

# Information Technology Platform of "Smart" Dental Clinic

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## Abstract

The new technologies have emerged in recent years that exclude direct human involvement in traditional activities. Modern information technologies are fundamentally changing the nature of work, in particular, of medical institutions. The urgent task of today is to identify areas in which information technology can transform their activities, and ultimately to identify processes that would change human work by computer facilities and adapt complex business processes to a changing working medical environment. The modern high-tech dental clinic operates 7 days per week and 24 hours per day, providing all kinds of medical, diagnostic and consultative dental care. Increasing competition in this market has significant specific features. The construction of an information system that allows to effectively support the business processes of managing a "smart" dental clinic in the conditions of stable growth of volumes of information flows and the inevitable complication of the processes of finding the necessary complete, reliable and up-to-date data is considered in the paper. The proposed information system of process support in the "smart" dental clinic is focused on improving the efficiency of management and improving the quality of medical services and high-tech support functions of patient records, patient admissions schedules, electronic medical records, payments with insurance companies, reporting services, providing services formation of regulated and unregulated financial and statistical reports, etc. The overall functionality of the information system is basic to a wide range of similar systems and is useful and in demand by customers and dentists.

## Keywords 1

Information Technology, Business Processes, Information System, "Smart" Dental Clinic, Medical Services.

## 1. Introduction

Use only styles embedded in the document. For paragraph, use Normal. Paragraph text. Paragraph text. Paragraph text. Paragraph text. Paragraph text. Paragraph text. Paragraph text. The need to improve the dental health of the Ukrainian population and the work of the dental service has generated a need to reform this industry. According to statistics, almost 88% of Ukrainian citizens have dental caries, 90% have periodontal tissue disease, and dentistry requires 75-80% of the population. In addition, 95% of participants in the anti-terrorist operation require dental treatment [1]. Every day in the dental offices specialists solve the problems of choosing the methods of treatment of caries, periodontal disease, periodontitis, malocclusion or lack of healthy teeth. Establishment of a system of measures for primary and specialized dental care, prevention of dental diseases, creation of a single dental environment is possible by implementation of information technologies in dental institutions of different forms of ownership.

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Dental clinics that exist in medical institutions and operate within the framework of medical insurance that require the introduction of information technologies for convenient implementation of processes related to maintaining documentation, communication with patients and medical colleagues.

As the market for dental services becomes more established and dynamic, competition intensifies and requirements for the effectiveness of their provision increase, there is a need to create integrated systems for managing the main internal and external resources of the clinic and to provide automation not only of the treatment process, but also a comprehensive solution to the problems of dental clinic management.

## **2. The state of research of the problem**

Shakhovskaya N., Kordiyak A.[2] proposed an information model of the medical diagnostics system in dentistry, defined the aims, objectives and scope of the system. The authors in the work [3] present the concept of implementing smart solutions to improve working conditions in a private dental clinic, in particular, smart solutions based on the integration of knowledge management structures and information and communication technologies.

The paper [4] summarizes a new approach to dental clinic services in Indonesia, based on a smart card transaction that operates and connects to an on-campus information and communication technology network. The applied dental clinical services based on smart cards help to support administrative procedures, payment of medical services and printing of medical data for permitted purposes. The smart card was used to run a web-based dental clinical program installed on a local cloud server. The proposed clinical service allows more flexible, secure and efficient ways of storing medical data, as the doctor has fully diagnosed and treated the patient's health. Extensive access to recorded medical data is available in real time. It can be used not only by an authorized doctor or nurse on duty at the clinic, but it can also allow patients' families and other health care centers to access it remotely.

Kovalchuk O., Perig V., Eremin O. [5] considered the possibilities of using information technologies to automate business functions at enterprises that work in specific industries, in particular in the field of medical services. Reham Alabduljabbar, Samir El-Masri and S. Arabia [6] consider to develop a simple web content management system for dental laboratories. Maintaining a long-term relationship between dental laboratories and their clients requires an active process of communication between two parties, so dental labs need web content management systems to monitor their activities. In role-based access systems, it is mandatory to collect and process user data to ensure reliability along with system security. That helps to improve user interaction on the system [7]. A review of modern systems has shown that although there are systems that offer treatment options, such systems do not provide medication recommendations at the health care facility, which is a significant omission, given the fact that disease treatment and medication are common in the dentist's workflow [8].

