Importance of the hospital information system using the example of Croatia – a study of the students' perspective

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***Abstract* – The hospital information system represents an integrated or separate system that started to be introduced into healthcare systems worldwide in the late 1960s, primarily in hospitals due to the complexity of their systems and the need for their more efficient functioning. In the Republic of Croatia, hospital information systems represent tools without which the functional management of the system or the functional performance of hospital activities, considering everything they involve, can no longer exist. This research presents the perception and awareness of students at the Faculty of Medicine Osijek regarding the hospital information system, how it functions and what it encompasses. The obtained responses were compared based on the students' year of study. There is a slight difference in the students' perception based on their year of study, and it was observed that students have a fairly realistic and good understanding of what the hospital information system encompasses.**

Keywords: administration; hospital information system; laboratory information system

I. INTRODUCTION

As the world around us becomes increasingly more digital and advanced, information has become more accessible than ever. Today, we cannot imagine a world in which we cannot access new or existing and familiar information at any moment to help us in our work or everyday life. Hospitals and other healthcare institutions had to keep up with this global digitization in order to optimize their work and the manner of storing older patient data. With the development of medicine in the late 20th century, there arose a greater need for easier documentation, processing, organization and storage of data on patients, hospital resources and test results. Furthermore, it was important to have insight into the monitoring of work control, resource consumption, efficiency of diagnosis and treatment, consumption of medications and more (1). The beginnings of use of information technology in hospitals were related to the pharmacy, laboratory, radiology and the financial aspect of hospital operations, with the main purpose being invoicing of services and revenue generation (2). As a result of digitization of medical processes, the hospital information system (HIS) was created. Hospital information systems are IT systems used for the hospital's administrative operations, hospital management, as well as patient care (3). By implementing the hospital information system in hospitals, the storage and monitoring of all hospital activities – medical, economic and legal – is made possible, ultimately facilitating the exchange of information between different hospitals. The purpose is to ensure better insight into the availability of tests and medical materials, better patient monitoring, comparison of related data among hospitals and simplified professional and healthcare work of medical staff. The question that is always asked on the topic of hospital information systems, especially in developed countries, is how effectively they streamline operations and whether they are being used correctly to maximize the return on investment in the information system. Another question that arises is whether the information system is fully tailored to the hospital's needs or if there are parts of the hospital's operations that are not covered by the information system (4).

The role of the hospital information system is much more important and extensive than simply providing access to a patient's medical record or making such information available to patients and medical staff. The hospital information system is used for systematic and logical storage of a large amount of data, bringing together various hospital wards into a single unit, enabling the quick and efficient completion of everyday tasks for medical staff, as well as simplifying and streamlining patient care. These are the ultimate objectives of a hospital information system, which are achieved through continuous monitoring of the work of medical staff and the use of medical instruments, machines and medications. It contains a subsystem that monitors the operations of the laboratory – the laboratory information system. In short, the role of the hospital information system is to integrate all the working parts of the hospital, from medical to administrative processes. Through the hospital information system, medical staff and hospital administration monitor the hospital's work, efficiency and material consumption while applying the highest security measures concerning patient treatment and data processing. In

addition to its importance from the perspective of patient treatment and hospital management, one of the most significant objectives of the hospital information system is invoicing and receiving payment for services rendered. This is most accurately done by collecting information on all procedures through the hospital information system and its modules. Thus the financial resources for the hospital's operation are ensured(2).

A. Structure of the hospital information system

The hospital information system is designed to bring together all parts of the hospital into a single unit and to bring together all hospitals into a single system, which has been done in Croatia (1). The information system encompasses activities that provide support for system management. The main role of the information system is to collect and process information in the form of data, which form the main basis for decision-making, whether in management or in treatment. Based on all of the above, information systems are created to meet three criteria: information quality, information security and information uniqueness (5).

Such an integrated system allows for easier exchange of patient data during diagnostics or treatment in different hospital wards and enables patients to use hospital services in all hospitals in the country. This results in faster patient data processing because the exchange of information among specialists is faster and more straightforward. The human factor in using the hospital information system is crucial, and patient safety in the treatment process is a top priority (5).

Every hospital information system consists of multiple subsystems, representing different sectors of the hospital. Hospital information systems generally consist of separate or integrated components. The main division of hospital information system components is based on the following subsystems: hospital management system, healthcare system, laboratory system, pharmacy system, radiology system, inventory, electronic medical record, business system and reporting system (5). Subsystems are further divided into modules, for ease of use and finding of relevant information.

