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# Analysis of Main Routes of Transmission of HIV using Multiple Regression Equation

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**Abstract**

In this paper we are going to analyse the main routes of transmission of HIV with the help of multiple regression equation. For this analysis we are considering the factors Heterosexuality, homosexuality, through blood and blood products, through syringe and infected needle, and parent to child (for children).

**Keywords:** Multiple linear regressions, HIV/AIDS, Routes of Transmission of HIV, one-way ANOVA.

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## Introduction

In our society, even after being the easiest to control and avoid, sexually transmitted diseases are the most common and among the most serious diseases. With the discovery of the powerful broad-spectrum antibiotics and penicillin, most of these diseases were under control, and some had even decreased enormously.[1]

Human immunodeficiency virus contamination and acquired immune deficiency syndrome (HIV/AIDS) is a diapason of conditions caused by contamination with the human immunodeficiency virus (HIV). Following initial contamination, a person may experience a brief period of influenza-like sickness. This is typically followed by an elongated period without manifestation. As the contamination headway, it interferes more and more with the immune system, making the person much more allowing to common contaminations like tumours, as well as opportunistic contaminations and tuberculosis that do not generally affect people who have strong immune systems. The late manifestation of the contamination is referred to as AIDS. This stage is often complicated by a contamination of the lung known as pneumocystis pneumonia, extreme weight loss, a type of cancer known as Kaposi's sarcoma, or other AIDS-defining conditions.[2]

HIV is imparted primarily via unprotected sexual intercourse (including anal and oral sex), infected blood transfusions, from mother to child during pregnancy, hypodermic needles, and breastfeeding. Some bodily fluids, such as tears and saliva, do not transmit HIV.[3] Common methods of prevention HIV/AIDS include needle-exchange programs, encouraging safe sex, and treating those who are contaminated. There is no curative or vaccine; although, antiretroviral therapy can deliberate the course of the disease and may lead to a near-normal life expectancy. While antiretroviral therapy diminishes the risk of death and complications from the disease, these therapies are costly and have side effects. The average survival time after contamination with HIV, without treatment is approximated to be 9 to 11 years, depending on the subtype of HIV.

Since its revelation, AIDS has caused an approximately 36 million deaths all over the world (as of 2012). In 2013 it resulted in around 1.34 million deaths. According to World Health Organisation, 38.0 million people were living with HIV at the end of 2019.HIV/AIDS is regarded as a pandemic disease outbreak which is present over a wide area and is actively expanding. [4][5]

Genetic studies indicate that HIV was emerged in west-central Africa during the late nineteenth or early twentieth century. AIDS was first acknowledged by the United States Centres for Disease Control and Prevention (CDC) in 1981 and its source HIV infection was specified in the early part of the decade. The most frequent mode of transmission of HIV is through sexual contact with a contaminated person. The majority of all transmissions worldwide occur through heterosexual contacts (i.e. sexual contacts between people of the opposite sex); although, the pattern of expansion differs significantly among countries.[6]

With regard to unprotected heterosexual contacts, estimates of the risk of HIV transmission per sexual act appear to be four to ten times higher in low-income countries than in high-income countries. In low-income countries, the risk of female-to-male transmission is estimated as 0.38% per act, and of male-to-female transmission as 0.30% per act; the equivalent estimates for high-income countries are, 0.08% per act for male-to-female transmission and 0.04% per act for female-to-male transmission.The risk of transference from anal intercourse is especially high, estimated as 1.4–1.7% per act in both heterosexual and homosexual contacts while the risk of transference from oral sex is relatively low, but it is still present. The risk from receiving oral sex has been regarded as "nearly nil"; although, a few cases have been reported. The per-act risk is coming out to be at 0 to 0.04% for receptive oral intercourse. In settings involving prostitution in low income countries, risk of male-to-female transmission as 0.05% per act and female-to-male transmission has been estimated as 2.4% per act.[7]

**Aim of the Study**

Aim of the study is to analyse the main routes of transmission of HIV so that appropriate measures can be undertaken wherever possible so as to minimize the transmission.