The aim of our study is to develop an information system that provides effective implementation of business processes in a dental clinic using the principles of project management:

- The management of the provision of medical services.
- Development of a database of patients.
- Development of a patient appointment schedule.
- Maintaining an electronic medical history.
- Settlements with insurance companies.
- Generating reports on services rendered, financial and statistical reports, etc.

## **3. The main part of research**

Modern dental clinics need both Informatization of customer interaction processes and optimization of internal business processes. To effectively solve this problem, the application "Dental clinic" has been developed, taking into account the specifics of implementing information technologies to improve the efficiency of daily activities and functions of the medical institution,

provides dental services, and has a convenient user interface with the ability to easily configure additional functions.

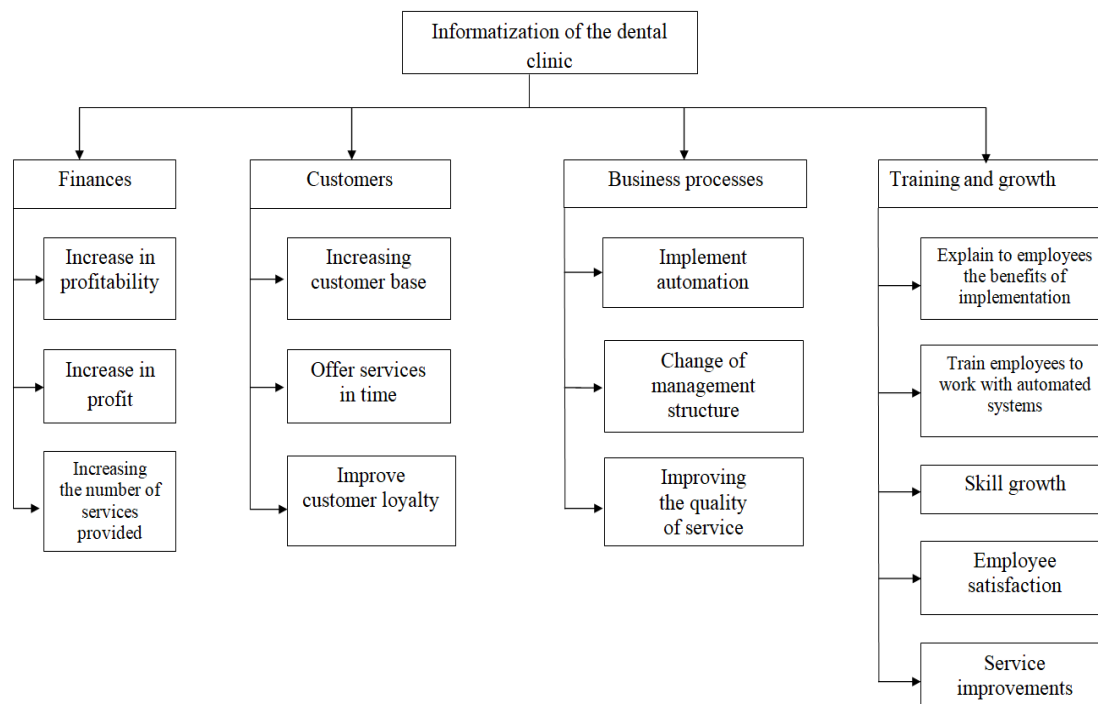
The work of the dental clinic is aimed at achieving a significant goal-to provide the best medical care for patients. However, the experience of patients is determined by the quality of services and other support tools that significantly affect the flow of patients, including communication between doctors and clients and the overall management of the clinic.

The work of the dental clinic is aimed at achieving a valid goal - to provide the best medical care for patients. However, patients' experience is determined by the quality of services and other supportive tools that significantly affect patient flow, including physician-client communication and overall clinic management.

A characteristic of the dental field is that many independent entities are often involved in its processes. It is in this area that it is advisable to implement information systems. In particular, the development of digital dentistry requires streamlining the processes that accompany the work of the dental clinic. At the first stage of information system [9,10] development the basic processes of dental clinic functioning were analyzed. The first indicator that was investigated - the capacity of the clinic, is characterized by the number of patients the doctor serves during the day.

