Technical report | Технический отчет
DOI: https://doi.org/10.35693/SIM643149

Remote assessment of treatment adherence based on the KP-25 questionnaire: a new telemedicine tool for remote compliance analysis

Andrei A. Garanin, Yurii A. Trusov

Samara State Medical University (Samara, Russian Federation)

Abstract

Aim – creation of a computer program using a modern programming language that allows remote assessment of patient treatment adherence based on the national KP-25 scale.

Material and methods. The program we developed was implemented using the modern programming language Python 3.8. This electronic assistant allows the user to automatically collect and systematize compliance data, conduct statistical analysis and store patient survey data. All these processes, depending on the operator's goals, can be carried out using local and cloud servers. If it is necessary to transfer data remotely, the program has the functionality to 'depersonalize' data about the respondent, which ensures safe and correct accumulation and storage of data.

Results. The program allows the user to evaluate 6 technical indicators calculated using formulas: importance of drug therapy, importance of medical support, importance of lifestyle modification, readiness for drug therapy, readiness for medical support, readiness for lifestyle modification. Calculation using integrated formulas also allows the user to display the result of the commitment calculation on the user's screen in four aspects: 1) commitment to lifestyle modification, 2) commitment to drug therapy, 3) commitment to medical support, 4) integral commitment to treatment. After the end of testing, the program saves the patient's answers to an Excel file located in the root folder of the program in the form of percentages, which are generated depending on the patient's response in accordance with the classical algorithm for interpreting the results of the questionnaire using integrated formulas.

Conclusion. This software product can potentially be used in the scientific process in conducting cohort and population-based studies aimed at assessing compliance in routine medical practice, as well as integrated into existing and promising medical information systems.

Keywords: treatment commitment, electronic assistant, COP-25 questionnaire, telemedicine, telemonitoring.

Conflict of interest: nothing to disclose.

Citation
Garanin AA, Trusov YuA. **Remote assessment of treatment adherence based on the KP-25 questionnaire: a new telemedicine tool for remote compliance analysis**. *Science and Innovations in Medicine*. 2025;10(3):211-217.
DOI: https://doi.org/10.35693/SIM643149

Information about authors
Andrei A. Garanin – MD, Cand. Sci. (Medicine), Director of the Research and Practice Center for Telemedicine.
ORCID: 0000-0001-6665-1533
E-mail: a.a.garanin@samsmu.ru

***Yurii A. Trusov** – MD, cardiologist at the SamSMU Clinics, assistant at the Department of Propaedeutic Therapy with a course in cardiology.
ORCID: 0000-0001-6407-3880
E-mail: yu.a.trusov@samsmu.ru
Corresponding Author

Received: 17.12.2024
Accepted: 04.02.2025
Published: 25.04.2025

Программа удаленной оценки приверженности лечению на основе опросника КОП-25: новый инструмент телемедицины для дистанционного анализа комплаентности

А.А. Гаранин, Ю.А. Трусов

ФГБОУ ВО «Самарский государственный медицинский университет» Минздрава России (Самара, Российская Федерация)

Аннотация

Цель – создание компьютерной программы с использованием современного языка программирования, позволяющей дистанционно оценивать приверженность лечению пациентов на основе отечественной шкалы КОП-25.

Материал и методы. Разработанная нами программа выполнена с использованием современного языка программирования Python 3.8. Данный электронный помощник позволяет в автоматическом режиме осуществлять сбор и систематизацию данных о комплаентности, проводить статистический анализ и хранить данные об анкетировании пациентов. Все эти процессы в зависимости от целей оператора могут осуществляться с использовнием локальных и облачных серверов. При необходимости передачи данных на расстоянии программа имеет функционал по «обезличиванию» данных о респонденте, что обеспечивает безопасное и корректное накопление и хранение данных.

Результаты. Программа позволяет оценивать шесть технических показателей, рассчитываемых по формулам: важность лекарственной терапии, важность медицинского сопровождения, важность модификации образа жизни, готовность к лекарственной терапии, готовность

к медицинскому сопровождению, готовность к модификации образа жизни. Расчет по интегрированным формулам также позволяет вывести на экран пользователя результат расчета приверженности по четырем аспектам: приверженность модификации образа жизни; приверженность лекарственной терапии; приверженность медицинскому сопровождению; интегральная приверженность лечению. После окончания тестирования программа сохраняет ответы пациента в файл Excel, расположенный в корневой папке программы, в виде процентов, которые порождаются в зависимости от ответа пациентов в соответствии с классическим алгоритмом интерпретации результатов вопросника по интегрированным формулам.

