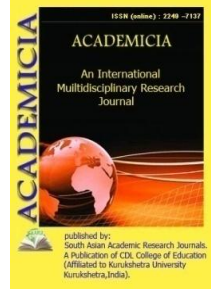




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## TECHNOLOGIES FOR ELECTRONIC GENERATION OF MEDICAL RECORDS IN MEDICAL INFORMATION SYSTEMS

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### ABSTRACT

*The article examines the documentation of medical records on electronic media, suggests the formalization and documentation of medical data in the “ExterNET” medical information system for maintaining an electronic medical history. The basic technologies and interface for documenting medical records, the formation of electronic templates for standardization, the design of electronic examinations of the doctor and the terminology used are given. In order to formalize and document medical records, “electronic templates for medical records” have been proposed; the template structure is composed in a strictly defined sequence corresponding to the medical stages of the document, in which all the information entered is formalized and structured as much as possible. A software solution for the formation of medical records, the structure of the descriptive part of the prepared templates for medical examinations, the use of special software allowing the procurement of terms in a six-level order are given. The use of such a technology of medical record provides a gain in time, standardization of the examination, the terminology used, structuring the medical information generated during the examination of the doctor for a detailed scientific analysis of the many signs of various pathologies to create a system to support diagnostic decision making.*

**KEYWORDS:** *Medical Information, Formalization Of Medical Data, Electronic Templates For Registration Of Medical Records, Electronic Medical History, Medical Information System.*

## INTRODUCTION

The transformations carried out in the public health system of the Republic of Uzbekistan put forward the problem of information support for all levels of the system, as the main problem of practical medicine. The significance of this problem is especially relevant in the emergency medicine system. In this regard, to carry out a phased transition from paper information technology to electronic information and communication technology of the organization of the treatment and diagnostic process (TDP) becomes a necessary task and is the basis for creating the information infrastructure of a medical institution on which to wake automation and organization and management TDP and medical institution as a whole. At the same time, the status of information becomes as a resource, and in emergency medical institutions it becomes strategic. This in turn requires the ability to quickly obtain the necessary information about patients.

In this vein, it is necessary, first of all, to translate TDP organizations from intuitive to evidence, and its management from bureaucratic to informational basis, which requires the involvement of modern medical information technology, special software and technical means of collecting, storing, processing and presenting to optimize its organization. information, as well as an electronic communication system for importing and exporting them on a scale of health facilities, a region and, if necessary, an industry [1-3, 7]. As is well known, the TDP is a technology of information interaction, on the one hand, the attending physician with the patient, and on the other hand, all medical personnel who have relations with the patient, among themselves. Automation of the TDP should not change this essence, moreover, it should develop and improve this essence in its own ways of handling information. It follows that, first of all, it is necessary to automate the interaction between the participants of the TDP and the process of documenting all the steps of this interaction [1, 4,8].

The main and obligatory carrier of this complex organized exchange is traditionally a paper case history of an officially approved form and structure. It serves for the accumulation of information, making medical decisions, being not only medical, but also a legal document. However, the inability to use it simultaneously by several participants of the TDP, difficult to read, as well as the arbitrary content of records, the lack of formalization of medical information makes it difficult to use it quickly and fully in the practice of emergency medicine.

It has been established [5] that the amount of readable information in paper information security does not exceed 75%, and the usefulness factor of stored information is 82%. As a result, in terms of a hard time limit, which is typical for emergency medicine, paper information security taking a lot of working time from the doctor (at least 30%) for registration, remains just a passive storage of information, with quality content far from what is required. It becomes obvious that the organizations of the TDP in case of emergency on the basis of paper workflow become a serious brake on the improvement of this process. The solution is obvious - it is necessary to introduce electronic information-analytical and communication technologies [6, 11, 20, 21].

In this case, on the one hand, there is the possibility of automated formation of a medical document, and on the other, their long-term and secure storage and, if necessary, operational processing, transmission and submission by the user, that is, provide information and intellectual support to the TDP.

Documenting medical records on electronic media requires the formalization and structuring of the sections of all the medical information used. The lack of formalization in the introduction of medical information by arbitrary text does not make it possible to give the inspection results a structure suitable for effective computer processing [1-3]. This requires additional coding of the text components.

