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# Automatic Interpretation of Laboratory Tests and Its Influence on Follow-up

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Abstract. Failing to follow up on the abnormal test results can cause serious health problems to patients. We conducted a retrospective medical record review of 3200 randomly selected patients aged 18 to 76 in 14 state clinics and two private laboratory services querying the common regional patient registry. One patient could be included (1 clinical case) in the study only once. We invited patients to take part in the interviews to gain a deeper understanding of the motives to follow up or not after receiving a recommendation and explanation of the role of the automatically generated interpretation in this decision. A qualitative study of the patients' motivation was performed with a group of 689 patients. All the patients who received their interpretations showed a much higher follow-up rate (68% average) than the patients who did not receive interpretations (49 % average). The results of our research demonstrated that there is a significant impact on the patients' decision to follow up on the tests. Patients consider time factor as an important advantage of the computer interpretations and are willing to get automatic interpretations if they can receive it faster than the ones from their doctor (question 4: median =3 out of 7). Discussing the reasons behind the decision to follow up, the patients do trust the computerized clinical decision support systems (question 5: median = 5 out of 7), however, they prefer to receive interpretations and recommendations from doctors (question 3: median = 7).

Keywords. laboratory test, interpretations, decision support systems, follow-up

#### 1. Introduction

Today, the use of computerized clinical decision support systems (CDSS) is gaining its traction in helping patients in various clinical situations [9; 19]. Such systems can produce patient-specific reminders, interpretations, and recommendations motivating a more appropriate delivery of care [10; 14]. For example, such systems are used to interpret laboratory test results [16], alert about vital signs being outside of a reference interval [1], support in dietary questions [5; 20], and many other critical issues. The effect of CDSSs on laboratory test ordering was assessed in several systematic reviews [6; 13; 15]. These reviews determined that, when integrated into clinical workflow, CCDSs have a positive influence on the process of test ordering by the doctors. However, when the decision to run a diagnostic test or to follow up on a test is switched from a doctor to a patient, the effect of a CDSS can be very strong. Direct access of patients to the test results can lead to the patients becoming better-informed [4], more engaged [8], and able to manage their care more efficiently [21]. Another potential benefit is improving patient safety. Casalino et al. discovered that 8–26% of abnormal test results are not followed up in a timely way

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[3]. Pillemer et al. demonstrated that access to test results is appreciated by patients and increases adherence. However, it may cause patient nervousness and increase the number of visits [12]. Direct access to the test findings may let patients pursue a proper follow-up rate. A major concern expressed in [18] is that direct access can cause excessive patient nervousness because they can face difficulties interpreting the results. Interpretations given by a CDSS can support patients as they proved to deliver correct interpretations, provide great user experience, and are generally accepted by the patients [16]. A good and timely provided interpretation of the laboratory tests results given to patients by a CDSS, especially in the situation when a patient does not visit a doctor after the test is done can help to decide how to proceed with the diagnosis without support from a healthcare professional. The objective of the research is to study how patients perceive the interpretations of the laboratory tests automatically generated by a clinical decision support system in comparison with the interpretations given by doctors and how this affects the follow-up rate.

### 2. Methods

A clinical decision support system provides interpretation of laboratory test results for patients [11]. The common regional patient registry with obligatory registration of all laboratory tests helps to identify all testing events for every patient, including a list of tests that the patient ordered. We conducted a retrospective medical record review of 3200 randomly selected patients aged 18 to 76 querying the common regional patient registry. One patient could be included (1 clinical case) in the study only once. We studied 4 groups of patients:

- 1. The patients from the first group received their test interpretations automatically generated by a clinical decision support system with a clear indication that the interpretation was done automatically by a clinical decision support system.
- 2. The patients from the second group received their interpretations personally from a doctor with a clear indication that the interpretation was done automatically by a clinical decision support system.
- 3. The patients from the third group received their interpretations from a doctor with no indication of their automated generation.
- 4. The patients who did not receive any recommendations, only the test results.

We selected six laboratory tests commonly done by the patients (86.4% of all laboratory tests ordered in 2018), for which a decision support system could generate interpretations. Interpretation of each test with abnormal results included a recommendation to run another specific laboratory test or to repeat the same test again depending on the conditions of the patient. Participants were randomly selected for each group, using Random Sampling method, that ensured comparability to Russian demographic distributions. The reference intervals for the patients were taken from the recommendations of the Ministry of Health of the Russian Federation. We considered test results to be abnormal only if they were at least 20% outside of the reference range because it indicated a danger or potential risk for the patient's well-being over time.