Modules allow for the structured presentation of all medical reports, the management of complete medical documentation, the management of complete nursing documentation, the complete subsystem of pathology, cytology and microbiology, adaptive multi-platform user interfaces, etc. (6).

In Croatia, the implementation of hospital information systems is at a high level. Software has been developed for the implementation of information systems in hospitals, laboratories and other healthcare institutions. The specificity of the system is addition of the mobile system called mRounds (mVizita) (7). This allows doctors to stay in contact with patients 24/7, if necessary. Communication is also possible through the eCitizens (eGrađani) system, which allows users to access all of their medical reports and referrals, facilitating the process of appointment scheduling for patients. There is also the eScheduling (eNaručivanje) system, which interacts with the Central Health Information System of the Republic of Croatia, the Croatian Health Insurance Fund and the Croatian Institute of Public Health (6).

To facilitate identification within the system, a barcode system has been implemented (6). Each patient is assigned a unique barcode that is used instead of their name and surname, as such an identification system can be complicated for data storage and can lead to errors if two patients have the same name and surname, potentially resulting in information mix-ups. The criterion of information security within the information system is thus met. Patients receive a barcode upon admission, which can be found on the documentation, patient wristbands and labels. The barcode must be provided on the container containing any sample provided by the patient. Barcode readers are available on all devices used in sample processing, ensuring that each sample is tested for exactly what the doctor requested in the referral, which also contains a barcode.

In addition to the hospital information system, the integrated unit also comprises other systems such as:

- BIS (business information system), which is used for the management of all administrative and financial activities, including the procurement of medications, reagents and other consumables, and which deals with all administrative and financial aspects of the hospital's operations
- HR (human resources), which is used for the management of all hospital employees, payroll calculations, working time records, etc.
- BI (business intelligence) system collects data from the HIS, BIS and HR systems and provides a reliable overview of the hospital's operations and organization, which helps improve its functioning (7).

B. Security of the hospital information system

Since the hospital information system was designed to function with a large number of users and since it brings together multiple hospitals and healthcare institutions, the security of data stored in it is of the utmost importance. Data security is managed on three levels (6):

- Vertical – confidential patient data are accessible based on the user's level of authorization
- Horizontal – employees of one healthcare institution cannot access the data of another healthcare institution
- Temporal – patient data cannot be accessed outside of patient treatment hours.

Each member of the medical staff has their own unique username and password, which may not be shared among colleagues. Usernames and passwords are used every time a staff member has to input or check data in the system. This way, if an error or omission in the system or a patient's medical record is observed, it can be traced back to the responsible employee. User passwords are changed every 90 days to reduce the likelihood of password sharing or information leaks (8).

IT support is also crucial when it comes to data security, as it is the responsibility of IT personnel to ensure that no malicious programs compromise the system. It is therefore essential to have adequate antivirus software, firewalls and

network traffic control. Licenses for these programs are renewed annually, and it is vital to keep them up to date (9).

In addition to antivirus software, it is important to have a proper firewall that prevents unauthorized users from gaining access to the system. It is recommended for each system to have two firewalls in case one fails, in order to ensure that the other firewall will continue to perform its function (9).

II. RESEARCH OBJECTIVES

Hospital information systems are the primary and basic tools used in hospitals when it comes to the flow of information required for decision-making, whether in regard to treatment or management. Considering this, efforts are made to raise awareness and increase knowledge of the functioning of information systems among college students. For that reason, the objectives of this study are:

- To examine the level of familiarity with hospital information systems among students at the Faculty of Medicine Osijek
- To examine their perception of hospital information systems
- To determine whether there are any differences in the perception of hospital information systems among students based on their year of study.

III. SUBJECTS AND METHODS

A. *Study design*

A cross-sectional study was conducted.

B. *Study design*

The subjects are students of the Faculty of Medicine Osijek. Students from all three study programmes were included: Undergraduate Study Programme of Medical Laboratory Diagnostics, Graduate Study Programme of Medical Laboratory Diagnostics and Integrated Undergraduate and Graduate Study Programme of Medicine. There were no exclusion criteria.

C. *Study design*

An online questionnaire containing a total of 10 questions, created for the purpose of this study, was used. The questionnaire consisted of two subscales. The first subscale concerns questions about the students' knowledge of the hospital information system and contains 10 questions with answers on a 5-point Likert scale. The second subscale concerns the students' perception on the importance of the hospital information system and contains questions with answers on a 5-point Likert scale.

