

**Centre des Etudes Doctorales Sciences et Techniques
&
Sciences Médicales**

THESIS DEFENSE

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CANDIDATE FOR DOCTOR SCIENCES AND TECHNIQUES

**Probabilistic Approaches to Epidemic Modeling:
Advancements in Stochastic Dynamical Systems**

Date :	Tuesday, December 26th, 2023
Time :	10.00 am
Location :	Conference Room, Building F, FST - Tangier

Committe Members

Pr. Mustapha EL JARROUDI	FST- Tangier	Chair
Pr. Abdelaziz TAAKILI	ENSAM – Meknes	Reviewer
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Pr. My Soufiane RECHDAOUI	EST- Meknes	Guest
Pr. Adel SETTATI	FST- Tangier	Supervisor

ABSTRACT

The history of humanity has always included a significant role for communicable diseases. Throughout the beginning of time, epidemics have infected populations, frequently killing a large number of people before dissipating. Epidemiologists use a variety of methods, including observational studies and clinical trials, to identify risk factors, investigate outbreaks, and evaluate interventions aimed at preventing or controlling the spread of disease. Mathematical modeling in epidemiology involves using mathematical equations to represent the spread and behavior of infectious diseases. The process involves characterizing the variables that affect the transmission of the disease, such as the infectiousness of the pathogen, the susceptibility of the population, and the effectiveness of interventions, and then constructing mathematical models that capture these factors. In general, mathematical modeling provides a powerful tool for predicting and controlling the spread of communicable diseases, and plays an essential role in informing public health policies and interventions. In contrast to deterministic models, which assume that the parameters governing disease transmission are fixed and constant over time, stochastic models incorporate random fluctuations in disease transmission rates, population susceptibility, and other key variables. This allows for a more realistic and nuanced representation of the complex and dynamic nature of epidemics. Stochastic models are particularly useful for studying the impact of environmental disturbances on disease transmission dynamics, such as natural disasters or public health interventions. By incorporating random variation in these factors, researchers can generate a range of possible outcomes and estimate the likelihood of different scenarios. Stochastic models can be more complex and difficult to analyze than deterministic models, due to their incorporation of randomness and uncertainty. As a result, analyzing stochastic models often requires advanced analytical techniques and computational methods. The present thesis aims to study the stochastic approach of some epidemiological models, driven by Brownian movements, Markov chains and Lévy processes, which are the most famous processes in the history of stochastic differential equations. Calculations on these processes allowed us to deduce a certain amount of information about the population. In particular, the persistence and extinction of the epidemic, the ergodicity and the existence of the stationary distribution and other asymptotic properties. To support the theoretical findings and demonstrate the clarity of the discovered conditions and thresholds, some numerical simulations are shown. The field of stochastic mathematical epidemiology is constantly evolving, and new tools and techniques are needed to analyze more complex models and make accurate predictions about disease transmission and control. This thesis has made a significant contribution to the field by improving upon existing studies and providing alternative tools for treating and analyzing more complex epidemiological and biological models.

Keywords: Stochastic epidemic models; Markovian switching; Disease extinction; Stochastic persistence; Stationary distribution; Persistence in mean; Lévy noise; Complex network.