THE "ABC SYSTEM": AUTOMATION BARCODES AND CHAOS

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ABSTRACT

Well recognized difficulties in disaster (multi-casualty) incidents, such as registration of patient identity, location, and ability to support medical / management decisions can cause the quality of care to decrease.

In order to preempt these and other difficulties, a computer assisted casualty management plan, part of the major incident plan, has been introduced to make effective use of the Emergency Hospital, a 100 bed, intensive and medium (60) care facility available in the University Hospital Utrecht. This facility is primarily intended for the admission of groups of patients.

This computer network has been developed to register, monitor progress of and care-requirements for any specific patient or for the group as a whole. Medical, nursing and logistical information is recorded with the aid of barcode scanners from prepared tableaus thus avoiding delays. These unique barcoded numbers for representing patients, locations, facilities and treatment groups are used in order to minimize errors. Through communication with the permanent hospital patient databank computer system, all data becomes part of the patient medical dossier.

1. INTRODUCTION

The Netherlands has focused interest on disaster management for decades. As early as 1953, with major flooding of its southwestern islands, interest in prevention of mass casualty incidents, development of emergency services, and in particulair hospital incident plans was reinforced.

In January 1992, the national government has as recently passed new legislation concerning (emergency) medical assistance during such situations [1,2]. Hospitals, though free in determining the specifics of their own major incident plan, must have such a plan. An updated outline of an admission procedure was supplied to all hospitals in February 1992 [3]. Nonetheless, experience and literature sources show that admission procedures remain a 'gray area'. Many workers in disaster management [4] have shown that important (medical) information, needed for triage and decision-making can be lost in the admission process [5].

In order to fully utilize a 100-bed emergency hospital, a computer assisted patient management system was developed, that makes information available centrally and peripherally, maximizes the use of triage, while minimizing information and time loss. The PC based local area network "ABC system" is geared to the logistic management of patients and patient-based information, specifically for groups of patients who may be admitted to a hospital setting in a short period of time. It acts as a satellite to the Hospital Information System. This system has demonstrated a 25% improvement in quality and quantity of information available.

We would like to present this system which has shown itself to facilitate the admission procedure of patients to the hospital and thereby promote the quality of care.

2. CURRENT SITUATION AND PROBLEM DEFINITION

The University Hospital Utrecht, an 890 bed teaching facility, moved to newly built facilities in 1989. An 8000 m^2 area of the ground floor has been allocated to the Ministries of Defense and Public Health, Welfare and Culture (WVC) and refurbished to provide an Emergency Hospital with a capacity of 400 patients.

The Department of Intensive Care and Clinical Toxicology of the University Hospital, which is affiliated with the National Poison Control Center (NVIC) of the National Institute for Public Health and Environmental Protection (RIVM) is located in the Emergency Hospital as an operational unit. This Unit has extensive experience in the treatment of groups exposed to chemical, biological or physical agents [6, 7].

The Emergency Hospital (**Figure 1**) is self contained and is designed to admit and treat 100 patients. It contains a triage and treatment center where flexible subdivisions hold 16 treatment stations. Diagnostic facilities (lab, X-ray and three operating rooms with recovery) are available. For Intensive care/high care 30 beds are arranged in four separate wards, in addition to a 60 bed medium care ward. If needed 300 additional (low care) beds are also available in the Hospital. Separate but adjoining facilities are available for use as waiting rooms and as a temporary morgue. The University Hospital and its Emergency Hospital serve as a primary (level 1) receiving facility for the central Netherlands.

When this Department was asked to accept responsibility for patients in the Emergency Hospital, its Emergency and Disaster Medicine staff members decided to review principal needs.

Examination of the literature showed that mass casualty procedures were not just 'scaled-up' versions of single patient oriented care [5,8]. Criteria concerning diagnostics and the level and scope of maintainance of care needed clear definition [9]. Additional organization of admission procedures as well as medical, nursing, and logistic systems required support by information management. Two items, the use of triage (sorting of patients with respect to required care), and the facilitation of command and control were earmarked as a 'spear-point' requirements and shall be discussed further.

2.1 Limitations

In looking at the objectives of the ABC system (**Figure 2**), two primary items were analysed. These were:

Triage and implementation: In daily practice, as in mass casualty incidents, choices in who should receive treatment (first) are made. To do this, history, examination and treatment results are made available to the physician and nurse who then implement and evaluate the treatments themselves. During mass casualty incidents patients are triaged, assigned an urgency-group (in which all the urgency-1 patients are treated before the urgency-2 patients receive attention) and 'passed' on to others.

