Computer simulation as a tool for testing disaster preparedness

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ABSTRACT:

BACKGROUND: Tests of disaster preparedness are usually done in full-scale exercises or simulations exercises. If simulations exercises could be performed using computer technique it could probably be easier and more cost effective. The key issue is to relate results to patient outcome. The aim of this paper is to present results from initial tests of a computer simulation program.

MATERIAL AND METHODS: A simulation program has been developed on the commission of the Swedish national board of health and welfare based on a Med Model® software. Three different scenarios were tested. Of the many different aspects that can be tested using this program we chose: 1) time when all patients arrived at hospital related to the activation of disaster plan, 2) the time before need of operation exceeded capacity, 3)) the time before need of intensive care (ICU beds) exceeded capacity and 4) patient outcome.

RESULTS: There was a time difference of at least 30 minutes before all patients had arrived at the hospital if disaster plan was activated or not. After four hours there will be a need for extra capacity of ICU beds. In all tested scenarios there will be a risk for unfavourable outcome of the patients.

CONCLUSIONS: Aspects of disaster preparedness can possibly be tested using computer simulation. Computer simulation is time saving and probably cost effective.

Introduction

Computer simulation is a tool that today is frequently used in different fields. One of these fields is the Medicare system. So far computer simulation has only been sparsely used for disaster planning (1). Tests of disaster preparedness have often been carried out as live exercises or tabletop exercises. However if computer simulations could be performed in this area it has a potential to be more cost-effective when evaluating the disaster preparedness.

Generally, disaster preparedness is based on the assumption that certain incidents can occur (2). This also includes incidents that occur on a daily basis like traffic accidents. Different scenarios and their possible consequences are some of the factors considered when planning the disaster preparedness. However, since most incidents and disasters have their own characteristics, a simulation system for testing disaster preparedness in computer environment would increase the possibilities to test different scenarios as well as changes in response.

A simulation system based on previously used computer software was developed on the commission of the Swedish national board of health and welfare at the Centre for Teaching and Research in Disaster Medicine and Traumatology in Linköping, Sweden.

The aim of this paper is to present results from initial tests of this system and thereby raising the question if this could be a future system where agreed upon variables could be tested.

Materials and Methods

MedModel®, a software program previously used for the purpose of simulation in hospital settings, was used (3). The data needed for simulation of pre-and intra hospital disaster preparedness was entered in the program. These data consisted of a patient bank, a selected geographic area and the following data regarding resources:

1. Ambulance stations with the real capacity on different times of day and week were placed at the correct location.
2. The capacity of the emergency wards, as well as the capacity of involved hospital to send out triage teams to scenes of incidents
3. Three months of ambulance dispatches and transports in the selected geographic setting.
4. Extra capacity available i.e. surgical and intensive care units when disaster plan is activated.

We consider the patient bank the most important feature since this will make evaluation possible in relation to patient outcome. This patient bank comprises 20 different categories of patients where all patients in one category have the same need regarding measures performed and time frame in which they must be performed, figure 1. By a combination of patients from the categories, many different scenarios can be created.

Several different aspects of the disaster preparedness can be tested. Table 2. However in this test we chose to determine outcome of three different scenarios based on three different types of incidents at one specified location, Table 1. Each scenario (A =bus crash, B= indoor fire or C=train crash)

Table 1. Three scenarios tested in computer simulation.

Scenario	A	B	C
Type of scenario	buss crash	indoors fire	train crash
Total number of patients	30	130	305
Number of dead	0	5	30
Number high priority	10	25	75

Table 2. Possible aspects of disaster preparedness that can be tested using simulations system tested in this study. All aspects can be related to patient outcome

1. Effects of changes in ambulance organisation
2. Effects of changes in geographic locations of ambulance stations
3. Effects of same scenario in different places and on different times
4. Effects of times for response to high priority patients not involved in incident
5. Effects on operation capacity and ICU capacity
6. Effects of different strategies for medical treatment on site, transportation, or on hospital
7. Effects of times for activation of disaster plan
8. Effects of changes in disaster plan regarding resources
9. Effects of involvement of care providers outside own county council
10. Effects of sequential incidents on multiple sites

Table 3. The times in minutes from first alarm to time when all patients have arrived at hospital with and without activation of disaster plan.

Scenario	A	B	C
Disaster plan not activated	210	480	660
Disaster plan activated	180	310	390

Table 4. The time (in hours) from first alarm to the time when the need of operation theatres and ICU beds exceeds resources even when disaster plan resources are activated.

Scenario	A	B	C
Operation theatres	-	-	4
ICU beds	-	5	6

Table 5. Number of patients that risk unfavourable outcome (complication or death) because of lack of resources. Disaster plan resources are activated.

Scenario	A	B	C
Number	3	13	106

Patient category number	4
Available for rescue	After 5 minutes
Measures needed	I.v. fluid
Resource needed	Paramedic or nurse
Time frame	Within 60 minutes
Time for measure	6 minutes
Required before transport	No
If not met	Risk of unfavourable outcome
Measure	Stabilisation of fracture
Staff needed	Paramedic or nurse
Time frame	Before evacuation
Time	4 minutes

Figure 1. In-data from one patient category (number 4) in patient bank. There are all-in-all 20 different patient categories in the simulation program.

consisted of a realistic number and combination of patient chosen from the patient bank. The geographic setting chosen was a county with approximately 400 000 inhabitants and the resources used in the simulation was the resources specified in the actual disaster plan.

