The Use of Information Systems in the Hospital in Times of Crisis

Katerina Vichova, Martin Hromada

***Abstract*—**There is increasing number of crisis in the world and we need to support hospital preparedness in this time. The crisis preparedness of the hospital is different and we need the hospital to be ready for all situations. In many fields are used information systems and in the hospital too. These systems are used in peaceful state and in the crisis state. There is the action plan of the electronic health system in the European Union and in the Czech Republic too. this plan creates support for further electronisation of healthcare. This paper is focused on the use of information system in the hospital in times of crisis. There was used the analysis of the selected system. At the end of this article we propose the new algorithm for the evaluation of the crisis preparedness of the hospital.

***Keywords*—**Crisis, Hospital Preparedness, Information System, Healthcare Facilities

I. Introduction

NATURAL disasters that originated from extreme weather events have been in an increasing trend in recent years [1]. United Nations International Strategy for Disaster Reduction (UNISDR) defines disaster as a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources [2]. However, each state has its definition of the disaster.

The Czech Republic defines natural disaster as an event not caused by fire and explosion, lightning, storms with wind speeds above 75 km / h [kilometers per hour], floods, flooding, hail, slumping soils, landslides and rock collapse, if they occurred in the context with industrial or construction traffic, sliding or collapse avalanches and earthquakes reaching at least the fourth international scale indicating the degree of macroseismic effects of earthquakes [3]. Next, the Czech Republic defines two terms – crisis situation and emergency event. The crisis situation is an emergency situation according to the law of the integrated rescue system, disturbance of the critical infrastructure or other hazards which state the state of danger, state of emergency or state of emergency (as the "crisis state") [4]. The emergency event is the harmful effects of forces and phenomena caused by human activity, natural influences, as well as accidents that endanger life, health, property or the environment and require the execution of rescue and disposal operations [5].

Critical Infrastructure means an element of a Critical Infrastructure or Critical Infrastructure Component System, the disruption of which would have a significant impact on state security, the security of the basic living needs of the population, the health of persons, or the state's economy [6]. The health of persons is ensured through a functional health system. The healthcare must be ensure in the hospital and other places in times of crisis too.

Information systems have become an essential part of our lives. The information system is a functional unit that provides collection, processing, preservation and accessibility of information and data. It includes information sources, media, hardware and software, and equipment, technologies and procedures, standards and employees [7]. Information systems in general are very important and indispensable part of the planning, organizing, managing and controlling.

The hospital uses an information system for their management. Hospital information systems are a particular element. They are interconnected with informatics and medicine. This is a unique combination, but necessary in today's world. Information systems allow the collection, storage, processing and distribution of information.

Medical informatics is a field of the theoretical and practical aspects of information processing based on the experience and knowledge gained in the performance of health care. It creates complex systems for the collection, validation, and analysis of clinical data using local and web technologies. The result can contain e. g. Health Registers and research projects. Medical informatics also includes activities focused on hospital information systems, data warehouses, health records and related legislation. The goal is also to ensure the implementation of end-user solutions such as medical professionals, health care facilities, or institutions. [8].

Information systems have been registered in healthcare facilities since the 1960s. They were mainly responsible for billing, patient records, and daily records. Later, the parts of

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the information systems were interconnected. Implementation of electronic documentation at all levels of healthcare facilities was undertaken. Nowadays, many information system modules are being used. One of them is electronic patient documentation, sharing results, etc. The information systems can also deal with communication between physicians (and Medical Rescue Service). This section will focus on this article. Hospitals may have an internal communication information system developed. This system communicates with medical staff, hospital and Medical Rescue Service.

Hospital information systems refer to any system that captures, stores, manages or transmits information related to the health of individuals or the activities of organizations that work within the health sector [9].

The health information system provides the underpinnings for decision-making and has four key functions: data generation, compilation, analysis and synthesis, and communication and use. The health information system collects data from the health sector and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision-making [9].

