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# Remote monitoring of patients with rheumatoid arthritis using a personal messenger

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**ABSTRACT**

***BACKGROUND:*** Remote medical technologies are a promising way to monitor patients during disease diagnosis, treatment, and subsequent rehabilitation. This paper reviews the clinical implementation and effectiveness of digital tools for remote monitoring and treatment control in patients with rheumatoid arthritis.

***AIM:*** The aim of the study was to evaluate safety, efficacy and technological features of monitoring patients with rheumatoid arthritis using a remote monitoring platform.

***MATERIALS AND METHODS:*** The prospective, non-randomized, controlled study included patients over 18 years of age with moderately to severely active rheumatoid arthritis who were discharged from the hospital for outpatient monitoring. Patients were divided into two groups for remote and in-person monitoring. Data for remote patient monitoring was collected through questionnaires using a Telemedbot Personal Messenger. The authors also used the Health Assessment Questionnaire (HAQ) to assess daily life functioning in patients with rheumatoid arthritis; the European Quality of Life Questionnaire EQ-5D questions to assess patient adherence, duration of morning stiffness, number of painful and swollen joints; and a visual analog scale to assess the overall condition. After 6 months, efficacy of rheumatoid arthritis treatment was assessed in both groups using the DAS28 index.

***RESULTS:*** The remote monitoring program involved 30 patients for 6 months. The in-person monitoring group also included 30 people. After 6 months, patients using the Telemedbot Personal Messenger achieved low rheumatoid arthritis activity and remission more often than the second group ($p$=0.049). In the remote monitoring group, 9 (30.0%) and 11 (36.7%) patients achieved remission and low disease activity, compared to 3 (10.0%) and 8 (26.7%) patients in the in-person monitoring group. Therefore, 20 (66.7%) people in the remote monitoring group were able to control the disease, while only 11 (36.7%) patients in the in-person monitoring group were able to do so.

***CONCLUSION:*** Remote monitoring using the Telemedbot Personal Messenger can be considered a potential way to increase the availability of medical care and efficacy of treatment for rheumatoid arthritis.

**Keywords:** rheumatoid arthritis; activity monitoring; mobile health; mHealth; telemedicine; digital medicine; remote monitoring.

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# Удалённое наблюдение за пациентами с ревматоидным артритом с применением платформы на базе персонального мессенджера

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## АННОТАЦИЯ

**Обоснование.** Дистанционные медицинские технологии — перспективный способ наблюдения за пациентами в ходе диагностики заболевания, лечения и последующей реабилитации. В настоящей статье авторы рассматривают интеграцию в клиническую практику и эффективность цифрового инструмента для осуществления удалённого наблюдения и контроля лечения пациентов с ревматоидным артритом.

**Цель** — оценка безопасности, эффективности и технологических особенностей наблюдения за пациентами с ревматоидным артритом с помощью платформы для удалённого мониторинга.

**Материалы и методы.** В проспективное нерандомизированное контролируемое исследование включены пациенты старше 18 лет с ревматоидным артритом с высокой и умеренной степенью активности, выписанные из стационара для амбулаторного наблюдения. Пациенты разделены на две группы: удалённого и очного наблюдения. Данные для удалённой оценки состояния пациентов получены путём анкетирования при помощи программного комплекса для наблюдения за пациентами на основе персонального мессенджера «Телемедбот». Также авторы использовали опросник HAQ для оценки функциональной способности в повседневной жизни у пациентов с ревматоидным артритом; европейский опросник качества жизни EQ-5D; вопросы для оценки приверженности пациентов рекомендациям, длительности утренней скованности, числа болезненных и припухших суставов; визуальную аналоговую шкалу для общей оценки заболевания. Через 6 мес. в обеих группах проведена оценка эффективности лечения ревматоидного артрита по индексу DAS28.

