IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 9, September 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Calculating The Expected Time To Seroconversion Of HIV Infected Using Two Source Of Transmission

Bharathidass[1], sathiyamoorthy[2] Lognathan[3] and Pandiyan[4]*

[1] Assistant Proffesor, Department of Statistics, Periyar EVR College, Trichy.
[2] Research Scholar, Department of Statistics, , Periyar EVR College, Trichy.
[3] Assistant Proffesor, Department of Statistics,Tirukkoilur college Arts &Sciences.
[4] Associate Professor, Department of Statistics, Annamalai University.

*Corresponding author's email: subashstat@gmail.com

Abstract

The public health issues have a lot of importance in our society, particularly the Human Immunodeficiency Virus (HIV) infection. If leave HIV had become be leading cause of deaths because of increased life expectancy. Statistical tools were derived from the firmly established theory of epidemiological modeling, although some adjustments are made because of specific characteristics of HIV infection. In this paper shock model approach to estimate the threshold level is been derived by three parameter Exponentiated Weibull distribution. The Data collected in trichy region and fitted for this model are also used to support be model development.

Key words : Epidemiological modeling, Expected time, HIV

INTRODUCTION

Mathematical models based on the underlying transmission of HIV might help the medical and community. such modeling is still vital in investigating how changes in the various assumptions and parameter values affect the course of the epidemic. Therefore, by developing such mathematical models, we can to some extent anticipate its spread in different populations and evaluate the potential effectiveness of different approaches for bringing the epidemic under control, and thus help to devise effective strategies to minimize the destruction caused by this epidemic.

The threshold beyond which the human immune system cannot wits and is represented as sum of two random variables. One can see for more details in Esary et al. (1973) and Pandiyan *et al.*,(2014), discussed about the expected time to cross threshold level of seroconversion period. In this chapter a stochastic model is discussed by considering the fact that a person is exposed to two different modes of transmission of HIV and the expected time to seroconversion are derived.

ASSUMPTIONS OF THE MODEL

- Sexual contacts are the only source of HIV infection person.
- The threshold of any individual is a random variable.
- If the total damage crosses a threshold level Y which itself is a random variable, the seroconversion occurs and a person is recognized as an infected.
- The interarrival time between the successive contacts are at random variable which are identically.

MODEL DESCRIPTION

The Cumulative density function (CDF) of the three parameter Exponentiated Weibull distribution

$$F(x,\theta) = \left[1 - e^{-\left(\frac{x}{\lambda}\right)^{k}}\right]^{\alpha} \; ; \qquad x > 0$$

The corresponding survival function is is given in equation (1), on simplification

$$\bar{H}\,(x) = e^{-\left(\frac{x}{\lambda_1}\right)^{k_1}} + e^{-\left(\frac{x}{\lambda_2}\right)^{k_2}} - e^{-\left(\frac{x}{\lambda_1}\right)^{k_1}} e^{-\left(\frac{x}{\lambda_2}\right)^{k_2}} \qquad \ldots (1)$$

The shock survival probability is given by

$$P(X_i < Y) = \int_0^{\infty} g^*(x)\; \bar{H}(x)\, dx$$

Now the threshold Y is such that it has two contacts namely Y_1 and Y_2. Transfer of Immune system from Y_1 to Y_2 is also possible. We have the threshold level of seroconversion is given by $Y = max(Y_1, Y_2)$.

$$P[max(Y_1, Y_2)] = P[(Y_1 < y) \cap (Y_2 < y)] \; = P[Y_1 < y]P[Y_2 < y]$$

Now that, Y_1 and Y_2 follow three parameter Exponentiated Weibull distribution with parameter $\lambda, k \; and \; \alpha$. The continous random variable denotes the threshold level. the survivor function i.e $P(T > t)$.

$$P(T > t) = \sum_{k=0}^{\infty} V_k(t)\, P\left(\sum_{i=1}^{k_i} X_i < max\; Y_1, Y_2\right) \qquad (2)$$

To find expected time of the threshold we D.r.to S=0 in equation in equation (3). Let the random variable U denoting inter arrival time which follows exponential with parameter c. Now $f^*(s) = \left(\frac{c}{c+s}\right)$, substituting in the above equation(4).