Health planners and decision-makers need different types of information including:

- health determinants (socio-economic, environmental behavioral, genetic factors) and contextual environments within which the health system operates;
- inputs into the health system and related processes including policy and organization, health infrastructure, facilities and equipment, costs, human and financial resources, health information systems;
- the performance or outputs of the healthcare system such as availability, accessibility, quality, and use of health information and services, the responsiveness of the system to user needs, and financial risk protection;
- health outcomes (mortality, morbidity, disease outbreaks, health status, disability, wellbeing); and
- health inequities, regarding determinants, coverage of the use of services, and health outcomes, and including crucial stratifies such as sex, socioeconomic status, ethnic group, geographic location, etc. [9].

It can be remarked that the information systems that have been created work in normal operation. However, the problem arises when a hospital supply failure occurs. It is then necessary for the hospital to be informed whether it is ready for an emergency.

The purpose of this article is to analyze the hospital communication information system.

II. History of the Health Information System

The aim of this chapter is a brief overview of the use of information systems in hospitals in the history of Larry Grandia.

Below, he created a decade-by-decade list of the primary influence driving healthcare in each period, the respective driver for the IT, and, finally, the HIT innovation.

TABLE I. History of Health Information System [10]

Decade	Healthcare Drivers	IT Drivers	Resulting Health Information Technology
1960s	Medicare Medicaid	Expensive mainframes Expensive storage	Shared hospital accounting systems
1970s	Hospital-wide communications Departmental systems processing	Smaller computers Improved terminals and connectivity	Expanded financial and administrative systems Results review Selected clinical department automation
1980s	DRGs	Networking Personal computers Cheaper storage Independent software applications	Integrated financial and clinical systems Managed care financial and administrative systems
1990s	Competition, consolidation Integrated hospital, provider, and managed care offering	Broadened distributed computers Cheaper hardware and storage	Expanded clinical department solutions Emergence of integrated EMR offering
2000s	More integration Beginnings of outcomes-based reimbursement	Mobility Emerging cloud computers and cloud based big data analytics	Emerging, broad-base clinical decision support Broad operational departmental systems with EMR integration Emerging data warehousing and analytics solutions

Table 1 illustrates the development of information systems in the individual decades. The first part represents healthcare drivers. The second part shows IT drivers. The last part shows resulting health information technology.

We can say that the development of information technology is still growing.

III. eHeath in the European Union and Czech Republic

Healthcare systems are increasingly dependent on information and communication technologies. Even they can help provide quality care for citizens. The eHealth Action Plan sets out clear steps for the electronicisation of health in the European Union.

Information and communication technology has become a truly revolutionary part of European healthcare in recent years. The European Union has found that their implementation effort has been greatly fragmented and disparate.

In the European Union, where people are completely free to move to the other Member States. It is necessary to integrate them into a mutual communication that should ensure the highest standards of healthcare, whether patients are anywhere.

The main goal is to build a unified European eHealth space [8].

The European Union has set targets for eHealth. Here are the three essential points.

Citizens health - eHealth tools will enable sharing of information needed to care for citizens health and to save their lives.

Improving the quality of healthcare and access to it - eHealth will become an integral part of the policy area of health, and EU countries will jointly coordinate their political, financial and technical strategies.

Streamlining eHealth tools and enhancing their user comfort and use - healthcare staff and patients will be involved in planning, development, and implementation [8].

The European Union has developed action plans for the development of e-Health. The first action plan was for the period 2004 - 2010. Another one for the 2012-2020 cycle followed this action plan. These action plans deal with the issue of electronising healthcare in the EU. The aim is to provide opportunities to make up for the steps taken. Furthermore, it is the goal of introducing the proposed procedures into the practical plane.

The targets for the 2012-2020 period include support for the Member States and healthcare providers in the development of ICT solutions in the best interests of patients, the healthcare system, and society. Also, provide helpful support towards the innovation of the environment and the best use of changes in health care.

The primary health initiatives coordinated by the European Union include the standardization committees and the Working Party on E-Health. This group has the task of working with Member States to address ICT issues and contributing to the effective implementation of the i2010 strategy of the European Information Society for growth and employment, which preceded the eHealth Action Plan and set out concrete preparations for 2010.

The Czech Republic was also involved in these Action Plans. The following section describes the eHealth system in the Czech Republic.

