Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Computer Science 18 (2013) 631 – 640

Procedia Computer Science

2013 International Conference on Computational Science

Impact of Preventive Behavioral Responses to Epidemics in Rural Regions

P. Schumm[1], W. Schumm[2], and C. Scoglio[1]*

[1] *K-State Epicenter, Electrical and Computer Engineering Department*
[2] *Family Studies and Human Services School*
Kansas State University, Manhattan, Kansas, USA

Abstract

Various epidemics have arisen in rural locations through human-animal interaction, such as the H1N1 outbreak of 2009. To study the spreading of infectious diseases in rural regions, we have surveyed a rural county and its communities, and collected a dataset characterizing the rural population. From the respondents' answers, we build a social (face-to-face) contact network. With this network, we explore the potential spread of epidemics through a Susceptible-Latent-Infected-Recovered (SLIR) disease model. We simulate an exact model of a stochastic SLIR Poisson process with disease parameters representing several infectious illnesses. To explore an array of potential diseases, we vary the infection rate across the spectrum of outbreaks and quantify the social network susceptibility through the whole spectrum. The extent to which social dynamics can control the spreading process is studied across this disease strength spectrum. We explore two models of a susceptible individual's dynamics in response to infections observed among the individuals in his neighborhood, namely preventive behavior adoption and social distancing. Through extensive simulations, our investigation reveals the potentially powerful impacts of social spontaneous responses in rural settings. We compare the strategies over the spectrum, and demonstrate that behavioral responses are most effective in the intermediate range of infection strengths.

Selection and peer review under responsibility of the organizers of the 2013 International Conference on Computational Science

Keywords: human epidemics; data driven modeling; contact network; disease prevention and control; vaccination; preventive behavior

* Corresponding author. Tel.: +1-785-532-4646
E-mail address: caterina@ksu.edu.

Selection and peer review under responsibility of the organizers of the 2013 International Conference on Computational Science
doi:10.1016/j.procs.2013.05.227

1. Introduction

In general, the spread of infectious diseases can be contained by human response using different approaches. When vaccines are not available, it is important to resort to spontaneous changes in individuals' behavior toward contagion-preventive habits. Modeling spontaneous human reactions to the spread of infectious disease is an extremely important topic in current epidemiology [1], and has recently attracted substantial attention. A review of the existing results on the interaction of the epidemic spreading and the human behavior can be found in [2]. In particular, Poletti et. al. developed a population-based model where susceptible individuals could choose between two behaviors in response to presence of infection [3]. Funk et. al. showed that awareness of individuals on the presence of a disease has interconnected dynamics with the disease itself, and awareness can help reducing the epidemic size [4]. Perra et. al. [5] considered the case where individuals go to a "feared" state when they sense infection. Since most of the existing results are for population-based models, they are suitable for a society of well-mixed individuals. Concerning individual-based models, a new model, in which an "alert" state is considered, has been proposed in [6]. In any case, assessing the effectiveness of mitigation strategies and behavioral responses both from a public health point of view and from individuals' perspectives is a complex and not fully-explored problem. In particular, a thorough evaluation and comparison of feasible mitigation strategies in the specific setting of rural regions is missing. In other words, not only the amount of success a given strategy can provide is not determined, but also its related cost in economical and social terms is unknown.

In this paper, we carry out extensive simulations on a weighted contact network determined by collected data in the City of Chanute and Neosho County in the State of Kansas. In particular we study the impact of contact reductions [7] and social alertness [6] as mitigation strategies over a spectrum of disease strengths. Our contribution consists in providing a thorough analysis and comparison of mitigation strategies in a rural region. We derive results on which mitigation strategy has greater potential to be efficient as a function of the epidemic strength. We expect that our results can guide the development of practical guidelines for health officials to contain and suppress epidemics in rural regions. We describe data collection and analysis in section 2. Section 3 includes the models descriptions for the network, for the epidemic spreading, and also for mitigation strategies. In section 4, results are presented and discussed. Finally section 5 concludes our article.

2. Data Collection and Analysis

As of the 2010 U.S. Census, Neosho County was a rural county with 16,512 residents in 571.5 square miles in southeastern Kansas. Most of the population was White (94.1%); a majority were female (50.6%) and many (17.4%) were 65 years of age or older. The median household income was $36,702 with 17.0% living below the poverty level. Between July and October 2010, the towns of Chanute, Thayer, and Galesburg were selected to participate in a survey concerning factors that would predict the spread of epidemics in rural areas. The final number of available and eligible households were 143, 65, and 162 in Thayer, Galesburg, and Chanute, respectively, with total $N = 370$. A tailored design method was used to incentivize survey responses obtaining a final overall response rate of 65.4%.

A majority (56%) of the respondents reported being from Chanute compared to 23% from Thayer and 10% from Galesburg (the remaining percentage did not specify). Of the 357 participants, the largest number were ages 45 to 64 (47.1%), with 26.1% 65 years of age or older and 18.8% (26-44) and 8.1% (18 to 25) younger than 45. Due to rounding, the percentages do not sum to 100.0. In the following, we report two key results. In terms of compliance, nearly 49% of respondents said they would still visit at least one or two households