SCHOOL OF INDUSTRIAL ENGINEERING

SEMINAR

Hospital Stockpiling for Influenza Pandemics

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ABSTRACT

This dissertation addresses the problem of stockpiling of medical supplies for networks of hospitals in anticipation of flu pandemics. The objective of this research is to provide engineering reasoning to support public health and practitioners making more effective pandemic stockpiling decisions. Specifically, we consider the problem of determining the stockpile quantity of a single medical item for each hospital. We take into consideration hospitals' mutual aid relationships with which each can borrow from or lend to others when needed. Moreover, we incorporate surge demand redistribution among hospitals to ensure that community needs are appropriately accounted for.

In this research, the hospital stockpiling problem is modeled as three different noncooperative strategic games. The first model is a generalized game in which each hospital is assumed to have a probability of responding to pandemics. It considers all response outcomes of a network of hospitals and different flu scenarios. Each hospital selects its stockpile level while minimizing its expected stockpile cost. We prove the existence of a Nash equilibrium and develop an algorithm to identify a set of stockpile levels that represent an equilibrium solution. We apply this approach to a set of hospitals in a large metropolitan area and demonstrate the equilibrium stockpile levels, from which we draw managerial insights and policy implications of the solution concept.

In the second model, each hospital pre-determines its pandemic response level. Taking into account all the response levels, each hospital then decides the stockpile level that minimizes its expected cost. We adopt a sampling approach to estimate the expected stockpiling cost for each hospital. We further discover that the Nash solution of the game is sensitive to hospitals' pre-determined response levels. Analyses using this model suggest the central planner (such as the local government or public health) design a pandemic planning mechanism such that hospitals in the community would make stockpile decisions least costly to the system.

The third game model adopts a linear demand function to approximate demand redistribution among hospitals during a pandemic. Each hospital makes its decision on stockpile level based on its expected demand and selects the best decision that maximizes its overall net reward. We assume that a hospital's own stockpile has positive impact on its demand level while the other hospitals' stockpile levels have negative impact on its demand level. We prove the existence of a Nash equilibrium in this game, and use an algorithm to identify a solution. The results show that public health or local government decision makers may utilize monetary incentives or subsidies to encourage higher system-wide stockpiling.

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