From the student's bench, we are all trained to observe a certain stage in the design of various types of examinations. For example, always the examination of the patient begins with the questioning of complaints, anamnesis, then descriptions of objective and local status, after which the doctor interprets a certain conclusion, writes specific recommendations on laboratory and instrumental examinations, prescribes medications or establishes indications for surgery, etc. Stages are also characteristic for other types of medical records, examinations of the patient, registration of all types of epicrisis and diaries, registration of protocols of operations, etc. It means that it is possible to standardize and structure all kinds of medical records and in a sequence to use them for documenting on electronic media [22, 23].

## **MATERIALS AND METHODS**

An important stage in the creation and application of the complex medical information system (MIS) "ExterNET" on the basis of the Fergana branch of the Republican Scientific Center for Emergency Medical Care was the creation of "electronic templates for the registration of medical records" [22, 23] in which all information entered is maximally formalized and structured according to sections. This report provides information on the sections and content of electronic templates for registration of medical records on the example of abdominal surgery.

Development of electronic templates is carried out in two stages:

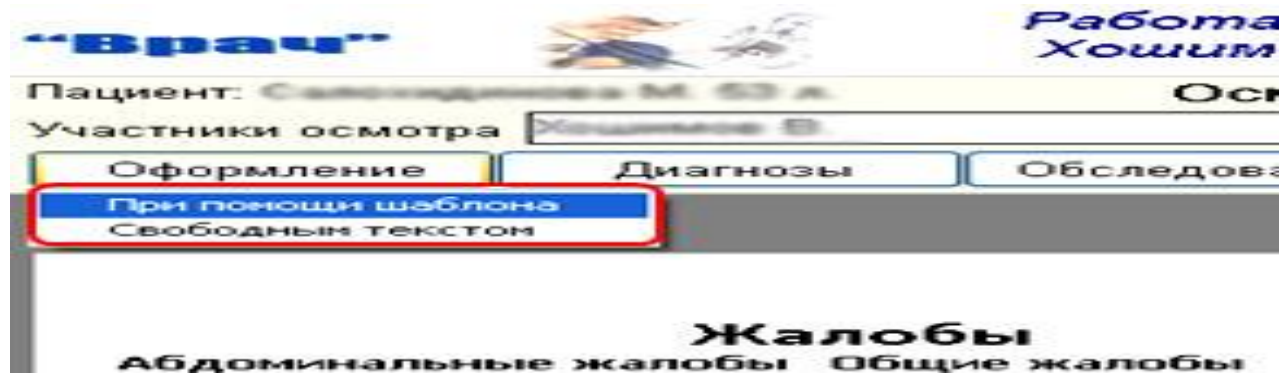
1. Development of special software, with corresponding sections and a six-level deepening. Outwardly it looks like a table. In other words, this is a universal basis where you can create arbitrarily new types of electronic templates (Figure-2);
2. Saturation of the program with medical information. In fact, the compilation of an electronic template.

By content, an electronic template is a set of medical terms and expressions arranged in a certain sequence, that is, it is structured. The structure of the template is made in a strictly defined sequence, corresponding to the medical stages of the document, for which it is designed.

All created templates consist of two sections: "Descriptive part of the scan" and "Inspection findings".

1. Descriptive part of the examination. To design a descriptive part of a doctor's examination, the program provides two methods (Figure-1):

- 1) free text, that is, the doctor writes arbitrarily, for this a separate window is opened, like a blank sheet of paper.
- 2) with the application with the help of a template, when you select it, the prepared electronic template for this technology is given further.



**Figure 1. Selection of the design method**

Using a template. To order the medical terms and expressions in the appropriate structure of the descriptive part of the prepared templates of medical examinations, we used special software - a tool that allows you to prepare the terms in the six-level block (Figure-2).

1. at the first level, the name of the template.
2. on the second part of the template - part.
3. on the third - objects.
4. on the fourth - the parameters of the symptom or symptom of the disease.
5. on the fifth - the properties of the parameters of the symptom.
6. at the sixth - the received values of the parameter property of the symptom.



