

MODELING COVID-19 SPREAD WITH POPULATION MOVEMENT: A COMPARATIVE STUDY ACROSS VARIOUS COUNTRIES

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Abstract. This paper proposes a logistic equation with population flow to describe the evolution of the first five COVID-19 waves in fifteen countries across five continents. The model is based on epidemiological data from the Center for Systems Science and Engineering (CSSE) and the World Health Organization (WHO). Unknown parameters are estimated using the least-squares method, leading to explicit analytical expressions for the estimators. Comparisons with the classical logistic equation show that the proposed model provides a better fit for all considered epidemic waves, increasing the average coefficient of determination from 0.442 to 0.739. The results confirm that incorporating a population flow parameter improves epidemic modeling by reducing the time-lag limitation of the classical logistic approach. The proposed model offers a simple and efficient tool for analyzing epidemic dynamics.

Keywords. Mathematical modeling, Pandemic, COVID-19, logistic equation, parameter estimation.

AMS (MOS) subject classification: 34A34, 92C60, 92D30.

1 Introduction

COVID-19, a disease caused by the SARS-CoV-2 virus, is a zoonotic infection that first emerged in Wuhan, Hubei Province, China, in December 2019. Although its exact origin remains debated, the virus rapidly spread throughout China and subsequently worldwide. On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic [1, 2].

There has been growing interest among various international and local organizations in combating and controlling this epidemic through the development of strategic plans and the implementation of public health protocols, including social distancing, mask wearing, social isolation, and the development and distribution