Заключение. Разработанный программный продукт потенциально может быть применен в научном процессе при проведении когортных и популяционных исследований, которые направлены на оценку комплаентности и в рутинной медицинской практике, а также интегрирован в существующие и перспективные медицинские информационные системы.

Ключевые слова: приверженность лечению, электронный помощник, опросник КОП-25, телемедицина, телемониторинг.

Конфликт интересов: не заявлен.

Для цитирования:
Гаранин А.А., Трусов Ю.А. **Программа удаленной оценки приверженности лечению на основе опросника КОП-25: новый инструмент телемедицины для дистанционного анализа комплаентности.** *Наука и инновации в медицине.* 2025;10(3):211-217. DOI: https://doi.org/10.35693/SIM643149

Сведения об авторах
Гаранин А.А. – канд. мед. наук, директор научно-практического центра дистанционной медицины.
ORCID: 0000-0001-6665-1533
E-mail: a.a.garanin@samsmu.ru
***Трусов Юрий Александрович** – врач-кардиолог Клиник СамГМУ, ассистент кафедры пропедевтической терапии с курсом кардиологии.
ORCID: 0000-0001-6407-3880
E-mail: yu.a.trusov@samsmu.ru
Автор для переписки

Список сокращений
ХНИЗ – хроническое неинфекционное заболевание; АГ – артериальная гипертензия; КОП – клиническая оценка приверженности; ССЗ – сердечно-сосудистое заболевание; ИМ – инфаркт миокарда; ИБС – ишемическая болезнь сердца; СД – сахарный диабет; ФП – фибрилляция предсердия; ХСН – хроническая сердечная недостаточность.

Получено: 17.12.2024
Одобрено: 04.02.2025
Опубликовано: 25.04.2025

INTRODUCTION

Adherence to treatment (compliance) can be characterized as a patient's measurable ability to follow medical prescriptions. It includes regular medication intake, lifestyle modifications, and observance of medical recommendations.

Comliance is critically important in achieving positive therapeutic results and, in many aspects, shapes the patient's health prognosis. According to World Health Organization experts, compliance with medical prescriptions is considered one of the most significant factors influencing public health [1, 2]. Focusing on treatment adherence can substantially enhance the effectiveness of healthcare initiatives and programs.

At the moment, the methods of therapeutic compliance evaluation may be divided into two main groups [3]: direct (analyses and direct supervision of medication intake) and indirect (use of various questionnaires and scales).

Although direct methods of evaluation of compliance with recommended treatment are very accurate, they are seldom used in routine clinical practices and are usually resorted to in clinical trials. Among alternate approaches, such as interviews, analysis of admissions, questionnaires the latter are considered the most economically viable to evaluate the patients' compliance with prescriptions [4].

In modern clinical practice, the emphasis is placed on questionnaires that enable quantitative assessment of treatment compliance levels. These tools are universal and applicable to patients with various diseases; they facilitate automated data collection and analysis, which makes them particularly convenient.

Among the well-known questionnaires use to evaluate compliance, MMAS-4 and MMAS-8 are worth a special mention. While MMAS-4 has limited sensitivitiy, specificity and reliability [5], its successor, the MMAS-8, shows significantly higher sensitivity values with a comparable level of specificity [6]. It is to be noted, however, that complete reliance on this new tool requires additional research. Despite such advantages as brevity and ease of use, the two questionnaires have several disadvantages: the evauation scale is qualitative, not quantitative; lack of possibilities to evaluate other aspects of compliance than medication intake.

In order to overcome the said restrictions, the Russian questionnaire for quantitative evaluation of treatment compliance was developed, the COP-25. Created in 2009, this tool was designed to evaluate compliance with instructions of patients with arterial hypertension, but found use in other fields of medicine [7]. Treatment compliance assessment is of particular importance in patients with chronic non-communicable diseases (CNCDs) within the framework of outpatient follow-up. The protocol published in 2015 provides a detailed description of treatment compliance analysis methods. Studies have demonstrated the high sensitivity, specificity, and reliability of the COP-25 questionnaire, making it a valuable tool in clinical practice.

