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Original Article

Development of Digital Competence of Portable Telemedicine Complex Operators for Optimizing the Provision of Medical Care

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ABSTRACT

A complex of six advanced training programs for the management of a portable telemedicine complex was developed on the basis of Federal State Budgetary Educational Institution of Higher Education "North-Western State Medical University named after I.I. Mechnikov", the Ministry of Health of the Russian Federation. A pilot training program "Operator of a portable telemedicine complex" was implemented for persons with a full-time graduate degree. 17 trainees took part in the program. According to the results of the program, all the trainees had passed certification testing successfully and demonstrated sufficient development of the digital competence of portable telemedicine complex operators to optimizing the provision of medical care. The results of the program allowed to identify positive aspects of its implementation, namely training in a comfortable and familiar environment by 85.7%; the opportunity to combine work and studies by 57.1%; and the opportunity for repetitive self-assessment by 28.6%. The article presents the results of the study under the additional agreement dated September 24, 2020 No. 075-15-2019-1346/1 to the agreement dated June 13, 2019 No. 075-15-2019-1346 with the Ministry of Science and Higher Education of the Russian Federation as a part of implementing the federal target program "Research and development in priority areas of development of the scientific and technological complex of Russia for 2014-2020", event 1.2, stage 01 Code: 2018-14-000-0001) on the topic "Development of a portable telemedicine complex for optimizing the provision of medical care"(UIP of the project: No. УИП RFMEFI60418X0201).

GRAPHICAL ABSTRACT

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Introduction

Telemedicine is defined by the World Health Organization (WHO) as "healing from a distance." It is the use of telecommunications and information technology to provide patients with remote therapeutic services [1-4]. Telemedicine is used by doctors to send digital images, video consultations, and remote medical diagnoses. Individuals no longer need to make an appointment with a doctor in order to receive treatment [5-7]. Specialists can treat patients who live in areas with restricted access to treatment thanks to the usage of secure video and voice links [8–11]. The need to introduce a portable telemedicine complex into the processes of medical care provision is conditioned by the priorities of telemedicine development in Russia, as well as by the possibilities of efficiency significant increase concerning biomedical information collection, processing, transmission and storage [12–14]. The team of authors revealed an incomplete correspondence of the qualification characteristics of healthcare workers (the list of positions in accordance with the UWRB) to the competencies necessary for the effective use of a portable telemedicine complex. This discrepancy is caused not only by the need for informatization and digitalization of the treatment and diagnostic process [15], which was actualized several years ago, but also by the limited amount of "digital competencies" in educational standards of different levels of training for healthcare workers [16,17].

The availability of medical care is the most important problem of health care organization, population life quality improvement, especially in hard-to-reach regions, the Arctic zone, as well as on the island territories of the Russian Federation [18,19]. The main medical resources are concentrated in cities, even in those regions of the Russian Federation, where the majority live in rural areas [20,21]. Some regions still have difficulties in transport accessibility provision from healthcare organizations; in the use of communication facilities, almost all constituent entities of the Russian Federation are faced with the problem of a shortage of doctors and other medical workers in rural and remote areas [22]. At the same time, the most important task to preserve life is a timely and accurate assessment of the patient's condition at the pre-hospital stage [23]. Thus, the development of an easy-to-implement and effective method for assessing the severity of a patient's condition using a telemedicine complex is an extremely urgent task [24]. Another important aspect of such technical solutions is the possibility of efficient automated work, which reduces the unnecessary organizational burden on competent experts [21,25].