$$l^*(s) = \frac{\left[1 - g^*\left(\frac{1}{\lambda_1}\right)^{k_1}\right] f^*(s)}{\left[1 - g^*\left(\frac{1}{\lambda_1}\right)^{k_1} f^*(s)\right]} + \frac{\left[1 - g^*\left(\frac{1}{\lambda_2}\right)^{k_2}\right] f^*(s)}{\left[1 - g^*\left(\frac{1}{\lambda_2}\right)^{k_2} f^*(s)\right]}$$

$$- \frac{\left[1 - g^*\left(\left(\frac{1}{\lambda_1}\right)^{k_1} + \left(\frac{1}{\lambda_2}\right)^{k_2}\right)\right] f^*(s)}{\left[1 - g^*\left(\left(\frac{1}{\lambda_1}\right)^{k_1} + \left(\frac{1}{\lambda\lambda_2}\right)^{k_2}\right) f^*(s)\right]} \quad \ldots (3)$$

The inter arrival time which follows exponential distribution is subsisted in Laplace transform of equation. we finally obtain the expected time in the equation(4).

$$E(T) = \frac{{\lambda_1}^{k_1}\mu_1 + 1}{c} + \frac{{\lambda_2}^{k_2}\mu_2 + 1}{c} - \frac{\left[\mu_1{\lambda_1}^{k_1}\mu_2{\lambda_2}^{k_2} + \mu_1{\lambda_1}^{k_1} + \mu_2{\lambda_2}^{k_2} + 1\right]}{c\left[\mu_1{\lambda_1}^{k_1} + 1 - \mu_1{\lambda_1}^{k_1} - \mu_1\mu_2{\lambda_2}^{k_2}{\lambda_1}^{k_1}\right]} \ldots (4)$$

Where

C = Time interval of CD4 count, μ_1 = Platelet count

μ_2= Activated Partial Thromboplastin Time λ_1= Prothrombine Tim

λ_2= Viral RNA , K_1= CD8 count K_2 =protein 24

Table :1 Data observed of the infected person

Age	Time interval of CD4 count C	μ_1 Platelet count	μ_2 Activated Partial Thromboplastin Time	λ_1 Prothrombine Tim	λ_2 Viral RNA
34	405	230	22.6	16.1	1360
27	706	210	25.6	18	1556
30	516	260	58.2	22.3	1650
45	945	246	70.6	27.6	1959
28	146	205	20.6	21.3	612
42	590	340	59.7	29.4	1552
33	242	225	27.1	14.6	812
30	415	175	19.5	13.9	1293
28	253	190	31.8	11.4	673
47	346	148	28.4	12.4	994
32	526	250	85.4	15.8	1267
44	80	110	22.7	26.4	268
38	256	240	22.6	14.5	689
55	430	210	17.3	16	1750
39	530	179	26.8	19.6	1681
52	600	416	120.4	26.9	1908
29	297	199	30.4	18.3	853
33	458	160	27.3	15.4	1548
38	269	176	19.9	11.8	759
46	556	256	46.8	16.3	1761
47	526	350	60.9	22.4	1689
52	340	195	35	11.5	879
35	310	169	42.6	14.6	794
34	405	210	43.6	15.9	1268
46	425	280	34.2	11.7	1164
34	254	190	31.8	11.4	670
46	348	144	28.4	12.4	994
41	527	250	85.4	15.8	1260
45	80	110	22.7	26.4	268
49	255	241	22.6	14.5	689

CONCLUSION

In the study blood samples were collected from HIV positive individuals residing in Trichy . Stochastic model was applied to assess the progression of illness among the infected individuals.

Out of the 30 HIV positive patients table 1 given above for observation there were 18 males and 12 females in the age group 28 to 55 . It is observed on the basis of studying the CD4 count of the two variables

viz. Platelet count, pothrombin, time and activated partial thromboplastin time and viral RNA that the time to reach threshold is very near once the CD4 count starts decreasing.

When CD4 count is kept fixed with other parameters Platelet count, pothrombin, time and activated partial thromboplastin time and viral RNA the inter-arrival time $'c'$, which follows Exponential distribution, is an increasing parameter. Therefore, the value of the expected time $E(T)$ to cross the threshold of seroconversion is decreasing,

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