This would work fine if the patient cohort arrived in bulk (making comparison possible) and no patient improved or became unstable later (vertical evaluation). The physician who sees all patients - and as such can triage effectively - evaluates at 'the door' to the hospital and expects his instructions to be implemented by others in the hospital. Decentralized information (medical chart) is available, but must remain with the patient.

Registration and locatization of patients: Most hospitals have extensive computer systems and charting procedures to document medical and nursing information. During mass casualty incidents these (often time consuming procedures) break down. Typically, as with

BAZIS, the Hospital Information System used in 60% of the hospitals in The Netherlands, this system supplies subsystems for location, laboratory, financial and text files. These systems work with the patient registration number on a per patient per subsystem level: it cannot document groups and is not programed to follow rapid changes. In (international) practice (medical) information made available to the physician from the prehospital situation is limited; it is typically noted on a "patient tag" [1,2]. Regrettably, these pre-numbered tags allow only 'uni-directional' development of the patient's history [10].
Particularilly the processing of patients who have (potentially) been exposed to chemical substances, procedures and registration / charting of patients (who may or may not have been exposed) has been shown to be deficient [11,12].

Analysis of regular practice, exercises with simulation-patients in different regional hospitals and during the eight mass casualty incidents in the University Hospital showed information loss (**Figure** 3) to be a potential difficulty. Due to large floor-areas and the large number of personal involved, command and control also re-mained a concern [12].

3. COMPUTER ASSISTED CASUALTY MANAGEMENT

The major incident management plan was restructured to correct a number of the problems summarized above. Algorithms were designed to be parallel to or approach normal daily routines [8]. Simple and clear cut limitations and boundaries were defined. Command and control became the responsibility of a centrally located multidisciplinary team. A number of additional aspects of the management of each patient had to be introduced: information concerning the type of patient and a number of specifics about each patient was to be centrally available within seconds after their arrival. An up to date location of each patient should be readily obtainable, as should be the chart. Each patient should be clearly identified (patient registration number) while name address etc. should be available as soon as possible.

In 1993 a dynamic system became available that is capable of identifying and tracing patients, while at the same time assisting in the medical, nursing and logistical documentation of the patients, allowing real time as well as prospective and retrospective analysis of treatment (needs). Information gathered about each patient automatically becomes part of the permanent medical file in the Hospital Information System (HIS).

3.1 The ABC system:

The "ABC" PC based network was developed as an independent satellite system of HIS. It uses one of the UNIX systems with COMZIS (a linking program) to communicatie with HIS and its subsystems such as PATREG (registration), LABZIS (laboratory results) and others. Communication was realised via IEEE-ethernet [13] working with the OSI-model. Physically, the coaxial and fiber-optic cables already in use in the hospitals were employed. The ABC-system has its own server (486-DX, 50 MHz, 16Mb memory, 210Mb HD-capacity), and at least ten user stations (386-DX, 33 MHz, 4Mb memory, 40Mb HD-capacity) (Figure 1: the "•"). The stations also incorporate the command group in the receiving area and the directorate (Board of Directors: responsible for total hospital effects).

With regard to the software, the ABC-applications were written with Nantucket Clipper V. 5.01 and Microsoft C, V 6.00. This choice was made so that communication with HIS (Pascal) would be possible within an environment acceptable to hospital privacy-demands. Records in the database are divided into three parts: General disaster data, Patient data, and Fixed descriptive data.

The general disaster data relates to all patients of a specific disaster: an example is the patients who are all victims of a bus accident. This data will be stored in a text-field in which free text can be entered. This allows the cohort as a whole to be identified.

The patient data relates to one patient. All patient data is linked to a patient identification number and a date-time group. This data is further divided into six categories (**Figure** 4). These are information categories that were already part of the regular medical and nursing charts.

General patient data relates to personal data such as name, address, birthday and gender. Patient location data supplies the previous and current location data, for example in X-ray, of each patient. Patient urgency data describes the medical status of the patient. For example, urgency I indicates a patient whose life is in jeopardy and must be helped as soon as possible. Patient destination data is a combination of destinations and treatments. It indicates expected location(s) and treatment. The complete routing of the patient can be followed by means of the destination data. Patient medical indication data supplies medical diagnosis such as "left pneumothorax". Additional remarks allows free text to be entered, when for example a medical diagnostic code is not available.