Material and Methods

Patients who previously had limited access to health care services can now see a physician without leaving their home because to telemedicine. Seniors who want to age in place can now do so thanks to medical streaming gadgets. Individuals with contagious disorders do not have to expose themselves to others in congested waiting rooms, which reduces disease spread [26–30]. As the part of the additional agreement (September 24, 2020) No. 075-15-2019-1346/1 to the agreement (June 13, 2019) No. 075-15-2019-1346 with the Ministry of Science and Higher Education of the Russian Federation as the part of the federal target program implementation “Research and developments of the scientific and technological complex of Russia in priority areas for 2014-2020" [14], the Measure 1.2, the stage 01 Code: 2018-14-000-0001) on the topic "Development of a portable telemedicine complex to optimize the provision of medical care" (UIP of the project: UIP No. RFMEFI60418X0201) the following was obtained: "The method for assessing the patient's condition at the pre-hospital stage" (patent RU2020139192) using a telemedicine complex, on the basis of which the indicators of the patient's condition are assessed, the results of such an assessment are inserted into the interface of the telemedicine complex, which processes the results and issues information about the patient's condition with the recommendations for further assistance to the patient [31,32]. At the same time, the telemedicine complex [33] assists a patient automatically: At the beginning of work, the telemedicine complex provides a video link for a competent expert who takes part in assessing the condition and provides additional recommendations for the patient, and checks the correctness of processing the results of the patient's condition evaluation [34,35].

The developed portable telemedicine complex (Figure 1) is a set of peripheral medical equipment with storage in a dust and moisture protective case, a power supply system and a software environment for remote consultations between the PTC Operator and the consultant doctor, as well as a developed decision support system by the PTC operator for the diagnosis of emergency conditions.

Figure 1: PTC appearance

A portable telemedicine complex to optimize the provision of medical care is designed to carry out prevention, collection, analysis of patient complaints and anamnesis, as well as for medical monitoring of the patient's health condition for subsequent transmission of the collected information to a medical worker via communication channels [36].

The portable telemedicine complex includes the following equipment:

a) transport case TSUNAMI 483720; b) portable computer (notebook) HP Pavilion Power series, the version 15-cb016ur; c) medical small-sized video camera (endoscope) KG-003; d) electronic stethoscope Littmann 3200BK27; e) electrocardiograph EK1T-1/3-07 AKSION (1/3-channel) with combined power supply; f) wireless microphone for speech, the model Megafon 2.4G PRO; g) pulse oximeter CHOICEMMED, the model MD300C22; h) tonometer Omron Mit Elite Plus HEM-7301-ITKE7; i) breathalyzer DINGO E-010; j) electric digital thermometer Omron Eco Temp Basic MC-246-RU; k) portable urine analyzer Etta AMP-01 on test strips; l) portable biochemical blood analyzer CardioChek PA; m) Accu-Check mobile blood glucose meter; n) active USB hub GiNZZU GR-388UA; o) wireless microphone headset; -HUAWEI E3372h-153 2G/3G/4G modem; p) video capture card; and q) a set of connecting cables and chargers.

Each medical device included in the complex is located in a strictly designated place. The location of each device should be the most convenient based on its dimensions, functionality and availability of consumables (Figure 2).

For the first time, the developed software environment PTC is designed to solve the following tasks: a) integration with the Database of the regional segment of the USHIS; b) remote audio and video communication with the doctor on duty, consultations using an enhanced qualified electronic signature; c) transmission of peripheral medical equipment indications; d) storage of the database and medical knowledge base on the server and locally on the device; e) for offline work with the device; f) interface for working with instruments and viewing instrument readings; g) knowledge base for data analysis with the identification of indicators beyond the norm; h) optimization of PTC operator training within the framework of the distance learning system implementation; and i) support of decision making by the PTC operator.

The operating system Windows 10 must be installed for the program to function. A set of drivers is required, which is supplied with the medical equipment for the correct operation of the connected medical devices.