**Figure 2.** The interface of the program for creating electronic templates for documenting medical records

Example:

**Level 1:** Inspection of the abdominal surgeon in the admission diagnostic department (DD)

**Level 2:** Complaints

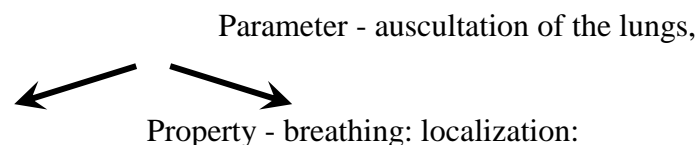
**Level 3:** Abdominal complaints:

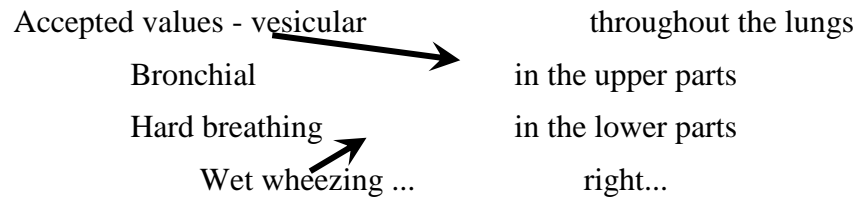
**Level 4:** Complaints of Pain

**Level 5:** localization

**Level 6:** in the upper half of the abdomen, in the lower half of the abdomen, in the right half of the abdomen, in the left half of the abdomen, in the right hypochondrium, in epigastrium, .... ..

When filling out medical information, or rather creating a new template, the first four levels are subject to mandatory filling. All six levels of the template are displayed on the screen. The content of these levels must be printed out. However, for the possibility of «maneuvering», the fourth and fifth levels have the ability, if desired, of the template creator, to be displayed for reading, but not printed. The fifth and sixth levels are filled arbitrarily: either one, or one, or none. When developing a software application, the need for links at the fifth and sixth levels was clarified, which was successfully implemented. For example: A patient may have wet wheezing in the lower parts of the lungs, and vesicular breathing in the upper parts.





Without the use of references, the entry will look like this: Auscultation of the lungs: breathing vesicular wet rales, in the upper parts, in the lower parts.

After using the links, the entry now looks like this: Auscultation of the lungs: vesicular breathing in the upper parts, wet wheezing in the lower parts.

In addition, when preparing a number of medical examinations (epicrisis, consultations, consultations, etc.), the doctor uses the already available information about the patient:

- from previous examinations (data of anamnesis, complaints, described statuses);
- from the results of the survey (conclusion of laboratory and instrumental examinations);
- from the list of prescriptions (data of ongoing treatment), etc.

In the software developed by us this is provided as follows: at the sixth level, the template creator has the ability to specify from which types of inspections which parts and sections of the scan the program should provide automatically. In this case, for example, if the physician chooses «to be hospitalized with complaints» when preparing his examination from the initial data, the program will automatically provide the patient's complaints recorded during hospitalization. The doctor remains to choose from the information provided essential, and the program will automatically compose the text. It should be noted that the program will provide complaints, not anamnesis, statuses or other. In the same way, if the doctor chooses the examinations on admission or status, or the treatment program will automatically provide only relevant information. It all depends on how correctly the template is created, what tasks are given by the template compiler when creating sections with automatic transfer, because the program can differentially transfer text, dates, time, numerical values, conclusions, etc. The described technology relieves the doctor of a new examination from the routine turning over the medical history, with the purpose of selecting the necessary information about the treatment carried out, the measures of their results received to the present day.

After composing the template, the creator must specify:

1. what kind of expert is this template used for;
2. type of template: examination, diary, protocol of operation, instrumental examination or other;
3. What type of diagnosis is displayed using this template: diagnosis of DD, clinical, final, or other?

## 2. INSPECTION FINDINGS.

The above described technology is used only for processing the descriptive part of the text of the medical examination. After its registration, the physician proceeds to the next part of the examination concerning the findings, namely:

- **Diagnoses;**
- **Surveys** (laboratory, instrumental, consultation);
- **Appointments** (medicinal, non-drug - regimen, diet, care, manipulations, procedures, dressings, surgery).

These parts of the examinations are designed in a universal, formalized form, so that they could be applied to all kinds of electronic templates, regardless of the specialty of the doctor, the type of examination and, most importantly, in what way the descriptive part is framed - free text or using a template. Information on the description of their structure, content, methods of application will be given in a separate message. As a result, the appearance of the template in the electronic medical history is as follows (Figure-3).