**Review of Literature**

Ira M. Longini et al.,1989 [8]estimate the distribution and mean length of the incubation period for acquired immunodeficiency syndrome (AIDS). This work represents one of the most complete statistical descriptions to date of the natural history of HIV infection.V Zunzunegui et al. 1992 [9]analyse 130 heterosexual couplesin which the male was seropositive for the human immunodeficiency virus (HIV) with the only possible risk factor for the companion being the sexual intercourse with the case index.F R Cleghon et al.,1995 [10] indicates the trends in prevalence and ascertain risk factors for HIV-1 among sexually transmitted disease (STD) clinic attenders in Trinidad.C CEkweozoret al., 1995 [11]identify epidemiologic and clinical patterns associated with human immunodeficiency virus (HIV) infection in sexually transmitted disease (STD) patients in Nigeria.The male: female ratio of HIV-seropositive subjects was practically the same (1.01:1).

C Mukhopadhyay et al., 2001 [12]in his controversial study a total of 7,904 persons visiting University Hospital of Banaras Hindu University (BHU), Varanasi, were screened for HIV antibody by ELISA and/or rapid test. The overall sero-prevalence of HIV (3.17%) in that area was higher than that of Uttar Pradesh and India as a whole. Majority of the HIV positive were found to be within the age group 15-44 years, with heterosexual mode as the main route of transmission. Majority of seropositive women (62.52%) were working in a low-income job and were mainly infected by their spouse who was mostly migrating labourers of lower socioeconomic group and with less than primary level of education.

A Le Tortorec and N Dejucq-Rainsford 2010 [13]study answers to some important questions like does the male genetical tract constitute a viral reservoir, who otherwise show an undetectable blood viral load or What is the aetiology of the semen abnormalities observed in asymptomatic HIV-infected men?NikolozChkhartishvili et al., 2011 [14] study was to describe the extent of the HIV epidemic among women in the Republic of Georgia and to identify factors associated with HCV co-infection in that population.Patience I. et al., 2018 [15] research focused on analysing the incidence of HIV/AIDS disease in states affected by the activities of the Boko Haram insurgency in Nigeria.

**Formula and Calculation of Multiple Linear Regressions**

$Y_i=\beta_0 +\beta_1 X_{i1}+\beta_2 X_{i2} +...+\beta_p X_{ip}+\epsilon$

where, for i=n observations

$Y_i$=dependent variable

$X_i$ =independent variables

$B_0$ =y-intercept (constant term)

$B_p$=coefficients of slope for each independent variable

$\epsilon$ **=** error term of the model

(Also known as the residuals)

The coefficient of determination (R-squared) is a statistical scale that is used to measure how much of the variation in outcome can be explained by the variation in the independent variables. $R^2$ always increases as more independent variables are added to the MLR model even though the independent variables may not be related to the outcome variable.[16][17][18]. $R^2$ by itself cannot thus be used to identify which predictors should be included in a model and which should be excluded. Range of $R^2$ is 0 to 1, where 0 symbolise that the outcome cannot be predicted by any of the independent variables and 1 symbolisethat the outcome can be predicted without error from the independent variables.[19]

**Methods and Data**

The objective of this study is to identify the main driving force of HIV/AIDS epidemic in Rajasthan, the primary and secondary data is collected from different departments and the agencies of the state government. On the basis of secondary data collected from RSACS and HSS, the main routes of transmission of HIV positive cases are analysed. This analysis is doneusing the statistical technique of multiple regression analysis. For this, district wise yearly data of total population of Rajasthan in years 2011-2016 is considered. For the multiple regression analysis, the dependent variable is the number of sero-positive cases and the independent factors affecting it are Heterosexuality, Homosexuality, through blood and blood products, through syringe and infected needles, parent to child (for children). In our study, we analyse that what factors really affect the dependent variable of number of sero-positive cases in total population in different years.

First the regression statistic is considered to know that how much of the variation of dependent variable is explained by the independent variable. We can find out this by using the value of Rsquare. After this the results of ANOVA are to be analysed, to draw the result whether all the coefficients of the regression equation are equal to zero or not. For this null hypothesis is set to be as all β's=0 and the alternative hypothesis is set as there is at least one βwhich is not equals to zero. After concluding the result of ANOVA, there can be two cases first, the null hypothesis is accepted. If this happens then we stop ANOVA and conclude that all the coefficients in our regression equation are zero. But if the null hypothesis is rejected, we conclude that at least one of them is not equals to zero. The tabulated $F_{0.05}$ for5 and 27 d.f = 2.572. If calculated $F_{0.05}$ is greater than tabulated value then we reject null hypothesis.

Now we need to analyse further to know exactly which factor among independent variable has no significant effect on our dependent variable and what factors are putting a significant effect on the dependent variable. Hence, the regression analysis concludes in a regression equation for the dependent variable in a linear combination of the independent variable.