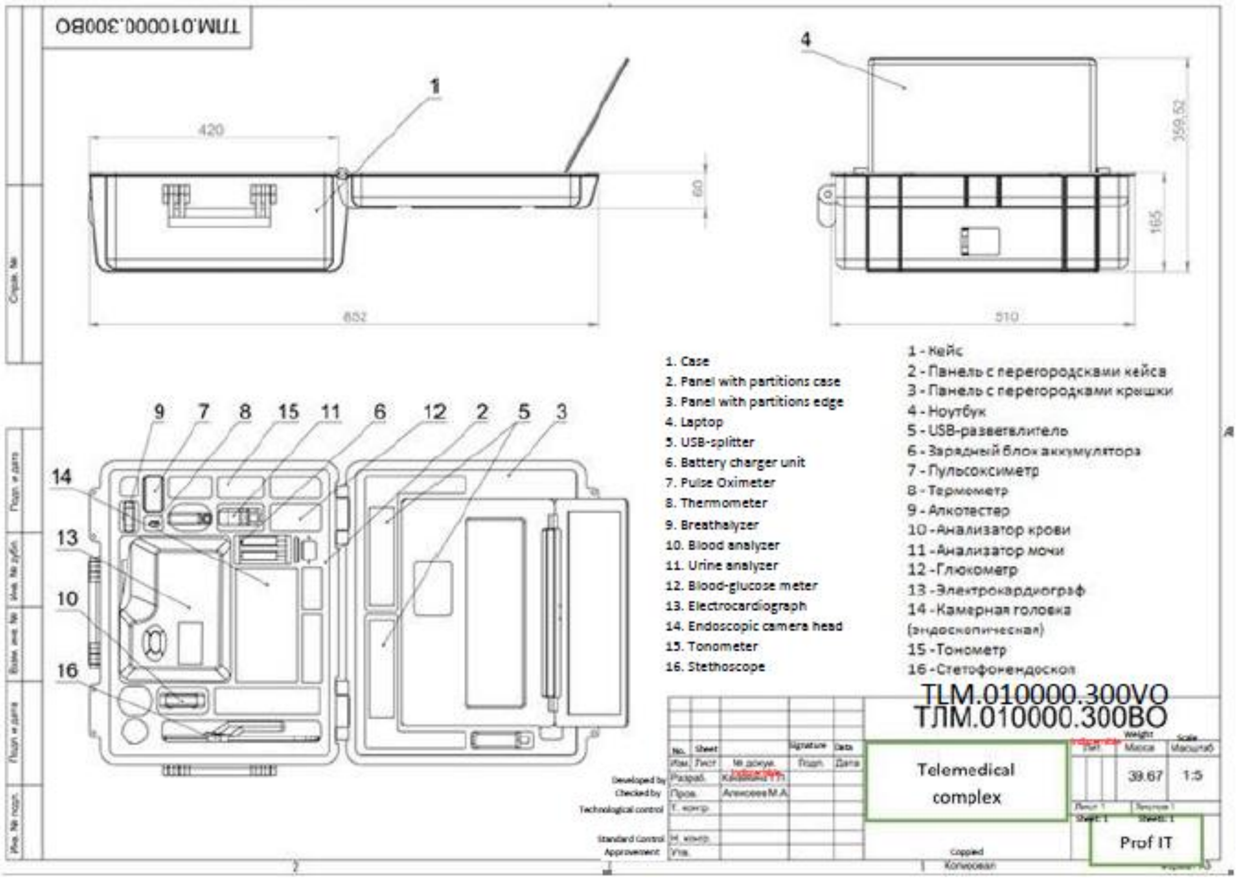

Figure 2: Location of devices in a portable telemedicine complex. 1- Case; 2- panel with case partitions; 3- panel with cover partitions; 4- notebook; 5- usb hub; 6- accumulator charger; 7- pulse oximeterэ 8- thermometer; 9- breathalyzer; 10- blood analyzer; 11- urine analyzer; 12- glucose meter; 13- electrocardiograph; 14- camera head (endoscopic); 15- tone meter; 16- phonendoscope

The program components are implemented using the following programming languages: PHP; 1C. The development environment is CMS Bitrix. Figure 3 presents the main modules of the studied program.

