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THE USE OF TELEMEDICINE TECHNOLOGIES TO CREATE A MEDICAL INFORMATION SYSTEM FOR MEDICAL AND SOCIAL CARE

Introduction. *The use of digital medicine methods is becoming more relevant due to the COVID-19 pandemic, the current martial law in Ukraine, and the lack of medical equipment in some rural areas.*

The same applies to the provision of medical care to the chronically ill. Such assistance includes, in addition to medical and diagnostic measures, also social measures, such as care for the sick and disabled, provision of food, etc. These measures are united under the term "medical and social assistance".

The purpose of the paper *is the application of digital medicine methods, which include telemedicine technologies, in the course of the construction of the Medical Information System (MIS) model for assistance to the chronically ill with the telemedicine module for implementation of appropriate medical services in hospital home conditions.*

Results. *The types and methods of telemedicine technologies were analyzed, the diagram of business processes of the "Telemedicine" module was designed. The modules of the system were described with the specification of their realization, and the technical realization of the MIS for chronic care was carried out. The technical requirements of the "Electronic prescription" module were described, and the diagrams for the tasks that are frequently used in practice were provided.*

Conclusions. *Based on the results of the analysis of capabilities and experience of using modern telemedicine systems, the architecture of medical information system for the medical and social care of patients was developed which covers the doctor and patient modules, united functionally by defined business processes with the performance of specific functions (online interaction between doctor and patient, issuing an electronic prescription etc.).*

The use of the proposed MIS which is made using a modern REST API platform for downloading files directly from clients, and an application implemented on the basis of the Waterfal method and the Python programming language, ensures the organization of the interaction of the medical staff with patients, in particular, the implementation of remote consultation and the provision of electronic prescriptions on based on entries in the patient's electronic card.

Keywords*: medical and social assistance, telemedicine technologies, medical information systems.*

INTRODUCTION

During the COVID-19 pandemic, people who needed constant check-ups with doctors and visits to medical facilities were at risk of getting the coronavirus infection. This could have occurred in a live queue at a health care facility, either through contact with any surfaces or due to the actions of others who neglect to wear medical masks or are the carriers of the infection in the incubation period.

It should also be noted regarding the elderly category or people with disabilities, for whom visiting health facilities in person can be very difficult, or even lead to worsening of health due to excessive physical activity. In rural areas, there is an insufficient number or remoteness of healthcare facilities and an insufficient amount of medical equipment.

For now, there is already some experience in the use of telemedicine technologies in so-called home medicine [1]. The same applies to patient consultations when their implementation requires the direct participation of patients and consultants, and certain resources.

The development of telemedicine has been given a great attention in the majority of developed countries. This may be due to the effectiveness of telemedicine in facilitating quick access to specialists, diagnostics, and treatment and preventing injuries and diseases [2, 3]. The use of telemedicine has also been useful during COVID-19 [4]. Telemedicine has played an important role in the fight against massive epidemic outbreaks [5]. Different countries around the world are using telemedicine as an effective way to test, and remotely monitor patients with mild symptoms of COVID-19, tracing contacts and triaging symptoms. Telemedicine technology has been effective in fighting the Ebola virus in some areas of Africa.

Although the above studies have shown how various telemedicine applications can support measures to limit the negative impact of COVID-19, there is a serious lack of research on telemedicine that would provide a basis for determining user satisfaction with telemedicine services. We believe there is little research on the use of telemedicine to provide medical services to patients with chronic diseases. There are also many barriers such as geographical access, affordability, accessibility, and acceptability of access to health care in developing countries. These barriers become more problematic for women, children, the elderly, and people with physical disabilities.

To overcome these barriers, the healthcare segment is now using telemedicine solutions to increase the reach of its services. The rapid development of information technology, particularly web technologies, has opened up new opportunities to provide better healthcare to society. Telemedicine is gradually becoming a viable policy option for governments in developing countries.

The World Health Organization (WHO) defines telemedicine as: "The provision of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies to exchange valid information for diagnosis and treatment, prevention of diseases and injuries, research and evaluation, and for the continuing education of health care providers, all in the name of improving the health of individuals and their communities" [6].

PROBLEM STATEMENT

In the modern world, there is a rapid development of Internet technologies, affecting many areas of modern human life. The development of technology allows establishing connection of healthcare institutions and facilities with any state-level institution, thus freeing people from queues, and paperwork and saving their time. Currently, numerous multipurpose platforms and services have been created in the world, that allow society to exchange knowledge, skills, experience, etc. Therefore, information technologies can also be applied in the medical sphere to provide medical care remotely through telemedicine to people who, for various reasons, do not have the physical ability to visit a medical facility, but only remotely via telemedicine methods.

Studies have shown that primary health care physicians described telemedicine as a more flexible, patient-centered way to provide care. The benefits of using telemedicine to treat older patients included reducing delayed care and increasing on-time care, increasing physicians' efficiency, improving communication with caregivers and patients, reducing the patients' travel burden, and allowing more patients to be treated [7]. Issues included unequal access for rural, elderly, or cognitively impaired patients. Physicians noted that payment parity with in-person visits, along with video and telephone visits, and the easing of restrictive regulations helped to continue the usage of telemedicine.

Besides, during the COVID-19 virus pandemic, it was discovered that existing approaches and technologies for providing prehospital medical care during supercritical facilities loading were ineffective, resulting in a huge load on the devices for artificial ventilation of the lungs (ventilators) and high mortality among the

infected [8]. It was obligatory to develop effective means for the implementation of such medical services, which would help to provide high-quality assistance to patients on time. The analysis showed that it is the application of telemedicine that will provide an opportunity to implement such objectives [9].

Telemedicine means providing remote clinical services through bilateral real-time communication between the patient and the health care provider via electronic audio and visual means [10]. With telemedicine, people can avoid the additional risk of getting sick during the pandemic, the elderly can receive medical care while staying home, and people in rural areas can receive qualified consultations without visiting distant health care facilities. Also, telemedicine gives an advantage not only in the "doctor-patient" direction but also in the "doctor-doctor" direction. The above-mentioned direction allows experienced doctors to share their experience with less experienced ones, as well as the opportunity for doctors to consult with more qualified specialists on the treatment of their patients. The main advantage of telemedicine in today's conditions is the continuation of consultations in doctor-doctor and doctor-patient directions at a distance.

