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Discrete-Event Simulation Engineering in Evaluation of Medical Treatment Capability against Biochemical Terrorist Attacks

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Abstract

Large-scale victims would flock to the nearest hospital in a short period of time against biochemical terrorist attacks. It better treat these victims within the "Golden Hour" as more as possibly. In this paper, we proposed a new method to predict the medical treatment capability with two steps. First of all, we built a model to calculate the number of victims arriving in hospital with Monte Carlo Simulation engineering method, and then simulated this model to generate the victims-flow arriving in hospital and made chi-square test to find out that these data distribution follow Poisson distribution approximately. Secondly, we built another model to calculate the medical treatment capability based on the generated data from the first simulation. As a result, we can get the capability and main factors influencing it. The parameters in these models and procedures can be adjusted depending on specific scenarios, so that they can be integrated in decision support systems of relevant engineering areas and play an auxiliary role for decision-makers in an emergency management.

Keywords:medical treatment capability;biochemical terrorist attacks;engineering ;discrete-event simulation engineering;

1. Introduction

Biochemical terrorist attacks refer to the activities whose goals are to produce fear in the population with a subsequent disruption of society[1],such as Sarin gas incident which occurred in Matsumoto city on June 27,1994 and again at Tokyo subway in 1995.These attacks all brought on tremendous loss of personnel and property .According to historical lessons and biochemical materials' peculiarity, it's known that if such terrorist attacks happened, most people would seek for treatment in near hospitals by themselves except that a few persons, who weren't able to walk due to attacks, would have to wait for ambulance rescues. The Aum Shinrikyo event indicated that almost 14 to 15 times as many people as were estimated to be actually symptomatic will show up at hospitals, requesting treatment. Therefore, there would be large demands for medical treatment, and the hospital would be in a crowded state called "surge capacity"[2].Above researches are relevant to problems how to reduce and alleviate crowded scenes in emergency departments[3],but they have unique characteristics. Morbidity and mortality are affected if care is not instituted with the first hour after injury [4].

Predicting the medical treatment capability exactly is very critical regardless of natural disasters or biochemical terrorist attacks that lead contagious diseases happen[5,6].According to Larson's researches, even if victims were successfully diagnosed, antibiotics were distributed broadly and drug adherence was high, two pounds of weapons-grade anthrax dropped on a large city could result in more than 100,000 deaths. The reason for the catastrophic

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death toll: Not enough people would receive antibiotics quickly enough to prevent symptom from developing, and those who developed symptoms would overwhelm the medical facilities[7].However, if decision-makes could know the hospital's medical treatment capability in advance, they would transport victims exceeding the capability of the hospital to other hospitals, or transport doctors from other hospitals to the hospital dynamically to improve the emergency treatment performance.

Many researchers have developed issues on the medical treatment capability in various perspectives: References [8-12] discuss simple Queuing Theory and transient Queuing Theory approach. The simple Queuing Theory is just adaptive to the scenario that is steady system which the process is time invariant. For a system having a large number of victims, the transient approach becomes infeasible[12].On the other hand, References [13-15] all adopted discrete-event simulation methods to analyze resources utilization, staff level, proper layout in emergency rooms, and related problems on emergency. These approaches can handle with large-scale victims scenarios because Monte Carlo simulation is relatively insensitive to the size of the state space.

We decide to use discrete-event simulation method to formulate a series of models, based on the assumption of a biochemical terrorist attack scenario that is consistent with true world, comparing with aforementioned researches. These models are simulated subsequently. In this way, we can get the medical treatment capability of a hospital against a specific biochemical terrorist attack.

2. Scenario Assumption

The place of our research is set against a certain large subway station, such as a subway station of Line One in the city of Beijing taken as an example. These destinations are often be targeted as the place of terrorist attacks for terrorists because of large-scale people. Based on the observation we make at the station and scattered problems in reference [14], our models involve the following scenarios.

There are always two subways arriving in opposite at the subway station, and every subway has six carriages, and each carriage can admit 245 persons more or less. So it adds up to 1,470 persons when the subway is full of passengers, and there exists almost 2,940 persons when the two subways arriving at the station at the same time. During the peak periods, such as morning, the carriage can admit 300 persons, so the passengers of the two subways are added up to 3,600 persons approximately. Thus, the station can hold up passengers at least from 1,700 persons to 2100 persons, and at most from 3,300 to 4,200, including about 300-600 persons waiting for subways on platform. On average, there exists about at least from 700 persons to 900 persons, and at most from 1,700 persons to 2,000 persons.

It is known that victims would spend at least five minutes on walking from the station to arrive the nearest hospital if a biochemical attack happened. Therefore, few victims would arrive at hospital during the first five minutes of the “Golden Hour”. Likewise, most persons would have arrived at hospital before an hour, so few victims would arrive in hospital during the last five minutes of the “Golden Hour”, too. As a result, we mainly simulate the scenario that victims arrive in hospital between 5 minutes and 55 minutes of the “Golden Hour” after the attack happened.

We built two models in terms of time based on the above scenarios:(1)Model of Arrived Victim in a hospital(2)Model of Medical Treatment Capability of a Hospital. In what follows, we present our methodology.

3. Model of Arrived Victims in a Hospital and Simulation

3.1. Model of arrived victim

Based on the above assumption, we formulate the following notations.

Let's first introduce our notation, let $D = \{d_1, d_2, \cdots, d_n\}$ denotes the set of the places in the emergency, and let $T = \{t_1, t_2, \cdots, t_m\}$ denotes the set of the time in the emergency, and let $S = \{s_1, s_2, \cdots, s_l\}$ denotes the set of the places of the hospitals in the emergency, and let $A_{d_i t_j}$ $(d = 1, \ldots, n; \; t = 1, \ldots, m)$ denotes the number