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BRIDGING "WOULD BE" AGENT-BASED WORLDS WITH THE EMERGENT REAL-WORLD EPIDEMIC DYNAMICS

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What is usually done with detailed agent-based epidemic simulators for the analysis of the emergent dynamics and/or the investigation of different intervention strategies- such as vaccination and/or quarantine- is running many scenarios with different initial conditions and for long times to get the relative macroscopic information. However this is rather a trial and error- approach, time consuming and thus insufficient for systematic computations.

From an applied perspective, poor understanding of the evolving emergent macroscopic epidemic dynamics may have negative consequences in risk-management and control-policies decisions. For the systematic analysis of the emergent epidemic dynamics and the design of efficient control strategies a prerequisite is the availability of reasonably accurate dynamical models as these arise in the form of Ordinary and/or Partial Differential Equations. However real-world situations are characterized -due to their complexity (including but not limited to heterogeneities in the characteristics of the (finite size) population and the contact transmission network) and uncertainty (including for example parameter and model inaccuracies) - by the lack of such good explicit, coarse-grained macroscopic evolution equations in a closed form. Hence, in the lack of such coarse grained models, conventional numerical and control algorithms cannot be used directly for systems level analysis and the design of efficient control policies.

The systematic bridging of the scale where good and detailed agent-based models may be available and the emergent-macroscopic scale where we want to investigate the dynamics of the spread, design and control its behavior, constitutes a major challenge in contemporary epidemiology. Multi-scale computational methodologies that can tackle the above problem have the potential to advance further better mathematical modeling, understanding, predicting and designing of better public health strategies to combat emergent epidemics.

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I will show how the so called Equation-Free multiscale modelling framework [1] can be used to effectively analyze certain aspects of the dynamics of agent-based epidemic simulators on networks [2, 3, 4]. I focus on the efficient systematic investigation of the dependence of the emergent dynamics with respect to epidemiological and contact transmission network parameters by constructing the coarse-grained bifurcation diagram, the identification of critical points that mark the onset of outbreaks, and the analysis of rare-events that may trigger outbreaks of phenomenologically latent infectious diseases. Based on the proposed methodology, I also present results on the analysis, forecasting and design of control policies for the Ebola epidemic that swept through the countries of West-Africa, especially in Liberia and Sierra Leone within 2014 and 2015 [5, 6].

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