National eHealth Development Plan in the Czech Republic

The goal of the National eHealth Development Plan was to create a politically acceptable basis for a comprehensive national eHealth concept. The plan was based on studies of the current conditions in the Czech Republic, but also on available information in the EU and the world. The essential priorities are the high quality of health care, availability of health care and long-term stability of the healthcare delivery system.

Critical areas of the project:

- national policy, legislation, and standards,
- electronic health documentation,
- electronic identification of the patient and the healthcare worker,
- health information network,
- electronic education for citizens and health professional [8].

This project, which was planned for the implementation of total eHealth along with other projects, has been interrupted. A new strategy was issued by the Ministry of Health of the Czech Republic in 2014: Health 2020 - National Strategy for the Protection and Promotion of Health and Disease Prevention.

The introduction of the obligation to issue eReceptions for 2018 was planned. However, doctors were not sufficiently prepared for it. However, the obligation here is but is not fined in case of non-compliance. eRecpet is a recipe displayed in electronic form. A doctor exposed eRecept is stored in the Central Repository of Electronic Recipes.

This project was not implemented in its entirety. Individual hospitals have developed their information systems.

IV. Method

Four methods of scientific work were used in this article. The method of analysis is used due to the fact that it uses the principles of logic to achieve the set goal and provide the framework to explore the principles of information systems. The induction method was used, where this method serves to examine the fact of creating a hypothesis from the points obtained. Comparison method allows evaluating and analyzing processes and approaches in the surrounding countries and the developed states. Finally, a heuristic usability analysis was used.

The information systems have many advantages and disadvantages, and therefore the heuristic analysis of usability was performed on these systems. This assessment is used for the qualitative evaluation of the systems. Based on the analytical studies, we determined the staff of the hospital for the analysis of the information systems. We conducted an evaluation using the following equation:

Where, UIS is usability of the information system, R is sum of the results (acquired points) and H is amount of evaluated heuristics.

A set of the evaluation questions (70 problems) was used, and these issues were divided according to the several indicators. These indicators fall into seven categories.

The general indicator describes the essential information from a broad perspective where this information was investigated. The next part of this indicator determines whether the system works and if we can use the system without help (user´s guide). The last part solves whether the system contains only the relevant elements and information about the problem.

The second indicator is named the usability. The usability finds out whether the system has the intuitiveness of the application. The next part determines the abilities to control the system/application in the particular conditions and to be adequately displayed on the mobile devices.

The third indicator is named the security, which solves credibility and the possibility of the system breach. The second part of this indicator ascertains of the content of the map as actual.

The fourth indicator deals with the content of the system. This indicator solves whether the system includes any advertisements and the misleading elements.

The fifth indicator looks into the search part of the system. It observes whether the results match the searched query.

The sixth indicator deals with graphics. This indicator solves the composition layout, typography, font color, and their suitability is evaluated as well as the aesthetic impression of the system.

The seventh indicator is named technological. The indicator identifies information about the use of the Internet. Additionally, mobile device customization is determined. Eventually, page load information is retrieved [11].

Finally, communication with mobile devices was evaluated. The possibility of a mutual connection was assessed. The feedback is provided. The bulk messages are being sent. Finally, teams can be created for bulk messages.

TABLE II. EVALUATION OF "COMMUNICATION" INDICATOR OF THE INFORMATION SYSTEM

Question	**Score**
Can the information system communicate with mobile devices?	1
Is feedback received?	1
Can communication be considered to be trustworthy?	1
Can the information system receive a reply from the recipient?	1
Does the information system send bulk messages?	1
Can you preselect teams that will be sent SMS during the mercenary period (shift)?	1
Is it possible to resend the message if the message is not received?	1
Is there security against misuse of these SMS messages?	0
Total	**7**

The goal of the appraisal is to get feedback on the selected crisis management information system. Each item gained the following value:

- -1 = does not meet,
- 0 = partially meets,
- 1 = satisfies,
- the field is empty if the question is not relevant.

V. RESULTS

Information systems are also used in the hospitals. The aim of this chapter is to evaluate the usability of the selected hospital information system. The evaluation was carried out according to the proposed method.