Although different aspects of disaster preparedness can be studied using this simulation system we chose in this test to focus on three variables: a) the amount of time it would take before all patients have arrived at hospital, with and without disaster plan activated, b) the estimated time when demand of operation theatres and/or ICU beds when disaster plan is activated and c) patient risk for unfavourable outcome.

By activating the disaster plan we mean that additional resources in forms of transportation capacity (ambulances), operation capacity and ICU capacity are available and a disaster management group is activated. Additional resources can of course, vary and is in this testing not the key issue but merely used to demonstrate that there will be differences in results if a disaster plan is activated or not.

It should be recognised that this model is based on an assumption that all decision made by a management group are correct in content and time.

Results

The time span from alert to time when all patients have arrived at the hospital was in scenario A (buss crash with 30 victims) 210 minutes without activation of disaster plan, and 180 minutes if plan was activated. Table 3. The results from the other scenarios show, in this respect, greater differences when activating plan or not. The estimated time until the demand of operation and ICU capacity exceeds the resources is shown in table 4. Only in the largest scenario (train crash) there will be a lack of operation capacity, but both in the middle size scenario (fire) and in the large scenario there will be a shortage of ICU beds, Table 4.

In all scenarios tested there is a risk of an unfavourable outcome. Table 5. In the largest scenario with more than 400 victims, 106 patients risk unfavourable outcome, that is risk for death and/or complication

Discussion

It is not until after an incident or disaster has occurred that there is a possibility to fully evaluate the disaster preparedness of an organisation. From a planning point or view there is therefore a need to in advance assess a possible outcome of incidents as accurate as possible in order to optimise the preparedness.

One way is to test the preparedness in full-scale disaster exercises. However, these must be planned, performed and evaluated very meticulously in order to be extensive enough for all functions to be tested. In comparison this option is reasonable expensive and cannot be used to often for several

reasons, availability of personnel being one. Another way is to test different scenarios in simulation models. This could be done either by different education and training systems or as a computer simulation (4,5). If the purpose of a simulation only is to evaluate disaster preparedness computerised simulation could well be the best option. The main advantages with these simulations are that it can be repeated many times and many different aspects of the preparedness can be studied in limited amount of time and to a very small cost. The main problem is how to construct a system that will show reliable results. In this paper we present results from a simulation using the software Med Model®. This program was chosen since it previously has been used in several different settings involving the Medicare system (3) and to our knowledge, there are no other simulation systems that have the functions we think are necessary. An important part is the patient bank. In our opinion, all training in disaster medicine should be related to patient outcome. The patient bank in this program is designed so that all patients have a pre-determined outcome if certain conditions are met or not. Fig 1. There are 20 different patient categories, all with different needs that need to be fulfilled within specified timeframes. This important data is in the process of being validated with a national trauma register as reference. The patient outcome when using this simulation system is to be considered as a performance indicator (2,6,7).

Scenarios are created by combination of patients (number, and from the different categories) from the patient bank. All different kinds and sizes of scenarios can thereby be created. We recommend that, in order to draw conclusions from results, realistic and standardized scenarios being used. We would like to encourage persons involved in disaster preparedness to suggest types and sizes that could serve as template when running the simulations. The program can handle several different scenarios (major incidents) in each session. The different scenarios can also be placed on different geographic locations so that effects can be evaluated when incidents occur at any distance from involved hospitals. A simulation with scenarios where incidents occur in sequence and where there is limited access to site of incident could be tested.

This simulation program makes it possible to study several different aspects of the preparedness, Table 2. In present paper we focus on some of these aspects as a demonstration. The results from these test simulation indicates that there is a risk for unfavourable outcome for the patients in all scenarios. The results also indicate the differences when disaster plan is activated or not.

Furthermore, this simulation also gives clues as to when there will be a need for additional (more than what the disaster plan stipulates) operation and ICU capacity. Showing this as a time span, gives a clue as how much time needed before the extra resources are needed and measures in order to prevent this shortage could be performed. After doing changes that is considered necessary, it is possible to repeat the simulation again and se the effects.

This simulation system also makes it possible to compare preparedness of different regions. A set of pre-designed incidents can be tested taken into account regional capacity, distances disaster plans etc. Comparisons can be made and this could serve as an instrument to determine how different regions in the best way can cooperate.

It is also possible to test different scenarios in computer simulation and compare results to other forms of simulation. Thereby there is a possibility to use the computer simulation as a template for what could be considered as optimal management.

The possibilities of using a simulation program like the one presented in this paper are numerous. However, it must always be remembered, a simulation is just what the word says and not the reality. Results must be interpreted with this in mind. But, since computer simulation is an accepted tool for many different purposes in a modern society, there is no reason why disaster preparedness should be an exception. The quality of the results is in this system, as well as in other systems, is depending on the reliability of the in-data. There is a need to validate both the in-data and the simulation program. Both these processes are in progress on commission of the Swedish national board of health and welfare.

Conclusions

Different aspects of disaster preparedness can possibly be tested using computer simulation program where results can be shown in relation to patient outcome.

Using simulation program for testing disaster preparedness is time saving and is probably cost effective.

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