**Результаты.** 30 пациентов использовали программу дистанционного наблюдения 6 мес. Группа очного наблюдения также состояла из 30 человек. Через 6 мес. среди пациентов, использующих персональный мессенджер «Телемедбот», низкая активность ревматоидного артрита и ремиссия достигались чаще, чем во второй группе ($p$=0,049). В группе удалённого наблюдения ремиссии и низкой активности заболевания достигли 9 (30,0%) и 11 (36,7%) пациентов против 3 (10,0%) и 8 (26,7%) в группе очного контроля. Таким образом, в группе дистанционного наблюдения у 20 (66,7%) человек удаётся контролировать заболевание, в то время как в группе очного наблюдения это удаётся сделать лишь у 11 (36,7%).

**Заключение.** Удалённое наблюдение с помощью мессенджера «Телемедбот» можно считать потенциальным инструментом повышения доступности медицинской помощи и эффективности лечения ревматоидного артрита.

**Ключевые слова:** ревматоидный артрит; контроль активности; мобильное здравоохранение; mHealth; телемедицина; цифровая медицина; удалённое наблюдение.

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# 利用个人聊天软件平台对类风湿性关节炎患者进行远程监测

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## 摘要

**论证。**远程医疗技术是在疾病诊断、治疗和后续康复过程中，监测患者的一种很有前景的方法。在本文中，作者对类风湿关节炎患者的远程监测和治疗控制的数字工具有效性与临床实践的融合进行了研究。

**目的** — 评估使用远程监控平台对类风湿性关节炎患者进行监测的安全性、有效性和技术特点。

**材料和方法。**这项前瞻性非随机对照研究，纳入了出院接受门诊随访的18岁以上，患有严重和中度活动性类风湿关节炎患者。患者分为两组：远程监测和面对面监测。远程评估患者病情的数据是通过个人聊天软件平台 “Telemedbot”的患者监测软件包进行问卷调查获得的。同时，作者还使用了HAQ问卷来评估类风湿关节炎患者的日常生活能力；欧洲生活质量问卷EQ-5D；评估患者对建议的遵守情况、晨僵持续时间、疼痛和肿胀关节数量的问题；用于整体疾病评估的视觉模拟量表。6个月后，使用DAS28指数对两组患者的类风湿关节炎疗效进行评估。

**结果。**30名患者参加了为期6个月的远程监测计划。 面对面监测组也有30名患者。6个月后，使用个人聊天软件平台“Telemedbot”的患者中，类风湿关节炎的低活动度和病情缓解高于第二组（$p$=0.049）。在远程监测组中，分别有9名(30.0%)和11名(36.7%) 患者获得缓解，且疾病活动度较低，而面对面对照组中分别有 3名(10.0%)和8名(26.7%) 患者获得缓解。因此，在远程监测组中，有20人（66.7%）成功控制了疾病，而在面对面监测组中，只有11人（36.7%）能够控制病情。

**结论。**使用个人聊天软件平台“Telemedbot”进行远程监控可以被认为是提高医疗服务的可用性和类风湿性关节炎治疗有效性的潜在工具。

**关键词：**类风湿性关节炎；活跃性监控；移动医疗；mHealth；远程医疗；数字医学；远程监测。

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## BACKGROUND

Optimizing medical care in the setting of overwhelming healthcare system burdens as well as staffing and time constraints requires innovative, flexible solutions. Modifications are being made to the medical institutions' workflow management, patient routing systems, and continuing medical education programs. With a greater number of software being available every year, modern technology breakthroughs offer an array of possibilities.

These devices and software have been employed in diverse medical fields, especially by rheumatologists. Rheumatic and musculoskeletal disorders require long-term (sometimes lifelong) monitoring by specialists. Without appropriate monitoring, these disorders exert permanent effects on patients' physical and mental health, as well as their social lives [1]. To enhance treatment outcomes, rheumatologists use electronic medical records, artificial intelligence, machine learning, clinical decision support systems, and wearable technology with data transfer capabilities, including mobile devices [2]. This software facilitates patient data classification and rapid, long-distance data transfer. Moreover, it allows delegation of certain routine tasks to digital assistants, streamlines diagnostic search, and minimizes time expenditures for healthcare personnel [3].

