International Journal of Computational and Theoretical Statistics
ISSN (2210-1519)
Int. J. Comp. Theo. Stat. 5, No. 1 (May-2018)

http://dx.doi.org/10.12785/ijcts/050102

Computing the Infection Period of HIV and TB Patient through Non-Deterministic Model

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Received June 11, 2017, Revised January 9, 2018 , Accepted February 26, 2018, Published May 1, 2018

Abstract: Very few researches have been done jointly with Human immunodeficiency virus (HIV) and Tuberculosis (TB). Through this study, an attempt has been made here using statistical model to calculate the verge point of a patient, who has been infected by HIV and TB. Many researches with different family of distribution had been studied earlier. Once the patient is infected, the threshold level counts down which will be observed in the model, to suggest the goodness of fit. Through numerical values, it is interpreted as when the infection period increases the survival time of the patient decreases as when the infection period increases.

Keywords: Expected time, HIV, Patient, TB, Threshold, Survival, Generalized Rayleigh Distribution

1. INTRODUCTION

Tuberculosis (TB) is a disease caused by a bacteria called *Mycobacterium tuberculosis* (MTB). It usually affects the lungs, but can also affect other parts of the body. Mostly it does not have symptoms and is termed as latent tuberculosis. If left untreated, about 10% of latent infections can progress to active disease and kill about half of those infected. It is reported that there were 9.6 million of active TB cases which led to around 2 million deaths in 2014 [1]. The spectrum of conditions caused by HIV is named as Human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS) [2-4]. In humans, T cells are essential to the immune response and without them; the body cannot fight infections or kill cancerous cells. Finally, the depletion of $CD^{+}4$ T cells by HIV result in AIDS. This weakens the immune system [5] and thereby, increases the risk of common infections like tuberculosis as well as other opportunistic infections and tumors that rarely affect people who have working immune systems [6]. It is found that 2.6 million new cases of HIV infection and 1.8 million AIDS-related deaths occur per year [7].

The term TB and HIV/AIDS co-infection denotes the patients who have both HIV infection, and also either latent or active TB disease. In such cases, the disease speeds up the progress of the other. In addition to the rapid progression from latent to active TB caused by HIV infection, MTB also hasten the progress of HIV infection [8]. MTB-HIV co-infections pose particular diagnostic and therapeutic challenges and exert immense pressure on health care systems in African and Asian countries with large populations of co-infected individuals [9]. About 5.5 million people are infected with HIV in South Africa, which accounts 12% of the country's total population [10]. According to World Health Organization (WHO), approximately 270,000 active TB cases are reported in every year [11]. Among adult active TB cases, nearly 60% are found with HIV positive because co-infection with HIV and MTB increases significantly the probability of progression from latent to active TB. Main routes of HIV transmission include significant exposure to infected body fluids or tissues, sexual contact, and vertical transmission (i.e. from mother to child during pregnancy, delivery, or breastfeeding) [12]. No chance of getting HIV infection if exposed to stools, urine, nasal discharge, sweat, saliva, mucus secretions, tears, or vomit unless these are contaminated with blood [13].

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Matias de Carvalho et al. (2008) [14] found a very low CD4 cell counts in majority of patients who presented with HIV/TB co-infection. In HIV/TB co-infection cases, MTB rises the HIV viral load, which consequently results in host immunosuppression and the virulence of the bacilli. As a result, quiescent MTB will be reactivated by an increase in HIV induced immunosuppression. A T-cell that is activated by MTB infection produces more HIV than a quiescent cell; HIV expression increases in the face of co-infections. The elevated HIV viral load rises the rate of disease progression, which in turn increases HIV infectiousness [15].

A. Communicable Diseases (HIV and TB) in Saudi Arabia

The surveillance for HIV is ongoing in Saudi Arabia since in 1984. Clinical suspicion, screening of contacts of HIV infected patients, routine examination of blood and organ donors, prisoners, intravenous drug addicts, patients with other sexually transmitted diseases, expatriates pre-employment testing are the possible indications for HIV testing [16].