TABLE III. RESULTS OF EVALUATION OF THE INFORMATION SYSTEM

Indicators	Number of points	Number of questions	Answered	Score
General	5	8	6	91.67%
Utility	6	10	10	80%
Security	5	6	6	91.67%
Content	3	6	6	75%
Graphics	5	5	5	100%
Technology	3	5	5	80%
Communication	7	8	8	93.75%
Total	34	48	46	87.44%

Table 1 shows the results of heuristic usability analysis. This analysis was performed on a selected hospital information system. As can be seen, the highest score was obtained by the graphical indicator. Graphics are essential for quick orientation in the system. The system must be clear and usable even when dealing with the crisis. On the other hand, the worst evaluated indicator was the content indicator.

The first indicator "General" was evaluated positive (91.67%). Appraisal shows that the app is getting loaded, functioning, and properly displayed. The system contains only relevant elements and information on the subject. He has no misleading ads. At first look, you can understand the purpose and focus of the application. The application is intuitive. It can be used without the need for help. It acts as a Checklist in some parts. If the required points are not met, the system will not allow the user to move to the next point.

Utility indicator has focused on user layout and usability. The analysis shows that the information is presented in a precise form. The most important news, features, and tools are at the top left of the screen. The most important and most used tools are immediately available. The application is also suitable for users without prior experience. During weaknesses is that the system is not adapted to the touch control. Afterward, it is difficult to operate under specific conditions (in the car).

The third indicator evaluated security. The analysis showed that all information is located on the same URL. The application does not contain severe spelling or typographical errors. There is technical support or FAQ for severe cases. Help is understandable, written in Czech, without mistakes and misspellings. It can not be said about this system that its credibility and security cannot be compromised. In today's world, we can not say with any system that it is entirely safe. The information system can always be at risk of cyber attacks.

The fourth indicator evaluated "Content" of the system. The content indicator has identified some shortcomings. There is no quick list of frequently visited points. The system does not have a logo. On the other hand, it is possible to say that the application is fast. The headlines are short and concise. The system does not contain misleading elements or available modules.

The fifth indicator rated the graphics system. It was evaluated very positively. Based on the analysis we evaluated as the best. It can be said that the arrangement of the composition does not disturb the user. The individual tools and menu items are separated. All parts of the application have a uniform impression. Colors are suitably selected. The related tools and information are close to each other.

The sixth indicator evaluated technology of the system. The system can run on an Internet. Page loading is not required every time you move around the system. The disadvantage is that the app is not customized for mobile devices.

The last indicator evaluated communication with users. This indicator was also assessed very positively (93.75%). The analysis showed that the system could communicate with

mobile devices. Feedback on acceptance of the message is provided. The system can receive a response from the recipient and display it (color representation: positive - green, negative - red). The system sends messages in bulk. There are no time losses. The system can pre-select teams. These teams are then contacted in bulk according to the current shift, etc. If the message is not received by the recipient, the message will be notified again.

Overall, it can be judged that the information system is usable and suitable for further development. An advantage is a division into normal and crisis mode. These are used according to the current situation in the hospital.

VI. Discussion

The purpose of this article was to evaluate the selected hospital communication information system. This system serves to communicate with medical staff and individual departments. It also helps to communicate with the Medical Rescue Service. The system works both in the normal mode and in the event of a crisis.

The information system was evaluated based on a heuristic usability analysis. It contained approximately fifty questions. The aim of the analysis is to find the strengths and weaknesses of the tested system. Based on the analysis, it was found that the information system is usable and suitable for further development. The overall usability of this system was 87.44%. The evaluated part was the graphics page of the system. That is very important for quick orientation in the system. That enables the users to acquire and operate the information system quickly. Another very well-rated indicator is communication of the information system with the mobile device (93.75%). The system can call a collectively selected team of the medical staffs. The system waits for feedback and evaluates the situation. On the other hand, the worst-ranked indicator is the content indicator of the system (75%). The system still has shortcomings that should be improved.

Due to the positive results of the evaluation of the information system, it can be stated that the system is very suitable for the introduction of the new module.