The most diverse set of digital tools in rheumatology are available to patients with rheumatoid arthritis (RA), the most prevalent autoimmune inflammatory disease [4, 5]. In recent years, RA incidence in Russia has risen by 17.5%. The prevalence of RA-related disability is rising along with the number of RA patients [6]. A comprehensive understanding of RA mechanisms and treatment approaches, skilled rheumatologists, and advancements in drug therapy and rehabilitation programs enable effective treatment of RA, resulting in remission or minimal disease activity [7–10]. However, maintaining treatment outcomes over the long term remains a challenge in real-world clinical settings. Furthermore, for certain patients, the mitigation in baseline disease activity during treatment was inadequate. This may result from less stringent monitoring of treatment efficacy following therapy initiation at the onset, during relapses, and after treatment [11, 12].

Remote monitoring solutions for patients with RA exhibit substantial clinical promise. Current guidelines indicate that regular monitoring by a rheumatologist during outpatient follow-up enhances the likelihood of achieving and maintaining remission or low-level disease activity, which is the primary objective of RA treatment [4, 13]. Several studies and systematic reviews on remote medical care have been published in the past five years. In 2022, the European League Against Rheumatism (EULAR) published the first guidelines for remote medical care in patients with rheumatic and musculoskeletal disorders [14]. In most publications, patients who use specialized remote monitoring programs typically have better or equivalent treatment outcomes than those who use traditional patient care techniques. However, recent systematic reviews have highlighted several challenges in the development, implementation, funding, and safety and efficacy assessment of remote monitoring software [15].

## AIM

To evaluate the safety, efficacy, and technological features of remote monitoring in RA utilizing a personal messenger developed by the Department of Hospital Therapy of the Sechenov University and to examine patient satisfaction parameters.

## MATERIALS AND METHODS

### Study design

This was a prospective, non-randomized, controlled, open-label, experimental, single-center study (Fig. 1).

### Eligibility criteria

The study included male and female patients over 18 years old with moderate to high disease activity who were discharged for outpatient-based follow-up and had signed a voluntary informed consent form. The Russian and EULAR recommendations were followed in making the diagnosis [3, 8, 12]. The exclusion criteria were as follows:

- Patients who developed RA before the age of 16;
- Patients with malignancies or mental disorders;
- Patients with a history of stroke or a transient ischemic attack during the previous six months;
- Patients with injuries or other conditions that exacerbate pain and restrict joint mobility;
- Patients who were pregnant or lactating; those without smartphones; and those who were not proficient in the joint self-assessment procedure (for the remote monitoring group).

Patients were omitted from the study if they met the exclusion criteria or declined to participate further.

### Study setting

Every patient was followed up at the Rheumatology Department of the Sechenov University Clinical Hospital No. 1.

### Subgroup analysis

The study included two groups. Group 1 patients received the standard of care with in-person consultations and used remote monitoring software. Group 2 patients only received in-person consultations.

### Intervention

Questionnaires were employed to collect data for the remote patient status evaluation. The study used questionnaires

