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THE USE OF AN ARENA SYSTEM IN DEVELOPING AND IMPLEMENTING READINESS OF HOSPITAL MANAGEMENT TO DISASTROUS SITUATIONS

David Bregman, Dagan Gilat, Lion Levi

The College of Management, Information Systems Dept.
School of Business Administration, Tel-Aviv, Israel

Phone: 972-3-963-4276

Fax: 972-3-9634210

E-Mail: dudi@colman.ac.il

ABSTRACT

Introduction: Theoretically, simulation of disastrous situations has many advantages in that it prepares hospital staff to cope with the real scenario. We hereby describe our experience with developing and implementing the use of simulation software as a drilling technique used by Israeli hospitals.

Methods: The system is based on SIMAN/Arena software. Knowledge and database for a basic multi-casualties incident (MCI) was developed. It contains detailed casualties' description, to be compared with the real hospital capabilities (staff and infrastructure). A consensus committee decided on the crucial model issues and set the thresholds for quality performance indicators. Interfaces to the different hospital's information systems (IS) were developed and the various output documents of each exercised step were updated. Before drilling, the hospital managerial staff gets a notice and has to prepare the data on the anticipated resources. The simulation staff, as well as representatives from the hospitals, then conducts the limited scale drills (LSD).

Simulation System Scheme: The simulation model is implemented using Arena modules. The model holds all the simulation logic and user defined events which are implemented using VBA. The VBA block stores and retrieves information from the Microsoft Access Database and Microsoft Excel. This integration gives us the option to respond to various events of the simulation, the user interface and to produce reports from the database. We can also manipulate model information during the simulation.

Results: During the LSD, the trained hospital staff gets two kinds of input: copies of reports on patients entering the stations and has to feed its IS; timed phone notifications of problems in each station. During a 90-minute drill, the system provides 50 timely reports and 20 phone problems. The evaluation of the LSD is mainly based on the following: 1) observing the staff's ability to solve various problems; 2) constructing a detailed picture of the situation and avoiding bottlenecks; 3) measuring the effectiveness of the hospital's IS. The drill ends with a discussion. Conclusions are drawn from each drill in order to find methods for optimizing the conduct of the hospital. An animation tool proved to be useful in describing bottlenecks in the emergency room, diagnostic departments and operating rooms.

Conclusions: The system has been used widely for more than 4 years by all general hospitals in Israel as part of the preparation process for disasters. We found that simulation techniques and a preparatory limited scale drill has advantages in evaluating and improving the preparedness of hospitals in the management of an MCI before a full scale drill is carried out.

1 INTRODUCTION

The reaction of hospitals' senior decision-makers to rapidly changing situations during disasters is critical (Brisman et. al. 1989, Eldar and Adler 1987). Decisions concerning resource allocation and directing the flow of patients within the hospital have a direct influence on the outcome of patients. A suitable plan and successful training are essential for the improvement of the total functioning of the hospital.

Improved and economic methods, based on simulation models, have been developed recently and are successfully used in the regular planning and training programs of preparing hospitals in Israel for conventional and non-conventional disasters (Eldar and Adler 1987, Nissan and Eldar 1971, ACEP 1992, Levi et.al. 1997). In these models, a network of service stations represents the hospital. In each station, diagnostic and treatment services are provided, utilizing the available resources. One of the major criteria for evaluating the efficient functioning of the hospital is the avoidance of bottlenecks. This can be done by the appropriate allocation of resources of manpower and equipment, as well as by the appropriate direction of casualty flow (ACEP 1992, Levi et. al. 1997, Waeckerle 1991, Geva et. al. 1991, Cowan and Cloutier 1988).

The pre-set goals of the simulation system are to assist in all stages of preparation: 1) to evaluate the hospital disaster plan without activating the whole system. This is called a limited scale drill (LSD); 2) to train the decision-makers and to assist in managing real situations by identifying bottlenecks and evaluating possible solutions.

We hereby describe our experience with developing and implementing the use of a simulation system as a drilling technique used by Israeli hospitals.