**3.1: A Statistical Analysis of Route of transmission of HIV positive cases using Multiple Regression Method in 2011-12:**

For dependent variable, Y (Total number of HIV sero-positive cases), variation is due to 5 independent variables:

$X_1$= Heterosexuality, $X_2$= Homosexuality, $X_3$= Through blood and blood products, $X_4$=Through syringe and infected needles, $X_5$= Parent to child (for children)

For overall population, 99.5% of the variation in HIV sero-positive cases is explained by the variation in the 5 variables.

Table 3.1.7:Regression statistics of route of transmission of HIV positive cases for total population in year 2011-12

| **Regression Statistics** | |
|---|---|
| Multiple R | 0.997796783 |
| R Square | 0.995598419 |
| Adjusted R Square | 0.994783312 |
| Standard Error | 29.32659966 |
| Observations | 33 |

$H_0$: $\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=0$

$H_1$: At least one of the β's are not 0

Null hypothesis is rejected as the p-value is less than 0.05.

**Table 3.1.8: Result of one-way ANOVA for route of transmission of HIV positive cases for total population in 2011-12**

| ANOVA | | | | |
|---|---|---|---|---|
| | Df | SS | MS | F |
| Regression | 5 | 5252459.392 | 1050491.878 | 1221.431955 |
| Residual | 27 | 23221.33509 | 860.0494478 | |
| Total | 32 | 5275680.727 | | |

**Table 3.1.9: Regression analysis of route of transmission of HIV positive cases for total population in year 2011-12**

Further, $H_0$: $\beta_i=0$vs $H_1$:$\beta_i \neq 0$; i=1, 2, 3, 4, 5

| | **Coefficients** | **Standard Error** | **P-value** |
|---|---|---|---|
| Intercept | -15.72421148 | 6.317186 | 0.01927 |
| Heterosexual | 0.744745032 | 0.066876 | 0.00000 |
| Homosexual | 1.5111323 | 2.715878 | 0.58252 |
| Through blood and blood products | 5.913676383 | 1.529622 | 0.00063 |
| Through syringe and infected needles | -6.136870213 | 5.079409 | 0.23745 |
| parent to child (for children) | 5.551748427 | 0.579865 | 0.00000 |

For the dependent variable of total HIV positive cases in year 2011-12, null hypothesis for heterosexuality, through blood and blood products, parent to child (for children) is rejected. And for homosexuality and through syringe and infected needles, null hypothesis is accepted. In year 2011-12, route of HIV transmission in female is mainly due to heterosexuality, through blood and blood products, parent to child (for children).

Regression equation will be: $\hat{Y}$=-15.72421148+ 0.744745032$X_1$ +1.5111323 $X_2$ +5.913676383$X_3$-6.136870213$X_4$ + 5.551748427$X_5$

**3.2: A Statistical Analysis of Route of transmission of HIV positive cases Using Multiple Regression Method in 2012-13**

For overall population, 97.9% of the variation in HIV sero-positive cases is explained by the variation in the 5 variables.

**Table 3.2.7: Regression statistics of route of transmission of HIV positive cases for total population in year 2012-13**

| Regression Statistics | |
|---|---|
| Multiple R | 0.989528 |
| R Square | 0.979166 |
| Adjusted R Square | 0.940475 |
| Standard Error | 50.01748 |
| Observations | 33 |

$H_0$: $\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=0$

$H_1$: At least one of the β's are not 0

Null hypothesis is rejected as the p-value is less than 0.05.

**Table 3.2.8:Result of one-way ANOVA for route of transmission of HIV positive cases for total population in 2012-13**

| ANOVA | | | | |
|---|---|---|---|---|
| | Df | SS | MS | F |
| Regression | 5 | 3292168 | 658433.6 | 328.9867 |
| Residual | 27 | 70048.96 | 2501.749 | |
| Total | 32 | 3362217 | | |

**Table 3.2.9:Regression analysisof route of transmission of HIV positive cases for female in year 2012-13**

Further, $H_0$: $\beta_i=0$ vs$H_1$:$\beta_i\neq0$; i=1, 2, 3, 4, 5

| | Coefficients | Standard Error | P-value |
|---|---|---|---|
| Intercept | 2.072319 | 11.13886 | 0.85375 |
| Heterosexual | 1.282559 | 0.068357 | 0.00000 |
| Homosexual | -15.9321 | 10.61098 | 0.14443 |
| Through blood and blood products | 8.714204 | 2.980649 | 0.00678 |
| Through syringe and infected needles | -17.2286 | 8.491665 | 0.05207 |
| parent to child (for children) | 0 | 0 | 0.00000 |

For the dependent variable of total HIV positive cases in year 2012-13, null hypothesis for heterosexuality, through blood and blood products is rejected. And for homosexuality and through syringe and infected needles, null hypothesis is accepted. In year 2012-13, route of HIV transmission in female is mainly due to heterosexuality, through blood and blood products.

