UDK: 623.618.7:517.93:62-231-02
COSATI: 06-05, 17-02, 15-05

Application of Telepharmacy: Importance of a Pharmacy Technicians' Role

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In this paper, the systems of telepharmacy services are presented considering several aspects. The first part considers the basic components of the telepharmacy systems. Examples of telepharmacy application in military services and, above all, in rural areas are presented. Then, the role of pharmacists and pharmacy technicians in telepharmacy systems is analyzed. In the second part, the importance of the role of technicians for quality execution of the telepharmacy program is proved by one illustrative, mathematical example, using the analysis of several system parameters.

Key words: **pharmacology, telepharmacy, military application, rural areas, queuing systems.**

Introduction

TODAY more and more attention is paid to the health of people. The aim is to facilitate the monitoring of health and provision of health services at any place and at any time. This has been enabled by the development of modern telecommunication services and by expanding the coverage area of telecommunication networks, which can provide connection of very remote and sparsely populated areas with larger centres, where there are pharmacists, responsible for providing pharmacy services. This provision of pharmacy services from a distance is the subject of a modern branch of pharmacy - telepharmacy. Telepharmacy is a method used in pharmacy practice in which a pharmacist utilizes telecommunication technology to oversee the aspects of pharmacy operations or provide the patient care services, [1]. Telepharmacy services include but are not limited to drug review and monitoring, dispensing, compounding verification, medication therapy management, patient assessment, counselling, clinical consultation, decision support and drug information. Areas of telepharmacy application are constantly expanding, and thus its military application becomes important. This ensures that pharmacy care becomes available at the most remote military sites and facilities, where the presence of pharmacists may not be provided. But, even more important is telepharmacy application in rural areas. The type of the implemented service may be adjusted to the needs of concrete situation.

Telepharmacy and the areas of its implementation

Telepharmacy is the provision of pharmacy services and care using modern communication technologies to patients where direct contact with the pharmacist is not possible. So, it is a way of providing pharmacy services "at a distance". In itself, it is not a technology, but is based on the use of new technological solutions [2]. Significant and rapid growth of telepharmacy services is anticipated in the near future all over the world [3]. In recent years the telepharmacy market has exponential growth and it is expected that this trend will continue also in the upcoming period.

Areas of telepharmacy services application are: small pharmacies, usually in rural areas, [2], nursing homes, [3], hospitals (mainly at remote locations), medical offices, prisons, military bases, (war) ships, etc. The largest project related to the implementation of telepharmacy is US program launched in 2006 in the areas covered by Naval Hospital Pensacola, Florida, and Bremerton in Washington State, [4, 5]. The program is initialized by the US Navy Bureau of Medicine. Over the time, the project has spread to four continents, and already in 2010 was comprised of more than 100 locations that have implemented telepharmacy services. In this way, many sites without real-time communication obtained for the first time possibility to connect with other sites. Besides, there are sites with the established pharmacy service, but pharmacist may be on vacation, may be ill, or temporarily absent. In this case telepharmacy provides possibility to connect the site with another location, where there is a pharmacist. Pharmacist is usually located in the Naval Hospital and supports one or more clinics in the same command area.

Starting from the Navy, telepharmacy services began to spread to other branches of the US army: aviation, ground forces, etc, and now it is present in all army branches, [6]. These systems are based on a research, conducted by the US Department of Defence, of commercially available technologies suitable for use in telepharmacy systems, [7].

US army has considered one more way of telepharmacy implementation: Automated Drug Dispensing Systems

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(ADDS), [8]. The intention is to equip remote locations, where soldiers are situated, with dispensing cabinets, containing the most necessary medications. In [8] it is emphasized that Bosnia is a region where military believes it will be possible to install such cabinets.