2 THE LIMITED SCALE DRILL

The simulation drill is performed as two teams' game: the simulation team, and the hospital's trained senior management team. The trainers' team (the simulation staff) acts as a dynamic shell that simulates and reflects the design and functioning of the hospital; the external and prehospital organizations, and the development of events. The dynamic development includes various disaster events, patient flow (quantity, type and severity), local obstacles and adverse events, and the effects of decisions on the developing situations.

Before drilling, the hospital managerial staff (the trainees) gets a notice and has to prepare the data on the anticipated resources. The simulation team, which includes representatives from the hospitals, then conducts the limited scale drill (LSD). The simulation team generates with the aid of the system various pre-planned "events" announcements. These coupled with the flow of casualties simulates both external and internal environments, such as:

- 1) Casualties arrival at the hospital, their injury type and severity, their age and other specific characteristics (Figure 1).

Mortality	StagePriority	StageDescription	StageProbability	StageNumber	Inj.
0	1	TRiage	100	1	7
0	1	EXAMINATION & TREATMENT	100	2	7
0	2	X-RAY	100	3	7
0	2	OPERATION	15	4	7
0	1	HOSPITALIZATION	100	5	7

Figure 1: Injuries and Stages

- 2) Adverse and problematic events at that time, such as bottlenecks in overwhelmed locations of triage, diagnosis and treatment (Figure 2).

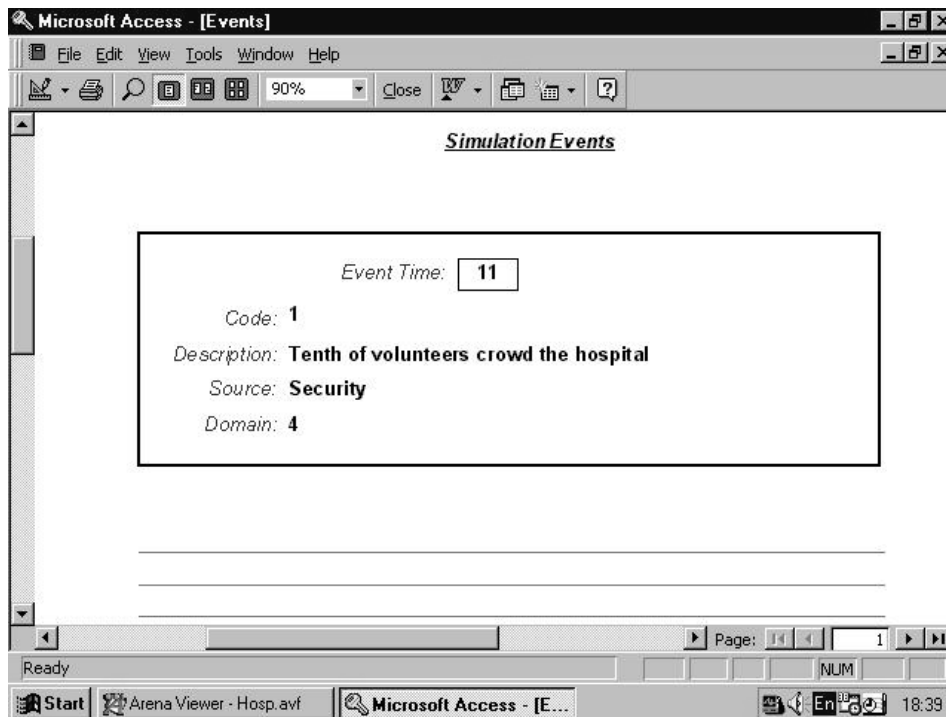


Figure 2: Events in the Simulation

During the LSD, the trained hospital staff get two kinds of input from the simulation team:

