Assess the impacts of human mobility change on COVID-19 using differential equations with Google Community Mobility Data

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Background: In June 2020, Arizona, U.S., emerged as one of the world's worst coronavirus disease 2019 (COVID-19) spots after the stay-at-home order was lifted in the middle of May. However, with the decisions to reimpose restrictions, the number of COVID-19 cases has been steadily declining week-over-week. Arizona is considered to be a good model in slowing the epidemic.
Methods: To estimate the COVID-19 transmission dynamics in Arizona, we fitted the human mobility integrated metapopulation susceptible-infectious-removed model to publicly available datasets on COVID-19 cases and mobility changes in Arizona, and estimated parameter values. Using these estimated parameters, we simulated the dynamics of the disease spread base on varied mobility restrictions. We also explored the correlation between different activity categories and COVID-19 cases and estimated the impact of mobility restriction on retail and recreation.
Findings: Our simulations showed that by reducing human mobility, the peak time was delayed, and the final size of the epidemic was decreased in all three regions. Specifically, a 20% reduction in mobility could prevent a peak occurring for a month, 40% could delay the peak for three more months. With an overall 41% mobility reduction, we can contain the virus resulting from reproduction number less than one. The mobility reduction is most effective for Central Arizona with more than double effect than for Southern Arizona by an increasing 1% reduction rate.
Interpretation: This study suggests that rapid and effective mobility control measures are crucial in controlling the COVID-19 epidemic in Arizona. While the situation around COVID-19 in Arizona has been improving, the epidemic is not yet under control. As the trajectory of the outbreak in Arizona and beyond will depend on human mobility until a COVID-19 vaccine is available, our findings could help policymakers implement or lift mobility restrictions.
Keywords: COVID-19; mobility restriction; mobility data; transmission model; simulation