Recent studies demonstrate that effective long-term monitoring can be achieved using telemedicine technologies [8–10]. However, the integration of information and communication technologies and telemedicine tools into routine clinical practice raises a number of challenges that require in-depth analysis and optimization to enhance healthcare quality and improve collaboration among all stakeholders.

AIM

Creation of a computer program using a modern programming language that allows remote assessment of patient treatment adherence based on the national COP-25 scale.

MATERIAL AND METHODS

The Scientific and Practical Center for Telemedicine at Samara State Medical University has developed software tools to assess treatment compliance using the Russian COP-25 scale. These tools comprise a software suite with three web applications. This solution enables healthcare providers

to efficiently and accurately collect patient adherence data during both in-person outpatient visits and telemedicine consultations.

Our program is written in the modern programming language, Python 3.8. The electronic assistant enables automated collection and systematization of data on patient compliance, perform statistical analysis and store data from patient questionnaires. These processes, depending on the operator's goals and objectives, may be performed on local and cloud-based servers. In case of necessity of long-distance data transfer, the program, has an option of depersonalization of the interviewee's data ensuring secure proper collection and storage of information.

Following the results of work on the electronic assistant, certificates of state registration of computer programs were obtained: "Program of remote quantitative evaluation of therapeutic compliance based on the COP-25 questionnaire" (registration No. 2024619892, registration date: 27.04.2024); "Program of remote quantitative evaluation of therapeutic compliance based on the COP-25 questionnaire" (registration No. 2024660040, registration date: 02.05.2024); "Questionnaire for the quantitative evaluation of therapeutic compliance: the COP-25 calculator" (registration No. 2024660243, registration date: 03.05.2024).

RESULTS AND DISCUSSION

Our program is designed for the remote quantitative evaluation of patients' compliance with therapy in the process of dynamic follow-up to perform scientific research, therapy or prevention; it is implemented based on the COP-25 questionnaire. To that end, the software package is installed to the disk specified by the user in the doctor's workstation. Once installed, the electronic assistant is launched by running the executable file (.exe). After launching, the program generates a window in the user's desktop with 25 questions from the classic variant of the COP-25 scale. Once all questions are answered, the program uses integrated formulas to automatically calculate the indicators of therapeutic compliance, shows the user the result of the interview with the score and their interpretation describing the patient's level of compliance with treatment (**Fig. 1**).

The program evaluates six technical indicators calculated using formulas: significance of drug therapy, significance of medical follow-up, significance of lifestyle modification, readiness to drug therapy, readiness to medical follow-up, readiness to lifestyle modification (**Table 1**).

The calculation using integrated formulas also enables output of the compliance calculation in four aspects: 1) compliance with lifestyle modification; 2) compliance with