The third type of record in the ABC-system is the fixed descriptive data. These define the codes which appear in the patient data, such as location codes, urgency codes, medical indication and treatment codes.

Barcodes: Development of a user-friendly system was one of the tasks assigned. Information-processing should require a minimum of time and be thoroughly reliable; experience with the system could not be guaranteed due to its infrequent use.

This led to interactive and other non-keyboard oriented facilities. No standard was available. In cooperation with "Stichting UAC/Transcom", the Dutch member of the International Article Numbering Association), the possibilities were studied [14] for creating unique numbers in our system for patients, diagnoses, locations and treatment, by utilization of a new identifier in the "UCC/EAN Application Identifier Standard" (**Figure** 5). The use of 128 symbol technique for barcoded alfanumeric information gave the simplicity required. Codes, and patient identification numbers, are applicable internationally (in all EAN countries). This also prompted the use of the WHO ICD-9/10-CM diagnostic codes [15].

In close cooperation with PHI (Woerden NL), which allowed for extensive testing, nine PSC "moving beam hand-held, non contact" barcode readers with nine Intermec wedge readers were purchased.

Patient registration numbers: The 200 patient registration numbers prepared for special situations have been coded to include unique prefixes and suffixes. These numbers correspond to a fictitious name and birthdate, because the automated HIS patient databank requires such data. In this way the different laboratories can use regular channels to 'return' the results. These numbers correspond with preprinted ID-bracelets and medical status folders complete with laboratory and other forms as needed. It also allows comatose patients to be recognized by the use of a defined unique number, while enabling other patients to be recognized with their own names as soon as possible.

Tableaus: Using large sheets a system was developed for representing the barcodes. On these sheets, barcoded information (**Figure** 6) was divided into a number of categories. The urgency codes 1 - 5 were defined, using international standards. Location codes define wards and bed locations. This makes it possible to 'assign' a bed to a specific patient (even before this patient has arrived), and recognition of the use of this bed (i.e. required facilities and personal) while the patient may be elsewhere. It also allows priorities (anticipation) within the patient group by different diagnostic facilities. Medical indication and treatment codes describe the vital signs and (important) types and locations of injuries, as well as treatment begun or expected. In all about 50-60 options are currently available.

3.2 Experience and results to date

During the four occasions on which the ABC system was used registration of data was done simultaneously both in the ABC-system and handwritten in patient charts. This enabled a comparison of manual procedures with the new automated procedures. We found an improvement of at least 25 % [16] when using the ABC-system in the:

- quality of information (301 vs 246 'items' correct);
- quantity of information (318 vs 257 of the 350 'items');
- accessibility (major improvement, questionnaire).

In other experiments it was shown that improvement tends to increase when less registration time is available, that is in more stressful situations.

4. AN EXAMPLE

A patient arrives in the ambulance hall and receives a patient identification number (a bracelet is put on, the medical chart supplied). Here, his identification number is entered along with relevant information from the pre-hospital situation. The first step(s) in his routing is assigned. The hospital administration can 'recognize' his presence (**Figure** 7) and location and can inform (local) government as such.

Assuming that this patient is comatose he remains a number during the first period. In the Emergency hospital a physician assigns the clinical urgency group. This is registered in the ABC system allowing the X-ray department to anticipate on the (high urgency) patient who has just arrived. A patient in the medium care ward will now not be called, but will wait until the patient we are describing has been x-rayed. The Intensive Care notes that an ICU bed has been assigned and can anticipate on the new arrival.

Family, calling the hospital can be informed of the location, urgency and some general information as soon as the identity of the patient is established (generally upon arrival in the wards), using drivers' license etc.

5. CONCLUSION

We believe that the quality of care provided to groups of patients is largely dependent on the ability to control the flow of these patients, the available knowledge concerning priorities set during triage and the follow-up.

In creating this model the registration of patients (without the need for specific identification), diagnostics and treatment can commence immediately using barcoded information. The system also allows different users to be continuously up-dated as to patients who can be expected and the needs of these patients. Important "policy-making" decisions can be made by teams responsible for patient care, logistic support, and hospital administration, thus allowing a high level of care to be provided.

Other applications suggest themselves within regular hospital patient logistics and management, in the EMS under special circumstances, and to identify a patient in such a way that hospital and patient number remain unique.