Implementation of telepharmacy requires that many important aspects are previously analyzed. Data presented in [9] are the result of a very comprehensive study, and these data and method of analysis may be used as the starting point, when some new telepharmacy system is prepared for initialization. Tested system was installed in one small village in Scotland, i.e. in rural area. Data were collected among system stakeholders to perceive what are the problems of telepharmacy introduction and, especially, its (TelePharmacy) Robotic Supply Service (TPRSS) implementation. The study is carried out on the representative sample of local residents and healthcare professionals collecting data related to baseline and follow-up analysis. The methods for data collecting were questionnaires, focus groups and interviews. Beside this, data about number and type of purchased products, prescription forms deposited and dispensed items, which were collected by TPRSS logs, were also analyzed. The main results of this analysis show that the tested system is feasible, efficient, easily accessible and easily used. The most frequently used services in this TPRSS system were prescription ordering and over-the-counter medicine purchase. After the system testing period, more than 80% of users included in the analysis reported that they would implement the system.

One different system for telepharmacy application is presented in [10]. It was installed in USA with centre at Tampa Veterans Health Administration (TVAH) hospital, Florida, covering several remote clinics. Patients on long-term anticoagulation had to visit TVAH hospital at frequent time intervals and some of them needed a few hours to travel to TVAH hospital. In this therapy pharmacist has to be included, but there were no pharmacists at the remote clinics. Only clerks were situated at the remote sites. Equipment installed on the link between TVAH hospital and the remote clinic (first of all applied video link) allows pharmacist in Tampa to supervise therapy implementation as it is face-to-face interaction. A pharmacist can see a patient and the parts of his body, patient's laboratory results and on the base of this the pharmacist is able to make assessments and decisions dealing with medications. Authors of the article also considered a possibility to implement such a system in treatment of hypertension, dyslipidemia and diabetes.

The aim of the telepharmacy system presented in [11] is to support veterans (persons older than 65 years), who are discharged from hospitals directly to their homes. It is intended to veterans from rural and highly rural areas, many of whom live alone. Pharmacists in town centres, where the hospitals from which veterans are discharged are situated, overviewed the medical documentation of veterans included in this program and called them and their family members by phone in the first week after leaving hospital. Pharmacists were able to reconcile medications, assess adherence and identify potentially inappropriate drugs on the base of these calls. The detailed statistical analysis on the collected data and comparison to the results from the control group has shown that more than a half patients had some clerical error in discharge summary (medication list). Veterans, who were included in program, were 70% less likely than veterans in control group to have an acute care visit in 30 days after hospital discharge. There was no program influence to hospital readmission and mortality in this period of time. The mean duration of all calls to one veteran was slightly more than one hour. This analysis proves that pharmacists' activities implementing telepharmacy program are very important to rural veterans after they leave hospitals. Priority in the research was given to those who take a great number of medications (12 or more), those who have cognitive impairments, congestive heart failure and are older than 75 years.

Telepharmacy is implemented more in countries where there are great, rarely populated areas. It is more necessary in USA or Australia than in Europe. North Dakota is one of the USA states where telepharmacy implementation started relatively long time ago, at the beginning of the 21st century. Legislation rules were established in 2003-2004. Number of the operational telepharmacy sites reached 25 central sites and 56 remote sites in 2012, [12]. Of these total 81 sites, 53 were retail sites and 28 hospital sites. In that moment, the system was serving 40000 rural citizens.

Presentation of telepharmacy systems and services

Telepharmacy systems are based on the engagement of pharmacists in the centre from which the entire system is managed and on the engagement of pharmacy technicians, who are "extended arm" of pharmacists at the remote locations. Telepharmacy may not be implemented without a pharmacy technician on duty, [6]. Technicians are key players in the telepharmacy advance both in inpatient and outpatient services. Experience from the implemented telepharmacy systems is that technicians like this job, because it gives them more scope than working together with pharmacist on a site, [13]. The job of a pharmacy technician in telepharmacy services cannot be adequately realized by nurses, because it is necessary to make a lot of decisions, for which nurses are not trained. The job of a pharmacy technician will become one of the most attractive fields for those who are trying to find job, or who are planning to change their actual jobs, [14]. The importance of the technicians' role in telepharmacy service may be best illustrated by the words from [15]: "a technician is the "backbone" of the pharmacy. In a telepharmacy, the technician is the backbone, spine, vertebrae, muscle tissue, cartilage - you get the point".