D. *Study design*

Categorical data are expressed in absolute and relative frequencies. Normality of distribution of numerical variables was tested using the Shapiro-Wilk test. Due to non-normal distribution, data were described using the median and interquartile range. Differences in continuous variables with regard to the two independent groups were tested using the Mann-Whitney U test. All p-values are two-tailed. The significance level was set at Alpha $\alpha = 0.05$. For statistical analysis, MedCalc® Statistical Software version 20.218 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2023) was used.

IV. RESULTS

The study involved 40 subjects (students), of whom 13 (33%) were male and 27 (67%) were female. The subjects' median age was 21 (with an interquartile range from 20 to 22 years of age), ranging from a minimum of 19 to a maximum of 26 years of age. Most of the subjects were in their 2nd and 3rd year of study, and in terms of the study programme, 18 (45%) subjects attended the Undergraduate Study Programme of Medical Laboratory Diagnostics, while 16 (40%) of them attended the Integrated Undergraduate and Graduate Study Programme of Medicine.

During their studies, 31 (77%) subjects stated that they had taken a course related to medical informatics/bioinformatics (Table 1).

TABLE I. SUBJECTS' BASIC CHARACTERISTICS

	Number (%) of subjects
Sex	
Males	13 (33)
Females	27 (67)
Year of study	
1st year	8 (20)
2nd year	13 (33)
3rd year	10 (25)
4th year	2 (5)
5th year	5 (12)
6th year	2 (5)
Study programme	
Undergraduate Study Programme of Medical Laboratory Diagnostics	18 (45)
Graduate Study Programme of Medical Laboratory Diagnostics	6 (15)
Integrated Undergraduate and Graduate Study Programme of Medicine	16 (40)
Did you attend a course related to medical informatics/ bioinformatics during your studies	
No	9 (23)
Yes	31 (77)

A total of 30 (75%) subjects strongly agree with the statement that better connection among medical staff results in more effective patient treatment, while 23 (60%) strongly agree with the statement that they think that better hospital digitization positively affects work organization of medical staff.

29 (73%) subjects strongly disagree with the statement that they have never heard the term hospital information system, 24 (60%) strongly disagree with the statement that HIS is not something they will use in their future work as medical professionals, and 21 (53%) subjects strongly disagree with

the statement that medical professionals should not have access to all relevant data of their patients (Table 2).

TABLE II. SELF-ASSESSMENT OF PERCEPTION OF THE HOSPITAL INFORMATION SYSTEM

	Number (%) of subjects					
	1	2	3	4	5	Σ
I think that hospitals are not sufficiently digitized.	3 (8)	11 (28)	10 (26)	8 (21)	7 (18)	39 (100)
I have never heard the term hospital information system.	29 (73)	7 (17)	2 (5)	2 (5)	0	40 (100)
I first heard the term hospital information system in one of the courses at the Faculty.	10 (25)	5 (13)	9 (22)	10 (25)	6 (15)	40 (100)
I think that HIS is not something I will use in my future work as a medical professional.	24 (60)	12 (30)	3 (8)	1 (2)	0	40 (100)
I think that medical professionals should not have access to all relevant data of their patients.	21 (53)	9 (22)	9 (22)	1 (3)	0	40 (100)
I think that protection of patients' data should be one of the hospital's priorities.	1 (2)	1 (2)	9 (23)	7 (18)	22 (55)	40 (100)
Better connection among medical staff results in more effective patient treatment.	0	0	2 (5)	8 (20)	30 (75)	40 (100)
I think that better hospital digitization positively affects work organization of medical staff.	1 (3)	0	2 (5)	13 (32)	23 (60)	39 (100)
Connecting hospital wards in a single information network is unnecessary and dangerous.	19 (48)	15 (37)	6 (15)	0	0	40 (100)
I think that in my work as a future hospital employee, I will not have any connection with the hospital information system.	26 (65)	8 (20)	5 (13)	1 (2)	0	40 (100)

Subjects in Group 2 (4th to 6th year of study) agree, to a statistically significant extent compared to those in Group 1 (1st to 3rd year of study), with the statement that they have never heard the term hospital information system (Mann-Whitney U test, P = 0.03), and they agree, to a statistically significant extent, with the statement that HIS is not something they will use in their future work as medical professionals (Mann-Whitney U test, P = 0.02).

Subjects in Group 1 agree with the statements that protection of patients' data should be one of the hospital's priorities (Mann-Whitney U test, P = 0.008) and that better connection among medical staff results in more effective patient treatment (Mann-Whitney U test, P = 0.01), to a statistically significant extent compared to those in Group 2.

Subjects in Group 2 agree with the statement that in their work as future hospital employees, they will not have any connection with the hospital information system, to a statistically significant extent compared to those in Group 1; however, this is on the borderline of statistical significance (Mann-Whitney U test, P = 0.05) (Table 3).