Externally, the template is divided into three parts:

### 1. The Upper Panel

It is not a betrayal; here the following information is automatically presented and organized by the program:

- Name of the patient;
- Name of inspection;
- Name of the doctor who makes the inspection;
- Inspection time.

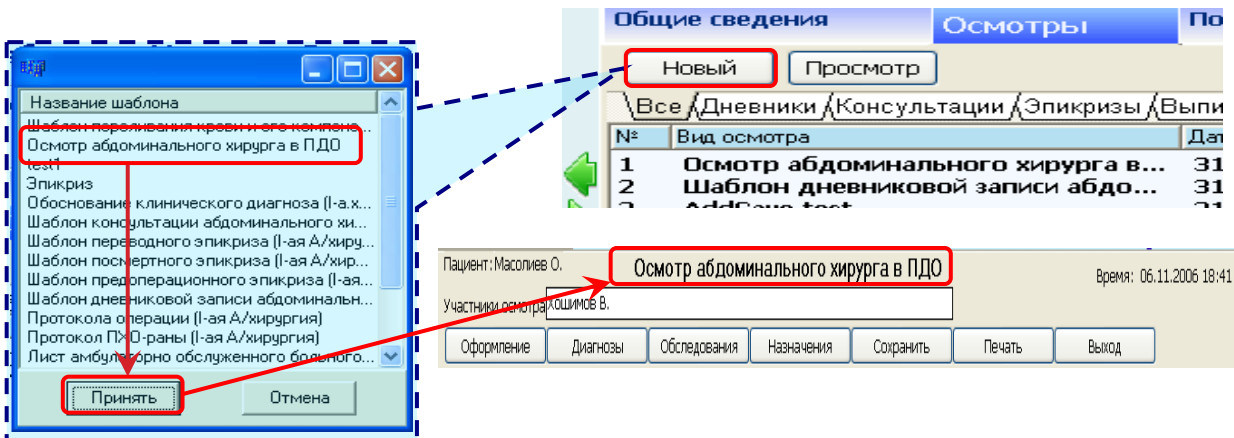
**2. The middle panel.** Here are the buttons for the possibility of creating inspection leads (see above), buttons for saving, previewing and exiting.

**3. The bottom panel.** It is the largest. It forms the descriptive part of the inspection (see above). Here is a text preview blank (in the left half) and a window where you can view the content of the automatically generated text of the descriptive part (in the right half) in the dynamics (Figure - 3).

The screenshot shows a web-based interface for a medical record. At the top, it displays patient information: 'Пациент: Селезнева М. Ю. а.', 'Участники осмотра: Кисинев В.', '19.04.2007', and '10:25:25'. The title is 'Осмотр абдоминального хирурга в ПДО' and the time is '28.04 12:33'. Below this is a navigation bar with buttons: 'Оформление', 'Диагнозы', 'Обследования', 'Назначения', 'Сохранить', 'Просмотр', and 'Выход'. The main content area is divided into two columns. The left column contains a list of sections: 'Жалобы' (with sub-items 'Абдоминальные жалобы' and 'Общие жалобы'), 'Anamnesis morbi' (with sub-item 'Со слов больного'), 'Anamnesis vitae' (with sub-items 'Со слов больного', 'Аллергологический анамнез', 'Эпидемиологический анамнез', 'Бытовой анамнез', 'Семейный анамнез', and 'Наследственный анамнез'), 'Status praesens' (with sub-items 'Общая часть', 'Дыхательная система', 'Сердечно-сосудистая система', and 'Мочевыделительная система'), and 'Status Localis' (with sub-items 'Пищеварительная система', 'Рана', and 'Местный статус'). The right column is currently empty.

Figure 3. Appearance of the electronic template for registration of medical records

It should be noted here that all the blanks are concentrated in the «new» button. It is located in the section of all inspections, to use it you need to activate the new inspection button. In this case, the doctor is provided with a list of prepared electronic templates in an additional window. The doctor needs to choose the right one. Also, we explain that all the examinations completed so far are concentrated in the section on the electronic medical history (EMH) called «examinations». They are presented in chronological order with the possibility of viewing each. So, the doctor needs to issue a new examination. According to the described technology, you need to select the required template from the list. To do this, it activates the «new» button, and a window with a list of prepared templates appears. After theselection, you must press the accept button and you will go directly to the selected scan window (Figure -4).



