*VII International Conference on Mathematics and its Applications in Science and Engineering*
*(ICMASE 2026)*

ICMASE 2026

# DYNAMICS OF MEASLES-RUBELLA CO-CIRCULATION: A MATHEMATICAL MODEL INCORPORATING WANING IMMUNITY, ISOLATION, VERTICAL TRANSMISSION, AND ADAPTIVE PUBLIC HEALTH RESPONSE

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## ABSTRACT

In this study, an extended deterministic compartmental model was formulated to investigate the co-circulation dynamics of measles and rubella. The model consists of eleven ordinary differential equations and incorporates four key epidemiological mechanisms: waning of partial vaccine-induced immunity, early detection and isolation of infectious individuals, a public-health-driven dynamic vaccination rate, and vertical transmission of rubella. The positivity and boundedness of the model solutions were established, and the disease-free, measles-free, and rubella-free equilibrium points were derived. The basic reproduction number was obtained based on the next-generation matrix method, and the local and global stability of the disease-free equilibrium were analysed. Applying the normalized forward sensitivity index method, the influence of each model parameter on the reproduction number was determined; the measles transmission rate, rubella transmission rate, and waning rate for vaccine-induced partial immunity were found to have the highest positive impacts, while early detection and baseline vaccination had the strongest negative impacts. Finally, the outcome of the numerical simulations carried out to demonstrate the disease dynamics under distinct intervention scenarios showed that increasing early detection and implementing dynamic vaccination significantly reduce disease prevalence and resurgence risk, whereas waning of partial immunity can lead to resurgence, highlighting the need for booster doses and sustained public health measures.

***Keywords*** Measles-rubella co-circulation · Dynamic vaccination · Waning immunity · Sensitivity analysis

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