Because of the type of service provided, a dentist's workday is usually equivalent to his or her capacity. The clinic collects information about the bills paid by patients, which becomes the basis for statistical analysis. When developing an information system, the fact that the number of primary clients waiting for service in the clinic's office area is taken into account. This value should be neither zero nor so large that clients who wait too long for treatment do not decide to leave. Another indicator, the waiting time is the difference between the time when a person requests a service and the time at which it is planned to agree on the provision of this service.

The purpose of the system implementation is to bring the waiting time closer to zero. As a result of the analysis, a tree of goals for the implementation of the information system "Dental Clinic" was formed (Figure 1).



**Figure 1:** Tree of goals

Development a system of information support for patient care in a dental clinic is relevant, since recording all the work done by the doctor, as well as quick viewing of previous works, will help to avoid mistakes in further practice, which will save time allocated for one client, and will allow you to accept more patients.

The architecture of the developed dental clinic information system includes several subsystems:

- Business process planning and control subsystem, which contributes to strategic planning and operational development of a single integrated operational plan for the clinic, their management; formation of a balanced system of key indicators; control of the implementation of the work plan, circulation of documents, etc.
- The medical services management subsystem provides patient records for appointments, maintaining patient files, electronic medical history for recording dental services provided, recording the results of examinations and laboratory studies, registering and processing x-rays, maintaining personal accounts of patients for medical services, generating a report of staff work.
- The subsystem of quality management of medical services, which functions include the selection of quality indicators, establishing operational quality control of medical personnel, monitoring and auditing the quality of dental clinic services, identifying deviations, developing and planning measures to ensure the quality of services provided in the clinic.
- The patient communication management subsystem, which provides for maintaining and analyzing the results of marketing activities, recording requests to the clinic based on information from various advertising sources, recording and analyzing contacts, evaluating the state of communication with patients, developing and supporting patient loyalty programs, generating messages with a reminder, greeting, notification of patients, recording, analyzing and working out patient complaints in order to prevent patients from refusing service.
- Document management provides maintenance of electronic archives of medical records (medical history) of patients, formation of templates of electronic documents used in the clinic, normative and reference information, maintenance of an electronic archive of documents, search, download and upload of documents.
- The communication management subsystem [11] contributes to the effective management of the address book of dental clinic patients[12], interaction and exchange of electronic messages, electronic patient registration logs, and doctors' work schedules.
- The contract management subsystem that helps maintain a register of internal processes of a dental clinic, prepare and agree on contracts, plan and monitor the performance of work under contracts, and report on contracts.
- Staff management subsystem. Maintaining the organizational structure of the service system, personnel data on employees. Maintaining reports on the training, experience and competence of medical staff. Management of training and retraining of staff. Maintaining staff reports.

The dental business operates in a highly competitive environment, which generates the need to create an information system that is accessible through the clinic's website. As evidenced by the practice, about 60% of potential clients find a clinic over the Internet, analyzing services and responses to them, which ensures the construction of effective communications with clients.

Thanks to the capabilities of the Internet, patients are well aware of new dental technologies. There are 3D techniques for printing a dental cap that an orthodontist can install immediately on the day of admission. Patients search for and choose dentistry using digital scanning systems, milling machines for crown printing and related software.

Installing the application on a smartphone provides access to the information system and facilitates the receipt of an instant photo or video for the diagnosis, which, if necessary, is sent with the accompanying message to the colleague, for a remote consultation. Dental telecommunications technologies allow discussions on any surgical, prosthetic, periodontal, orthodontic, or endodontic interventions in any of the messengers, providing a comprehensive approach to dental services.

The information system allows the creation of a database of clinical and laboratory photo documents, which provides the registration of various clinical cases, allows you to create reports on the complexity of the treatment, share information with colleagues, doctors and dental technicians.

The information system is developed using web-technologies, the program can be run through any modern browser (Internet Explorer, Mozilla, Safari, Chrome, etc.) and on any platforms (Windows, Mac OS, Linux). An important feature of the system is the availability of a flexible mechanism for providing access to the creation and use of medical records, which allows you to quickly customize the individual filling of documents (questionnaires, protocols, examination results, etc.), as well as add new ones.