- 1) Copies of reports on patients entering the stations which had to be fed to the hospital IS (*Figures 3-4*);
- 2) Timed phone notifications of problems in each station and recording of the trainees' response. During a 90-minute drill there are about 15 timely reports and 20 phone problems. With the aid of the computerized simulation system, the simulation team and the trainees are released from the constant need for calculations of casualty flow in critical areas, needs, queues, and resource use (*Figures 5-6*). As a result they can easily anticipate problems and bottlenecks in various locations. The trainees react via the various tactical means to the events announced, and the simulation team responds to their reactions by continually processing other consequent related events and providing the trainees with another set of problems created or solved. The simulation team can provide a realistic picture every single minute, based on statistical and mathematical calculations, performed by the simulation system, and can present the implications of the dynamic proceedings of events and of the trainees' decisions. The hospital management is tested as a team and trained on its ability to anticipate the real consequence of events in real time. Secondly we measure its ability to diagnose and pinpoint to important problems, but mainly on its ability to prevent the development of expected bottlenecks and other adverse events and problems before they occur.

Methodical stops are possible at every single point during the exercise, and the relationship between the exercise time and real time can always be set anew according to the decisions of the trainers or trainees.

An open discussion with all the participants is held at the end of the exercise, aimed at pinpointing special

Problems encountered and learning possible tactical solutions and their consequences.

The evaluation of the LSD is mainly based on the following:

- 1) Observing the staff solving various problems;
- 2) Constructing a detailed picture of the situation;
- 3) Measuring the effectiveness of the hospital IS. The drill ends with a discussion. Lessons are drawn from each drill in order to find methods for optimizing the conduct of the hospital. An animation tool proved to be useful in describing bottlenecks in emergency room, diagnostic department and operating rooms.