TB infection is found to be associating with HIV infection in the world. Alrajhi et al. (2004) [17] retrospectively studied medical charts of 437 TB patients from 1995-2000 in Riyadh. Among those screened (N=178, 41%), 2 (1.1%) of them were HIV positive. In Saudi Arabia, screening for HIV in TB patients remains underutilized [18].

TB in Saudi Arabia is still not fully controlled despite the huge efforts exerted by the government, represented by the Ministry of Health. According to the National TB Programs to eradicate the disease, TB continues to create issues even with the implementation of Directly Observed Treatment Short-course (DOTS). It was expected that this program would bring the disease under control, but unfortunately the success has been limited [19].

2. SKETCH THE USE OF STATISTICAL MODEL

Since the commencement of the epidemic disease, statisticians have framed models to define and predict the course of the infection, both at the microbiological level and in a reference population, made up of one or more risk groups. Using well-established theory of epidemic modeling, the statistical tools were derived in this study, with mild changes wherever it needs due to specific characteristics of epidemic infection. A deterministic model for the transmission dynamics of TB in Cameroon was designed and it includes lack of access to treatment and weak diagnosis capacity as well as both frequency-and density-dependent transmission. More sensitive areas were identified using Gauss-Newton method. This model predicted that a gradual increase of TB model parameters could significantly reduce the disease burden on the population within the next 15 years [20]. A TB/HIV model, a highly simplified deterministic model that incorporated the joint dynamics of TB and HIV was introduced. This model computed the reproduction numbers of each infectious disease and the overall reproduction number for the full system [21].

In this paper, the statistical calculation equipped with; contact with different infected variable is an important issue to be considered when the immune system affected in human body. It is found as successive contacts may significantly increase the damage even though the damages are independent. The immune system exposed to shock which cause damage is likely to fail when the total cumulated damage exceed a threshold level. When the survival does not accumulate the increase in shock which is the inter-arrival time, the expected survival of the human immune system will reach the threshold.

3. DISTRIBUTION FOR OBSERVING PROBABILITY SURVIVAL TIME

The expected time to cross the threshold level particularly in HIV is been studied and discussed [22-23]. In general, assuming that the threshold follows a Generalized Rayleigh Distribution (2005) it can be proved that for HIV and TB transmission, the transfer of immune epidemic from HIV to TB is possible. Still there is no possibility to examine an individual item to control its threshold Y, in this case the threshold must be a random variable. Shock probability is explained in equation (1).

$$P(X_i < y) = \int_0^{\infty} g_k(x)\bar{H}(X)dx \quad (1)$$

Survival analysis is a class of statistics for studying the occurrence and timing of events. The survival function $S(t)$ is$S(t) = P(T > t)$. It may occur that successive shocks are progressively effective in causing damage, even though they are independent. The term survival data is used for measuring the time to some event. The renewal process states that P (exactly k policy decisions in (0, t)) =$F_k(t) - F_{k+1}(t)$ with $F_0(t) = 1$.

4. MEASURE AIMED FROM STATISTICAL BEHAVIOR OF EXPECTED TIME

There are several types of data that arise in everyday life. Among these, there are simple data, grouped data, truncated data, censored data, progressively censored data, and so on. The reason is that the considered subject is alive while evaluating the study and the objective is to revel his/her lifetime which exceeds the age at the time of estimation. Data that measure, the length of time until the occurrence of an event are called survival data. $P(T < t) = L(t) =$ The distribution of Life time (t); $L(t) = 1 - S(t)$. The inter arrival time is calculated for the HIV and TB with special parameters.

$$E(T) = \ 1/c\left[\frac{\mu + 2\lambda_1}{[2\lambda_1]} + \frac{\mu + 2\lambda_2}{2\lambda_2} + \frac{\mu + 2(\lambda_1 + \lambda_2)}{2(\lambda_1 + \lambda_2)}\right] \tag{2}$$

5. DISCUSSION

In Saudi Arabia, Ministry of Health (MOH) is the main provider of health care services. Since 1970, Health has included in the national 5-year development plans and considered as an main part of overall development in the country. It is observed that the eighth national development plan 2005–2009 had addressed a number of public health issues. Furthermore, a full range of treatment is available across eight specialist centers in Saudi Arabia and MOH is planning to establish additional eight centers. HIV coordinators in each regional directorate who coordinate all MOH prevention, treatment and care programs by concentrating on emerging the dialogue with general public, student community and religious leaders [24].