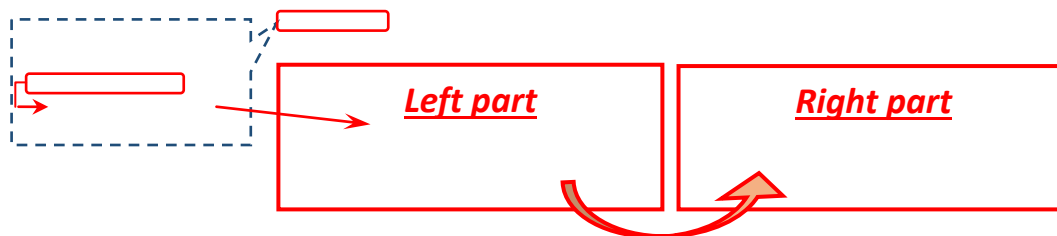
**Figure 4. Choosing an electronic template for a new medical examination**

The top unchanged panel automatically has the following information:

- Name of the patient;
- Name of inspection to be executed;
- Date and time of the inspection;
- Participants in the survey.

The name of the examination, the patient's name, date and time, these items are filled in automatically. You need to fill in this item manually.

The main buttons in this window used to design the corresponding sections of any inspection are the following buttons: Execution of the scan, Diagnosis, Examinations, Appointments (Figure-5).



**Figure 5. The terms selected from the left part of the window are displayed on the right part.**



As noted above, a set of medical terms, expressions, signs of various symptoms are staffed using a six-level depression. Of these, the first three will automatically be displayed:

1. Name of the examination (Inspection of the abdominal surgeon in the DD);
2. Its parts (Complaints, Anamnesis morbi, Anamnesis vitae, Status praesens, Status localis);
3. Objects of parts (for example, in complaints abdominal and general)

The appearance of the workpiece is as follows.

The remaining fourth, fifth and sixth levels are hidden inside the third level. To form the text of the doctor, you must hover the cursor and click on the third level. After that, the program will open the fourth level, selecting the required expression from the fifth level, the doctor goes to the sixth level. The last sixth level is opened in the form of a list of accepted values in a separate

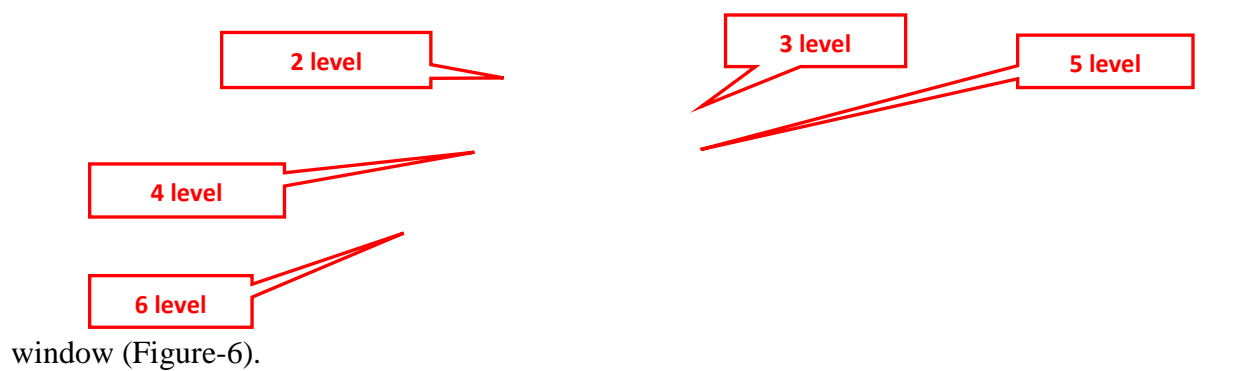


Figure 6. The selected terms on the left are displayed on the right. The figure shows the levels from 2 to 6.

