STOCHASTIC ANALYSIS AND APPLICATIONS
https://doi.org/10.1080/07362994.2024.2413632

A comparison of stochastic and deterministic dynamics of tuberculosis model

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ABSTRACT
Tuberculosis is a deadly infectious disease leading to a major health concern in Southern India while there are major obstacles to controlling its spread. Here, we present a mathematical model with five compartments. We categorize the infected compartment into two subcategories: latent TB-infected individuals and active TB-infected individuals. By introducing white noise in a deterministic system, we formulate a stochastic system. We investigate the model in deterministic and stochastic framework, followed by data calibration using TB infection data from Kanyakumari District in South India from 2019 to 2023. In the deterministic model, we derive the disease-free and endemic equilibrium points, compute the basic reproduction number, and examine their stability. Moreover, we perform sensitivity analysis to evaluate how variations in model parameters affect TB prevalence. In addition, we study the uniqueness of solutions of stochastic model. After that we derive the conditions for disease extinction and stochastic permanence, and execute extensive simulations to capture the variability and randomness in TB transmission dynamics. This study signifies that stochastic dynamics is richer than deterministic one in the way of mitigation TB transmission.

ARTICLE HISTORY
22 July 2024
1 October 2024

KEYWORDS
TB transmission; white noise; data calibration; permanence; extinction

1. Introduction

As one of the biggest threats to global health in the modern era, tuberculosis (TB) continues to place a heavy burden on societies and healthcare systems all over the world. Mycobacterium tuberculosis is the agent that causes tuberculosis (TB). If the lungs are affected, the disease spreads through the air when infected individuals cough, sneeze, or split. Ten million people develop tuberculosis each year. Even though tuberculosis is a common and treatable illness, 1.5 million people worldwide pass away from it every year, making it the leading infectious disease. Approximately 25% of the world's population is thought to have latent tuberculosis (TB), with half of those affected living in eight countries: Nigeria, India, the Philippines, Pakistan, China, South Africa, Bangladesh, and Indonesia.[1, 2].

Stochastic modeling, which incorporates environmental noise, helps understand infectious disease dynamics. It provides insights into population dynamics and emphasizes randomness and unpredictability in disease transmission. This approach enhances knowledge of disease

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