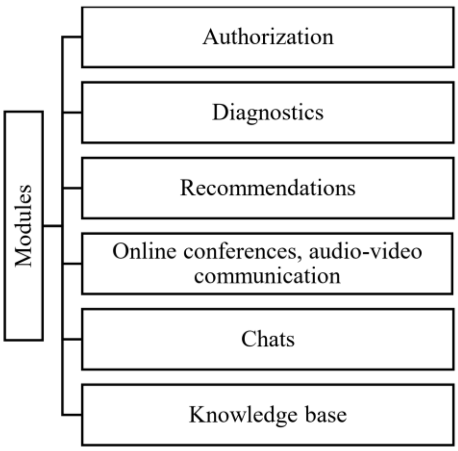

Figure 3: Basic software modules of the PTC

Thus, the PTC operator is responsible for competent service and correct operation of the complex. At the beginning of work, the telemedicine complex simultaneously provides the access to video communication for the PTC operator, who, when connected, takes part in assessing the condition and provides additional recommendations for assistance provision to the patient. Also, the PTC operator checks the correctness of the patient's condition result processing and, if necessary, makes adjustments.

Result and Dissection

Telemedicine is being used by healthcare organizations, physician practices, and skilled nursing institutions to deliver more efficient care. Electronic medical records, AI diagnosis, and medical streaming devices, all integrated with telemedicine software, can help providers diagnose and treat patients more effectively. Providers can use the latter to keep an eye on patients in real time and change treatment regimens as needed. In the end, this results in better patient outcomes [37–43]. Comparing the functions of the PTC operator when using a portable telemedicine complex with the requirements of professional standards from primary care physicians, it seemed expedient to form a list of "digital competencies", individual knowledge and skills required when working with the complex. Thus, the professional standard "Operator of a portable telemedicine complex" was developed for the first time. A key feature of the professional standard should be its focus on the experts with different initial levels of education, which will allow existing employees of healthcare organizations to perform various labor functions, having received additional professional education under the advanced training program. PTC operator functions include: a) access to the Patient Database; b) the ability to add a new patient; c) the ability to fill out a patient case; d) the ability to communicate with a consultant physician via chat; e) the ability to request a teleconsultation with a consultant physician; f) the ability to edit the data of his account; g) the access to the Knowledge Base; h) the ability to add users to the Database; i) the ability to edit user data; j) the ability to edit the Knowledge Base; k) the ability to add patients; l) the ability to edit the patient data; m) acceptance of requests for data editing; and n) the ability to create log in for users.

At the same time, the functions of a consultant physician are as follows: a) access to the Patient Database; b) access to patients' cases; c) the ability to fill out the conclusion in the patient's episode contained within the case; d) the ability to respond to the requests of the PTC Operator via chat; e) the ability to conduct teleconsultations with the PTC Operator; f) the opportunity to request a consultation with an expert of narrow practice to clarify the diagnosis; and g) the ability to edit the details of his account.

In accordance with the developed professional standard, a set of additional professional advanced training programs "Operator of a portable telemedicine complex" was compiled and tested (program duration - 18 academic hours). In order to form new and improve the existing competences of health workers, three programs are proposed: a) For the persons with higher education in the following specialties: General medicine, pediatrics, dentistry, and preventive medicine; b) for the persons with secondary education in the following specialties: Clinical medicine, health sciences and preventive medicine, pharmacy, nursing; and c) for the persons with secondary or higher professional education in the specialties and areas that are not related to the specialties of medical workers.

Now, 17 people mastered the advanced training program "Operator of a portable telemedicine complex" for the persons with higher full-time medical education. Upon completion of the advanced training program, the students passed an anonymous survey on the use of distance learning technologies and work in the university distance learning system, the results of which are presented in Table 1, 2.

