International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 20 (2018) pp. 14832-14833

Disease Dynamics of Tuberculosis: a Modeling Report

Indu Ratti

Sikh National College, Banga, Punjab, India.

INTRODUCTION

Tuberculosis (TB) is an infectious disease usually caused by the bacterium Mycobacterium tuberculosis. TB affects the lungs, but can also affect other parts of the body. Most infections do not have symptoms, in which case it is known as latent TB. Almost 10% of latent infections progress to active disease which, if left untreated, kills about half of those infected. The classic symptoms of active TB are a chronic cough with blood-containing sputum, fever, night sweats, and weight loss. It was historically called “consumption” due to the weight loss. Infection of other organs can cause a wide range of symptoms.

The World Health Organization estimates that 1.8 billion people—one third of the world’s population—are infected with Mycobacterium tuberculo- sis. Last year, 10 million fell ill from TB and 1.6 million died. New infections occur in about 1% of the population each year. In 2016, there were more than 10 million cases of active TB which resulted in 1.3 million deaths. This makes it the number one cause of death from an infectious disease. More than 95% of deaths occurred in developing countries, and more than 50% in India, China, Indonesia, Pakistan, and the Philippines. The number of new cases each year has decreased since 2000. About 80% of people in many Asian and African countries test positive while 5–10% of people in the United States population test positive by the tuberculin test. In 2017, 10 million people fell ill with TB, and 1.6 million died from the disease (including 0.3 million among people with HIV). There is growing resistance to available drugs, which means the disease is becoming more deadly and difficult to treat. There were 558,000 cases of drug resistant TB last year.

LITERATURE REVIEW

Many mathematical models have been developed and studied to explain a variety of features on the transmission of TB. In this review, they basically report what existing studies have found and discussed.

The first model that studies the transmission of TB is given by [1] in 1962. The model has three compartments: noninfected (susceptible), infected non- cases (latent TB), and infected cases (infectious). They did not include age distribution in the model. The next model by [9]introduced heterogeneity (age) but also changed the method used for calculating infection rates. Their goal was to compare different control strategies. The next model was [15] and it was the first nonlinear system of ordinary differential equations that models TB dynamics. They did not use law of mass action, instead assumed homogeneous mixing. They did not take into account population structure.

So far the models we discussed focussed on developing countries. [10] was the first paper to study the dynamics of TB in USA. They assumed the same compartments as in Waaler et al. several researchers constructed a series of dynamical models for TB progression and transmission in scenarios that took these factors into consideration [2, 3, 4, 5, 6, 7]. A linear partial differential equation model for TB transmission is proposed by Vynnycky and Fine [11]. To search for an optimal strategy for TB vaccination, another dynamical model including age structure, contact structure, and vaccination is proposed by Castillo- Chavez and Feng [12]. Earlier models (prior to the

1970s) targeted the evaluation of control strategies of TB [14, 13, 15, 9], such as vaccination strategies. The control models should include control strategies for latent reservoir. Such models such as Blower [88] and Castillo- Chavez and Song [73] exist in the literature.

CONCLUSION

We simply report few studies that exist in literature. As already mentioned, there are many mathematical models that study TB. Different models include and discuss different components of the mechanism. This report will give a preliminary idea of literature which may guide future researches.

REFERENCES

[1] H. T. Waaler, A. Gese, and S. Anderson (1962) The use of mathematical models in the study of the epidemiology of tuberculosis, Am. J. Publ. Health, 52:1002–1013.

[2] S. M. Blower, A. R. McLean, T. C. Porco, P. M. Small, P. C. Hopwell, M. A. Sanchez,and A. R. Moss (1995). The intrinsic transmission dynamics of tuberculosis epidemics, Nature Medicine, 1(8):815–821.

[3] S. M. Blower, P. M. Small, and P. C. Hopwell (1996). Control strate- gies for tuberculosis epidemics: New models for old problems, Science, 273:497–500.

[4] S. M. Blower and J. L. Gerberding (1998). Understanding, predicting and controlling the emergence of drug-resistant tuberculosis: A theoret- ical framework, J.Mod. Med.,76:624– 636.

[5] C. Castillo-Chavez, A. F. Capurro, M. Zellner, and J. X. Velasco- Hernandez (1998). El trans- porte

pblico y la dinmica de la tuberculosis a nivel poblacional. Aportaciones Matemaqticas, Serie Comunicaciones, 22:209–225.

[6] Z. Feng, C. Castillo-Chavez,and A. F. Capurro (2000). A model for tuberculosis with ex- ogenous reinfection, Theor. Pop. Biol., 57:235–247.

[7] T. C. Porco and S. M. Blower (1998). Quantifying the intrinsic transmission dynamics of tuberculosis, Theoretical Population Biology, 54:117–132.

[8] C. S. ReVelle, W. R. Lynn, and F. Feldmann (1967). Mathematical models for the economic allocation of tuberculosis control activities in developing nations, Am. Rev. Respir. Dis., 96:893–909.

[9] S. Brogger (1967). Systems analysis in tuberculosis control: A model, Amer. Rev. Resp. Dis., 95:419–434.

[10] S. H. Ferebee (1967). An epidemiological model of tuberculosis in the United States, NTA Bulletin , January, 4–7.

[11] E. Vynnycky and P. E. M. Fine (1997). The natural history of tubercu- losis: The implications of age-dependent risks of disease and the role of reinfection, Epidemiol. Infect., 119:183–201.

[12] C. Castillo-Chavez and Z. Feng (1998). Global stability of an age- structure model for TB and its application to optimal vaccination strate- gies, Math. Biosci., 151:135–154.

[13] H. T. Waaler, A. Gese, and S. Anderson (1962) The use of mathematical models in the study of the epidemiology of tuberculosis, Am. J. Publ. Health, 52:1002–1013.

[14] H. T. Waaler and M. A. Piot (1970). Use of an epidemiological model for estimating the effectiveness of tuberculosis control measures, Bull. World Health. Org., 43:1–16.

[15] C. S. ReVelle, W. R. Lynn, and F. Feldmann (1967). Mathematical models for the economic allocation of tuberculosis control activities in developing nations, Am. Rev. Respir. Dis., 96:893–909.