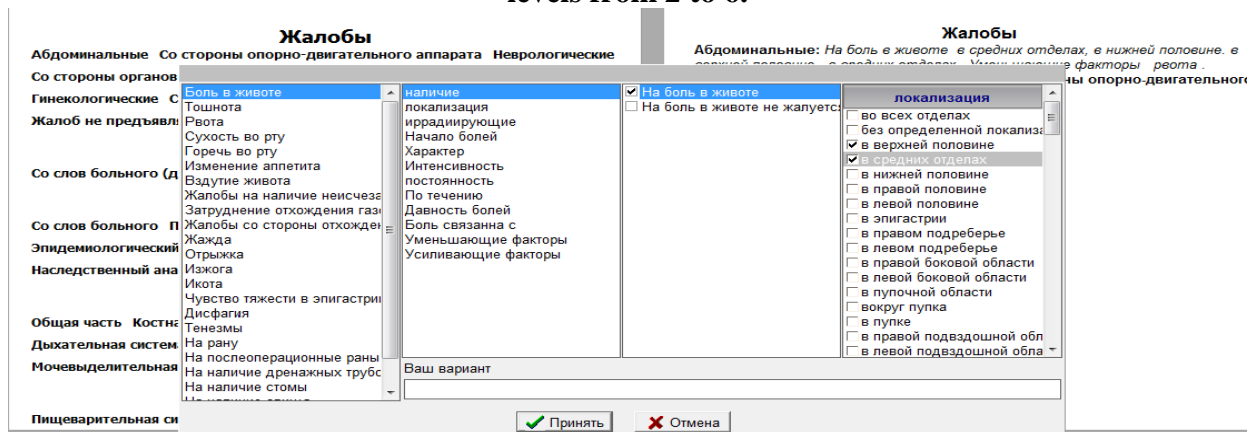
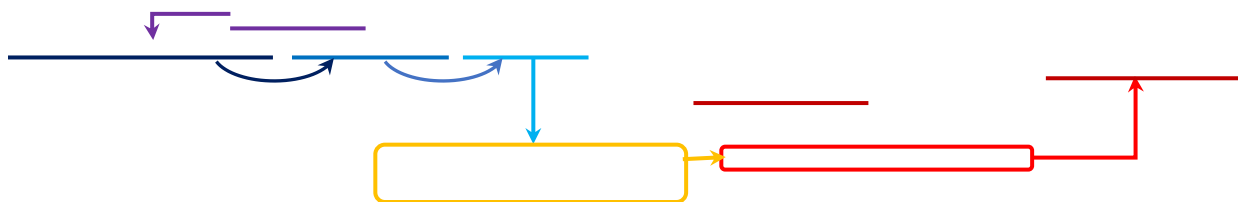


Figure 7. Selecting the received value

The user needs to click the left mouse button to «open» the contents of each term or expression (they change color when you hover the cursor), while the properties of this attribute (level 5) are displayed in red. After selecting the value received (level 6), the «accept» button must be activated by clicking the mouse. To delete an entry in the right window, you can return to the corresponding item in the template in the left window, mark the parameter and activate the «cancel» button (Figure-7).

Thus, the text in the right half of the window will automatically be generated. Moreover, expressions from the second, third, fourth, fifth and sixth levels will be arranged in order, describing a particular symptom or feature with the ability to control the correctness of the description (Figure– 6, 8).

As an example, we give the following expression: Complaints of pain in the right hypochondrium, epigastria giving to the right shoulder and shoulder blade (Figure-8).



**Figure 8. On the left side the selected terms are underlined, in the right one you see the text automatically generated by the program.**

Having issued one inspection section, you will similarly issue the following section. Thus, a set of prepared terms and expressions will automatically form a description of the inspection.

In the absence of the necessary term or expression, which describes a feature at the bottom of the window, each time the user is given the opportunity to describe his variant by arbitrary text - the window is called «your option» (Figure-9).



**Figure 9. The window «Your option»**

At registration of some inspections (epicrisis, consultation) the doctor needs information about the rendered help, treatment, operations, previous examinations, given laboratory and instrumental examinations. When making such inspections in the corresponding sections of the templates, the program will automatically provide the necessary information, the doctor will only choose the required amount of information, activate the «Accept» button, and it will automatically be transferred to the right field, again with the possibility of correction. After verifying the correctness of the information entered, you can finally save the information. By activating the print button, you can get a printout of the entire document (this inspection).

## RESULTS

For registration of medical records of the abdominal surgeon, described by the technology, the following types of templates are created:

1. Preliminary survey plan.
2. Initial examination of the abdominal surgeon (in the DD and the department).
3. The diary recording of the abdominal surgeon.
4. Preoperative epicrisis.
5. The protocol of the operation.
6. Indication for transfusion of blood and its components.
7. Protocol of blood transfusion and its components.
8. The consultation of doctors.
9. Justification of the

clinical diagnosis. 10. Stage epicrisis. 11. Translational epicrisis. 12. Posthumous epicrisis. 13. The discharge epicrisis. 14. Consultation of the abdominal surgeon.