Systems are very positively prepared for situations where there is routine hospital service. Hospitals do not have the problem of a crisis where more patients are receiving. In that case, they will use a traumatology plan. That makes it possible to handle the crisis as well. However, this is still only a situation where the hospital is fully functioning and supplied. However, the crisis may occur when there is a shortage of hospital supplies. It may be a power outage, food or water supply (drinking, utility).

It is, therefore, appropriate to introduce a new information system module that would evaluate the hospital's preparedness for such crisis. It could determine the situation, the current inventory, the current number of hospitalized and medical staff. At this time, it would evaluate the required number of the stocks.

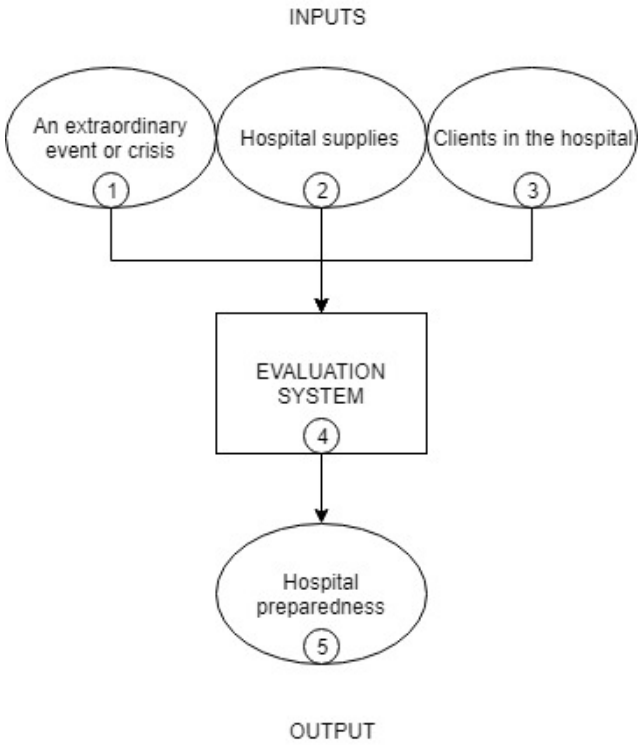

Fig. 1. Evaluation process for hospital

Figure 2 illustrates the process of evaluating the hospital regarding preparedness for an emergency or a crisis when supplies would be interrupted. Inputs and outputs for the evaluation system are taken into account. Entrances include hospital supplies and contractual arrangements in the event of an emergency supply to the hospital. There are also threats that endanger the hospital. Finally, these are inhabitants of the hospital. Here are taken into account the persons hospitalized and the medical staff of the hospital.

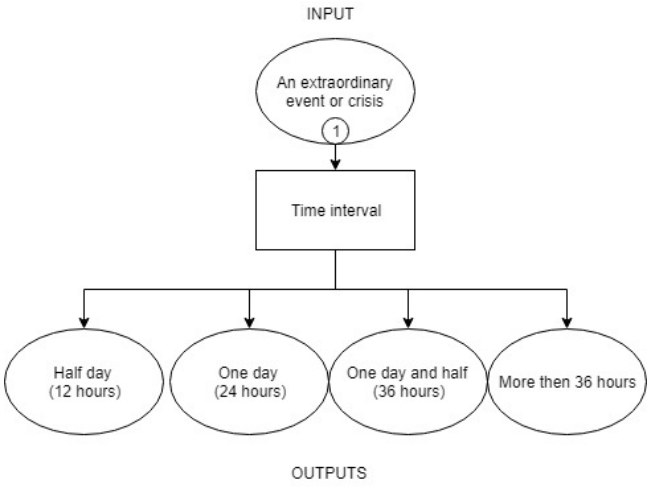

Fig. 2. Firt input – An extraordinary event or crisis

Figure 3 shows the diagram of the first input – an extraordinary event or crisis. We can see, that there are the different type of the time interval. These intervals means, how

long the situation will affect the reference object – hospital. This part was selected to the four parts. Firstly, it is time interval half day, less than 12 hours. Secondly, it is time interval one day. It is time interval from 12 hours to 24 hours. Thirdly, it is time indicator one day and half, and it is in the time interval from 24 to 36 hours. Finally, it is more than 36 hours.

