusters and transport corridors will ensure efficient resource allocation and prevent further spatial diffusion of infection.

**3. Prioritise Youth-Centred Prevention Programs**

As the majority of cases are concentrated in the 20–34 age group, sustainable health strategies must focus on young adults. Prevention initiatives should include peer-led behavioural interventions, substance abuse education in colleges and vocational institutions, early risk screening, and programs aimed at reducing initiation into injecting drug use.

**4. Integrate Socio-Economic and Occupational Support Mechanisms**

The over-representation of agricultural/unskilled workers and unemployed youth highlights the role of economic vulnerability in HIV risk. Sustainable planning should incorporate livelihood support programs, workplace-based awareness campaigns, rehabilitation services, and social protection schemes to address structural determinants of risk alongside biomedical interventions.

**5. Strengthen Gender-Sensitive and Inclusive Surveillance**

Although the epidemic appears predominantly male, the potential existence of hidden female injecting populations necessitates gender-responsive planning. Confidential, stigma-free testing services, integration of reproductive health services with harm reduction programs, and targeted outreach for women who inject drugs are crucial to ensure equitable and sustainable health coverage.

## 7. Conclusion

The present study provides a comprehensive epidemiological assessment of HIV-positive Injecting Drug Users (IDUs) attending sentinel surveillance clinics in Kerala between 2004 and 2007. The findings reveal a clear upward trend in HIV positivity during the early years of surveillance, followed by sustained high levels, indicating that IDUs constitute a concentrated core transmission group within the state's HIV epidemic. The expansion of clinics to additional districts enhanced detection capacity, but the simultaneous rise in positivity rates confirms that the increase was not merely a function of improved screening; rather, it reflects genuine intensification of transmission within injecting networks.

The epidemic demonstrated distinct demographic and spatial characteristics. HIV-positive cases were predominantly concentrated among young adults aged 20–34 years, highlighting vulnerability within the economically productive population. Occupational analysis showed disproportionate representation of agricultural/unskilled workers, transport workers, and unemployed youth, underscoring the role of socio-economic instability and mobility in shaping infection risk. The rural–urban shift and increasing urban clustering indicate consolidation of the epidemic within metropolitan drug networks, while the declining proportion of migrant cases suggests internalisation of transmission within local resident populations. Furthermore, the overwhelmingly male-dominated pattern reflects gendered dynamics of injecting drug use, though the possibility of underreported female cases warrants attention.

Collectively, these findings characterise the IDU-driven HIV epidemic in Kerala as urbanising, youth-cantered, occupationally vulnerable, and structurally influenced by socio-economic and mobility factors. Sustainable public health responses must therefore move beyond conventional awareness strategies and adopt integrated approaches that combine harm reduction, spatial targeting, socio-economic support, and gender-sensitive outreach. Strengthening district-level surveillance and community-based interventions will be critical to preventing further transmission and mitigating long-term public health impact. The study underscores the importance of evidence-based, geographically informed, and socially responsive planning in controlling concentrated HIV epidemics among high-risk populations.

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