Why Population Heterogeneity Matters for Modelling Infectious Diseases

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Abstract:

The COVID-19 pandemic highlighted significant differences in infectious disease burden among sociodemographic groups in the United States, underscoring the need for modelling approaches that can capture the complex dynamics driving these heterogeneities. Specifically, variation in case incidence, mortality, and disease burden has been observed across subpopulations stratified by race, ethnicity, sex, age, and geographic region. Accurately incorporating fine-grained sociodemographic attributes into infectious disease models remains challenging due to complex correlations among individual characteristics. Additionally, accurately modelling transmission while accounting for exposure differences among population strata requires a detailed understanding of transmission risk across interaction settings. We address these challenges by incorporating drivers of exposure risk and detailed sociodemographic data into EpiCast—a large-scale agent-based model of respiratory pathogen spread in the United States. Using this model, we demonstrate how differences in the rate of infections between key demographic groups emerge in households, workplaces, and schools.

Our findings show that embedding fine-grained population heterogeneity into infectious disease models can produce uneven outcomes in predicted disease burden among racial groups, driven by factors such as household size and workplace exposure risk. This study demonstrates the potential of detailed models of infectious disease spread to inform policy intervention design for future pandemics.