A stochastic study of SARS-CoV-2 evolution in Italy and Lombardy

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Aim of the present work is the study of the evolution epidemic event in Italy, with specific emphasis for the northern Lombardy region where the Sars-CoV-2 has been particularly intense and violent. The analysis is fully based on the Italian data and a SEIR transmission model developed within a Markov Chain Monte Carlo (MCMC) method to fit the parameters through a MetropolisHastings (M-H) algorithm. The evolution of a possible mitigation of the present isolation measures (lockdown) is presented in detail taking into account the stochastic nature of the model.

I. INTRODUCTION

We present here only a schematic structure of our work, based essentially on the Figures and their captions.

A synthetic discussion of the procedures is given in the attached Auxiliary Notes.

II. THE MODEL

(see Auxiliary Notes)

A. The parameters

(see Auxiliary Notes)

B. The results for Italy

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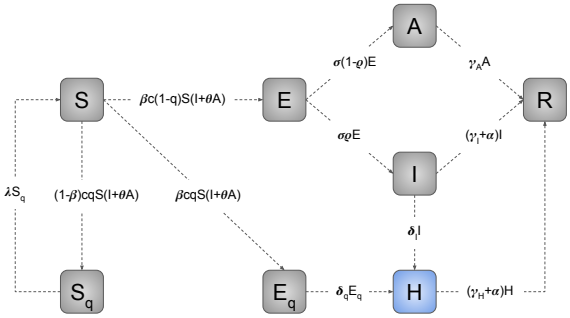

FIG. 1. Diagram of the model simulating the novel Coronavirus (Sars-CoV-2) infection in Italy. The population is stratified in Susceptible (S), exposed (E), infectious but not yet symptomatic (pre-symptomatic) (A), infectious with symptoms (I), hospitalized (H) and recovered (R), quarantined susceptible (S_q), isolated exposed (E_q) and isolated infected compartments. Interventions like intensive contact tracing followed by quarantine and isolation are indicated (cfr. ref. [8]).

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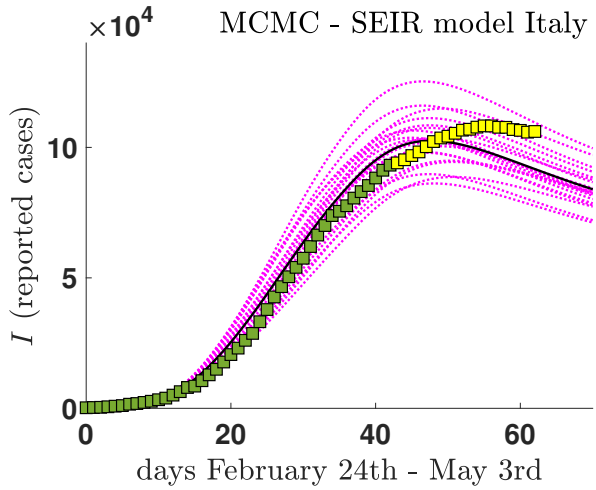

FIG. 2. The reported cases of Infected as given by data in refs.[14, 15] are shown (as a function of time) by the green squares (up April 6th) and yellow squares (from April 7th to April 22nd). Tese last data are not included in the fit procedure and represent a pure predicted region. The behavior of the stochastic model results follows the data in a consistent way within the large error-bands of a systematic (normal) sampling.

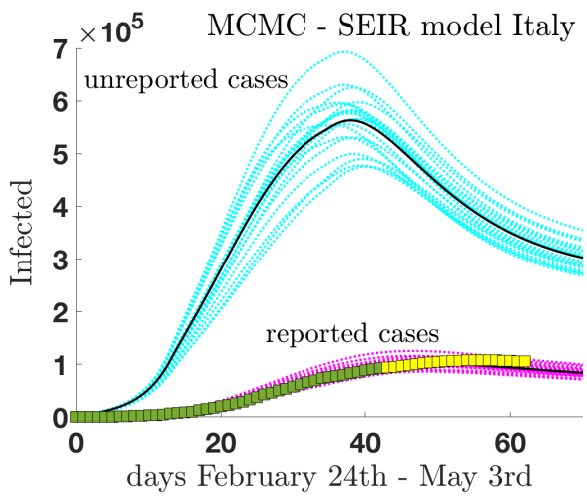

FIG. 3. The reported case of Fig. 2 are compared by the predicted "unreported cases", i.e. the a-symptomatic and unknown infected individuals as predicted by our model. The unreported cases represent in our model, a large fraction of the infected individuals.

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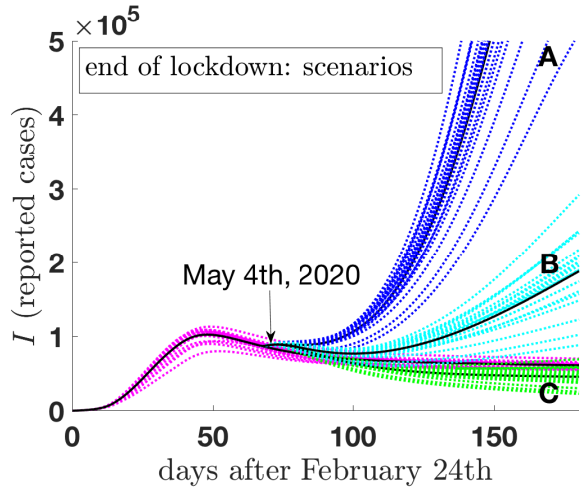

FIG. 4. Scenarios for a mitigation of the lockdown period in Italy starting from the announced date of May 4th. Three different scenarios are shown depending on the efficiency in respecting social distancing and social tracing.
Scenario A: a social contact rate rather similar to the regular rate (only a reduction of a factor of two is included) would result in a violent secondary outbreak.
Scenario B: A stronger reduction of the contact rate which excludes social events (school, restaurants, events...) .
Scenario C: Further inclusion of social tracing and quarantine.