As an example of the advantages of using formalized information input, we give several fragments from the clinical situations in which it is used for its intended purpose:

- a) The indication in the item «patient's condition» as «heavy» contributes to the automatic insertion of the patient into the list of «severe patients» in the workstations [22] of the on-duty surgeon, department head, responsible surgeon, deputy director of surgery, chief physician, director. Ensuring improved patient monitoring and increased continuity in the stages of helping to involve different levels of management;
- b) Information on the existing allergy to medicines in the physician's workstations of the doctor who makes the next appointment;
- c) The result of the determination of the blood group in the template of the indication for blood transfusion, in the requirement for blood to the department of blood transfusion;
- d) The entry in the protocol of the drainage location operation is addressed to the nurse in order to adequately fix the discharges from the drains.

In the analysis, the maintenance of medical records in electronic form showed informativeness of the medical history (MH) this amount of information [5], measured in letters or words, as well as various relationships of a certain type of information to the total. To analyze the information content of the information security, a study of electronic and paper information security was carried out; 50 paper information security were randomly selected from the archive and as many electronic. As a result of the study, the following data was obtained: data on the number of documents in Paper MH - 23.4, Electronic MH -23.4. It can be seen that the number of documents in the electronic history corresponds to its paper version; Information about the information content of data informativymedical historyis shown in table-1.

**TABLE 1.DATA INFORMATIVITYMEDICAL HISTORY**

<b>Indicator</b>	<b>Paper MH</b>	<b>Electronic MH</b>
The average amount of information, words	879,2	3070
The average amount of "readable" information, words	656,8	3070
The average amount of "unreadable" information, words	222,4	-

Table 1 shows that the average number of words recorded in an electronic medical history is 71.37% more. This is caused by the use of formalized inspection templates, mainly control inspections, in which the maximum number of abbreviations or incomplete phrases are noted. In this case, there are no problems with paper information security - corrections or illegible words. The obtained results allowed us to propose a coefficient of useful information storage (CUIS) of information security, determined by the following formula (1).

$$K_{\text{CUI}} = Q_r / Q * 100\% \quad (1)$$

From the formula (1) it can be seen that the coefficient of useful information storage in the MH shows what percentage of the information recorded in the medical history can be read, and thus analyzed by the medical staff. With an ideal method of storing information, this indicator should be equal to 100%. In the study, the following values of the coefficient of useful information storage were obtained: so in Paper MH - 74.7%, and in Electronic MH - 100%.

Based on the analysis, it is possible to draw the following conclusions: that about 25.3% of the information recorded in the paper information security can not be read, and thus, the time spent on its insertion is wasted. It should be noted that the respondents participating in the study are themselves practicing physicians and have already developed certain skills to analyze bad handwriting, intuitively suggesting the logic of the diary entry. If non-medical workers are taken for research, then the percentage of unread information would most likely be much higher.

Analysis of the coefficient of useful information storage depending on the age of doctors shows that there is a deterioration of handwriting with age. In other words, with the growth of professionalism and value, for example, a practicing surgeon, the quality of the documentation he compiles deteriorates. Therefore, it is obvious that the value of using MIS is growing along with the growth of professionalism of employees, and the most demanded medical documentation has the maximum efficiency of medical documentation.

The analysis of the one-time entry of information during its repeated use and the time spent on entering medical data used by the EMH can be shown in the following formula (2, 3):

$$\text{On paper: } H = n * h \quad (2)$$

$$\text{In the electronic version: } H = 1 * h \quad (3)$$

Here  $H$  is the elapsed time,  $n$  is the multiplicity of data entry,  $h$  is the time taken to maintain data once.

Analysis of labor costs for the preparation of case histories - the use of EMH in some operations requires more time than working with paper information security. Especially a lot of time is spent at the stage of mastering the medical information system. The undeniable advantage of EMH, according to many authors, should not lead to a significant complication of the daily work of the doctor. Those. the use of an MIS should be justified not only from the point of view of its effectiveness, but also from the point of view of staff labor costs associated with the use of an MIS. In this regard, the hypothesis of a higher ratio of information content to the labor time of the EMH compared to its paper counterpart is considered. For this, the time spent on completing the check-up examination of the doctor of the emergency department in paper and EMH was completed, table-2 shows the indicators of labor costs for working with information security.