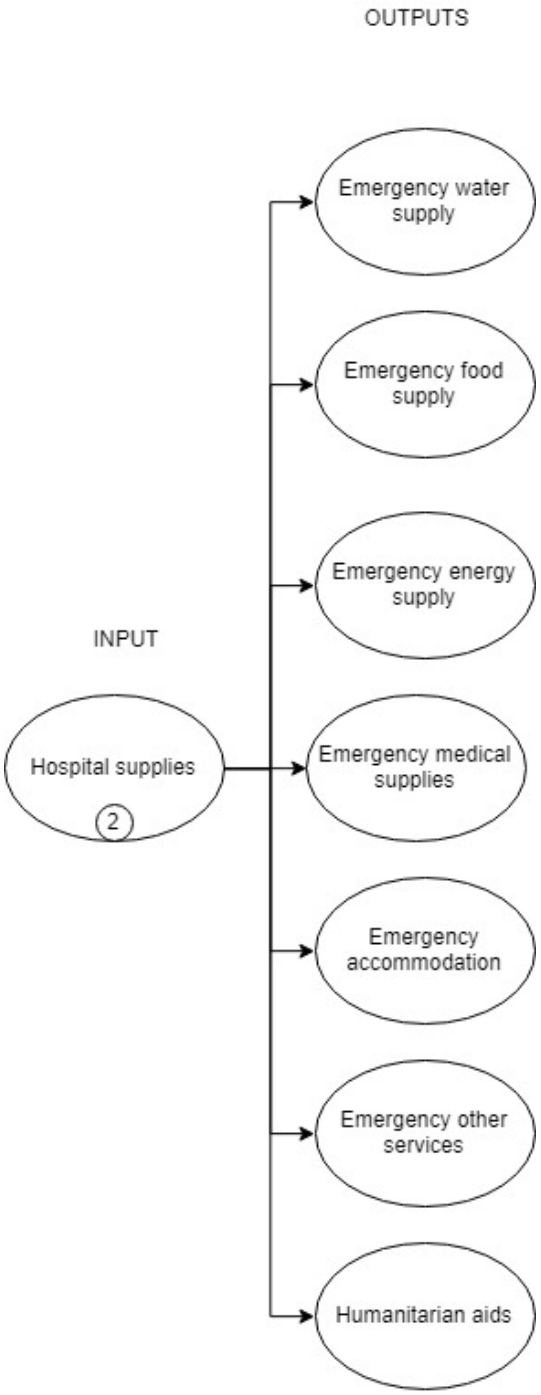

Fig. 3. Second input – Hospital supplies

Figure 4 shows the diagram of the second input – hospital supplies. We can see, that there are seven types of the emergency hospital supplies. There belongs emergency water supply, emergency food supply, emergency energy supply, emergency medical supplies, emergency accommodation, emergency other services, humanitarian aids. Firstly, there is the output emergency water supply where belongs drinking water, utility water and quality of the drinking water. To the second output we can place hot food, raw materials, equipment of the kitchen and other. To the third output we can place supply of energy, heat supply, supply of fuel. To the fourth output we can place medical supplies, blood, blood plasma. To the fifth output we can place accommodation supply – moving within the hospital and moving outside the hospital. And to the final two outputs belong other services and humanitarian aids.

The following figure 5 shows the last input of the purposed algorithm. This input deal with clients in the hospital. In times of crisis, when is the need of the emergency supplies we must know the number of clients in the hospital. This number is essential for the amount of emergency food deliver and for emergency water deliver too. This input was then devided into three categories. Firstly, it is health condition – diet. This category distinguieshes clients based on their diet (liquid, mush, racional, etc.). Secondly, it is health condition – accuray (acute, and stabilized). Finally it is the age of the clients (children, adult, senior).

