
Wikno, 16th–20th September 2025

# MATHEMATICAL INSIGHTS INTO THE DYNAMICS OF ACUTE AND CHRONIC BACTERIAL INFECTIONS

**Pascoal Martins da Silva**

Polytechnic University of Coimbra - ISEC,
Portugal and Centre for Mathematics of the University of Coimbra, Portugal

## ABSTRACT

Bacteria are single-celled microorganisms and among the most basic forms of life, having emerged nearly a billion years ago. The human body contains trillions of bacteria, outnumbering our own cells by a ratio of approximately 10 to 1. Some bacteria are beneficial, such as those residing in the human intestine, while others can cause serious diseases, including pneumonia, cholera, and bacterial meningitis.

In the environment, bacteria can alternate between two distinct states: a planktonic state, in which they float freely, and an immobile state, in which they form biofilms—structured bacterial communities that act as a "fortress," protecting the bacteria from antibiotics, increasing multidrug resistance, and reducing the effectiveness of the immune response.

A large body of medical literature suggests that chronic infections are associated with biofilm formation, whereas acute infections are primarily driven by planktonic bacteria. But can these observations be explained mathematically?

The aim of our talk is to present a class of mathematical models that provide such an explanation. These models describe the dynamics of acute and chronic bacterial infections within a host. They incorporate the main components involved in the process—namely, the immune system, antibiotic treatments, bacterial communication via chemical signals, and biofilm formation—and explore how these elements interact. A wide range of numerical simulations will also be presented to illustrate the model's predictions.