Regression equation will be: $\hat{Y}=2.072319+1.282559X_1-15.9321X_2+8.714204X_3-17.2286X_4$

**3.3: A Statistical Analysis of Route of transmission of HIV positive cases Using Multiple Regression Method in 2013-14**

For overall population, 99.7% of the variation in HIV sero-positive cases is explained by the variation in the 5 variables

**Table 3.3.7: Regression statistics of route of transmission of HIV positive cases for total population in year 2013-14**

| Regression Statistics | |
|---|---|
| Multiple R | 0.998899 |
| R Square | 0.9978 |
| Adjusted R Square | 0.997393 |
| Standard Error | 15.64064 |
| Observations | 33 |

$H_0$: $\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=0$

$H_1$: At least one of the β's are not 0Null hypothesis is rejected as the p-value is less than 0.05

**Table 3.3.8: Result of one-way ANOVA for route of transmission of HIV positive cases for total population in 2013-14**

| ANOVA | | | | |
|---|---|---|---|---|
| | Df | SS | MS | F |
| Regression | 5 | 2995649 | 599129.8 | 2449.131 |
| Residual | 27 | 6604.998 | 244.6296 | |
| Total | 32 | 3002254 | | |

**Table 3.3.9: Regression analysis of route of transmission of HIV positive cases for total population in year 2013-14**

**Further, $H_0$: $\beta_i=0$Vs $H_1$:$\beta_i\neq0$; i=1, 2, 3, 4, 5**

| | Coefficients | Standard Error | P-value |
|---|---|---|---|
| Intercept | 2.451492 | 3.885692 | 0.53341 |
| Heterosexual | 1.047767 | 0.045045 | 0.00000 |
| Homosexual | 1.535391 | 1.909215 | 0.42831 |
| Through blood and blood products | 2.457914 | 1.39703 | 0.08984 |

| | | | |
|---|---|---|---|
| Through syringe and infected needles | 0.57304 | 2.464421 | 0.81788 |
| parent to child (for children) | 0.844761 | 0.533363 | 0.12487 |

For the dependent variable of total HIV positive cases in year 2013-14, null hypothesis for heterosexuality is rejected. And for homosexuality, through blood and blood products, through syringe and infected needles and parent to child (for children) null hypothesis is accepted. In year 2013-14, route of HIV transmission in female is mainly due to heterosexuality.

Regression equation will be: $\hat{Y}=2.451492+1.047767X_1+1.535391X_2+2.457914X_3+0.57304X_4+0.844761X_5$

**3.4: A Statistical Analysis of Route of transmission of HIV positive cases Using Multiple Regression Method in 2014-15**

For overall population, 99.5% of the variation in HIV sero-positive cases is explained by the variation in the 5 variables.

Table 3.4.7: Regression statisticsof route of transmission of HIV positive cases for total population in year 2014-15

| Regression Statistics | |
|---|---|
| Multiple R | 0.998369 |
| R Square | 0.996741 |
| Adjusted R Square | 0.996138 |
| Standard Error | 19.23878 |
| Observations | 33 |

$H_0$: $\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=0$

$H_1$: At least one of the β's are not 0

Null hypothesis is rejected as the p-value is less than 0.05.Table 3.4.8: Result of one-way ANOVA for route of transmission of HIV positive casesfor total population in 2014-15

| ANOVA | | | | |
|---|---|---|---|---|
| | Df | SS | MS | F |
| Regression | 5 | 3056571 | 611314.3 | 1651.617 |
| Residual | 27 | 9993.53 | 370.1307 | |
| Total | 32 | 3066565 | | |

**Table 3.4.9: Regression analysis of route of transmission of HIV positive cases for total population in year 2014-15**

**Further, $H_0$: $\beta_i=0$ Vs$H_1$:$\beta_i\neq0$;i=1, 2, 3, 4, 5**

| | Coefficients | Standard Error | P-value |
|---|---|---|---|
| Intercept | 0.388389 | 4.607429 | 0.93344 |
| Heterosexual | 0.961188 | 0.038507 | 0.00000 |
| Homosexual | 2.28171 | 1.471289 | 0.13259 |
| Through blood and blood products | 1.164854 | 1.706747 | 0.50074 |
| Through syringe and infected needles | 3.518859 | 2.132822 | 0.11056 |
| parent to child (for children) | 1.825417 | 0.503667 | 0.00118 |

For the dependent variable of total HIV positive cases in year 2014-15, null hypothesis for heterosexuality, parent to child (for children) is rejected. And for homosexuality, through blood and blood products and through syringe and infected needles, null hypothesis is accepted. In year 2014-15, route of HIV transmission in female is mainly due to heterosexuality, parent to child (for children).

