Tuesday, July 24th, 10:30 **Room: C8.2.06**

MINISYMPOSIUM

EPIDEMIC MODELS: FROM INDIVIDUAL DECISION TO COLLECTIVE DYNAMICS

Organizer:
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Minisymposium Keywords: Behavioral epidemiology, Vaccination coverage, epidemic, epidemic propagation

Mathematical epidemiology produces many models to describe the epidemic propagation; however, until recently, the individuals were treated as ”mechanical particles” who react to external stimuli in a pre-defined fashion. However, experimental data suggests that the decisions that people make influence in a non-negligible way the overall epidemic dynamics, i.e., the dynamics depends on the behavior of the individuals. The decision can appear at several levels:

• for vaccine-preventable diseases (when vaccination is not compulsory) the individual (or his/her parents) can decide whether to vaccinate or not (the so called ”vaccination games”): although the decision of a single individual does not influence the course of the epidemic, the overall sum of individual decisions have a strong impact and has to be taken into account by the public health authorities;

• when the prevention measures are expensive (in terms of time, money, ...) the amount of prevention is a decision variable (for instance it can depend on the infection risk);

• the information spread on social networks can lead to vaccination decisions related to what close acquaintances have done.

The goal of this mini-symposium is to bring together researchers interested in the mathematical models that quantify this impact of individual level decisions to the overall epidemic dynamics.

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PUBLIC HEALTH INTERVENTION IN BEHAVIORAL VACCINATION MODELS: ANALYSIS AND CONTROL

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Joint work with Alberto d'Onofrio (IPRI-Lyon), Piero Manfredi (University of Pisa), Rossella Della Marca (University of Parma)

Keyword: Behavioral epidemiology.

When children vaccination is not mandatory, the choice to vaccinate or not vaccinate children is often the result of the balance between two perceived risks: the risk of infection and the risk of side effects caused by the vaccine. This phenomenon is known as rational opposition (or pseudo-rational exemption) to vaccination. The rational opposition is paradoxically due to the vaccine–induced rarity of many infectious diseases and may result in a decline in vaccination coverage and consequently an increased risk of future resurgence of infection [1] (see also A. d'Onofrio's talk in this minisymposium). However, the *Public Health System* (PHS) may enact public campaigns to favor vaccine uptake.

In this talk we present some very recent results in the framework of behavioral epidemiology [2] concerning the interplay between private vaccination choices and actions of PHS to favor vaccine propensity [3, 4, 5] The impact of key 'components' on the disease transmission are investigated, including seasonality, latency time and, of course, human behavior. The main tools used include qualitative analysis of dynamical systems and optimal control theory.

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VACCINE OPINION DYNAMICS: IMITATION GAME RELOADED

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Keywords: Behavioral Epidemiology, Imitation Game, Vaccine Hesitancy.

Behavioural Epidemiology of Infectious Diseases (BE) [6] is the new discipline that aims at modeling the role of human behavior in the spread and in the control of Infectious Diseases. BE stemmed from the fact that classical behavior-free mathematical models based on statistical mechanics are often not adequate to describe the complex challenges induced by the Post-Trust Society.

In presence of a widespread vaccine hesitancy, for example, it is fundamental to model the dynamics of vaccine propensity (VP) that is determined by the out–balance between information on the disease spread and information and rumors on (real and imaginary) vaccine-related side effects [9]. Moreover it is of relevance also the modeling of actions enacted by Public Health authorities to favour vaccine uptake [10] (see B. Buonomo's talk in this Minisymposium).

A classical tool of BE to represent the vaccine propensity dynamics is the imitation game dynamics (IGD) [8, 9, 10], a classical tool of Game Theory frequently used in Theoretical Economy. In this Talk we will review some recent results on IGD in BE (and on its limitations).

In particular, we will shortly illustrate:

- Economy–free modeling of IGD as a double contagion of ideas [7]
- The interplay between IGD of VP and the demographic changes in the target population [11]
- Modeling of irrationality [12]
- Going beyond imitation Dynamics [13]

Other important topics such as putting the IGD for VP in the right economic context will be illustrated in the B. Buonomo's talk.

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SOCIAL DISTANCING EPIDEMIC GAMES, DIAGNOSIS, AND INCOMPLETE INFORMATION

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Keywords: Epidemic game, Infection risk, Prevention and infection risk, Incomplete information decision.

Within the epidemic game literature, there is a disagreement over whether increases in infection risk can discourage prevention. In one theory, increases in infection pressure motivate prevention, while in another, there is a turning-point beyond which investments drop off. The discrepancies between these theories can be resolved by modeling diagnosis events explicitly. A unified theory exhibits a turning-point in the optimal social-distancing response to infection pressure. The turning point is a consequence of decision making under incomplete information. With reliable diagnosis, prevention always offsets infection risk. Without reliable diagnosis, individuals may be best-off assuming they are infected once infection pressures are sufficiently high. This creates a public-health trap with high prevalence that can not be escaped by unilateral action. After estimate conditions for HIV, it seems the turning-point effects may contribute to traps for core-groups found in some sub-Saharan countries.

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A MEAN FIELD GAMES APPROACH TO IMPERFECT VACCINATION

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Keywords: Individual vaccination strategies, Mean field games.

We analyze a model of agent based vaccination campaign against influenza with imperfect vaccine efficacy and durability of protection. We prove the existence of a Nash equilibrium by Kakutani's fixed point theorem in the context of non-persistent immunity. Subsequently, we propose and test a novel numerical method to find the equilibrium. Various issues of the model are then discussed, such as the dependence of the optimal policy with respect to the imperfections of the vaccine, as well as the best vaccination timing. The numerical results show that, under specific circumstances, some counter-intuitive behaviors are optimal, such as, for example, an increase of the fraction of vaccinated individuals when the efficacy of the vaccine is decreasing up to a threshold.

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[13] A. d'Onofrio, P. Manfredi (2018) *Dynamics of vaccine propensity nder voluentary vaccinations: going beyond the imitation game dynamics* (submitted).