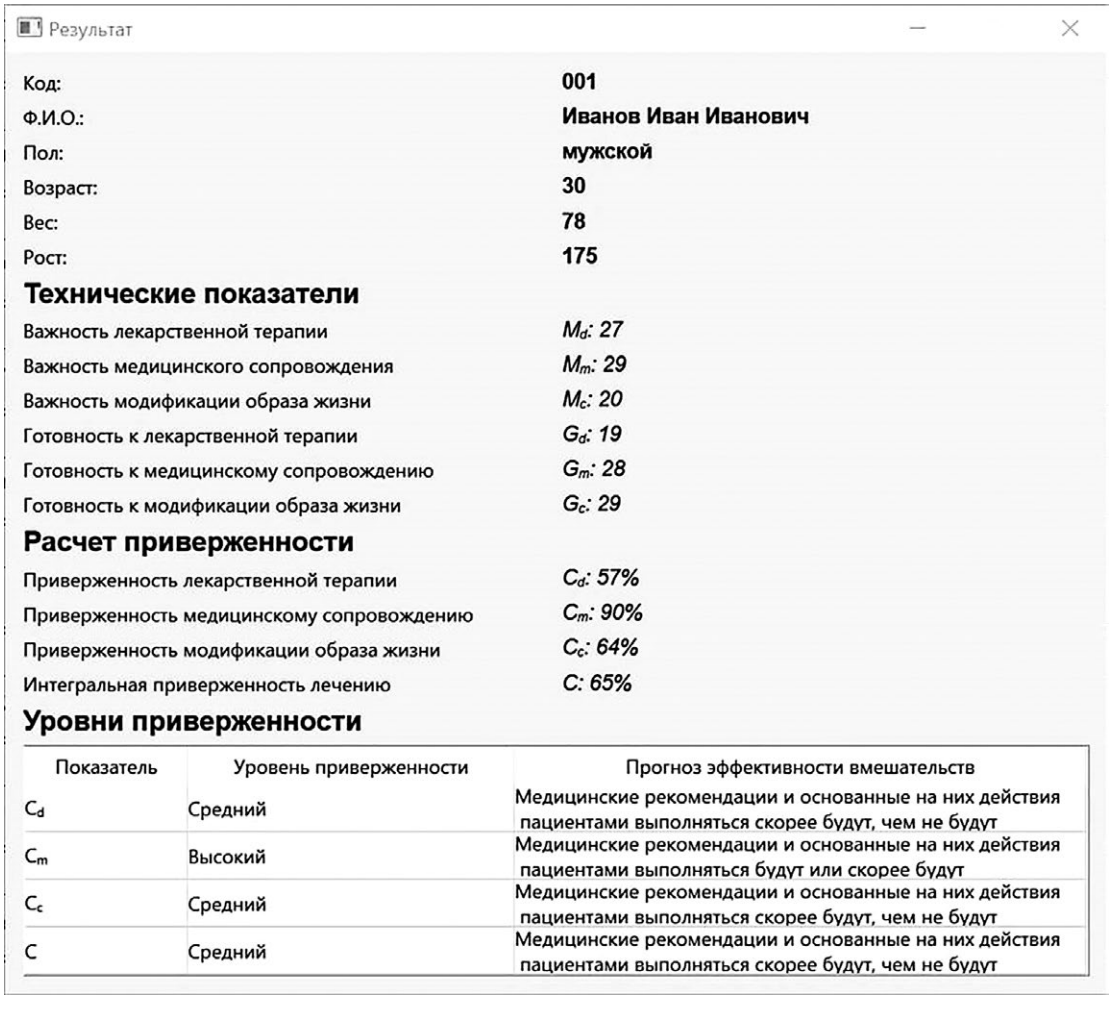

Figure 1. *Appearance of the doctor's electronic assistant based on the domestic scale KOP-25, generated by the core of the program when launched from the browser.*

Рисунок 1. *Внешний вид электронного помощника врача на основе отечественной шкалы КОП-25, порождаемого ядром программы при запуске из браузера.*

Indicator	Name	Question No. (sum of scores)
Significance of drug therapy	Md	2, 3, 4, 6, 14
Signigicance of medical follow-up	Mm	1, 5, 10, 11, 13
Significance of lifestyle modification	Mc	7, 8, 9, 12, 15
Readiness to drug therapy	Gd	16, 17, 18, 20, 21
Readiness to medical follow-up	Gm	16, 19, 20, 24, 25
Readiness to lifestyle modification	Gc	19, 22, 23, 24, 25

Table 1. *List of 6 technical indicators for the results of patient interviews using the electronic version of the KOP-25 questionnaire*

Таблица 1. *Оценка 6 технических показателей по результатам интервьюирования пациента с помощью электронного варианта опросника КОП-25*

drug therapy; 3) compliance with medical follow-up; 4) integral compliance with treatment.

The calculation of these values is performed using the following formulas.

Compliance with lifestyle modification:

$$Cc=1 \div \frac{((30 \div Mc) \times (60 \div Gc))}{2} \times 100 \quad (1),$$

where:
Cc – compliance with lifestyle modification, %
Mc – significance of lifestyle modification, points
Gc – readiness to lifestyle modification, points
Compliance with drug therapy:

$$Cd=1 \div \frac{((30 \div Md) \times (60 \div Gd))}{2} \times 100 \quad (2),$$

where:
Cd – compliance with drug therapy, %
Md – significance of drug therapy, points
Gd – readiness to drug therapy, points

Compliance with medical follow-up::

$$Cm=1 \div \frac{((30 \div Mm) \times (60 \div Gm))}{2} \times 100 \quad (3),$$

where:
Cm – compliance with medical follow-up, %
Mm – significance of medical follow-up, points
Gm – readiness to medical follow-up, points

Integral compliance with treatment:

$$C= \frac{(Cm+2Cc+3Cd)}{6} \quad (4),$$

where:
C – integral compliance with treatment
Cm – compliance with medical follow-up, %
Cc – compliance with lifestyle modification, %
Cd – compliance with drug therapy, %.