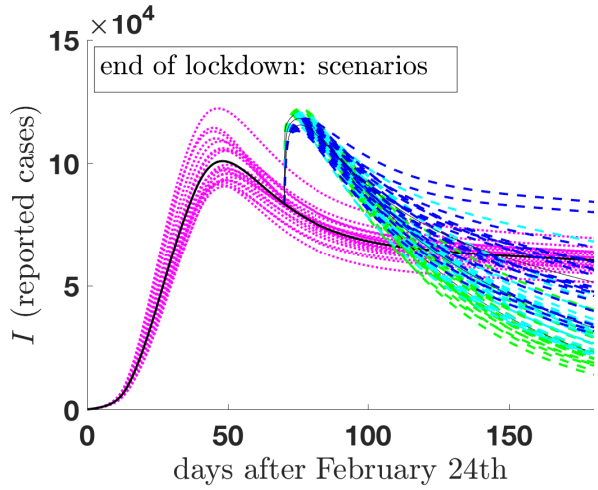

FIG. 5. Influence of rapid tests on the scenarios for a mitigation of the lockdown period in Italy starting from the announced date of May 4th. The number of reported infected is shown assuming a moderate efficiency in keeping social distancing (scenario (B) of Fig. 4) but increasing the rapidity of the tests; namely: 15 hours (blue lines), 8 hours (cyan lines) and 3 hours (green lines). We confirm within a stochastic approach, the results obtained within the deterministic model of ref. [].

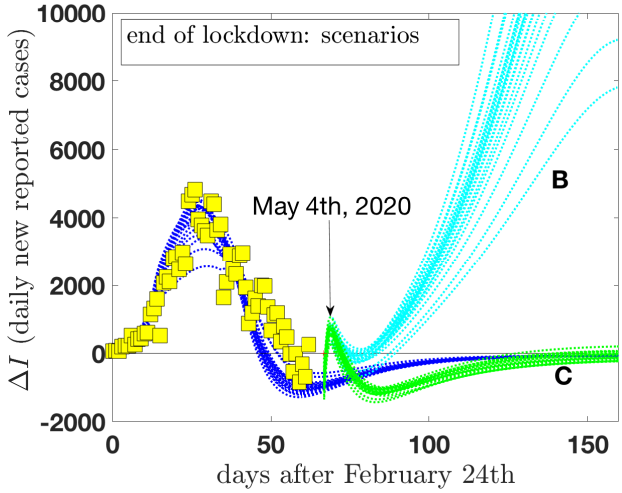

FIG. 6. The daily variations of new reported cases before and after May 4th. Two scenarios for a mitigation of are shown depending on the efficiency in respecting social distancing and social tracing.
Scenario B: a strong social contact rate reduction can be not sufficient.
Scenario C: Further inclusion of social tracing and quarantine are mandatory.

C. The results for Lombardy

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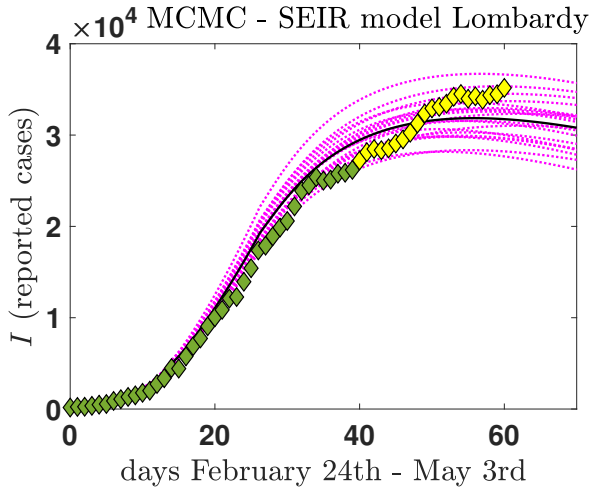

FIG. 7. The reported cases analysis of Fig. 2 for Italy is here specified for Lombardy data and predictions. The Model is consistently parametrized on the Lombardy data (see [14, 15]) within a specifc MCMC procedure (see Notes).

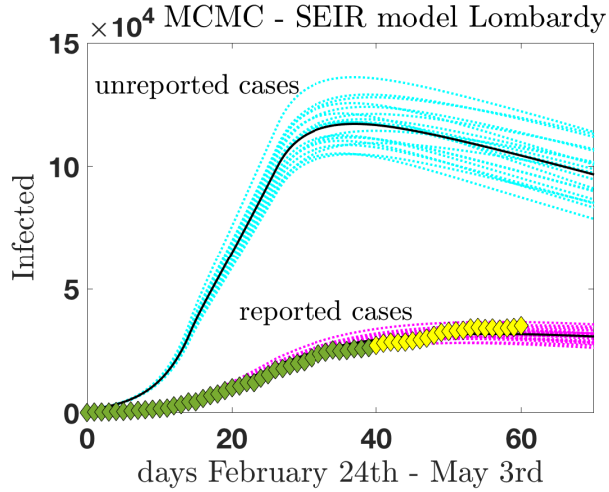

FIG. 8. As in Fig. 3 for the Lombardy population.

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