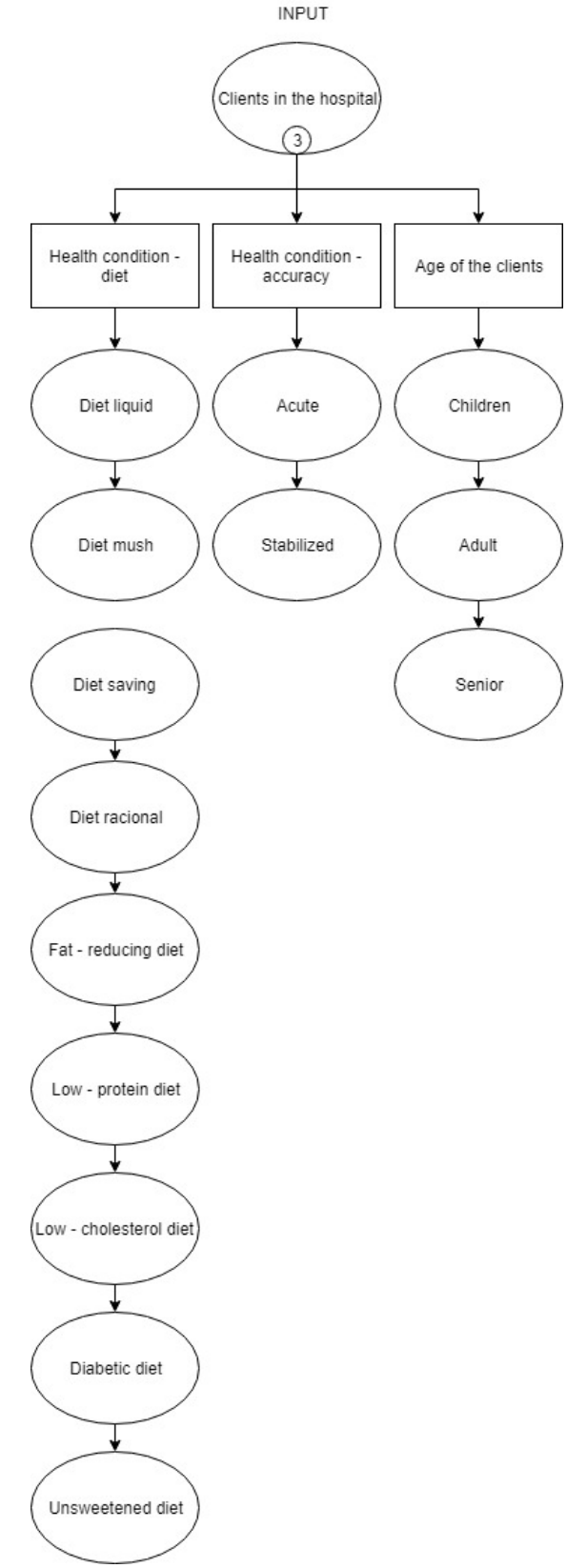

Fig. 4. Third input – Clients in the hospital

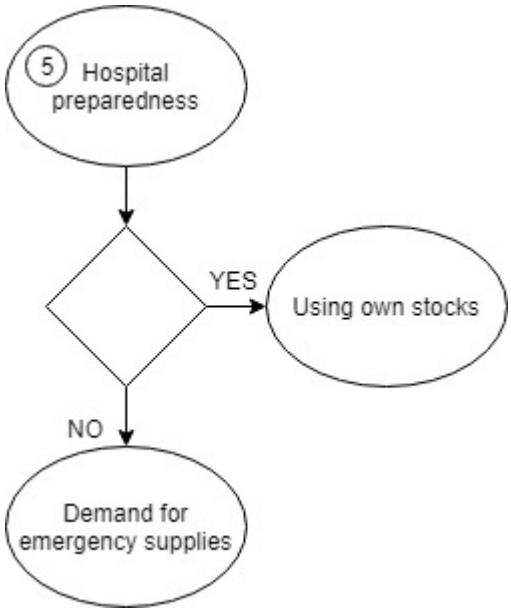

Fig. 5. Output – hospital preparedness

Figure 6 ilustrates the decision-making process of the evaluation crisis preparedness of the hospital. There are to options. Firstly, if the hospital is preparedness, use its stocks. On the other hand, if the hospital is not preparedness, demand for emergency supplies.

To this point, the existing information (communication) system of the hospital would be used.

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