The telemedicine industry and technologies have been developing rapidly for years now, and their benefits are obvious. However, the implementation processes are still not in good state. The adoption of telemedicine was humble so far, especially in Ukraine, as several interrelated barriers have yet to be overcome. While the hospital setting is a stable environment for implementing telemedicine solutions, the adoption of home telemedicine services (TMS) remains a relatively unexplored area. For the elderly population, due to the increase of chronic diseases and other age-related health disorders, TMS is a promising option to improve quality of life, reduce healthcare costs and provide more independent living. This makes older people the main target of efforts to implement TMS. TMS includes three core groups of services: access to the healthcare system at home (access to personal health records); assistive living technologies; and remote patient tracking and chronic disease treatment (vital indicator measurement and online communication) [11].

Telemedicine technologies are gaining great importance in providing medical and social care. Medical and social service is a type of professional practice that assists in the restoration, preservation, and strengthening of health by solving the problems of a patient/client who is in difficult life circumstances. This assistance includes preventive, therapeutic-diagnostic, rehabilitation, prosthetic-orthopedic, and dental care, as well as social measures for the care of the sick, incapacitated, and disabled people including the payment of temporary disability benefits [12]. We consider the digitalization of medical and social care, taking into account the use of information technology in the implementation of medical care for patients with chronic diseases who are being treated in a hospital home conditions.

As it known, telemedicine consultations can be divided into several directions.

1. Telemedicine consultations, both asynchronous and synchronous.

2. Use of telemedicine assistance by doctors of different specialties and for different diseases. For example, in order to disseminate the experience of surgery, it is now possible to use network video cameras to broadcast the surgical procedures with the assistance of a consultant surgeon [13, 14].

3. Mobile telemedicine complexes. Mobile diagnostic telemedicine complexes, usually, consist of computer telecommunication equipment and compact mobile telemedicine devices, which are used to perform full medical consultations and diagnostics [14]. Such complexes are provided to emergency teams, first-aid stations, and rural hospitals, as well as by the teams of the Center for Disaster Medicine, sanitary aviation, and medical units of the Ministry of Emergency Situations. The above-mentioned can effectively help in mountainous terrain, where access logistics to healthcare institutions is complicated because of the geographical location, an example of which is the experience of the Chernivtsi region [15].

Also, mobile complexes can be very useful in conditions of combat operations in Ukraine, with their help paramedics can consult with narrow-profile specialists and under their guidance perform complex operations for the defenders of Ukraine.

4. Remote biomonitoring systems. These can be bio-sensors, which are easily attached to the skin of a person and do not interfere with daily activities, recording ECG signals and blood pressure, which are associated with the smartphone application that records and sends ECG via GPRS to the to the relevant data processing centers, and if the life is threatened, after analyzing the signal can determine person's coordinates [16].

5. In the conditions of in-home telemedicine, it is the provision of remote assistance to patients after surgery or with chronic diseases at home.

In all the above cases, it is necessary to have the appropriate equipment, for example, a portable electrocardiograph for patients with chronic cardiovascular diseases, and devices that can measure body temperature, blood pressure, and partial pressure of oxygen. All data is sent to the cloud storage integrated with the MIS (medical information system). Consequently, telemedicine technologies optimize and increase the effectiveness of therapeutic and diagnostic measures, which, in turn, improves the quality of medical care [17, 18].

The purpose of the study is to apply the methods of digital medicine, which include telemedicine technologies, in the construction of the MIS model for assistance to chronically ill patients with a telemedicine module to provide appropriate medical services in a hospital home conditions.

THE MODEL OF A MEDICAL INFORMATION SYSTEM USING TELEMEDICINE METHODS

The providing of medical and social care to patients with chronic diseases which are in a hospital home setting is associated with a number of difficulties due to their inability to come to a health care facility. The patient should have the means of recording health indicators. The patient should be aware of their use, as well as the ways to communicate with the doctor. The support of patients with these needs is one of the tasks of medical and social care.

At the first stage, the goal was the construction of an MIS model, with the help of digital medicine methods, for medical and social care with a separate module for the chronically ill, using telemedicine technologies.

We suggested a model of medical information system with the implementation of medical and social care for patients at home with chronic diseases in the form of a hardware-software complex with a telemedicine unit.

As the hardware in this configuration were used portable ECG devices, a pulse oximeter, a glucometer, and a tonometer. All of them are connected with the software application to collect relevant data and their accumulation in the database, as well as to implement the communication with the doctor.

To display the implementation of the structural and functional diagram of the developed application we have developed the business process model using UML notations (Fig.1).

As can be seen from Figure 1, the business processes implemented in the MIS are as following.

1. The patient, being at home and using mobile diagnostic devices, registers his health indicators, which are sent to the database. The software mobile applications are integrated with the cloud platform, in which the health indicators are stored.