Regression equation will be: $\hat{Y}=0.388389+0.961188X_1+2.28171X_2+1.164854X_3+3.518859X_4+1.825417X_5$

**3.5: A Statistical Analysis of Route of transmission of HIV positive cases Using Multiple Regression Method in 2015-16**

For overall population, 99.5% of the variation in HIV sero-positive cases is explained by the variation in the 5 variables.

Table 3.5.7**:** Regression statistics of route of transmission of HIV positive cases for total population in year 2015-16

| Regression Statistics | |
|---|---|
| Multiple R | 0.999288 |
| R Square | 0.998576 |
| Adjusted R Square | 0.998313 |
| Standard Error | 12.07831 |
| Observations | 33 |

$H_0$: $\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=0$

$H_1$: At least one of the β's are not 0

Null hypothesis is rejected as the p-value is less than 0.05.

Table 3.5.8:Result of one-way ANOVA for route of transmission of HIV positive cases for total population in 2015-16.

| ANOVA | | | | |
|---|---|---|---|---|
| | df | SS | MS | F |
| Regression | 5 | 2763081 | 552616.3 | 3788.012 |
| Residual | 27 | 3938.91 | 145.8856 | |
| Total | 32 | 2767020 | | |

**Table 3.5.9: Regression analysis of route of transmission of HIV positive cases for total population in year 2015-16**

Further, $H_0$: $\beta_i=0$ Vs $H_1$: $\beta_i\neq0$; i=1, 2, 3, 4, 5

| | **Coefficients** | **Standard Error** | **P-value** |
|---|---|---|---|
| Intercept | 1.605431 | 3.052764 | 0.60325 |
| Hetrosexual | 0.986572 | 0.01611 | 0.00000 |
| Homosexual | 2.506592 | 1.709647 | 0.15416 |
| Through blood and blood products | 0.019438 | 1.246413 | 0.98767 |

| | | | |
|---|---|---|---|
| Through syringe and infected needles | 3.541974 | 1.817131 | 0.06173 |
| parent to child (for children) | 1.430094 | 0.2314 | 0.00000 |

For the dependent variable of total HIV positive cases in year 2015-16, null hypothesis for heterosexuality, parent to child (for children) is rejected. And for homosexuality, through blood and blood products and through syringe and infected needles, null hypothesis is accepted. In year 2015-16, route of HIV transmission in female is mainly due to heterosexuality, parent to child (for children).

Regression equation will be: $\hat{Y} = 1.605431 + 0.986572X_1 + 2.506592X_2 + 0.019438X_3 + 3.541974X_4 + 1.430094X_5$

**Conclusion**

The significant factors that affect the dependent variable for the total population in year 2011-12 are heterosexuality, through blood and blood products and parent to child (for children). In year 2012-13, heterosexuality and through blood and blood products are the two significant factors for HIV transmission for the total population. The main factor for the transmission in year 2013-14 is heterosexuality only. No other independent variable has the significant effect on the dependent variable.

In year 2014-15 and 2015-16, the transmission of HIV positive cases is significantly due to heterosexuality and parent to child (for children).

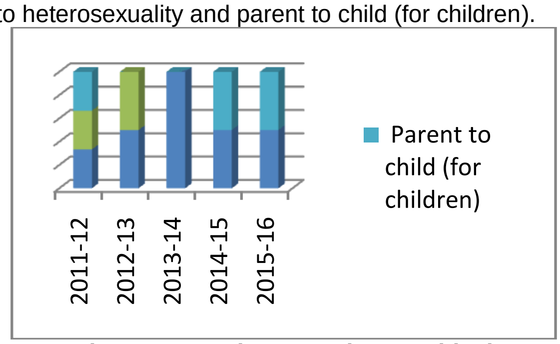


**Figure 3.6.3: The year wise graphical representation of the main factors affecting the total number of total population HIV positive patients**

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