A follow-up rate was calculated as a ratio of the number of patients who referred to a laboratory service for a follow-up investigation after receiving a recommendation within two weeks after the first test with abnormal test results had been completed and the interpretation was delivered to the patient. We calculated only the follow-up rate for the patients that had a recommendation to run additional laboratory tests. We invited patients

from groups 1 and 2 to take part in interviews to gain a deeper understanding of the motives to follow up or not after receiving a recommendation and the role of the automatically generated interpretation in this decision. The patients were invited by email and personal telephone calls. Patients were eligible for the study if they were 18 years and older and received a laboratory test interpretation during the previous months. We invited all the patients (1600) from groups 1 and 2 to participate in the interviews, 836 of them accepted the invitations: 421 from group 1 and 415 from group 2. From the patients who agreed, we formed a study group to represent the initial study population in terms of gender and age. Based on these constraints, we formed a group of 689 patients to run the study. The study was performed using one-on-one structured interviews. We asked the patients to rate questions 2–5 based on a Likert scale from 1 (not at all) to 7 (very much) [7]. For question 1, there were two possible answers: "yes" and "no". The interviews were done by one researcher by phone or in person. The interview agenda was developed by the project team and reviewed and accepted by the ethics committee of the regional Department of Health. Before the interview, the patients were informed about the goals of the research and received a printed declaration of anonymity and confidentiality. Every patient had signed a consent form before the interviews began. Interview agenda for the patients consisted of the following questions:

- 1. Q1: Did you notice that the recommendation was generated automatically?
- 2. Q2: Do you think the fact that the interpretations are done automatically affect your decision to follow up?
- 3. Q3: Do you think doctors will give a more precise and valid interpretation?
- 4. Q4: Would you wait to get a recommendation from a doctor rather than get an immediate interpretation from a CDSS?
- 5. Q4: Do you trust the interpretation given be a clinical decision support system?

#### 3. Results

The demographic data of the patients were recorded from the regional patient registry and presented in Table 1.

Gender	Group 1		Group 2		Group 3		Group 4		Age	Total
Age	>=60	<60	>=60	<60	>=60	<60	>=60	>60		
	19.4%	80.6%	19.4%	80.6%	19.4%	80.6%	19.4%	80.6%		
Males	47.0%		46.75%		47.38%		46.38%		38.8	46.87%
	74	302	70	304	76	303	72	299		1500
Females	53.0%		53.25%		53.62%		53.62%		39.4	55.13%
	97	327	95	331	97	324	99	330		1700
Total	171	629	165	635	173	627	171	629		3200

Table 1. Demographic characteristics of the patients

The follow-up rates for every group of patients are shown in Table 2. Table 2. Laboratory test follow-up rate for every group

2	1		20	1				
Gender	Group 1		Group 2		Group 3		Group 4	
	1		1		1		1	
Age	>60	<60	>60	<60	>60	<60	>60	<60
Males	59%	60%	73%	74%	75%	79%	48%	42%
Females	61%	61%	72%	75%	73%	80%	55%	49%
Total, age-dependent	55%	61%	72%	75%	74%	80%	49.7%	46%
Total	58%		74%		78%		49%	

Average follow-up 68% with interpretations

Table 3. Patients' attitude to the automatic test interpretations									
Question	Group 1		Group 2		Total				
	Mean	Median	Mean	Median	Mean	Median			
Q1	3.4	4	3.1	3	3.3	3			
Q2	6.8	7	6.1	7	6.2	7			
Q3	3.1	4	3.4	3	3.3	3			
Q4	5.9	5	5.7	5	6.8	5			

Patients' attitude to the automatic test interpretations is presented in the table 3.

#### 4. Discussion and conclusion

Patients are generally willing to have access to their test results [16], so the automatically generated interpretation, especially in the case when a patient is not visiting a doctor, can enhance their experience and increase follow-up rates.

Callen et al. in their systematic review revealed that 6.8–62% of laboratory tests were not followed up by patients [2; 17]. Utilization of clinical decision support systems for test interpretations can assist in overcoming the problem of failures to inform patients of abnormal outpatient findings, which is a common case now according to Casalino et al. with up to 26.2% of abnormal results not delivered to patients [3]. Automatic delivery of test result interpretations can potentially decrease the number of uninformed patients.

The results of our research demonstrate that there is a significant impact on the patients' decision to follow up on the tests. Promotion of laboratory test result notifications with detailed interpretations still demands communication effort and improvement of the algorithms to increase the reliability and trust to the patient-facing clinical decision support systems.

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