2. From the cloud platform, they are transmitted to the MIS to be stored in the patient's electronic health record.

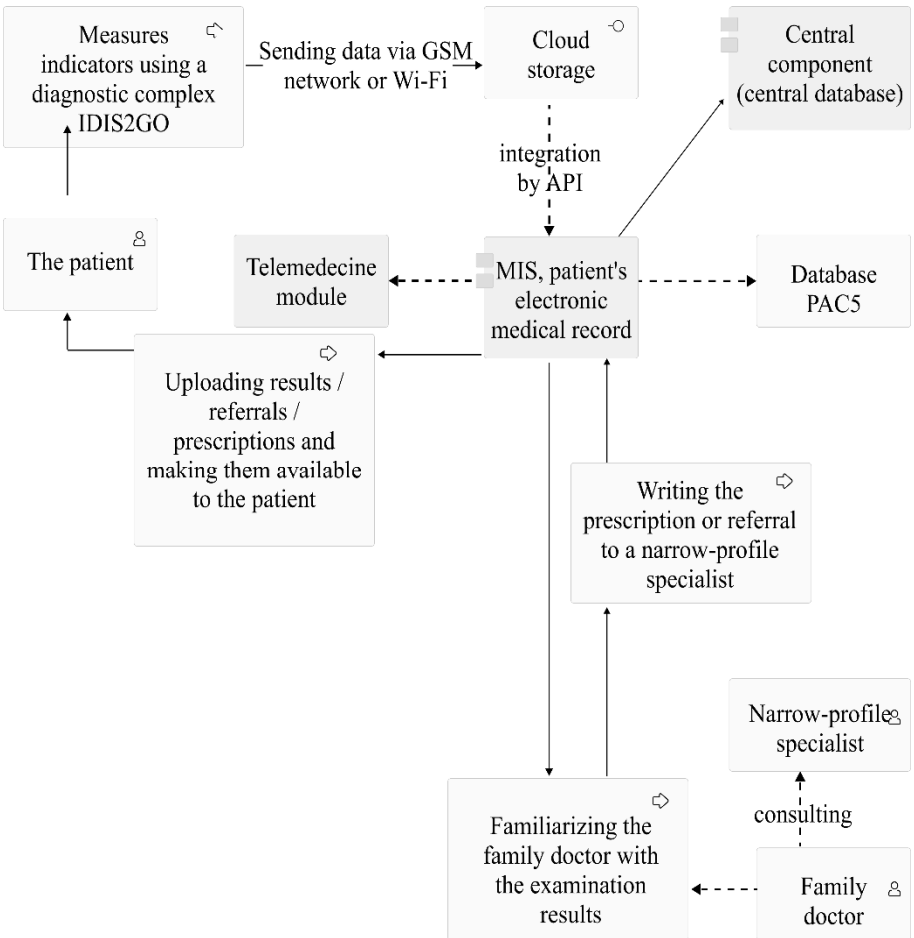

Fig. 1. The structure of business processes of the proposed MIS

3. The electronic medical record can be accessed by the family physician/therapist/pediatrician with the patient's informed consent. Accordingly, he monitors the health indicators of a chronically ill patient, makes an appointment depending on the dynamics of his condition, gives an e-prescription, or, if necessary, form a request for a narrow profile specialist consultation.

4. After request approval (the appointment of the consultant and the time of the consultation), the narrow-profile specialist provides the family physician with a real time telemedicine consultation or only in the form of document analysis.

5. Based on the conclusion above the family physician decides on the treatment of the patient: creates the necessary appointments, writes an electronic prescription, or decides to take the patient to the hospital urgently.

6. The electronic prescription is sent to a certain pharmacy, with the patient being notified.

7. Medical consultant's report is added in the patient's electronic medical record and is legally binding.

Also, worth mentioning the cloud-based Picture Archiving and Communication System (PACS) [19], that stores relevant digital medical images of the patient. This storage allows storing in an electronic patient record not only data obtained through mobile complexes but also from different laboratories with specific equipment.

Cloud storage, which stores the patient's electronic medical record, is a structural unit of the Central Database (CDB) of the Electronic Healthcare System of Ukraine [20]. Therefore, all electronic records and digital medical images are stored in the CDB.

Based on the list of business processes, the essential requirements for MIS are:

— the availability of mobile diagnostic devices, which can include portable electrocardiographs, blood pressure monitors, glucometers etc;

— use of an electronic medical record of the patient with appropriate access rights, which meets all the requirements of e-Health of Ukraine for connection to the Central Database [21];

— system for generating and transmitting electronic prescriptions.

Let us have a closer look at the last requirement. The electronic prescription is formed in accordance with the international standard State Standard of Ukraine ISO 17523: 2019 (ISO 17523:2016, IDT) "Requirements for electronic prescriptions". The most important question regarding e-prescriptions is what information is required to accompany e-prescriptions to ensure that the patient is given exactly the prescribed medicine, along with all relevant information that focuses on correct and safe use. This standard provides a core set of information requirements for supporting electronic prescriptions:

Patient Identification. Patient data content must support reliable long-term identification, and provide contact information (e.g., location or phone number). Patients must be able to identify themselves using an identification method that is recognized as legal in Ukraine. The identification information should include contact information to enable the routing of the patient in the case of an emergency.

Identification information of the healthcare professional who issues the prescription. The prescriber must be a health care professional, i.e., a person who is involved or associated with providing health care services to or caring for, the object of care (ISO/TS 27527).

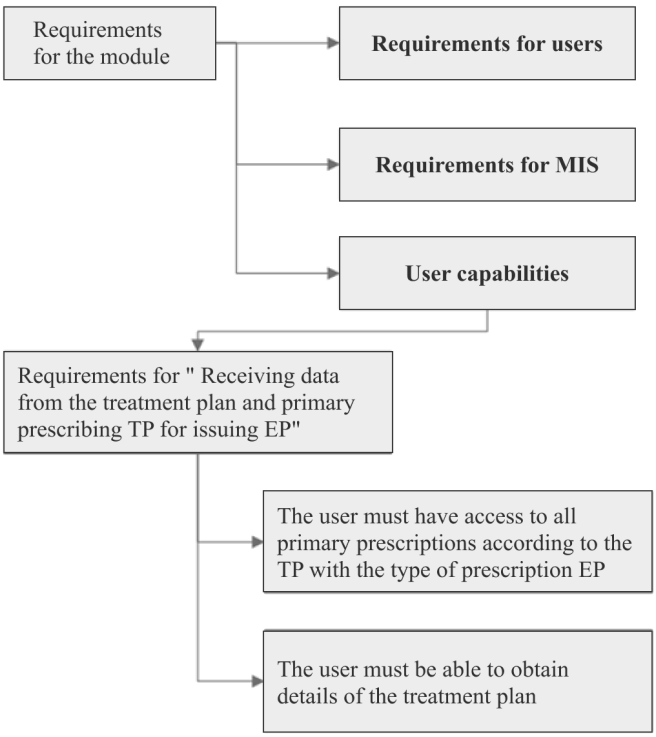

Fig. 2. Structure of the requirements for connecting the "Electronic Prescription" module of the EHCS

Identification of the prescribed medicine. The information provided in the electronic prescription should result in the pharmacist being able to reliably identify the prescribed medicine (or medical device). Preferably (recommended in the case of a medicinal product), the information be retrieved from a glossary of medicines. If this is not available, or if the product is other than the prescribed medicine, the pharmacist should be able to obtain enough information from the electronic prescription to dispense the appropriate product.

The requirements for the connection of the electronic prescription are important.