**TABLE 2.INDICATORS OF LABOR COSTS**

Indicator	Paper MH	Electronic MH
The time required to complete the diary entry, in seconds.	465,1	405,3
Amount of information recorded in the control	156,5	375,6

examination, words		
Amount of "readable" information, words	116,9	375,6

It is necessary to work 14.7% more time to work with a paper inspection checklist. At the same time, while maintaining the electronic form in the database, the system performs its processing, which is completely similar in content to the paper version of the inspection. Opened sentences were immediately formed, convenient for a cursory study, and thus more informative from a subjective point of view. In addition, 74.7% of the information in the paper record could be read, so the amount of useful information in the electronic version was 221% more than in the paper version.

In this regard, we consider the indicator  $P_{I/Lc}$  "Informativeness/Labor costs" to assess the validity of the use of medical information systems by the following formula (4):

$$P_{I/Lc} = Q_r / T \quad (4)$$

where  $T$  is the average time required to create a diary entry.

The results of the analysis of the indicators of the coefficient "Informativity/Labor costs" are given in table-3:

**TABLE 3. COEFFICIENT "INFORMATIVITY/LABOR COSTS".**

Indicator	Paper MH	Electronic MH
Coefficient "Informativeness/Laborcosts"	0,33	0,93

Thus, the use of the electronic version of the check-up, as the most frequently encountered document on the history of the disease, is a more effective way of storing medical information, because has a 64.5% greater value of the indicator "Informativeness/Labor costs".

## DISCUSSION

Many authors who worked in the field of MIS show the effectiveness of the use of electronic management of medical records of patients who are filled every day by nurses, doctors, and other medical personnel involved in the diagnosis and treatment of a patient [1,4,5,7,10,13]. When maintaining electronic information security, time efficiency is one of the advantages that the implementation of EMH can be highly appreciated, and research [13,14,17] shows the maintenance of electronic medical records of patients during therapeutic diagnostic procedures, documentation of medical records created by users, [5, 13, 16, 17, 18] with arbitrary texts, [4,13, 21] or a tabular version, choosing the necessary sections, [10, 13, 15, 16, 19] and special, specified user workstations for maintaining medical data of patients [1, 4, 6, 9, 15, 17].

However, the effectiveness of introducing EMH is associated with the use of computer users' literacy [2, 11, 16, 19]. One of the possible explanations for this in many MIS is the maintenance of an EMH that is poorly formalized and the medical data of patients is conducted mostly with arbitrary texts and a little formalized tabular form and the formation of an EMH is not always based on a single information field and database.

Mainly developed by the MIS, the maintenance of the EMH turns off the preservation of medical multimedia data of patients, which are recorded during the examination of patients with various medical devices to monitor the clinical activities of staff [4, 3, 12, 14]. But the main works do not envisage problems of conducting medical examinations and electronic registration of oral examinations of patients by doctors. Basically it is made in the form of arbitrary text. As we know, with arbitrary processing of medical examinations, the data obtained are difficult to analyze or conduct other scientific research using computer processing of the collected data.

In our work, we studied various achievements and shortcomings of keeping an electronic record of medical data obtained during the examination of patients, and the formalization of medical data for further intellectual analysis. An MIS based on a single information space that stores all patient information and medical data in the OBD system must be clearly formalized. Maintaining medical data obtained during the verbal examination of patients determines the course of treatment, or in this process the doctor forms his diagnoses. So the analysis of these data is important for science when creating a support system for making medical decisions. The system we have created has shown the efficiency of maintaining medical records and temporary indicators while leaving the created medical records useful for further computer analysis. The proposed by us technologists the formation of the medical examination of patients showed informativity and to be effective in time in comparison with the paper version of patient medical history.

## CONCLUSIONS

The application of the described technology of registration of a medical record gives: the gain in time, standardization of inspection, used terminology, conducts the doctor when documenting the standard design path recalling all the details that allow you to not lose sight of the right, structuring of medical information generated during the examination of the doctor for detailed scientific analysis of the numerous signs of various pathologies to create a system to support diagnostic decision making.

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