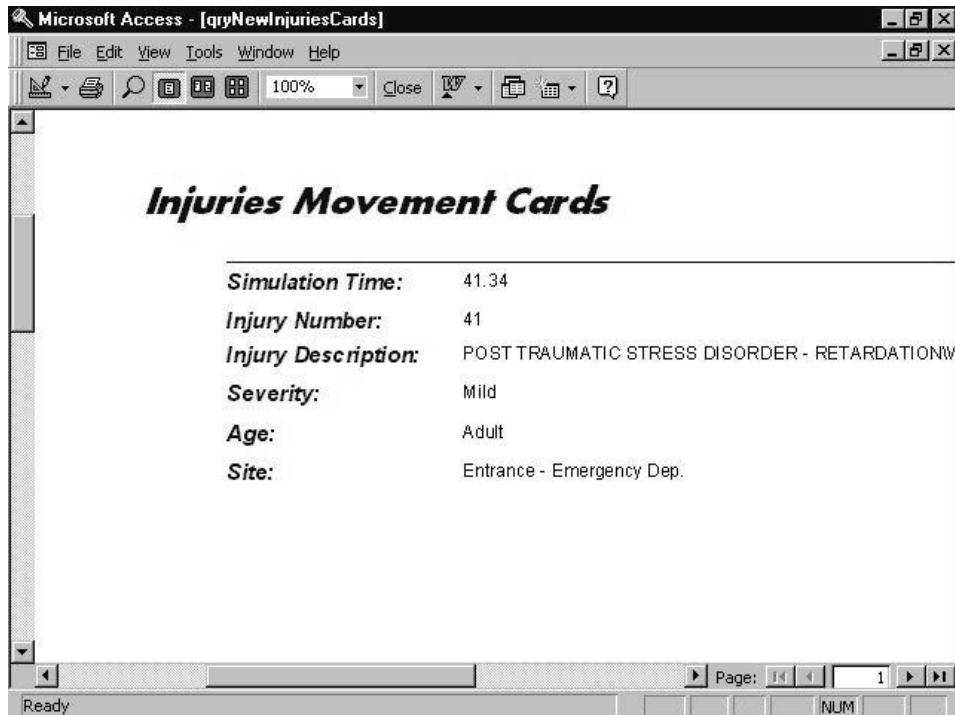


Figure 3: New Injuries' Data

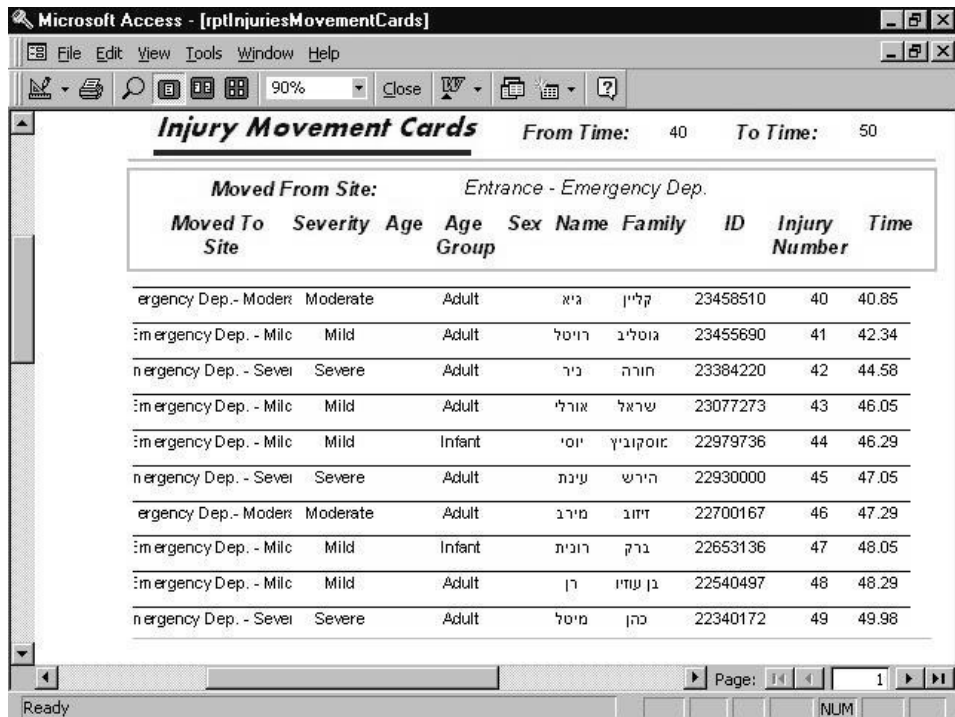


Figure 4: Injuries' Movements

Microsoft Access - [qryNewInjuries]

New Injuries From Time: 40 To Time: 50

Total	Severe	Moderate	Mild	
8	3	2	3	Adult
2	0	0	2	Infant
10	3	2	5	Total

Simulation Time	Injury Number	Age	Severity	Injury Description	Moved To Site
41.34	41	Adult	Mild	POST TRAUMATIC STRESS DISORDER - RETARDA	Entrance - Emergency Dep.
43.58	42	Adult	Severe	ABDOMINAL BLUNT TRAUMA - SHOCK	Entrance - Emergency Dep.
45.05	43	Adult	Mild	SHRAPNEL WOUNDS	Entrance - Emergency Dep.
45.29	44	Infant	Mild	BURNS <10%	Entrance - Emergency Dep.
45.90	45	Adult	Severe	BLUNT CHEST TRAUMA, DYSPNEA	Entrance - Emergency Dep.
45.96	46	Adult	Moderate	ABDOMINAL BLUNT TRAUMA - STABLE	Entrance - Emergency Dep.

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Figure 5: New Injuries Report for the Trainers' Team

Microsoft Access - [qryInjuriesMovements]

Injury Movement From Time: 40 To Time: 50

Simulation Time	Injury Number	Age	Severity	Injury Description
40.49	20	Adult	Severe	ABDOMINAL BLUNT TRAUMA - SHOCK
Moved From:		Emergency Dep. - Severe		To: Wait for Operation
40.85	40	Adult	Moderate	CLOSED #
Moved From:		Entrance - Emergency Dep.		To: Emergency Dep. - Moderate
41.34	41	Adult	Mild	POST TRAUMATIC STRESS DISORDER - RETARDA
Moved From:		Disaster Area		To: Entrance - Emergency Dep.
41.92	24	Infant	Moderate	OPEN #
Moved From:		Emergency Dep. - Moderate		To: Radiology
42.34	41	Adult	Mild	POST TRAUMATIC STRESS DISORDER - RETARDA

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Figure 6: Injuries Movement Report for the Trainers' Team

3 THE SIMULATION SYSTEM

The simulation model that simulates the hospital in disaster situations *is* implemented using Arena modules. The *model* holds all the simulation logic and user defined events which are implemented using VBA. This model reflects the dynamic functioning of the hospital at times of emergency and includes:

- Criteria for flow between the different sites of treatment/examination.
- Characteristics of care delivery.