The requirements for connecting the E-Prescription module according to the Electronic Health Care System (EHCS) are following (Fig. 2).

1. Requirements for the ability to issue an Electronic Prescription (EP). E-prescription is issued in a healthcare institution that provides medical care.

2. The subject of issuing an Electronic Prescription (EP). EP can be written out by: A user with the role "DOCTOR" chosen by the patient as his doctor for the provision of First Aid, as evidenced by the valid declaration on the choice of a FA doctor; a user with the role "SPECIALIST" who has the appropriate rights to create an EP depending on the settings of the reimbursement program. In order to issue a prescription, the doctor issuing the prescription must be registered and authorized in the eZdorovya system. Also, a valid declaration must be signed between the doctor and the patient.

3. Necessary steps for prescribing EP. The MIS must indicate the identifiers of the patient and the doctor in accordance with the signed contract; the possibility to indicate only the identifier of the interaction created by the current user; Date of EP creation ("created_at" parameter) cannot exceed date of interaction ("date" parameter) for more than 7 days.

4. Requirements for receipt. The user must be able to write out an EP using the following options: Determination of the identified patient ("person_id" parameter); when writing out an EP under the reimbursement program (the value is present in the "medical program_id" parameter), determine, within which interaction (created by him) of the user with the patient is prescribed EP, i.e. in specify the interaction identifier in the "context" parameter ("encounter_id" parameter); obligatorily choose the reimbursement program according to which the EP will be issued; the creation of an application for EP and creation of EP; if EP is prescribed on the basis of a treatment plan, then the requirements "Receiving data from the treatment plan and the initial appointment of the treatment plan for prescribing EP" must be followed:

a) regarding the data on primary designations:

- reasons for assignment (parameter "detail.reason_code");
- extended description ("detail.description" parameter);
- justification of reasons ("detail.reason_reference" parameter);
- expected result ("detail.goal" parameter);
- explanation of the status ("detail.status_reason" parameter);
- the result of recognition ("outcome_Codeable_Concept" parameter) if available;
- link to the appointment execution record ("outcome_Reference" parameter) — if available;

b) regarding the treatment plan:

- status ("status" parameter);
- category to be defined from the "eHealth/care_plan_categories" category directory ("category" parameter);
- name ("title" parameter);
- coverage period ("period" parameter);
- link to the interaction ("encounter" parameter);
- link to supporting info ("supporting_info" parameter array);
- medical condition ("address" parameter);
- extended description ("description" parameter);
- the reason for changing the status ("status_Reasons" parameter) — if available;
- notes ("note" parameter) — if available.

The user must be able to choose what is necessary to create an EP appointment with appointment type EP ("Medication Request") according to the treatment plan and go to the forming an application for EP step, in case the treatment and appointment plan is active according to the specified validity periods. The user in the MIS should not be able to issue an EP according to the appointment if the treatment plan has such status "Terminated", "Cancelled", "Completed" and/or primary assignments have "Cancelled" / "Completed" status. Information that is entered into the Register of Medical Records in reference to the electronic prescription includes:

- records of prescriptions;
- medical records on prescription redemption.

The array of all patient records in the Register constitutes the patient's electronic medical record. Data shall be entered into the Register and viewed through the electronic cabinet in accordance with the rights of access to the system defined by this Order or the regulations governing the functioning of the electronic healthcare system.

In this MIS with a module designed to record health indicators of patients with chronic diseases, an electronic prescription is a very important component, since patients with certain chronic diseases constantly need the appropriate medicine.

The electronic prescription must contain a healthcare specialist identifier (HCPI), a digital signature of the physician, the prescription identifier (according to the international standard ISO/TS 16791), and the dosage as the active substance content of the medication (according to Directive 2001/83, Article 1).

These steps are performed according to the following procedures (Fig. 3).

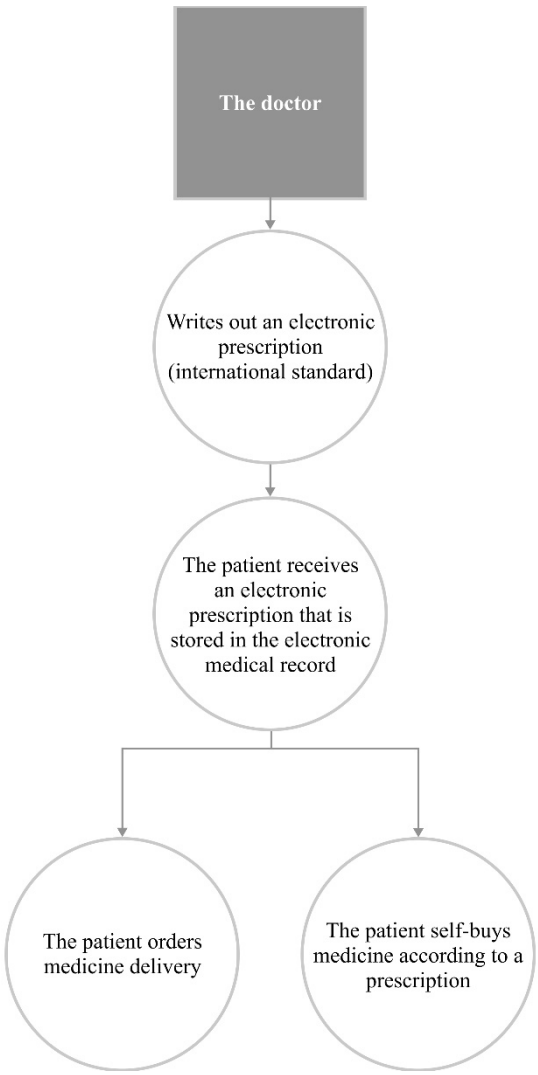

Fig. 3. Diagram of proceedings — issuing an electronic prescription

TECHNICAL REALIZATION OF THE MIS MODEL FOR MEDICAL AND SOCIAL ASSISTANCE

Since the proposed system includes features useful in providing medico-social care, it can become an integral part of e-Health. Consequently, it will have access to the database of physicians throughout Ukraine, and it will significantly simplify the implementation of this system.

The proposed MIS has the following basic modules.

A physician module supports communication between the physician and the patient and provides the opportunity to work with an electronic medical document. This module is implemented in the form of a mobile application, and is linked to the cloud storage, which means the CDB.