Upon completion of testing, the program saves the patient's answers in an Excel file in the root folder of the program as percentage values calculated depending on the answers of patients in accordance with the conventional algorithm of interpretation of questionnaire answers using integrated formulas. At the same time the doctor may perform a number of studies on a group of patients forming a database on their computer, and then perform a population analysis of therapeutic compliance, or compliance in a specific cohort or a specific patient. Moreover, the program enables any entitled observer to remotely evaluate compliance with therapy from any location and any computer connected to the Internet, thus providing the opportunity of mass remote evaluation of therapeutic compliance.

Following the interview with the patient using the COP-25 scale, the electronic assistant gives the doctor the possibility of recording and transferring the data as well as form a database. This assists in the making of a substantiated decision on prescription of drugs with consideration of evaluated compliance. Below are several options of use of our electronic assistant.

1. Deployment at a paramedic's workstation in rural health posts (RHPs) enables remote assessment of treatment compliance for RHP-visiting patients by physicians from central district hospitals or regional telemedicine centers during remote follow-up monitoring. This software solution also allows integration with regional medical information systems.

2. Development of a mobile application for patients under follow-up care, enabling self-assessment via the COP-25 questionnaire with subsequent automated treatment compliance evaluation, data transmission to the medical information system, and results analysis by the attending physician.

3. Development of a mobile application for industrial workers as part of occupational health initiatives, enabling periodic workplace assessment of treatment adherence using this digital tool among employees with chronic non-communicable diseases.

The important feature of this electronic assistant is the functionality of dynamic evaluation of compliance with the prescribed therapy, viz. analysis of efficacy of the treatment and adjustment of therapeutic plan over a long period of time. Not only does it register data on compliance but also compares results on different stages of treatment, which allows determining the trends and suggest more personalized treatment considering individual needs and behavior of the patient. This approach assists better outcomes of the therapy and improves overall patient satisfaction with treatment results. In outpatient and telemedicine practice, time constraints often limit thorough medical documentation. Digital assistants that streamline data entry and storage serve as valuable tools for optimizing clinician workflow.

The Scientific and Practical Center for Telemedicine at Samara State Medical University is conducting pilot studies to evaluate the efficacy of a digital assistant, particularly in remote follow-up monitoring. The research focuses on treatment adherence in patients with various chronic non-communicable diseases (CNCDs). This issue is of critical importance as many of these conditions require long-term therapy.

As per existing data, the level of non-complianc with treatment varies from 4 to 88%, and only about 50% of patients with CNCDs demonstrate long-term compliance. This emphasizes the need for development of efficient solutions to improve treatment compliance [11–14]. The electronic assistant may significantly influence the treatment outcomes not only from the new data, but also from evaluating the compliance dynamics in the long run. This enables the doctor respond to changes in the patients' behavior in a prompt way.

Modern technologies can significantly improve healthcare quality and physician-patient interaction, thereby enhancing treatment effectiveness. Treatment adherence assessment is particularly crucial for patients with cardiovascular diseases (CVDs), as these conditions represent the leading cause of disability and mortality. Circulatory system disorders frequently lead to severe complications, underscoring the need for adequate and consistent therapy. However, the national register REKVAZA, initiated in the Ryazan Region, identified a significant discrepancy between the medical prescriptions and modern clinical recommendations. This discrepancy emphasizes the importance of implementation of systems enabling doctors to supervise in a more closer manner the patients' compliance with treatment and meet the current clinical standards. It follows from the data that among 2548 outpatients with coronary heart disease (CHD) the statins, crucial for reducing the risk of cardiovascular accidents, were prescribed only in 28.7% cases. In the patients after a myocardial infarction (MI), this indicator was 42.3%, and in the patients after the second MI, 50%. In the patients with a cerebral stroke, this indicator was only 9.8%, and in patients with diabetes mellitus (DM), 18.9% [15]. These quantitative data emphasize the vital importance of a stricter adherence to recommendations once the therapy is prescribed, which would minimize the risk of potential complications and improve the quality of medical services. The EFFORT study addressed elderly patients aged over 65, of which 81.1% were in the age group of 65–74 years. These individuals suffered from arterial hypertension and had confirmed CHD, for which statin therapy is indicated. However, every third of them had MI, and 93% were diagnosed with arterial hypertension, which indicates the vulnerability of this age group and its need for special attention during treatment. Despite that, compliance with therapy is only significant in the initial stages of it. Active use of statins is typically observed during the first three months of treatment. With prolonged follow-up, compliance levels decline sharply. At three months, 34.2% of patients discontinue prescribed medications. Between four months and one year, this proportion increases to 69.9%, while compliance drops to 72.7% in the 1-5 year period. Regretfully, nearly 93.1% of patients discontinue therapy after five years, which represents a critical concern [16].