TABLE III. STATEMENT ASSESSMENT BY YEAR OF STUDY

	Median (interquartile range)		P*
	Group 1 (1st to 3rd year of study)	Group 2 (4th to 6th year of study)	
I think that hospitals are not sufficiently digitized.	3 (2 – 4)	3 (2 – 5)	0.93
I have never heard the term hospital information system.	1 (1 – 1)	2 (1 – 3)	**0.03**
I first heard the term hospital information system in one of the courses at the Faculty.	3 (1 – 4)	4 (3 – 4)	0.20
I think that HIS is not something I will use in my future work as a medical professional.	1 (1 – 2)	2 (1 – 3)	**0.02**
I think that medical professionals should not have access to all relevant data of their patients.	1 (1 – 2)	1 (1 – 3)	0.96
I think that protection of patients' data should be one of the hospital's priorities.	5 (4 – 5)	3 (3 – 5)	**0.008**
Better connection among medical staff results in more effective patient treatment.	5 (5 – 5)	4 (4 – 5)	**0.01**
I think that better hospital digitization positively affects work organization of medical staff.	5 (4 – 5)	4 (4 – 5)	0.21
Connecting hospital wards in a single information network is unnecessary and dangerous.	2 (1 – 2)	2 (1 – 3)	0.68
I think that in my work as a future hospital employee, I will not have any connection with the hospital information system.	1 (1 – 2)	2 (1 – 3)	0.05

V. DISCUSSION

This study aimed to show the students' perception of the hospital information system and to compare the results with regard to the beginning or end of studies. Students' perception is very important because upon completion of their studies, all students currently attending the Faculty of Medicine will be employed in healthcare institutions where some form of information system is used. As future medical professionals, it is important that they are familiar with the way the system works and that they understand the importance of proper treatment of their patients' data.

Before the survey was conducted, it had been hypothesized that subjects in Group 2 would be more familiar with the way the hospital information system works and what it consists of in comparison to those in Group 1. The reason for this is that,

as the studies progress, students become more involved in the processes taking place in the hospital, from patient admission to writing medical reports. Furthermore, those in Group 2 have more opportunities to see that process in practice, through exercises which they complete as part of their courses. On the other hand, students in Group 1 have not yet been introduced to the hospital system through clinical practice and they may be less familiar with how patients' data are processed, i.e., with the way the hospital information system works as well as its purpose.

Regarding the first question in the survey, "I think that hospitals are not sufficiently digitized", the majority of subjects answered that they disagree or that they neither agree nor disagree; however, many subjects answered that they agree and that they strongly agree. When those answers are divided according to the groups, answers provided by subjects in Group 1 ranged from 2 to 4, while those given by Group 2 ranged from 2 to 5. The difference in the answers is not statistically significant and the median for both groups is 3, but it can be concluded that students in Group 2, who have more experience in working in hospitals, answered "I agree" and "I strongly agree" more frequently because they think that hospitals are indeed not sufficiently digitized.

The second and third question offer insight into the students' familiarity with the term hospital information system. Answers to the second question, "I have never heard the term hospital information system", vary with regard to the year of study. All students in Group 1 answered that they strongly disagree with the statement, while answers of those in Group 2 varied from "I strongly disagree" to "I neither agree nor disagree". The answers were surprising, seeing as it was initially hypothesized that the students in Group 2 were more experienced in and familiar with the hospital information system. Answers to the question "I first heard the term hospital information system in one of the courses at the Faculty" also significantly vary when compared considering the year of study. Answers of the students in Group 1 ranged from strongly disagreeing to agreeing, while answers of those in Group 2 were that they neither agree nor disagree or that they agree with the statement. Therefore, it can be concluded from those two answers that students in Group 1 have heard of HIS, but mainly from other sources not including higher education, while answers of those in Group 2 indicate that they heard the term hospital information system in the course of their higher education.