A patient module allows the patient to transmit his/her measured functional indicators of health to the doctor and receive relevant recommendations from the physician. In this case, the function of remote consultation is also performed. This module is implemented in the form of a mobile application that is linked to the cloud storage – CDB.

An electronic prescription module helps doctor form the appropriate document and connect the patient with the pharmacy.

Technical characteristics of MIS. All the data used in the application is stored in the Trembita Public Cloud environment. The application uses REST API to upload files directly from clients. The application is implemented based on the Waterfall method. The main advantages of this method are clear requirements and timelines, which are documented from the beginning of the operation.

The programming language is Python. One of the advantages of Python is the possibility of using applications several times. For convenient and quick development of the project, the code editor Visual Studio Code was chosen, considering its convenient interface, numerous extensions, links to the use of different programming languages, and built-in debugger for errors search.

The system provides the exchange of text messages between the doctor and patient modules, the patient can make appointments, receive doctor's orders and electronic prescriptions, recommendations, and referrals to a narrow-profile specialists, as well as sending their own data for remote monitoring [22]. The Fast Healthcare Interoperability Resources (FHIR) standard is used to implement such tasks [23]. It implements the principles of interoperability, which can be described as following.

Interoperability can be generally defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [24]. Most definitions further distinguish between different components, levels, or layers of interoperability [25]. While these components may vary slightly across definitions, they typically distinguish between lower-level technical components and higher-level organizational components.

Technical compatibility provides the basic capabilities of data exchange between systems (for example, transferring data from a USB drive to a computer). This requires communication channels and data transfer protocols. With modern digital networks and communication protocols, achieving technical interoperability is usually relatively simple. However, transferring data from A to B is not enough. In this case, technical compatibility for effective interoperability is achieved through the interaction of mobile devices with cloud storage. Syntax compatibility defines the format and the structure of the data (for example, in an XML document). Structured medical data

exchange is supported by international standards' development organizations ISO, as well as Health Level Seven International (HL7) or Integrating the Healthcare Enterprise (IHE), which define healthcare IT standards and their use in systems. A new standard for health data transfer is HL7's Fast Healthcare Interoperability Resources (FHIR), which defines about 140 common healthcare concepts, referred to as resources, that can be accessed and exchanged using modern web technologies [26].

While standards such as FHIR have already defined the basic semantics of medical data, semantic interoperability is really the field of medical terminologies, nomenclatures, and ontologies. They guarantee that the meaning of medical concepts can be shared between systems, thus providing a digital common language for medical terms that is ideally clear to both humans and machines all over the world.

At the highest level, compatibility also involves organizations, legislation, and policies. Data exchange between health IT systems is not a goal itself but ultimately should help healthcare professionals work more efficiently and improve patients' health [27–29]. This requires common business processes and workflows that ensure the smooth provision of healthcare within institutions [30]. The implementation of this principle in the MIS is ensured by the organization of interaction between the medical staff and patients, which is regulated by the relevant documents of the Ministry of Health of Ukraine.

One of the functions of the developed MIS is to provide remote consultation. Before the consultation, the patient must first measure basic indicators — ECG, blood pressure, blood glucose etc. The patient enters all these data into a separate journal in the account, which can also be viewed by the doctor. All admission data, pre-recorded indicators, and the results of the medical tests are stored in the electronic patient record. PACS24 cloud service is also used for long-term storage and archiving of DICOM format images [31]. To access your own account, you need to register in the system and authenticate with a message on your phone number or document number. Authentication and authorization are implemented with the help of the Python library — Authlib. Electronic prescriptions are always available in the account for the patient to use at any time.

If the system has an automated registration system, the patient can automatically make an appointment with the doctor if there is vacant appointment time in schedule. The automated registration is implemented in the Python programming language with the help of either the Priority queue library or Appointment management system. The precedence diagram is shown in Figure 4.

