Health Care Manag Sci (2015) 18:318–333
DOI 10.1007/s10729-014-9310-2

Effect of individual protective behaviors on influenza transmission: an agent-based model

Elnaz Karimi · Ketra Schmitt · Ali Akgunduz

Received: 9 October 2013 / Accepted: 5 November 2014 / Published online: 13 January 2015

Abstract It is well established in the epidemiological literature that individual behaviors have a significant effect on the spread of infectious diseases. Agent-based models are increasingly being recognized as the next generation of epidemiological models. In this research, we use the ability of agent-based models to incorporate behavior into simulations by examining the relative importance of vaccination and social distancing, two common measures for controlling the spread of infectious diseases, with respect to seasonal influenza. We modeled health behaviour using the result of a Health Belief Model study focused on influenza. We considered a control and a treatment group to explore the effect of education on people's health-related behaviors patterns. The control group reflects the behavioral patterns of students based on their general knowledge of influenza and its interventions while the treatment group illustrates the level of behavioral changes after individuals have been educated by a health care expert. The results of this study indicate that self-initiated behaviors are successful in controlling an outbreak in a high contact rate location such as a university. Self-initiated behaviors resulted in a population attack rate decrease of 17 % and a 25 % reduction in the peak number of cases. The simulation also provides significant evidence for the effect of an HBM theory-based educational program to increase the rate of applying the target interventions (vaccination by 22 % percent and social distancing by 41 %) and consequently to control the outbreak.

E. Karimi · A. Akgunduz
Department of Mechanical and Industrial Engineering, Concordia University, Montreal, QC, Canada

K. Schmitt (✉)
Centre for Engineering in Society, Concordia University, Montreal, QC, Canada
e-mail: ketra.schmitt@concordia.ca

Keywords Influenza · Agent-based simulation · Health belief model · Individual behavior · Effectiveness

1 Introduction

Influenza outbreaks are a significant source of morbidity, mortality, hospitalization and work loss every year. These outbreaks lead to approximately 7,000 to 49,000 deaths, 3.1 million hospitalizations and a total economic burden of $87 billion in the United States alone [1]. These data clearly indicate that preventing and managing seasonal flu can result in significant public health improvements. Since seasonal influenza is predictable, it has the potential to be controllable with evidenced-based management strategies [2, 3]. While these strategies won't eliminate flu, better management can greatly reduce the number of individuals impacted as well as the severity and duration of illness. The impact of strategies like vaccination, quarantine and school closures on the control of these outbreaks has been extensively studied. However, the approaches that have been studied general fail to consider the self-initiated protective behaviors that individuals develop in the face of an infectious disease.

In the event of a disease outbreak with a high attack rate in a population, it is likely that much of the behavioral control would be done through personal protective behavior, such as vaccination or social distancing. Decreasing the amount of contact between infected and susceptible individuals by encouraging them to avoid crowded places or close physical contact with each other could slow the outbreak and lower its peak [4, 5]. For instance, during 1918 influenza pandemic, people developed self-isolation behaviour and avoided places where they might come into contact with others [6]. A high rate of personal protective behaviors such as vaccination, self-isolation, physical distancing, antiviral drugs, masks etc. in a population could have a significant impact on the severity of