Mathematical Modeling, Analysis, and Simulation of the COVID-19 Pandemic with Behavioral Patterns, Risk Perception, and Group Mixing

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As COVID-19 cases continue to rise globally, many researchers have developed mathematical models to help capture the dynamics of the spread of COVID-19. Specifically, the compartmental SEIR model and its variations have been widely employed. These models differ in the type of compartments included, nature of the transmission rates, seasonality, and several other factors. Yet, while the spread of COVID-19 is largely attributed to a wide range of social behaviors in the population, several of these SEIR models do not account for such behaviors. In this project, we introduce a new implicit COVID-19 model where contact rates depend on behavioral patterns adopted across the population. Specifically, we consider two sub-populations, one exhibiting normal behavior who do not reduce their contacts and another exhibiting altered behavior who reduce their contacts by practicing non-pharmaceutical interventions such as social distancing and self-isolation. The basic reproduction number for the model will be derived. The dynamics of these populations are modelled through a coupled system of ordinary differential equations that incorporate mixing patterns of individuals differing by activity levels, which could be proportionate mixing, preferred mixing, or like-with-like mixing. We also expand our model to include risk perception and irrational behavior, with appropriate pay-off functions.

Keywords: COVID-19, Compartmental Models, Social Behavior, Mixing Patterns, Non-pharmaceutical interventions