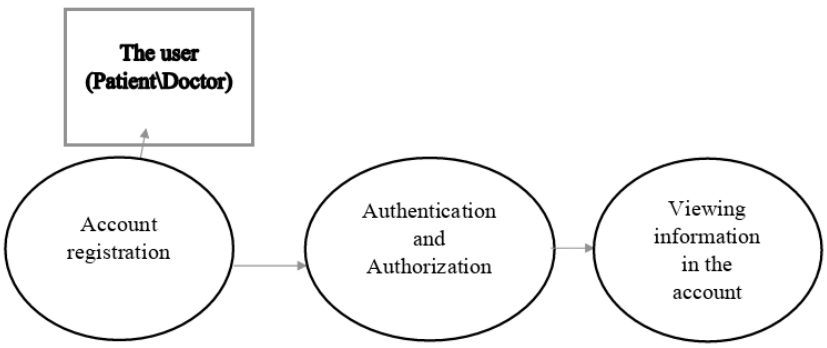

Fig. 4. Diagram of procedures — authentication and authorization

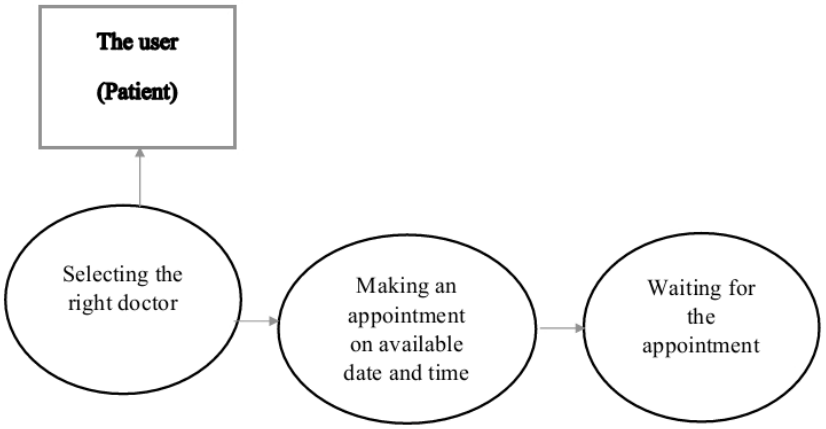

Fig. 5. Diagram of online appointment precedents

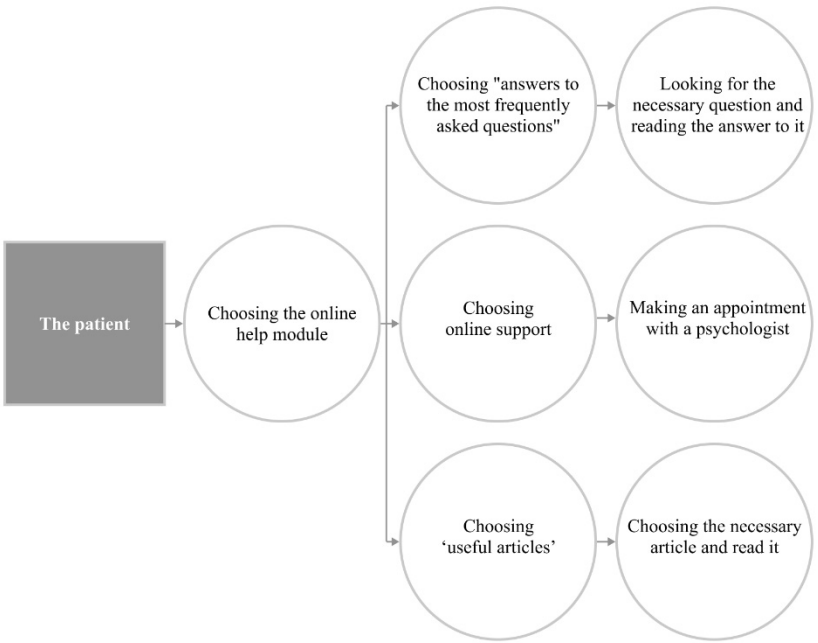

Fig. 6. Diagram of online support module usage precedents

Doctors in the EHCS also have their own accounts according to the registry of medical professionals. The doctor's account displays the number of people who make an appointment with the doctor and, accordingly, the schedule of appointments. The doctor can make adjustments, for example, cancel a patient's appointment if the doctor can't meet the patient. Also, the doctor can view the electronic cards of patients who have been to the appointment or have already made it (Fig.5).

A separate online support and assistance module provides answers to the most common questions related to both illnesses and the use of the program (Fig.6).

Consequently, using the above system with the telemedicine application provides services to the patient who is in a home hospital setting in the form of organizing interaction with the doctor and consultant in order to improve the effectiveness of medical and social care.

CONCLUSIONS

Based on the results of the analysis of the possibilities and experience of using modern telemedicine systems, the architecture of medical information system for medical and social care to patients, which covers doctor and patient modules, functionally united by specific business processes performing specific functions (online interaction between doctor and patient, giving electronic prescriptions etc.) has been developed.

The implementation of the proposed MIS is made using the modern platform REST API for downloading files directly from clients, an application implemented on the basis of the Waterfall method and Python programming language ensures the organization of interaction between the medical staff and patients, in particular the implementation of remote consultation and the provision of electronic prescriptions based on records in the patient's electronic record.

REFERENCES

1. Vitacca M., Scalvini S., Spanevello A., Balbi B. Telemedicine and home care: controversies and opportunities. *Breathe*. 2006. V. 3, no 2, pp.149–158.
2. Wootton R, Bonnardot L. Telemedicine in low-resource settings. *Front Public Health*. 2015;3:3.
3. Gutierrez M, Moreno R, Rebelo M. Information and communication technologies and global health challenges. *Global Health Informatics*. 2017, pp.50–93;
4. Smith AC, et al. Telehealth for global emergencies: Implications for coronavirus disease 2019 (COVID-19). *J Telemed Telecare*. 2020; 26(5):309–13.
5. Ohannessian R. Telemedicine: potential applications in epidemic situations. *European Research in Telemedicine*. 2015;4(3):95–8.
6. World Health Organization. Telemedicine: Opportunities and developments in member states: Report on the second Global survey on eHealth [Internet]. 2010. Geneva, Switzerland: World Health Organization. 93 p. (Global Observatory for eHealth Series). Available at: http://www.who.int/goe/publications/goe_telemedicine_2010.
7. Goldberg E.M., Lin M.P., Burke L.G., Jiménez F.N., Davoodi N.M., Merchant R.C. Perspectives on Telehealth for older adults during the COVID-19 pandemic using the quadruple aim: interviews with 48 physicians. *BMC Geriatrics*. 2022. V. 22, 188.
8. How Telemedicine is Affecting Home Health Care. Available at: https://www.theseniorlist.com/blog/how-telemedicine-is-affecting-home-health-care/
9. Ikram U., Gallani S., Figueroa J.F., Feeley Th.W. 4 Strategies to Make Telehealth Work for Elderly Patients. Available at: https://hbr.org/2020/11/4-strategies-to-make-telehealth-work-for-elderly-patients.
10. Weiquan Wang, Li Sun, Tao Liu, Tian Lai. The use of E-health during the COVID-19 pandemic: a case study in China's Hubei province. Available at: https://doi.org/10.1080/14461242.2021.1941184
11. Cimperman M., Makovec Brenčič M., Trkman P. Analyzing older users' home telehealth services acceptance behavior. *International Journal of Medical Informatics*, March 2016, 90:22-31. DOI:10.1016/j.ijmedinf.2016.03.002
12. Danko D. V., Povidaichyk O. S. Medical and social work with different categories of clients. *Scientific bulletin of the Uzhgorod National University*. 2009. Iss. 33, pp.51–54
13. Thomas L. What is Telemedicine? Available at: https://www.news-medical.net/health/What-is-Telemedicine.aspx