6. BIBLIOGRAPHY

[1] de Boer J, Goris RJA, Bal JH, (eds.): [Disaster Managment]. Bohn, Stafleu Van Loghum, Houten 1990. ISBN 90s 513 200 6. 1990.

[2] [Final report of the working group for the legislation on community and regional planning for disasters]. Ministery for the Interior, Department for Fire Services, January 1992.

[3] [Model mass-casualty management plan for hospitals]. Ministery for Public Health, Welfare and Culture, Department for Civil Defense and Disaster Preparedness. February 1992.

[4] Waeckfree JF: Disasterplanning and response. New Eng. J. of Med. 1991; 324 (12): 815-821.

[5] New B: Too many cooks? The response of health-related services to major incidents in London. King's Fund Institute, Research report 15. ISBN 1 870607 32 5, 1992.

[6] Sangster B, Meulenbelt J: Acute pulmonary intoxications, overview and practical guidelines. Netherlands Journal of Medicine, 1988; 33: 91-100.

[7] Hustinx WMN, van de Laar RTH, van Huffelen AC, Verwey JC, Meulenbelt J, Savelkoul TJF: Systemic effects of inhalational methyl bromide poisoning: a study of nine occupationally exposed due to inadvertant spread during fumigation. British Journal of Industrial Medicine (in press)

[8] Donabedian A: The quality of medical care. Science 1978; 200 (26): 856-864.

[9] Rhee KJ, Donabedian A, Burney RE: Assessing the quality of care in a hospital emergency unit: a framework and its application. Quality Review Bulletin 1987.

[10] Vayer JS, Ten Eyck RP, Cowan ML: New concepts in triage. Annals of Emergency Medicine 1986; 15(8): 109-112.

[11] Walsh DP, Lammert GR, Devoll J: The effectiveness of the advanced trauma life support system in a mass casualty situation by non-trauma experienced physicians: Granada 1983. Journal of Emergency Medicine 1989; 7: 175-180.

[12] Noordergraaf GJ, Deggens JW, van der Eijk KJ, Savelkoul TJF: [Exercise at the Drechtsteden hospital: the admission and treatment of victims of a chemical accident]. Oefening Refaja: oefening in de opvang en behandeling van slachtoffers na een chemisch ongeval. Report nr 348201009, National Instituut for Public Health and Environmental Protection. January 1993.

[13] Matthijssen RL, Truijens JHJMT. Computers, datacommunicatie & netwerken Academic Services, 1990.

[14] EAN Vademecum for EAN (International Article Numbering Association), Brussels 1992. UPC Guidelines Manula of the Uniform Code Council. Dayton OH. USA

[15] International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM)]. Commission on Preofessional and Hospital Activities, Ann Arbor MI. USA ISBN 90-70235-04-8/ 90-70755-08-4.

[16] Selier MT, Bouman JH, Noordergraaf GJ. Final report ABC-Project (parts 1 and 2). AZU-University Press. 1993.

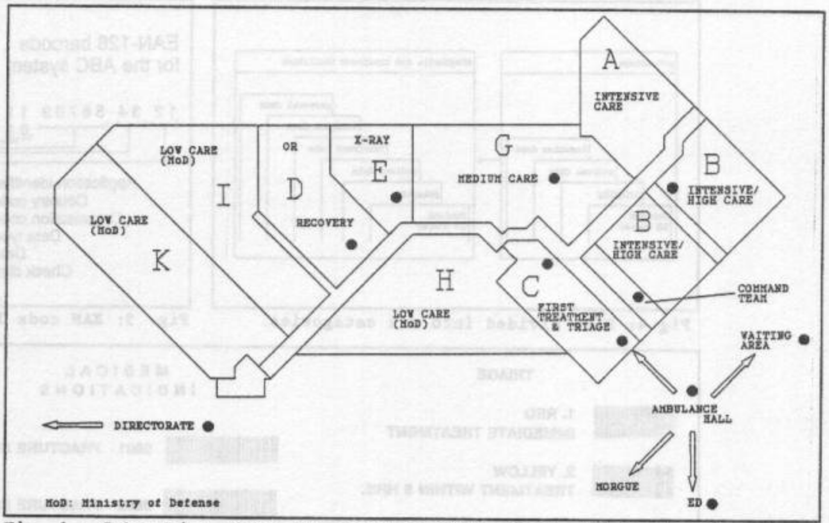

Fig. 1 : Schematics of the Emergency hospital, incl. "●" for the location of the user stations.