This last statement may be illustrated by an example from [16]. Thanks to the telepharmacy implementation and to pharmacy technician employment, pharmacy service was renewed in one small town in Montana, USA. Before that, drug store was closed many years ago, and citizens and staff from nursing home, rural health clinic and hospital were forced to purchase medication from a distant town. After introducing telepharmacy service, prescriptions may be delivered locally and medications may be picked up also locally, without any travelling. This example shows how important is the role of telepharmacy technician for the life of many people. It also shows how telepharmacy service and pharmacy technicians would be important in our country too, because there are many rural areas without traditional pharmacy service.

The activities of the technicians at the remote locations include but are not limited to, [17]:

- acceptance of the request for a prescription from the patient - prescription may be filled electronically or scanned, [5];
- input of the request for a drug into the computer;
- implementation of the billing process;
- product selection, preparation, packing and labelling;
- realization of audio and video connection to authorized pharmacist in a central location;
- sending to the pharmacist at the central location the digital

image of: a request for remedy, the original packaging of the drug, picture of tablet or capsule of the drug for identification, picture of the prescription (if it is scanned or written by a technician), or electronic form of the prescription;
- accepting the final result of dispensed drug verification from the pharmacist;
- help to the patient in the use of technological devices to obtain the necessary advice from pharmacist.

Pharmacy technician is the most important element of the telepharmacy program application. Without well-prepared pharmacy technicians, who have the confidence of, both, patients and pharmacists, telepharmacy system would not be possible. It is essential that pharmacy technician can successfully and quickly finish the job, which is within its competence, in order to minimize engagement of a pharmacist at a central location. In this way it is achieved that a pharmacist can manage a large number of remote locations in the telepharmacy system, but also a successful implementation of such a system creates greater confidence among users of the system. The use of drugs by patients, who utilize telepharmacy services, continues to be responsibility of pharmacist, as well as in conventional pharmacy systems. As a significant part of the responsibility, which is on the pharmacist in the classical system, now moves to the pharmacy technician, it is important that the technician has the proper qualifications and enough practice to perform the job. That is why the standards, which have to be met by a technician in the telepharmacy system, are higher than in the case of technician in the classic pharmacy system. The technician has more responsibility than in the conventional systems. Besides, it is necessary to be well acquainted with the modern communication devices, by which the connection is realized with the centre for system management, where the pharmacist is situated. Also, the technician guides a complete warehouse of drugs at the remote location.

The main tasks of a pharmacist in a central location are consulting services for all medicines, which are dispensed at a remote location. The pharmacist must remain responsible for all professional aspects of patient care, besides a great technician's help. Pharmacist's activities include but are not limited to:
- final verification of the recipe that was prepared by the technician;
- complete check of the drug use for each patient;
- mandatory counselling (teaching) of the patient.

The role of telepharmacy (i.e. pharmacists and technicians) is very important in decreasing the risk of adverse drug events, decreasing medication costs and opportunities for treatment failure. Events like prolonged hospitalization and (potential) death may be prevented using telepharmacy, [18]. This is especially important after a patient leaves hospital, when it is necessary to adequately continue a necessary medication.

Since telepharmacy systems require a completely new set of responsibilities and tasks of, primarily, pharmacy technicians, and, ultimately, also pharmacists, changes in legislation, which would support their new engagements, are necessary. Changes in legislation have been made in all countries where telepharmacy systems have been already applied, [19, 20], so similar changes should be enforced wherever the application of telepharmacy services starts. In addition, changes are needed in the educational system, especially when it comes to the part of the system that deals with pharmacy technicians.