14. Aliouche H. What is Remote Surgery/Telesurgery? Available at: https://www.news-medical.net/health/What-is-Remote-SurgeryTelesurgery.aspx
15. Telemedicine was implemented in cardiology at the Center for Emergency Medical Care Available at: https://bukoda.gov.ua/news/u-centri-ekstrenoyi-medichnoyi-dopomogi-vprovadili-telemedicinu-u-kardiologiyi (in Ukrainian)
16. Organization of medical and social assistance. Available at: https://stud.com.ua/27525/meditsina/organizatsiya_mediko_sotsialnoyi_dopomogi (in Ukrainian)
17. Yang Xiao, Hui Chen Mobile Telemedicine: A Computing and Networking Perspective.- Available at: https://www.routledge.com/Mobile-Telemedicine-A-Computing-and-Networking-Perspective/Xiao-Chen/p/book/9781420060461
18. 5 Most Important Ways Telehealth Helps Home Care Patients. Available at: https://www.chaptershealth.org/chapters-of-life-blog/patients/home-care-and-telehealth-the-five-most-important-benefits-to-patients/
19. Romanyuk O.A., Kovalenko A.S., Kozak L.M. Information support for interaction of instrumental research systems and long-term storage of digital medical images in health care institutions. *Kibernetika i vyčislitel`naâ tehnika*. 2016, no. 184. pp. 56–71. (in Russian)
20. Resolution of the Cabinet of Ministers of Ukraine dated April 25, 2018 No. 411 "Some issues of the electronic health care system". Available at: https://zakon.rada.gov.ua/laws/show/411-2018-%D0%BF#Text (in Ukrainian)
21. Order of the Ministry of Health of Ukraine dated February 28, 2020 No. 587 "Some issues of maintaining the Register of medical records, referral records and prescriptions in the electronic health care system". Available at: https://zakon.rada.gov.ua/laws/show/z0237-20#Text (in Ukrainian)
22. Kovalenko A.S., Kozak L.M., Romanyuk O.A. Information technologies of digital medicine. *Kibernetika i vyčislitel`naâ tehnika*. 2017, no. 1(187). pp.67–79. (in Russian)
23. Kovalenko O.S., Mishchenko R.F., Kozak L.M. Transformation of Clinical Decision Support Systems into FHIR Structures to Ensure Quality of Medical Care. *Cybernetics and Computer Engineering*, 2019. 4(198), pp. 78–94.
24. Benson, T. & Grieve, G. *Principles of Health Interoperability: SNOMED CT, HL7 and FHIR*. London: Springer-Verlag, 2016.
25. Oemig, F., Snelick, R. *Healthcare Interoperability Standards Compliance Handbook: Conformance and Testing of Healthcare Data Exchange Standards*. Switzerland: Springer International Publishing, 2016.
26. Bender, D. & Sartipi, K. HL7 FHIR: an Agile and RESTful approach to healthcare information exchange. in *Proceedings of the 26th IEEE International Symposium on Computer-Based Medical Systems* p. 326–331 (2013) Available at: https://doi.org/10.1109/CBMS.2013.6627810. (last accessed 04.04. 2022).
27. Offit K. Personalized medicine: New genomics, old lessons. *Hum Genet*. 2011;130:3–14. doi: 10.1007/s00439-011-1028-3.
28. Health information exchange. Available at: https://www.healthit.gov/topic/health-it-and-health-information-exchange-basics/health-information-exchange (last accessed 10.04.2022).
29. Health information exchange definition — Defined by experts. Available at: https://www.pdnseek.com/health-information-exchange-definition-defined-by-experts/ (last accessed September 04.05. 2022).
30. Detailed clinical model. Available at: www.detailedclinicalmodels.nl/dcm-en (last accessed 14.09. 2012)
31. Prime PACS. Available at: https://play.google.com/store/apps/details?id=com.rosenfield.PrimePACS&hl=uk&gl=US (last accessed 14.05. 2022).

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ЛІТЕРАТУРА

1. Vitacca M., Scalvini S., Spanevello A., Balbi B. Telemedicine and home care: controversies and opportunities. Breathe. 2006. V. 3, no 2, pp.149–158.
2. Wootton R, Bonnardot L. Telemedicine in low-resource settings. Front Public Health. 2015;3:3.

3. Gutierrez M, Moreno R, Rebelo M. Information and communication technologies and global health challenges. Global Health Informatics. 2017, pp.50–93;
4. Smith AC, et al. Telehealth for global emergencies: Implications for coronavirus disease 2019 (COVID-19). J Telemed Telecare. 2020; 26(5):309–13.
5. Ohannessian R. Telemedicine: potential applications in epidemic situations. *European Research in Telemedicine.* 2015;4(3):95–8.
6. World Health Organization. Telemedicine: Opportunities and developments in member states: Report on the second Global survey on eHealth [Internet]. 2010. Geneva, Switzerland: World Health Organization. 93 p. (Global Observatory for eHealth Series). Режим доступу: http://www.who.int/goe/publications/goe_telemedicine_2010 (Дата звернення: 12.05.2021)
7. Goldberg E.M., Lin M.P., Burke L.G., Jiménez F.N., Davoodi N.M., Merchant R.C. Perspectives on Telehealth for older adults during the COVID-19 pandemic using the quadruple aim: interviews with 48 physicians. BMC Geriatrics. 2022. V. 22, 188.
8. How Telemedicine is Affecting Home Health Care. Available at: https://www.theseniorlist.com/blog/how-telemedicine-is-affecting-home-health-care/ (Дата звернення: 11.04.2022)
9. Ikram U., Gallani S., Figueroa J.F., Feeley Th.W. 4 Strategies to Make Telehealth Work for Elderly Patients. Режим доступу: https://hbr.org/2020/11/4-strategies-to-make-telehealth-work-for-elderly-patients. (Дата звернення: 11.04.2022)
10. Weiquan Wang, Li Sun, Tao Liu, Tian Lai. The use of E-health during the COVID-19 pandemic: a case study in China's Hubei province. Режим доступу: https://doi.org/10.1080/14461242.2021.1941184
11. Cimperman M., Makovec Brenčič M., Trkman P. Analyzing older users' home telehealth services acceptance behavior. *International Journal of Medical Informatics*, March 2016, 90:22-31. DOI:10.1016/j.ijmedinf.2016.03.002
12. Danko D. V., Povidaichyk O. S. Medical and social work with different categories of clients. Scientific bulletin of the Uzhgorod National University. 2009. Iss. 33, pp.51–54
13. Thomas L. What is Telemedicine? Режим доступу: https://www.news-medical.net/health/What-is-Telemedicine.aspx (Дата звернення: 01.04.2022)
14. Aliouche H. What is Remote Surgery/Telesurgery? Режим доступу: https://www.news-medical.net/health/What-is-Remote-SurgeryTelesurgery.aspx (Дата звернення: 12.01.2022)
15. Організація медико-соціальної допомоги. Режим доступу: https://stud.com.ua/27525/meditsina/organizatsiya_mediko_sotsialnoyi_dopomogi (Дата звернення: 18.04.2022).
16. У Центрі екстреної медичної допомоги впровадили телемедицину у кардіології. Режим доступу: https://bukoda.gov.ua/news/u-centri-ekstrenoyi-medichnoyi-dopomogi-vprovadili-telemedicinu-u-kardiologiyi (Дата звернення:18.04.22)
17. Yang Xiao, Hui Chen Mobile Telemedicine: A Computing and Networking Perspective.- Режим доступу: https://www.routledge.com/Mobile-Telemedicine-A-Computing-and-Networking-Perspective/Xiao-Chen/p/book/9781420060461 (Дата звернення: 01.02.2022)
18. 5 Most Important Ways Telehealth Helps Home Care Patients. Режим доступу: https://www.chaptershealth.org/chapters-of-life-blog/patients/home-care-and-telehealth-the-five-most-important-benefits-to-patients/
19. Романюк О.А., Коваленко А.С., Козак Л.М. Информационное обеспечение взаимодействия систем инструментального исследования и системы длительного хранения цифровых медицинских изображений в учреждениях здравоохранения. *Киб. и выч. техн.* .2016, № 2(184). С. 56–71.
20. Постанова КМ України від 25 квітня 2018 р. № 411 «Деякі питання електронної системи охорони здоров'я». Режим доступу: https://zakon.rada.gov.ua/laws/show/411-2018-%D0%BF#Text (Дата звернення: 01.06.21).
21. Наказ МОЗ України від 28.02.2020 № 587 «Деякі питання ведення Реєстру медичних записів, записів про направлення та рецептів в електронній системі охорони здоров'я». Режим доступу: https://zakon.rada.gov.ua/laws/show/z0237-20#Text. (Дата звернення: 15.10.2021)