The information system provides automatic sending of messages confirming the patient's appointment time. The system's functionality allows for registration via Facebook, Twitter, Google, etc. The information obtained in this way is more reliable than the information used for registration via the site, since it provides access to a large amount of personal information of patients, since they tend to specify incorrect data. For a long time, processes in the field of dentistry were recorded mainly on analog media: information about patients was recorded on paper. The information system provides doctors with remote access to the personal and medical records of patients in a medical center, doctor's personal office, or home) based on their respective rights and roles.

The information system uses the technology of storing medical records in a single electronic file, organized in such a way that allows the doctor to quickly find out the features of the patient's reaction to medications, Allergy symptoms, data of the latest test results, etc., and is developed in accordance with the form of primary accounting documentation No. 043/o "medical card of a dental patient".

#### 4. The purpose of the system

The developed information system is designed to facilitate the process of collecting patient data, maintaining an electronic medical history, automatically collecting statistics, invoicing for services rendered, maintaining a work schedule, adjusting the doctor's workload, and automatically generating reports.

The registry function block is designed to perform the following functions:

- maintaining information about the clinic;
- getting doctors ' work schedules;
- maintaining information about doctors;
- to obtain a graph of the workload of the doctors;
- creating lists of doctors in this clinic;
- the formation of customer lists;
- generating reports on doctors ' workload;
- make an online appointment with a doctor.

When creating a behavior model for a projected or analyzed software system, it is necessary not only to imagine the process of changing its States, but also to detail the features of the algorithmic and procedural implementation of the operations performed by the system using a structural scheme (Figure 2.)

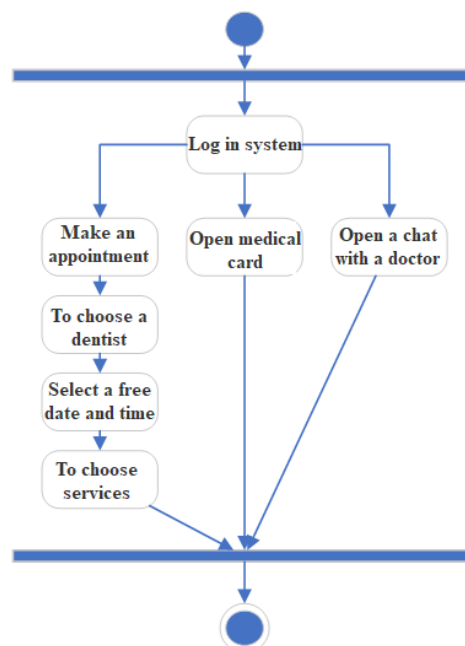


Figure 2: Activity diagram

Let's look at the sequence diagram for the main event flow of the "Make an appointment" use case. The user logs in and clicks the "Make an appointment" button. The "Make an appointment" window opens. The user adds notes. Then the date and time of reception is selected from the "DB Schedule". After that, the client clicks the "Done" button. The system creates a request, and then returns the request number to the user. A diagram of the sequence of actions for the main event flow of the "Make an appointment" use case is shown in Figure 3.

