MUR
Ministero dell'Università e della Ricerca

Politecnico di Torino
Dipartimento di Scienze Matematiche "G. L. Lagrange"

Integrated Mathematical Approaches to Socio-Epidemiological Dynamics

PRIN 2020 Project

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Reference ERC panels

PE1 Mathematics

- **PE1_10** ODE and dynamical systems
- **PE1_18** Scientific computing and data processing
- **PE1_21** Application of mathematics in industry and society

Research Context

The primary aspect of the outbreak of an epidemic is the loss of human lives, to which policymakers try to remedy. However, the socio-economic impact of a pandemic goes well beyond contagion and recovery dynamics and the reckoning of infected and recovered individuals. Yet, mathematical models traditionally used to describe epidemiological dynamics focus mainly on such aspects. While these models may provide a deep understanding of the dynamics of epidemic spread, such information is often not sufficient to make them effective support tools for the socio-economic management of an epidemic. In fact, policymaking in an epidemic requires to consider also individual, economic and social interconnected aspects, which may in turn have an influence on the dynamics of the epidemic itself. This has recently been exemplified by the Covid-19 pandemic, whereby authority decisions and the individual behaviour proved to be key in the evolution of the epidemic, whereas non-linear phenomena related to contagion dynamics played a minor role because, except in some limited contexts, the fraction of infected individuals has been always relatively small.

Goals and Expected Results

In this project, we address the interplay between epidemic spread and socio-economic phenomena connected with it. This will be done by developing and combining different modelling methods – ODE/PDE-based microscopic, kinetic and macroscopic models – and related analytical and numerical techniques. When feasible, the models will be extended to allow for stochastic factors to elucidate possible new features arising from randomness. We will pursue a data-oriented approach by integrating mathematical models with empirical epidemiological and socio-economic data for model validation and calibration. The ultimate goal is to provide a holistic support paradigm for the management of epidemics, which will help address socio-economic implications of a pandemic with a rational and quantitative mathematical-physical approach. To this aim, the research group includes experts in different fields, from kinetic theory to classical epidemic models, numerical computation, medical statistics. We expect our models to provide a more well-rounded perspective on epidemic dynamics, which will encompass different behavioural, economic and social factors. These models will potentially help optimise policymaking processes, e.g. by maximising the effectiveness of intervention measures and limiting the negative consequences of both the epidemic itself and of containment measures. As demonstrated by the management plans developed for the Covid-19 pandemic, outbreak control measures are currently conceived on the basis of a systematic analysis of contagion spread, whilst socio-economic aspects are taken into account in a methodologically less rigorous manner. One of the reasons is that, to date, a systematic mathematical-physical paradigm incorporating socio-economic dynamics as a fundamental component of epidemic spreading is still missing.

Project Structure

The main topics addressed by the project are:

T1 Multiscale modelling of structured/networked social contacts

T2 Behavioural and socio-economic epidemiological models

T3 Control and optimisation problems towards policymaking

T4 Data-oriented modelling and uncertainty quantification

They are organised in the following Work Packages:

WP1 Epidemiological models with space structure and for structured populations

WP2 Multiscale modelling of individual and collective contagion dynamics

WP3 Interplay between epidemic spreading and opinion formation processes

WP4 Socio-economic impact of epidemics

WP5 Crowd dynamics and small scale contagion spreading

WP6 Numerical methods for structured/networked models with uncertain parameters

WP7 Epidemiological data analysis and uncertainty quantification in epidemiological models

Research Units

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