Assessment of the impact of the COVID-19 vaccination campaign in Italy through epidemiological data-assimilation

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The pandemic of SARS-CoV-2 that has produced more than 271'000'000 cases and almost 5'300'000 deaths worldwide (as of December 15th, 2020) strongly hit Italy, with around 5'258'000 confirmed cases and 135'000 deaths. Never before has there been such an urgency for accurate epidemiological models to better understand the past epidemic dynamics, anticipate the next phases of the pandemic, and analyse the impact of the implemented intervention strategies.

This work presents a reliable decision support system for short-term forecasting (1-3 weeks) of the spatiotemporal spread of COVID-19 in Italy. The spatial epidemiological model is based on a network of local communities connected by human mobility fluxes [1,2,3]. In each community, disease transmission is described by an SIR model with an age structure, that includes ad hoc compartments relevant to COVID-19 transmission dynamics and for describing the vaccination campaign. This model additionally allows accounting for region-specific mobility restrictions during lockdown, behavioral change as a response to containment efforts and increased awareness. The tracking of changes in the underlying model parameters is obtained through data assimilation. An iterative particle filter, particularly suited for nonlinear systems due to its theoretical convergence guarantees, updates model parameters on a moving time window, thus avoiding time-consuming calibrations based on Markov Chain Monte Carlo. The convergence and stability of the developed algorithm, together with the forecast accuracy of the model, are investigated through hindcasting on the data collected during the COVID-19 epidemic in Italy. Moreover, we provide an estimate of the hospitalizations and deaths averted thanks to the vaccination campaign.

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