In order to realize telepharmacy services, appropriate telecommunications equipment is necessary. This equipment includes, [17]:

1. Computer, i.e. PC with a specialized software that supports pharmacy services; it is useful to use the same systems at the central and remote sites;
2. Video equipment, which allows the pharmacist at a central location to have insight into the prescription, which technician prepared at a remote location. Also, this equipment enables realization of video conference call, so pharmacist at a central location can supervise dispensing of medicines at a remote location and give advices to the patients. The pharmacist is able to communicate with technicians and other staff at the remote location;
3. Some transmission system. This may be one of the following transmission system: digital subscriber line (digital subscriber line - DSL), leased (detached) E1 links, modem, Internet connections, mobile connections. Advantages and disadvantages of the application of each of these possible system connections are presented in [2], [17];
4. Considering that it is necessary to ensure permanent operation of the telepharmacy system, the spare (redundant) telepharmacy equipment is necessary. This equipment provides telepharmacy services functioning in the case of basic equipment failure or inability to realize the functions using basic equipment.

Technicians' contribution – the illustrative example

The importance of the quality and speed at which technicians perform their tasks at the remote locations for the quality of the complete system for telepharmacy services realization were already emphasized. Here we are going to illustrate this with an example. In the moment of writing this paper the authors have not known the contribution in which the mathematical analysis of serving requests in a telepharmacy system was made.

We consider the system with 5 remote locations, which is controlled by a pharmacist. Therefore, we have 5 pharmacy technicians (one at each site) in the system. Let then t be some time interval. Technicians are grouped into two classes. The first one consists of the experienced technicians, so the mean time of pharmacists engaging at a central location, if the request comes from the location which is supervised by such a technician, is, on average, $0.5 \cdot t$. The second class consists of the technicians - beginners, so the mean time of pharmacists engaging at a central location in this case is t, which is twice as long as when experienced technicians are employed. The mean time between the new requests generation at each location is $5 \cdot t$.

Based on such defined parameters we can determine: the average service rate if we consider technician - beginner

$$\mu_1 = \frac{1}{t}, \quad (1)$$

the average service rate if we consider experienced technician

$$\mu_2 = \frac{2}{t}, \quad (2)$$

and, also, the request average arrival rate at each location particularly

$$\lambda = \frac{0.2}{t} \quad (3)$$

Telepharmacy systems are systems in which losses of generated requests are not allowed. In case that, in the moment of new request generation, a pharmacist at a central location is busy processing a request from some of the remaining four locations, the newly generated request will wait for further processing until the pharmacist becomes idle. We shall analyze such a system on the base of queueing systems theory, using Erlang C-formula. This formula is well known in queueing systems theory and it was first derived to be applied for the analysis of switching systems in telephony, [21, 22]. It provides the essential parameters related to the waiting of requests: average waiting time, the probability that the request is waiting on processing, and the probability that the request is waiting on processing less than a predefined target value - the Grade of Service. In literature, there is a known designation of such systems, presented by Kendall notation: M/M/1/∞. The first two letters "M" mean that the distribution of time between consecutive request arrivals (i.e. request generation from remote sites) is exponential and that distribution of request service time (i.e. distribution of pharmacist's busy time) is also exponential. The third designation "1" means that there is one service channel (i.e. one pharmacist) in a system. The last designation "∞" means that it is possible to have infinitesimal number of waiting requests in a system (i.e. infinitesimal number of new drug requests at remote sites).

The probability that the generated request must wait on processing can be expressed by the equation:

$$P_W = \frac{\dfrac{\left(\dfrac{\lambda}{\mu}\right)^N \cdot N}{N! \cdot \left(N - \dfrac{\lambda}{\mu}\right)}}{\sum_{i=0}^{N-1} \dfrac{\left(\dfrac{\lambda}{\mu}\right)^i}{i!} + \dfrac{\left(\dfrac{\lambda}{\mu}\right)^N \cdot N}{N! \cdot \left(N - \dfrac{\lambda}{\mu}\right)}} \tag{4}$$

where:
- λ - new request average arrival rate;
- μ - average service rate of generated requests;
- N - number of serving channels.