Table 1: The student survey on the use of distance learning technologies in the program

Benefits of distance learning technology use during the program implementation	Share of listeners who noted an advantage
The ability to combine work with study	57,1%
Learning process functionality (ICT use)	14,3%
Learning in a comfortable and familiar environment	85,7%
The ability to test yourself (multiple times)	28,6%

Table 2: The results of student survey on the issue of difficulties when working in the university distance learning system within the framework of the training by program

Difficulties during operation in SDO	Share of listeners who noted difficulty
Technical problems when working in EIEE	71,4%
Lack of skills required to work in EIEE	57,1%
Lack of training time	28,6%
Lack of teaching materials to complete the test	0,0%
The presence of a fixed time limit for the test	14,3%

Thus, the following main difficulties for students arose during the program mastering, on which program developers focused: Technical problems when working in EIEE by 71.4%, lack of skills required to work in EIEE by 57.1%, and limited time for training by 28.6%.

For the first time in practice, with the program students improved their competencies in the field of ability and readiness to work independently on a portable telemedicine complex. As the result of mastering the program, the listeners formed the digital competence of the portable telemedicine complex operators to optimize the provision of medical care, as well as the following areas: a) improvement of the necessary knowledge about the methods of work on the portable telemedicine complex; b) improvement of the necessary skills for the implementation of independent work on a portable telemedicine complex; and c) improvement of the necessary skills to perform medical examinations, determination of emergency conditions through the independent use of a portable telemedicine complex.

To assess the quality and effectiveness of training under the advanced training program "Operator of a portable telemedicine complex" within the training framework, input and final control of digital competence development was organized. The issue of assessing the effectiveness of the advanced training program is of particular relevance within the framework of the requirements for the speed of response and the processing of the results obtained. Based on the control results, the authors of the advanced training program, using the methods of statistical analysis, tested the hypothesis; it showed that the quality of the labor function by the PTC operator increased after completing the program training. Each student of the program passed the competence development test including:

a) The ability to use the hardware and software capabilities of a portable telemedicine complex within the framework of treatment and diagnostic functions implementation by medical experts;

b) the ability to enter, edit and transfer information received by medical experts during the implementation of the treatment and diagnostic process, and to carry out elementary maintenance of the portable telemedicine complex; and

c) The ability to examine a patient using a portable telemedicine complex in order to establish a diagnosis.

To check, the listeners were offered a situational task, for the solution of which the listener was required to examine a standardized patient using a portable telemedicine complex according to the algorithm shown in Figure 4.