Multiple studies show that lack of compliance with intake of oral anticoagulants by patients with atrial fibrillation (AF) may decrease their efficiency in actual clinical practice. The systematic review and the metaanalysis by S. Salmasi et al. (2020) included 30 different studies and determined hat up to 30% patients with AF do not comply with the prescribed anticoagulant therapy [17]. This emphasizes the need to focus on compliance, for the lack of compliance with treatment may have an adverse effect on the health of patients increasing the risk of clot formation and strokes. Another group is patients with arterial hypertension who also demonstrate lack of compliance. According to some studies, 43 to 66% of patients do not follow the doctors' advise on the intake of antihypertensive drugs; moreover, one year after the start of therapy, 40 to 65% of patients stop taking the prescribed drugs [18–20].

Studies demonstrate that patients with poor compliance with intake of essential cardiac medications face a 10-40% increased hospitalization risk [21, 22]. R. Mathews et al. (2015) found that only 71% of 7,425 patients after percutaneous coronary intervention maintained prescribed treatment at 6-week follow-up, while 25% showed suboptimal compliance and 4% exhibited poor compliance [23]. Most alarmingly, over one-third of patients miss antiplatelet therapy twice weekly or more frequently, significantly elevating the risk of stent thrombosis and recurrent myocardial infarction..

The study of ST de Vries et al. Found that the experience of patients with Type 2 diabetes mellitus shows various levels of compliance with therapy. The most manifested problems were found in patients taking glucose-lowering medications: 37.6% of patients did not comply with the proper treatment regime. Every fifth patient demonstrated low compliance with antihypertensive and lipid-lowering drugs [24]. A similar study performed by M. Viana found that among patients with chronic heart failure (CHF) compliance with angiotensin-converting enzyme inhibitors (ACEIs) was high, while significantly lower compliance rates were observed for beta-blockers and diuretics.

On a side note, if information about only one type of drug were used to evaluate compliance with treatment, such classification would have been inaccurate in over 20% cases [25]. This emphasized the importance of an individual approach, in which it is important to evaluate compliance with each type of drug seperately.

CONCLUSION

Treatment adherence assessment in patients with chronic non-communicable diseases has become a critical aspect of clinical practice. This is particularly relevant in telemedicine consultations and remote health monitoring. Integrating digital tools for dynamic adherence evaluation into modern medical information systems may optimize diagnostic and therapeutic processes while improving patient compliance with prescribed therapy. The use of modern digital solutions plays a pivotal role in scientific research aiming at development and implementation of primary and secondary prevention of chronic non-communicable diseases. The accumulated data may be used in the future as the basis for datasets to be utilized in machine learning which, in its turn, may facilitate development of medical decision-making support systems. In this way, development of technologies aimed at enhancing evaluation of compliance opens new horizons not only for improving healthcare quality, but also for creating novel opportunities in scientific progress and clinical practice. This advancement may lead to more effective and personalized treatment approaches, including for patients with comorbidities.

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Study funding. The study was the authors' initiative without external funding.	***Источник финансирования.*** Работа выполнена по инициативе авторов без привлечения финансирования.
Conflict of Interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Contribution of individual authors. Garanin A.A.: setting of tasks, writing and editing of the article, testing of computer software. Trusov Yu.A.: writing of the computer program, writing of the article. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	***Участие авторов.*** Гаранин А.А. – постановка задач, написание и редактирование статьи, тестирование программы для ЭВМ. Трусов Ю.А. – написание программы для ЭВМ, написание статьи. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.

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