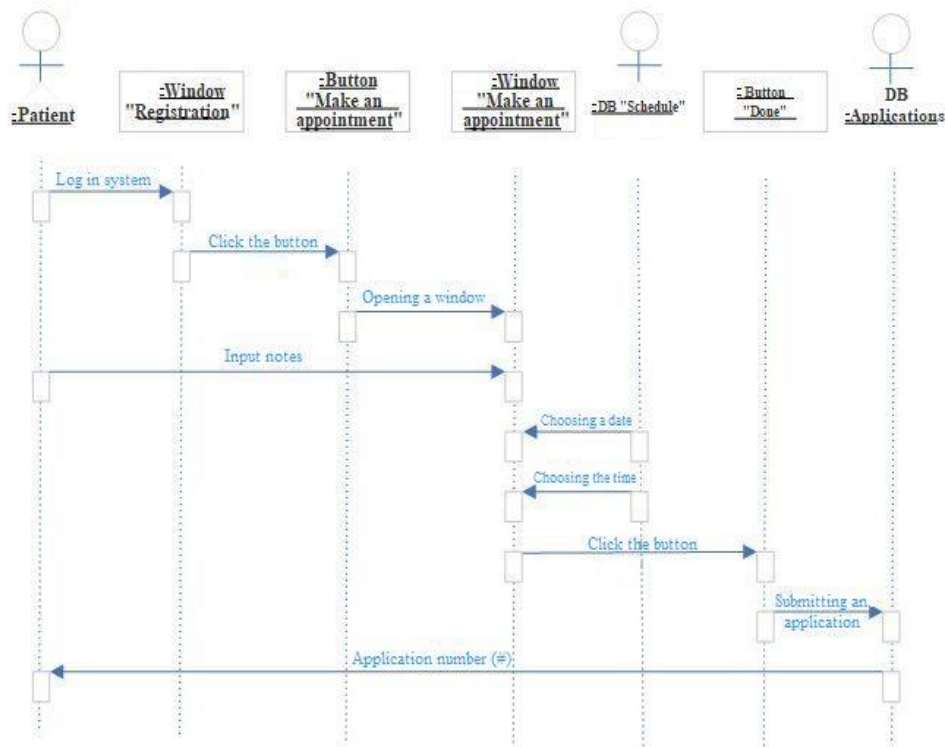


Figure 3: Sequence diagram

A diagram of the information system states that allows us to observe the process of transitioning a user state from one state (client) to another (patient) is depicted in Figure 4. The input parameter of this process is customer information. The process output reports on the services provided and a list of paid services. This information is accumulated in the database.

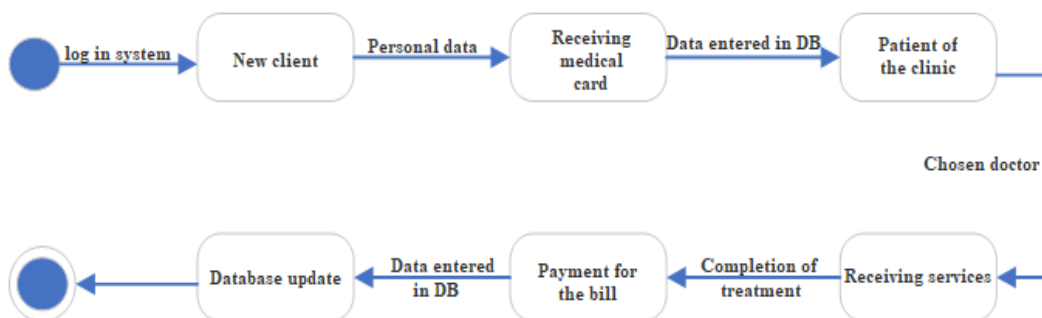


Figure 4: State transition diagram

The dental clinic information system contains numerous possibilities for automating repetitive processes: creating mailing lists, storing and searching patient data, setting up a reminder system, communicating with doctors who are members of the office, providing a function for recording patient visits to doctors, and so on. Let's consider a dental office that employs one dentist, a dental assistant, and an office Manager.

The dentist performs standard dental procedures for patient examination, dental treatment, and cleaning. The dental assistant assists the doctor in implementing these procedures by preparing the necessary equipment and connections. The office manager plans patient appointments, tracks bills, sends forms to insurance companies, and provides advice over the phone.

## 5. Description of system functions and structure

The software product performs the following functions:

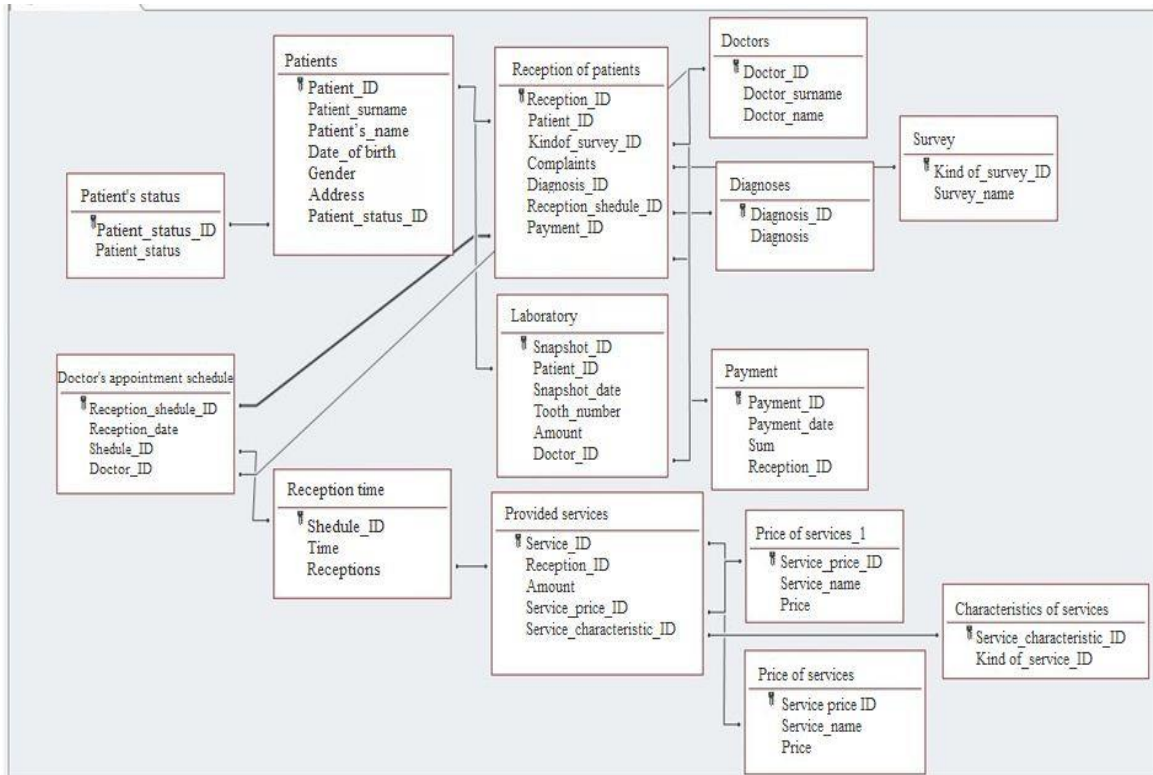
- receive and enter information about patients in a structured electronic medical record, integrated into a single information environment of the clinic;
- manage the appointment process: create new records indicating the type and list of services, visualize the appointment schedule at different times, create the necessary medical documentation based on the record, generate reports of services provided within the reception;
- generate patient profiles (based on medical profiles) and generate a block of medical documentation based on their data,
- generate review reports with uploading the results to a file and linking them to the patient's medical record.

The information system performs the following functions:

- create lists of dental clinic doctors-no more than 10;
- generate patient lists-no more than 10;
- create a schedule for doctors to receive patients-no more than 10;
- monitoring of doctors ' work schedules;
- provide the ability to view data about the clinic;
- provide the ability to view data about doctors;
- enter data about the patient and select the appropriate dentist;
- select the date and time of reception;
- correct input of information.

Thus, in order to compete with similar ones, the information system (Figure 5) ensures compliance with the following functional requirements:

- allows us to use a simple and functional web interface with the recording function;
- maintenance of the administrator, doctor, and patient interface parts;
- allows us to create and edit an electronic medical history containing records of the results of the doctor's work;
- print and display invoices for payment (Table 1).



**Figure 5:** Dental clinic data scheme

**Table 1**  
Patients

Attributes	Field type	Obligation
Patient_ID	INT	NOT NULL
Patient_surname	VARCHAR (50)	NOT NULL
Patient_name	VARCHAR (50)	NOT NULL
Date_of birth	DATE	NULL
Gender	VARCHAR (50)	NULL
Address	VARCHAR (50)	NULL
Patient_status_ID	VARCHAR (90)	NOT NULL

This system should allow clients to make appointments with doctors, take a questionnaire suggested by a doctor, and consult a doctor online. And doctors, in turn, search for a patient by various criteria, view the schedule of appointments and make notes or comments on the patient's treatment process.

The system will reduce the workload in the clinic and simplify some of the functions of the clinic's employees. The patient's card (Figure 6), contains the following data: full name, gender, date of birth, and the data shown in Figure 7. The functionality of the information system allows you to edit information, delete irrelevant data, and add notes or comments about the treatment or current state of the patient.