22. Коваленко А.С., Козак Л.М., Романюк О.А. Информационные технологии цифровой медицины. *Киб. и выч. техн.* 2017, №1(187). С.67–79.
23. Kovalenko O.S., Mishchenko R.F., Kozak L.M. Transformation of Clinical Decision Support Systems into FHIR Structures to Ensure Quality of Medical Care. *Cybernetics and Computer Engineering*, 2019. 4(198), pp. 78–94.
24. Benson, T. & Grieve, G. *Principles of Health Interoperability: SNOMED CT, HL7 and FHIR*. London: Springer-Verlag, 2016.
25. Oemig, F., Snelick, R. *Healthcare Interoperability Standards Compliance Handbook: Conformance and Testing of Healthcare Data Exchange Standards*. Switzerland: Springer International Publishing, 2016.
26. Bender, D., Sartipi, K. HL7 FHIR: an Agile and RESTful approach to healthcare information exchange. in *Proceedings of the 26th IEEE International Symposium on Computer-Based Medical Systems* p. 326–331 (2013) Режим доступу: https://doi.org/10.1109/CBMS.2013.6627810. (Дата звернення: 04.04. 2022).
27. Offit K. Personalized medicine: New genomics, old lessons. *Hum Genet*. 2011;130:3–14. doi: 10.1007/s00439-011-1028-3.
28. Health information exchange. Режим доступу: https://www.healthit.gov/topic/health-it-and-health-information-exchange-basics/health-information-exchange (Дата звернення: 10.04.2022).
29. Health information exchange definition — Defined by experts. Режим доступу:: https://www.pdnseek.com/health-information-exchange-definition-defined-by-experts/ (Дата звернення: September 04.05. 2022).
30. Detailed clinical model. Режим доступу: www.detailedclinicalmodels.nl/dcm-en (Дата звернення: 14.09. 2012)
31. Prime PACS. Режим доступу: https://play.google.com/store/apps/details?id=com.rosenfield.PrimePACS&hl=uk&gl=US (Дата звернення: 14.05. 2022)

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МЕТОДИ ТЕЛЕМЕДИЧНИХ ТЕХНОЛОГІЙ ДЛЯ СТВОРЕННЯ МЕДИЧНОЇ НФОРМАЦІЙНОЇ СИСТЕМИ МЕДИКО-СОЦІАЛЬНОЇ ДОПОМОГИ

Вступ. Використання методів цифрової медицини набуває все більшої актуальності у зв'язку з пандемією COVID-19, воєнним станом на території України, недостачею медичного обладнання в деяких сільських місцевостях.

Це ж стосується і надання медичної допомоги хронічним хворим. Така допомога включає, крім лікувально-діагностичних заходів, заходи соціального напряму, до яких належать догляд за хворими та непрацездатними, постачання продуктів харчування тощо. Ці заходи об'єднано під назвою «медико-соціальна допомога».

Метою роботи є застосування методів цифрової медицини, до яких належать і телемедичні технології, під час побудови моделі медичної інформаційної системи (МІС) для допомоги хронічним хворим з телемедичним модулем для здійснення відповідних медичних послуг в умовах стаціонару на дому.

Результати. Проаналізовано види та методи телемедичних технологій, спроектовано діаграму бізнес-процесів програмного модулю «Телемедицина», описано модулі системи із зазначенням технічних характеристик їх реалізації, здійснено технічну реалізацію МІС для допомоги хронічним хворим, описано технічні вимоги до модулю «Електронний рецепт», надано діаграми прецедентів МІС для завдань, які найчастіше використовують лікарі у практичній діяльності.

Висновки. За результатами аналізу можливостей та досвіду використання сучасних телемедичних систем розроблено архітектуру медичної інформаційної системи для надання медично-соціальної допомоги пацієнтам, яка охоплює модулі лікаря і пацієнта, функційно об'єднані визначеними бізнес-процесами з виконанням конкретних функцій on-line взаємодії лікаря та пацієнта, виписування електронного рецепта тощо. Використання запропонованої МІС, яка виконана за застосування сучасної платформи REST API для завантаження файлів безпосередньо від клієнтів та застосунку, реалізованого на основі методу Waterfal, та мови програмування Python, забезпечує організацію взаємодії лікарського складу з пацієнтами, зокрема здійснення дистанційного консультування та надання електронних рецептів на основі записів у електронній картці пацієнта.

Ключові слова: *медико-соціальна допомога, телемедичні технології, медичні інформаційні системи, електронні рецепти.*