The VBA blocks stores and retrieves information from the Microsoft Access Database and Microsoft Excel.

The *database* include both data and knowledge:

1) Characteristics of different disaster situations:

- Type of disaster.
- Distribution of types of injury and the degrees of severity.
- For each type: Stages required in the diagnostic/treatment process and where in the hospital it is performed.
- For each stage: Distribution of time required for performance; resources required (manpower and their skills, equipment).

2) Hospital characteristics:

- Layout, sites of treatment and their number.
- Manpower resources.
- Permanent equipment, type and quantity.
- Disposable equipment, type and quantity.

3) Events – problems and obstacles

The *user's interface* is implemented using Microsoft Access forms and reports. The forms and reports (Figures 5-6) enable the simulation team in getting the exact picture of the situation at each second of the drill. It is also used to input decisions' data, update basic parameters according to the development of the situation and create different reports for the trainees.

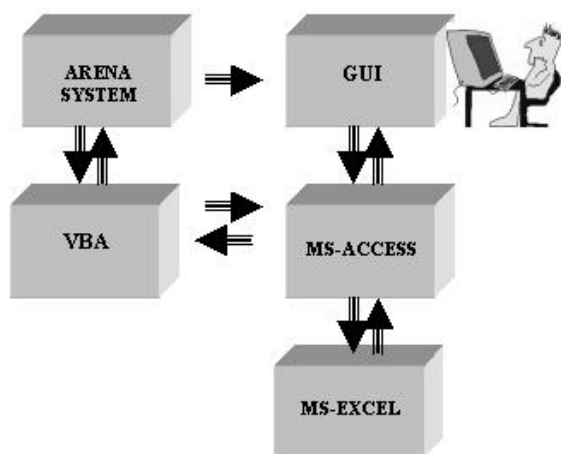


Figure 7: The System Structure

4SUMMARY

The computer simulation system includes knowledge and database that incorporates data on disaster situations and casualties and an activation model. The system acts as an "engine" for its various uses. It provides several tools for planning and mainly drilling teams. The main drilling objectives achieved are 1) the identification of lack or reinforcement of specific personnel; 2) specific medical equipment/medications, electromechanical system problems; 3) crowds within the hospital (relatives, curious people, volunteers) and security problems.

The limitations of this simulation technique are well known: it is based on a wide scale database and needs expensive investment in development of the model and the validation of its use; the hospital's model described only part of the whole situation and is limited in describing the real world.

We found that the described simulation techniques used in preparatory limited scale drill has advantages in evaluating and improving preparedness of hospitals for managing an MCI before a full scale drill is done. The current system is operational in all hospitals in Israel that has to be prepared for MCI.

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AUTHOR BIOGRAPHIES

DAVID BREGMAN, Ph.D., Senior Lecturer, Information Systems Department, The College of Management, Academic Studies - Tel Aviv, School of Business Administration; Adjunct Teaching Associate, Technion - Israel Institute of Technology, Faculty of Industrial Engineering and Management - Information Systems. Works on research, development and consultant of information systems, health care information systems, simulation techniques and management of disasters. Member of the council of *The Israeli Association for Medical Informatics* (chairman 1995-1997).

DAGAN GILAT, (dagan@ie.technion.ac.il) is a Doctorate student in the Faculty of Industrial Engineering and Management, Information Systems, at the Technion - Israel Institute of Technology. His M.Sc. thesis subject is on Queuing network performance evaluation. Specializes in developing simulation models using various Microsoft tools and languages.

LION LEVI, MD, MPA- A neurosurgeon and assistant director of Rambam Medical Center with experience in using simulation techniques and managing hospitals through disasters and multi-casualties incidents, in the present position and in the IDF-MC.