Accounting for reporting uncertainty, new variants and vaccinations when estimating the effects of non-pharmaceutical interventions for COVID-19 in 15 European countries

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After more than one year of experience with the coronavirus disease 2019 (COVID-19), many countries are still struggling to find a balance between epidemiological benefits and socioeconomic costs in calibrating non-pharmaceutical interventions (NPIs). In view of the severe social, economic and psychological effects of some of the adopted interventions, it is crucial to identify those interventions that are most effective in slowing the spread of the virus. However, current approaches to estimate the effect of NPIs typically focus on relatively short time-periods and either on the number of reported cases, hospital admissions or deaths. In this work, we propose a Bayesian hierarchical model as it provides a flexible framework to integrate these three complimentary sources of information in the estimation of the true and unknown number of infections while accounting for reporting delay and time-varying under reporting in the number of reported cases. In order to be able to use information on the entire course of the pandemic, we account for the spread of new variants and the number of vaccinations in the model. We implement a Markov Chain Monte Carlo algorithm to conduct Bayesian inference and estimate the effect of NPIs on publicly available data from 15 European countries.