- Registration and identification of patients;
- Localization of patients;
- Generating reports;
- Communication between the ABC-system and the HIS;
- Support analyse afterwards.

+ Low-costs in implementation and maintenance
+ Maximum in user-friendliness

Fig. 2: Objectives of the ABC system.

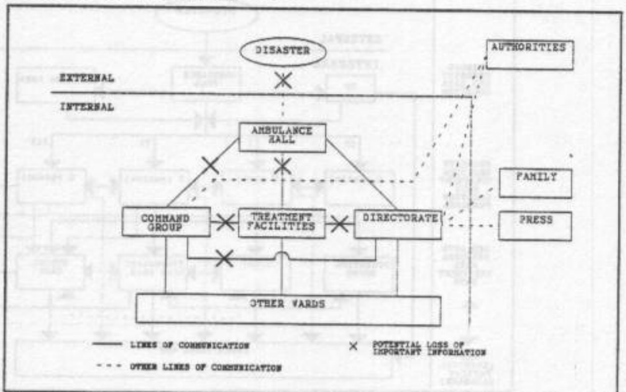

Fig. 3: Potential locations of information loss

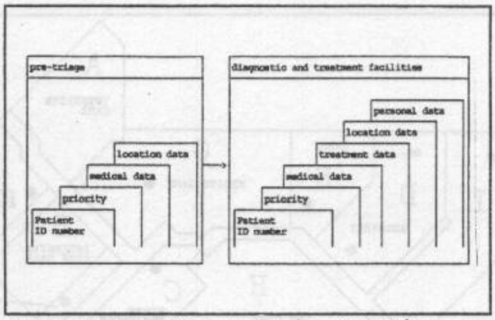

Fig 4: Data divided into six catagories.

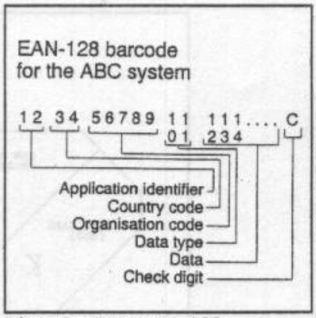

Fig. 5: EAN code 128.

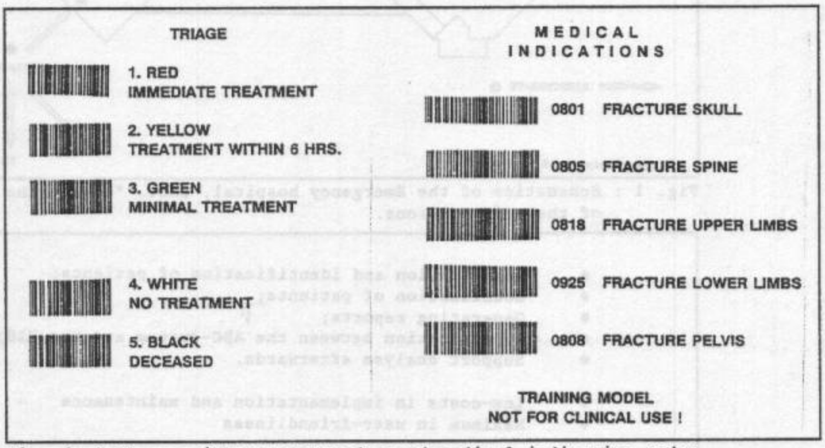

Fig. 6: Tableaus with urgency codes and medical indication codes.

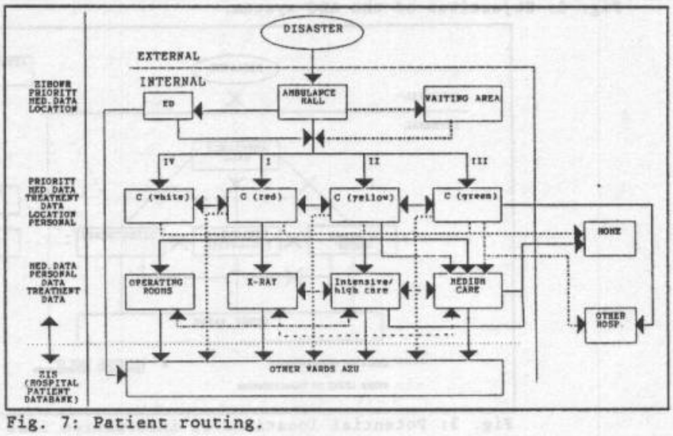

Fig. 7: Patient routing.