The requested average waiting time can be calculated from the equation:

$$T_{Wm} = \frac{P_W}{\mu \cdot \left(N - \dfrac{\lambda}{\mu}\right)} \tag{5}$$

And, finally, the Grade of Service (probability that waiting time is smaller than some target value) can be determined by the formula:

$$P_a = 1 - P_W \cdot e^{-\mu \cdot \left(N - \frac{\lambda}{\mu}\right) \cdot AWT} \tag{6}$$

where:
- AWT - acceptable waiting time.

Queueing system is stable (i.e. $T_{Wm}<\infty$, or $P_a>0$), if it satisfied the well-known condition that it is:

$$\lambda \le \mu , \tag{7}$$

i.e.:

$$\frac{\lambda}{\mu} \le 1 \tag{8}$$

The purpose of mathematical analysis, presented in this paper, is to develop an analytical tool, which can be implemented in the phase of telepharmacy system preparation (dimensioning), before it is realized in practice. It is important to conduct such an analysis before defining number of applicable telepharmacy sites, position of central locations, number of necessary pharmacists, and so on. This analysis is based on known formulas from queueing systems theory. Concrete values of parameters λ and μ (i.e. μ_1 and μ_2) may be changeable, according to the specific situation in the area, where it is intended to apply telepharmacy system, but mathematical formulas are known from queueing theory. Beside formulas' implementation for switching systems (telephone systems), it was proved that they may be also applicable for many systems from everyday life, where it is necessary to determine how long it is expected that we are going to wait in some queue and how it is possible to decrease this waiting time. For example, in [23, 24] we performed original analytical and simulation analysis of one practical system, based on the teaching process at the Faculty of Pharmacy. The subject of this analysis was technicians' engagement on the faculty when executing professors' and assistants' requests. When considering implementation of queueing systems for analysis of telepharmacy systems, mathematical analysis is a new and the main contribution of this paper.

The results of analysis

The concrete results of the analysis using the formulas (4-6) can be obtained by using one of the available calculators for the results based on Erlang C formula, [25]. For these calculations it is supposed that it is N=1, λ=5·0.2/t =1/t, while μ is obtained as the appropriate combination of μ_1 and μ_2.

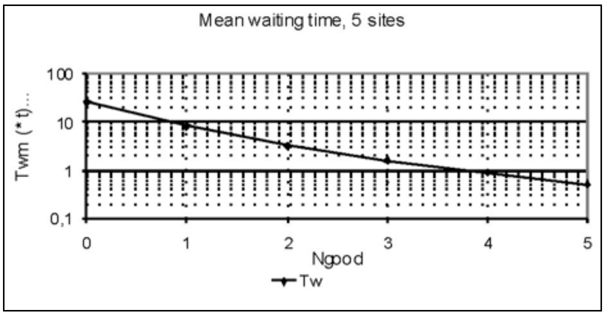

Figure 1. Request average waiting time on processing (T_{wm}) as the function of the number of experienced technicians (N_{good}), T_{wm} expressed as a multiple of base time interval (*t)

Fig.1 presents the request average waiting time on processing because pharmacist is busy as the function of the number of experienced technicians. Numerical values on the vertical axis (T_w) are values which multiply the base time interval t. When considering the values on the horizontal axis (N_{good}), they represent a number of experienced technicians, while the number of technicians - beginners is then 5-N_{good}. When all the technicians are technicians - beginners, average waiting time tends to infinity, and the system loses its sense. This is due to the fact that the condition expressed by equations (7) and (8) is not satisfied. When only 1 of 5 technicians is experienced, the average waiting time is reduced to 8·t. Further increase in the number of the experienced technicians reduces waiting time even more, so when all the technicians are experienced, this waiting time is significantly less than t.

Fig.2 presents the probability that newly generated request is waiting to be processed (in %) as the function of the number of the experienced technicians. This graphic is obtained by implementing formula (4). We can notice a linear decrease in the probability that the request is waiting processing when the number of the experienced technicians increases.