Figure 6: Patient's card



Figure 7: Details of patient's data

## Conclusions

The information system helps to save time and increase the efficiency of the dental clinic, because it provides the formation of detailed statistics on all its processes, records management in real time. Creating a patient database creates the ability to keep records of patients, to unify and organize patient data, to develop treatment plans, dental cards, to send SMS information to patients.

The information system is intended for automation of processes of planning, accounting and analysis of work of the dental clinic, as well as introduction of modern information and digital technologies in the practice of performing specific medical processes, improving the effectiveness of interaction of different units, officials of the dental clinic, patients, scheduling of staff, patient admission.

## 6. References

- [1] Methodical instructions for practical classes of the module "Prevention of dental diseases" (for students of the III course of dental faculty VI semester). URL: <https://bit.ly/3c034a5>.
- [2] N. Shakhovska, D. Kordiyak, Architecture of the medical system diagnostics in dentistry. Bulletin of the National University "Lviv Polytechnic" 805 (2014) 212–221.

- [3] J. Bartnicka, J. Lara, Smart solutions for improving working processes. A research experiences from dental clinic. *Multidisciplinary Aspects of Production Engineering* 2(1) (2019). URL: <https://www.semanticscholar.org/paper/Smart-solutions-for-improving-working-processes.-A-Bartnicka-Lara/fe8e009bbcd76df3fa195dff2039b74fd75ce36a>.
- [4] Elyas Palantei, Dewiani, Asrul Ramadhan, Sigit Lukman, A Smart Card based Campus Dental Clinic Services: Experimental Tests, in 2019 IEEE International Conference on Communication, Networks and Satellite (Comnetsat). URL: <https://www.semanticscholar.org/paper/A-Smart-Card-based-Campus-Dental-Clinic-Services%3A-Palantei-Dewiani/9dbf4d2eb0ec1e0b5ef4a216e56a8dfab0562725>
- [5] Y. Kovalchuk, V. Perig, O. Yeromin, Development of special applied solutions for automation activities of the dental clinic by means of modern information technical. *Efficient economy* 3. URL: <http://www.economy.nayka.com.ua/?op=1&z=2858>.
- [6] Reham Alabduljabbar, Samir El-Masri, S. Arabia, Design of Web Content Management System for Dental Laboratories. URL: <https://www.semanticscholar.org/paper/Design-of-Web-Content-Management-System-for-Dental-Alabduljabbar-El-Masri/02dcf95668d55b87a26046cd49b2354e221c3f39>
- [7] Wee Pheng Goh, Xiaohui Tao, Ji Zhang, Jianming Yong, Decision support systems for adoption in dental clinics: A survey. *Knowledge-Based Systems* 104 (2016) 195–206.
- [8] Serkan Türkeli, Kenan Kaan Kurt, Hüseyin Tanzer Atay, Mustafa Alpan Çiçek, Saffet Barış Karaca, Data Gathering and Processing in Cloud Based Dental Management Systems, in 2018 International Conference on Artificial Intelligence and Data Processing (IDAP). URL: <https://www.semanticscholar.org/paper/Data-Gathering-and-Processing-in-Cloud-Based-Dental-T%C3%BCrkeli-Kurt/2ea9e50a0c8fe453b7b3c22cebd30c25943041ac>.
- [9] A. Rzhеuskyi, N. Veretennikova, N. Kunanets, V. Kut, The information support of virtual research teams by means of cloud managers. *International Journal of Intelligent Systems and Applications (IJISA)* 10(2) (2018) 37–46. doi: 10.5815/ijisa.2018.02.04.
- [10] A. Rzhеuskyi, N. Kunanets, V. Kut, Methodology of research the library information services: the case of USA university libraries. *Advances in Intelligent Systems and Computing* 689 (2018) 450–460. doi:10.1007/978-3-319-70581-1\_32.
- [11] Pitera, V., Shakhov, A., Lohinov, O., Lohinova, L. The Method of Transfer of Research Project Results of Institution of Higher Education, in *IEEE 2019 14th International Scientific and Technical Conference on Computer Sciences and Information Technologies*, Lviv Ukraine, 2019, pp. 77–80. doi: 10.1109/STC-CSIT.2019.8929887.
- [12] T. Kysil, I. Izonin, O. Hovorushchenko, Information technology for choosing the trademark considering the attitude of consumer. *CEUR Workshop Proceedings* 2623 (2020) 133–140.