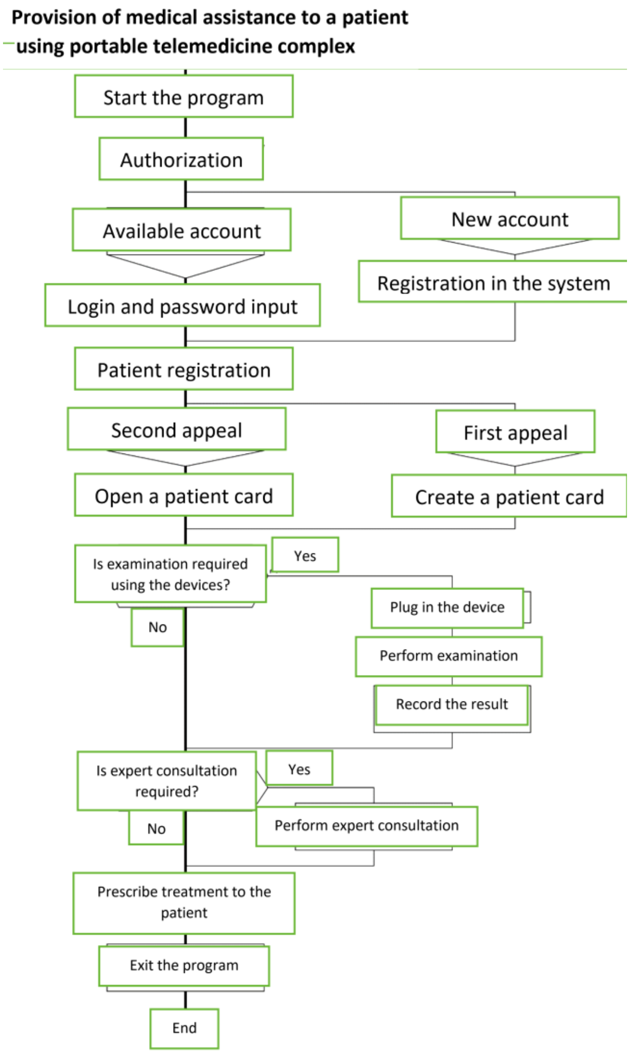

Figure 4: Algorithm for a situational problem solution to test the digital competence of the students mastering the program

When the students solved the proposed situational task, the development of three digital competencies (No. 1, 2, 3) was assessed according to the scale 0-10, where the score "0" reflects the lack of competence, and "10" means a high level of competence development. The results of checking the development of competencies are presented in Table 3.

Table 3: The results of digital competence development evaluation among the students of the advanced training program ("before" and "after" training)

Student cipher	Competence development evaluation					
	Input control			Resulting control		
	1	2	3	1	2	3
1	4	3	5	5	7	8
2	3	5	1	7	7	6
3	2	4	6	6	9	7
4	2	3	1	9	5	6
5	6	2	5	10	8	7
6	3	3	4	7	9	10
7	5	7	3	4	5	7
8	1	3	5	3	6	4
9	2	4	7	3	4	7
10	4	5	6	6	9	8
11	3	4	3	7	8	6
12	5	1	2	10	7	10
13	3	3	4	9	8	7
14	3	2	2	8	6	5
15	5	7	3	7	6	5
16	2	3	1	9	7	8
17	5	1	4	5	8	6

In order to reveal the significance of the differences between the samples, the data analysis of variance was applied. The analysis of variance results is presented in Table 4.

Table 4: The results of evaluation the reliability of differences between samples

Indicators	**Competence**					
	1		**2**		**3**	
	Input	**Final**	**Input**	**Final**	**Input**	**Final**
Sample size	17					
Group averages	3,41	6,76	3,53	7,00	3,65	6,88
Validity of differences	0,000011		0,000020		0,000020	

The obtained *p* values indicate the reliability of the differences between the samples by comparing the means for each competence, which confirms the hypothesis about the significant impact of training on the digital competence of students. At the same time, it is also of particular interest to assess the influence of the training passing factor on the final control result for each competence separately. Such an assessment was carried out by the method of variance analysis (Table 5).

Table 5: Results of data variance analysis

Indicator	**Competence**		
	1	**2**	**3**
Dispersion	208,7352941	186,6176471	186,6176471
P value	1,11724E-05	5,48312E-07	6,20927E-06

Based on the results of the analysis of variance, it was concluded that the significant influence of training on the assessment of digital competence development among students was confirmed, and the assessments of the first competence, i.e. ability to use the hardware and software capabilities of a portable telemedicine complex within the implementation of medical and diagnostic functions by medical experts, were more widely scattered.

Conclusion

The phrases telemedicine and telehealth have sparked a lot of controversy among healthcare professionals. The fact that the terminologies themselves have different definitions is one of the reasons for the debate. According to some experts, telemedicine is primarily centered on physicians, while telehealth encompasses all health workers. In the opinion of the teaching staff who developed and implemented the programs, the training topic was innovative, since for the first-time training was conducted on the example of a portable telemedicine complex designed to increase the availability and quality of first, and emergency medical care to the Russian Federation population living in hard-to-reach conditions (including the Arctic zone) at the prehospital stage using telemedicine technologies. Considering the above statements, a serious study of the new educational materials was done, since the group was not large and the students had a basic professional level of knowledge in this area, the program was successful and the listeners formed the digital competence of the portable telemedicine complex operators to optimize the provision of medical care.

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Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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