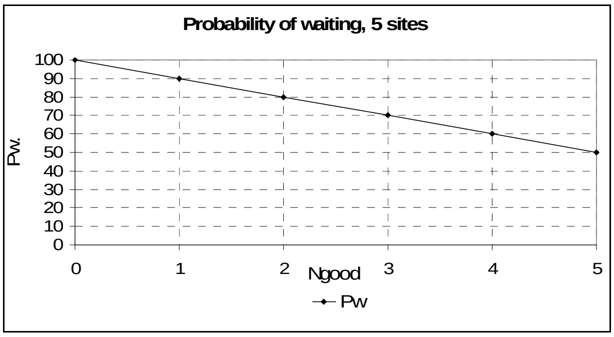

Figure 2. Probability that the request is waiting on processing (P_W) as the function of the number of the experienced technicians (N_{good})

Fig.3 presents (on the *x*-axis) the probability that the request waiting time on serving is less than a predefined target value (on the *y*-axis), i.e. the Grade of Service. The number of locations where there are experienced technicians is used as a parameter on this graphic. The improvement, which is achieved when the technicians are experienced, is significant: looking at the two extreme cases (when all the technicians are experienced and when all of them are beginners), the Grade of Service is improved 10, or even more times.

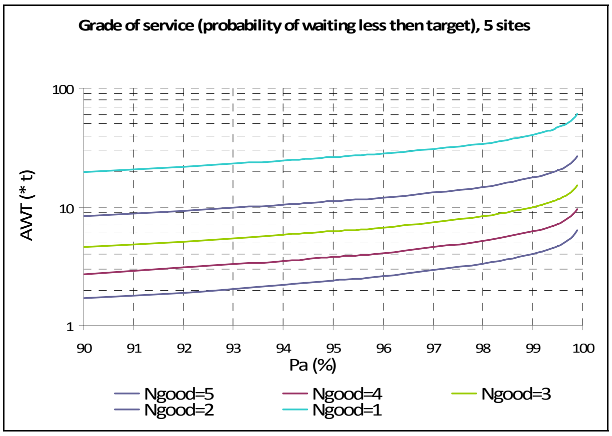

Figure 3. Grade of Service: probability (P_a(%)) that waiting time is smaller than the predefined target value (*AWT*), *AWT* expressed as a multiple of base time interval (**t*); number of the experienced technicians (N_{good}) is parameter for the characteristics

Example 1: let us suppose that we have a system with five remote locations, managed by a pharmacist on a central location. At each remote location there is a technician. Three of total five technicians at the remote locations are beginners and pharmacist's engagement when a request comes from such a location is 6 minutes. Remaining two technicians are experienced and pharmacist's engagement when communicating with these technicians is 3 minutes. Customer arrival rate at each location is 2 in an hour, meaning that mean time between two requests generation is 30 minutes. What is a probability that a customer, coming on a remote location, must wait, because pharmacist is busy, processing some request?

Solution: this is relatively simple problem and we can illustrate correctness of the implemented model, comparing this problem results with a graph.

As we have n_{beg}= 3 sites, which cause pharmacist's engagement of t_{beg}=6min. and n_{exp}= 2 sites, causing engagement of t_{exp}= 3min. and request generation rate is the same at each location, the mean pharmacist's engagement is

$$t_{mean} = \frac{\left(n_{beg} \cdot t_{beg} + n_{\exp} \cdot t_{\exp}\right)}{\left(n_{beg} + n_{\exp}\right)} = \frac{\left(3 \cdot 6\,\text{min} + 2 \cdot 3\,\text{min}\right)}{3+2} = 4.8\,\text{min} \tag{9}$$

It is emphasized that the customer arrival rate at each site is 2 in an hour. There are 5 remote locations, so the total arrival rate is 10 in an hour. It follows that a time between customers' arrival is t_{arr}= 6min.

Now we can determine probability that a new generated request will wait for processing. This probability is P_w=t_{mean}/t_{arr}= 0.8 = 8 0%, just as it can be read from Fig.2 for N_{good}=2.