Students in Group 1 gave identical answers to the questions "I think that HIS is not something I will use in my future work as a medical professional" and "I think that medical professionals should not have access to all relevant data of their patients", i.e., that they either strongly disagree or they disagree. These answers show that Group 1 students are aware of their role in using the hospital information system and that it is exceptionally important for them as medical professionals to have free access to all medically relevant data of their patients at any moment. Students in Group 2 answered those questions more broadly, i.e., in addition to "strongly disagree" or "disagree", there was also a significant number of "neither agree nor disagree". Based on the above, it can be concluded that they are less certain of what their future work in hospitals will entail, possibly because the students of the Graduate Study Programme of Medical Laboratory Diagnostics are included in Group 2 students, and their work will mostly involve the laboratory information system (LIS). The laboratory information system is one of the subdomains of the hospital information system, which comprises all aspects of laboratory work, from receiving samples to issuing medical reports (10). It is also important to note that regarding the question "I think that medical professionals should not have access to all relevant data of their patients", there were a lot more answers under 3, i.e., "I neither agree nor disagree". An approximately equal number of students answered that they disagree or that they neither agree nor disagree with this statement. This further points to the fact that Group 2 students are familiar with the General Data Protection Regulation, according to which a physician is generally only provided with the information necessary for them to perform the work within their area of expertise.

More than 20% of the subjects stated that they strongly agree with the statement "I think that protection of patients' data should be one of the hospital's priorities", while an approximately equal number of subjects stated either that they agree or that they neither agree nor disagree. Regarding this question, there is a visible difference in the median of answers considering the year of study. Students in Group 1 answered with 4 or 5 on average, i.e., that they agree with the statement, while the median of answers of Group 2 students was 3, i.e., there were a lot more answers that they neither agree nor disagree. This may also be due to older students having more experience in working in hospitals; they likely do not think that patient security is one of the main priorities because they believe that other issues should be prioritised when it comes to hospital budget or time dedicated to a specific problem. Of course, patient security is one of the hospital's priorities, as stated above. Extensive measures in implementation of security were introduced, ranging from each user of the hospital information system having a username and password that are changed every 90 days to using multiple antivirus programs and firewalls (8, 9).

The following three questions in the survey give us insight into the students' understanding of how the hospital information system functions and how it improves the hospital's operation. Answers to the questions "Better connection among medical staff results in more effective patient treatment" and "I think that better hospital digitization positively affects work organization of medical staff" were balanced – all students answered that they agree or strongly agree with these statements. This shows that students understand the importance of connection among medical staff from different hospital wards for more effective patient treatment, faster flow of information and simple and quick check of available tests, medications and other resources necessary for everyday hospital operation. This is also confirmed by answers to the question "Connecting hospital wards in a single information network is unnecessary and dangerous", where students answered that they disagree with the statement, regardless of the year of study. They thus recognize the importance of connecting all parts of the hospital into a single functional network and they believe that

there are no justifiable reasons not to implement that kind of digitization. Successful connecting of the hospital into a single information network depends on good hospital management, which, based on the reports of individual hospital wards, decides on how the hospital should continue to function as a unit and what changes should be implemented and where. Reporting to the management is carried out at multiple levels and it is important to take every step of work into account. This includes reports on the duration of the patient's stay, the communication between hospital wards, services provided in individual wards and so on (10).

The objective of the final question in this survey was to gain insight into the students' perception of their role in the hospital information system as potential future employees. More than 80% of the students answered that they disagree or strongly disagree with the statement "I think that in my work as a future hospital employee, I will not have any connection with the hospital information system". Fewer students, 13%, answered that they neither agree nor disagree, which was the case with students in Group 2, which also includes students of the Graduate Study Programme of Medical Laboratory Diagnostics. Students who complete this study programme will be the future employees of hospital laboratories, which are included in the laboratory information system. This may be the reason why they gave the answer that they neither agree nor disagree. Although the laboratory information system is a part of HIS, it includes activities specific for individual laboratories – haematological, cytological, microbiological laboratory, among others, which have their own protocols (9, 10).

VI. CONCLUSION

Information systems in healthcare are an essential tool for improving treatment and system management. Hospital information systems as systems within the most complex healthcare institutions represent an advanced tool for implementing all activities within the hospital. Awareness of hospital information systems, both with regard to advanced treatment methods and with regard to effective management methods, is something that should be raised among students, as future users of the system, as early as possible. After the conducted survey and interpretation of answers, it can be concluded that the students of the Faculty of Medicine Osijek are familiar with the hospital information system and have quite a good understanding of what it entails and how it functions. The hospital information system serves to bring together all parts of the hospital – from administrative operations to each individual hospital ward. It provides medical staff with easier access to medically relevant information on their patients, their medical history, any therapy they might be taking and information on available tests in the hospital, availability of specific medications and laboratory tests. By connecting otherwise separate hospital wards into a single unit accessible to every doctor, nurse or laboratory technician on their computer at any moment, their work is significantly improved, which results in faster and more thorough patient treatment. A slight difference was observed between answers given by Group 1 students and Group 2 students, but it is not relevant and stems from the fact that Group 1 students have less practical experience with the functioning of the hospital information system.

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