In addition, Saudi healthcare professionals should be provided with more awareness/ seminar/ guest lecture programs on the most important statistical method "SURVIVAL ANALYSIS" and they can be involved to execute appropriate measures to prevent TB infection in HIV-infected patients and also prevent the rapid progression to active TB HIV-infected patients with latent TB infection (LTBI). Likewise, Saudi medical students also encouraged to some extent for conducting health-related Behavioral Change Communication (BCC) activities in colleges during their community medicine posting.

6. CONCLUSION

The standard assumptions in shock models is the damage related either to the cumulative effect of a number of shocks or that failure is caused by a shock that exceeds a certain critical level. HIV and TB infected patients threshold level decreases once the inter-contact of survival time increases. The generalized Rayleigh distribution curve in the "Fig. 1" shows threshold level curve similar to the exponential curve, which shows that generalized Rayleigh distribution can be applied for the survival fit of the above equation (2).

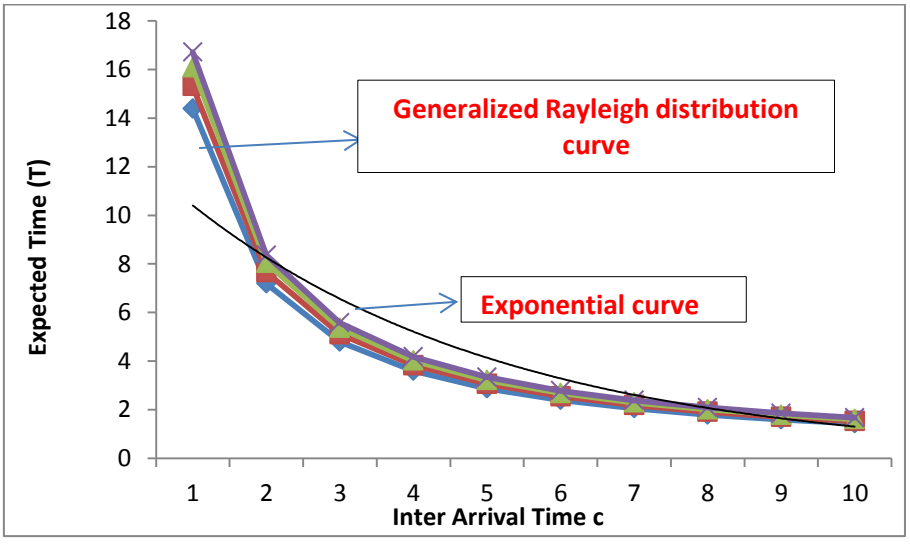

Figure 1. Generalized Rayleigh distribution curve and Exponential curve

REFERENCES

[1]. WHO, (2015 October). Tuberculosis fact sheet N104. [Online]. http://www.who.int/mediacentre/factsheets/fs104/en/.

[2]. Sepkowitz, K. A. (2001). AIDS-the first 20 years. New England Journal of Medicine, 344 (23), 1764–1772.

[3]. Kirch, W. (2008). Encyclopedia of public health, New York: Springer.

[4]. Krämer, A., Kretzschmar, M. & Krickeberg, K. (2010). Modern infectious disease epidemiology concepts, methods, mathematical models and public health (Online-August ed.), New York: Springer.

[5]. Hel, Z., McGhee, J. R. & Mestecky, J. (2006). HIV infection: First battle decides the war. Trends in Immunology, 27(6), 274–281.

[6]. WHO, (2015 November). HIV/AIDS Fact sheet N360. [Online]. http://www.who.int/mediacentre/factsheets/fs360/en/.