Example 2: it is necessary to apply in practice a telepharmacy system in which a pharmacist manages function of five remote locations, i.e. work of five pharmacy technicians. All 5 technicians are experienced, i.e. they passed all required training to utilize this system. The mean time between the generations of two requests at each of these locations is 30 minutes, while the time of the required pharmacist's engagement to process each of these requests (communication with the patient and pharmacy technician at a remote location) is 3 minutes. What is a request waiting time (because a pharmacist is engaged in some other request processing), which will not be overcome in at least 95% of the cases? What is, in this case, the request average waiting time for processing?

Solution: based on formulas (2) and (3), the value of the time interval is *t*=6 minutes. Using the graph in Fig.3, it is obtained that the waiting time interval on the pharmacists to become idle, which will not be exceeded in 95% of cases, is *AWT* = 2.4·*t* = 14.4 minutes. Average waiting time on pharmacist to become idle, according to Fig.1, is T_{Wm}= 0.5· *t* = 3 minutes.

Conclusion

This paper has two parts. The first part explains what telepharmacy is, and after that it presents the role of pharmacists and pharmacy technicians in telepharmacy systems. Several examples dealing with concrete telepharmacy systems are presented. They illustrate telepharmacy implementation in military purposes and, even more, in rural areas.

In the second part a mathematical analysis of a telepharmacy system is provided. The analysis refers to the process of engaging the pharmacist in the centre for system management. The necessary pharmacist engagement depends on the experience of pharmacy technicians on the remote locations. It is presented how the extent of technicians training affects the performance of the whole system: the necessary pharmacist engagement, the average waiting time at a remote location to communicate with the pharmacist in the centre of the system, the probability of this waiting and the Grade of Service.

In future work the plan is to analyze more complex queuing systems. In this way, it would be possible to mathematically present the engagement of both pharmacists and technicians, i.e. telepharmacy systems could be comprehensively analyzed.

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Received: 31.01.2017.
Accepted: 13.03.2017.

Primena telefarmacije: značaj uloge farmaceutskih tehničara

U ovom radu prikazani su sistemi telefarmaceutske usluge sa nekoliko aspekata. U prvom delu rada date su osnovne odrednice telefarmaceutskih sistema. Dati su primeri primene telefarmacije u vojnim službama i, pre svega, u ruralnim oblastima. Zatim je prikazana uloga farmaceuta i farmaceutskih tehničara u sistemima telefarmacije. U drugom delu jednim ilustrativnim matematičkim primerom prikazan je, analizom nekoliko parametara, značaj uloge tehničara za kvalitetno izvršavanje programa telefarmacije.

Ključne reči: **farmakologija, telefarmacija, vojna primena, seoska područja, sistem masovnog opsluživanja.**

Применение телефармацевтики: важность роли фармацевтических техников

В данной работе даны системы телефармацевтических услуг с несколькими аспектами. В первой части даются основные компоненты телефармацевтической системы. Есть примеры применения телефармацевтики в военных службах и, в первую очередь, в сельских районах. Затем показана роль фармацевтов и фармацевтических техников в системах телефармацевтики. Во второй части одним иллюстративным математическим примером, и анализом нескольких параметров, показанна важность роли технического персонала для качественного исполнения программы телефармацевтики.

Ключевые слова: **фармакология, телефармацевтика, военные применения, сельские районы, система массового обслуживания.**

Utilisation de la télépharmacie: importance du rôle des techniciens en pharmacie

Les systèmes du service télépharmaceutique sont présentés sous plusieurs aspects dans cet article. Dans la première partie on a donné les composantes de base chez les systèmes télépharmaceutiques. On a présenté les exemples de l'utilisation de la télépharmacie dans les systèmes militaires et avant tout dans les zones rurales. On a exposé ensuite le rôle des pharmaciens et des techniciens pharmaceutiques au sein des systèmes télépharmaceutiques. Dans la seconde partie on a présenté à l'aide d'un exemple mathématique et par l'analyse de plusieurs paramètres l'importance du rôle des techniciens pour la réalisation de qualité du programme de télépharmacie.

Mots clés: **pharmacologie, télépharmacie, utilisation militaire, zones rurales, système des files d'attente.**