Modeling Infectious Diseases Dissemination Through Online Role-Playing Games

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Abstract: As mathematical modeling of infectious diseases becomes increasingly important for developing public health policies, a novel platform for such studies might be considered. Millions of people worldwide play interactive online role-playing games, forming complex and rich networks among their virtual characters. An unexpected outbreak of an infective communicable disease (unplanned by the game creators) recently occurred in this virtual world. This outbreak holds surprising similarities to real-world epidemics. It is possible that these virtual environments could serve as a platform for studying the dissemination of infectious diseases, and as a testing ground for novel interventions to control emerging communicable diseases.

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Mathematical modeling is important in the study of infectious diseases and the development of public health policies. Even so, agent-based modeling and similar simulations are limited in their potential to account for changes in human behaviors during epidemics. This has led to searches for novel methods to simulate human daily interactions.[1,2]

One possibility lies in existing Internet role-playing games. The numbers of participants in these virtual worlds have grown rapidly since 1996, involving millions of players engaged in interactive play. Each world develops its own economy, with production, assets, and interactive trading with Earth economies.[3] These virtual worlds are realized in meticulous detail, and are inhabited by characters played by real people worldwide, as well as by nonplayer characters controlled by set programs. These different types of characters have varied and complex options for interacting with each other—an environment that may be suitable for testing dissemination patterns of infectious diseases.

The possibility of epidemics in these virtual worlds is not merely academic. A serious epidemic of an infectious disease[4] recently erupted among the virtual characters in "World of Warcraft," one of the most popular multiplayer online games.[5] Although the disease had been created by game administrators, its consequences were unanticipated.[4] Information on this outbreak was retrieved from players' forums, allowing insights on dissemination patterns in this virtual outbreak and on the potential of these virtual environments for modeling infectious disease outbreaks and control.

OUTBREAK DETAIL

The outbreak began on late September 2005 when the "World of Warcraft" game administrators introduced a new virtual creature that had the ability to cast a disease ("corrupted blood") on its opponents. In addition to inflicting severe damage on the target character, the disease "infected" close contacts who could spread the disease to others in close proximity.[6] Game administrators presumably believed that the short period of infectivity (several seconds), as well as its highly lethal effect, would render the disease self-limiting. This proved not to be the case.

The pandemic plague that resulted is unique. Unlike previous "virtual plagues" that had been officially planned, this was a local effect that went out of control—a naturally occurring virtual outbreak. In the words of one player, "What happened next was just plain weird. When infected adventurers returned to town at the end of their quest, they inadvertently passed along the Corrupted Blood infection to those nearby. In short order, the plague ravaged the population. Game administrators were baffled. As they scrambled to quarantine areas of the game world, the disease quickly spread beyond their control. Partially to blame was the game's feature that allows players to teleport from one area to another, and which made it possible for the plague to rapidly reach the most distant regions of the map."[6]

According to information from various Internet blogs, several epidemiologic attributes enabled this uncontrolled dissemination of the disease. One was the lack of residual immunity following convalescence. This enabled characters to be reinfected and re-enter the transmission cycle. The second characteristic was its infectivity to the virtual animals ("pets"). While pets were relatively resistant to the lethal effects of the disease, they were infective to other pets and humans, thus serving as a disease reservoir. Continuous cycles of the disease between pets and humans could therefore allow the infection to simmer until the group reached densely populated areas. Third, ill characters could teleport, thus introducing a disease with short infectivity period through large distances. Lastly, once the plague reached the cities, it did not just infect other players but also the nonplayer characters of the city, providing a large "bystander" population that also spread the disease.

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COMMENT

This plague is the first unplanned large-scale virtual infectious disease in game worlds. There have been smaller unplanned outbreaks. In May 2000 players of "The Sims" were outraged when their game characters died of an infection contracted from virtual guinea pigs that had not been adequately cared for.[7] However, this recent outbreak was substantially larger and more complex in its evolution and outcomes. This could be in part due to the detailed environment and character interactions in "World of Warcraft."

Some events in this outbreak are surprisingly similar to recent emerging infections. The role of an asymptomatic-yet-infective animal reservoir, for instance, is evident in avian influenza. Asymptomatic ducks had an important role in allowing this otherwise relatively lethal avian disease to become endemic in East Asia and spread to other parts of the world.[8] Furthermore, attempts by game administrators to quarantine infected areas proved futile due to the ability of characters to rapidly teleport to distant lands. This is similar to the role of air travel in the rapid global spread of severe acute respiratory syndrome (ie, SARS).

Some observers have suggested that the unexpected spread of this virtual infection was the deliberate strategy of malicious players. It is possible that players were able to sustain the transmission cycle of the disease by keeping in close contact with another player while constantly healing each other until they reached populated cities. If so, this incident may also count as the first virtual act of bio-warfare.

Mathematical modeling experts may find some utility in this outbreak as a case study, applying models to predict future disease dissemination and adequacy of various interventions.[1,2] The basic reproductive rate in virtual illnesses can be quantified, the population-specific force of infection can be assessed, and predicted outcomes can be compared with actual events influenced by player-dependent behaviors.

Multiplayer online role-playing games may even be useful as a testing ground for hypotheses about infectious disease dissemination. Game programmers could allow characters to be inflicted by various infectious diseases, some of which may not be visible to the player, and track the dissemination patterns of the disease in specific subpopulations. For example, modes of transmission could be defined for automated nonplaying characters whose behavior and mixing patterns are set, as well as for human-directed characters whose behavior is difficult to predict. Various interventions could be tested, including treatment (either freely dispensed or sold), vaccination, isolation and quarantine.

While the parallels with a real-world outbreak are striking, the artificial nature of the games limits them as models for the real world and might even lead to misleading conclusions about real infectious outbreaks. The mixing patterns and interactions among the game figures may be considerably different from those in real life, and would depend heavily on the rules and goals of the game. The most obvious example would be the risk-taking behavior of virtual characters, which depends heavily on the penalties for death or illness and the availability of a "game saving" option.

FIGURE 1. Epidemic in the World of Warcraft.

Despite these limitations, there could be advantages to studies in virtual worlds. The mixing patterns and behavior observed in the game can be precisely measured and accounted for (without the usual epidemiologic problems of incomplete ascertainment or loss to follow-up). Furthermore, the rules and environment could potentially be adjusted to allow better modeling of specific real-life scenarios. (Admittedly, this approach depends on the ability to make these changes without undermining the essential pleasures of the game.) Expert modelers of infectious diseases might consider collaborating with the game's administrators. Such collaborations could harness the immense computational power invested in these economically-driven, large-scale virtual environments, while allowing simulations more wide-ranging than any options currently available.

The game's administrators eventually cured the plague with a "spell" that was distributed rapidly to players en masse.[6] If only real life were that simple.

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