[7]. UNAIDS, (2010). Chapter 2: Epidemic update. UNAIDS report on the global AIDS epidemic 2010. [Online]. http://www.unaids.org/documents/20101123_GlobalReport_Chap2_em.pdf.

[8]. Mayer, K. (2010). Synergistic Pandemics: Confronting the Global HIV and Tuberculosis Epidemics. Clinical Infectious Diseases, 50(3), S67. http://cid.oxfordjournals.org/content/50/Supplement_3/"

[9]. Pawlowski, A., Jansson, M., Sköld, M., Rottenberg, M. E. & Källenius, G. (2012). Tuberculosis and HIV Co-Infection, PLoS Pathogens, 8(2), e1002464.

[10]. UNAIDS (2006). 2006 Report on the global AIDS epidemic. UNAIDS: Geneva.

[11]. World Health Organization (WHO) (2007). Global tuberculosis control: surveillance, planning, financing. WHO: Geneva.

[12]. Markowitz, S. & Rom, W. N. (2007). Environmental and occupational medicine, (4th ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.

[13]. Kripke, C. (2007). Antiretroviral prophylaxis for occupational exposure to HIV. American Family Physician, 76 (3), 375–376.

[14]. Matias de Carvalho, B., Monteiro, A. J., da Justa Pires Neto, R., Grangeiro, T. B., & Frota, C. C. (2008). Factors related to HIV/Tuberculosis coinfection in a Brazilian reference hospital, Brazilian Journal of Infectious Diseases, 12(August), 281-286. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.874.6121&rep=rep1&type=pdf

[15]. Vermund, S. H. & Yamamoto, N. (2007). Co-infection with human immunodeficiency virus and tuberculosis in Asia. Tuberculosis, 87, S18-S25.

[16]. Madani, T. A., Al-Mazrou, Y. Y., Al-Jeffri, M. H. & Al Huzaim, N. S. (2004). Epidemiology of the human immunodeficiency virus in Saudi Arabia; 18-year surveillance results and prevention from an Islamic perspective. BMC Infectious Diseases, 4:25. doi:10.1186/1471-2334-4-25.

[17]. Alrajhi, A. A., Halim, M. A. & Al-Abdely, H.M. (2004). Mode of transmission of HIV-1 in Saudi Arabia, AIDS, 18(10), 1478-1480.

[18]. Omair, M. A., Al-Ghamdi, A. A. & Alrajhi, A.A. (2010). Incidence of tuberculosis in people living with the human immunodeficiency virus in Saudi Arabia. International Journal of Tuberculosis and Lung Disease, 14(5), 600-603.

[19]. Al-Hajjaj, M. S. (2000), The outcome of tuberculosis treatment after implementation of the national tuberculosis control program in Saudi Arabia. Annals of Saudi Medicine, 20(2), 125-128.

[20]. Moualeu, D. P., Roblitz, S., Ehrig, R. & Deuflhard, P. (2015). Parameter Identification for a Tuberculosis Model in Cameroon. PLoS ONE, 10(4): e0120607. https://doi.org/10.1371/journal.pone.0120607

[21]. Roger, L-I. W., Feng, Z., & Castillo-Chavez, C. (2009). Modeling TB and HIV Co-infections. Mathematical

biosciences and engineering, 6(4): 815-837. doi:10.3934/mbe.2009.6.815

[22]. Subramanian, C., Rajivgandhi, R. & Vinoth, R. (2012). Estimation of the Generalized Logistic Distribution based on the Expected time in Shock Model. Global Journal of Mathematical Sciences: Theory and Practical, 4(12), 57-62.

[23]. Sukla, D, P., Raja, D., Ramasamy, J. & Vinoth, R. (2013). Preventing Threshold in Human Immune Virus of Infected Persons through Statistical Model. International Journal of Pharmaceutical and Healthcare, 1(2), 43-46.

[24]. WHO, (2013). Country cooperation strategy for WHO and Saudi Arabia 2012-2016 [Online] .http://apps.who.int/iris/bitstream/10665/113227/1/CCS_Saudia_2013_EN_14914.pdf.