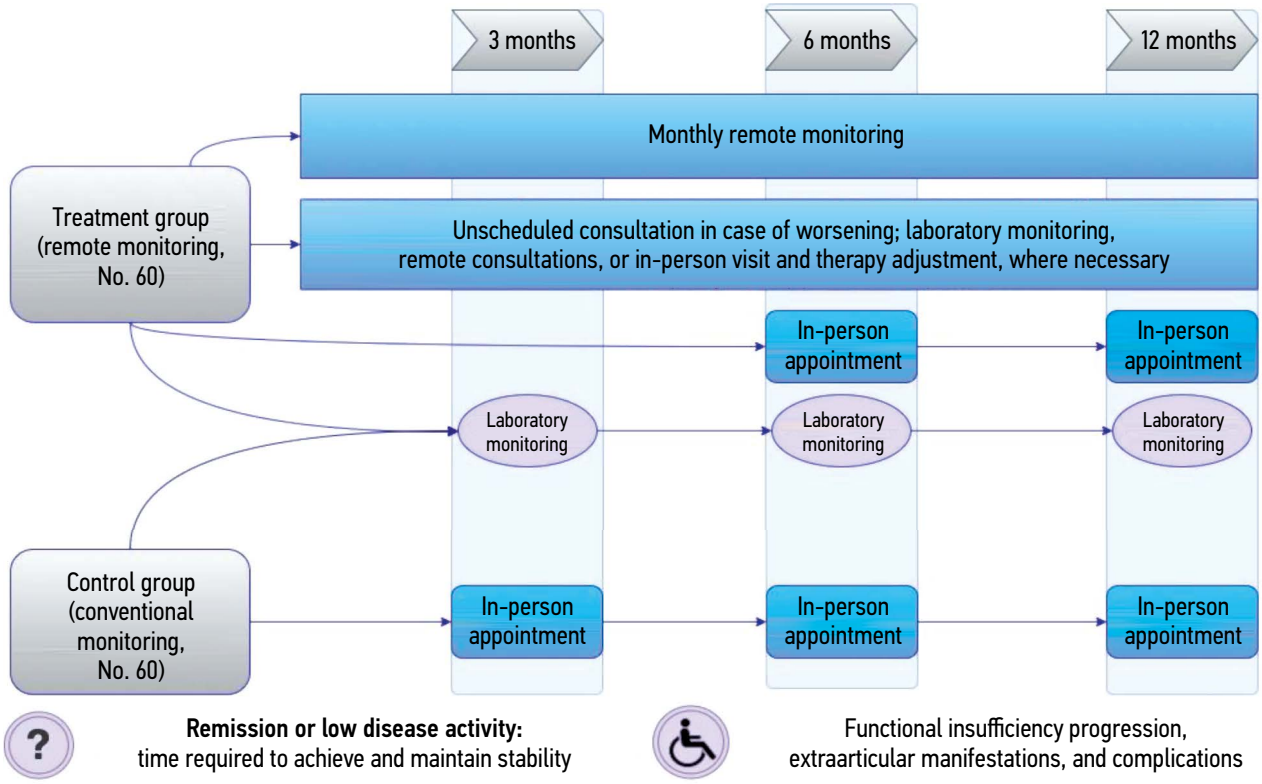


**Fig. 1.** Study design.

validated for clinical studies as well as recommended for treating and monitoring patients with RA and validated for clinical studies. These included the Health Assessment Questionnaire (HAQ) to assess daily life functioning in patients with rheumatoid arthritis; the European Quality of Life Questionnaire (EQ-5D) questions to ascertain patient adherence, duration of morning stiffness, and the number of tender and swollen joints; and a visual analog scale to assess the overall condition [3]. Moreover, the questionnaires were employed to gauge alterations in the condition of the RA patients.

### *Remote monitoring*

Patients in the remote monitoring group received monthly reminders to complete a questionnaire in the software (mobile application). Patients could request an unannounced consultation and complete an unscheduled survey if their condition deteriorated. The questionnaire responses were immediately reported to the attending physician. The physician contacted the patients by phone in the following scenarios:

- When the responses in the questionnaire indicated adverse developments;
- At the patient's request and on unscheduled questionnaire completion;
- Insufficient decrease in RA activity.

Where necessary, these patients were referred for a follow-up examination to assess RA activity using DAS28 and CDAI. Additionally, the patients were consulted over the phone or in person.

### *Personal messenger-based software*

The personal messenger-based remote monitoring software Telemedbot consists of interface subsystems, an internal software interface (Application Programming Interface, API), a backup subsystem, and PostgreSQL and Redis database management systems (DBMS) for short-term and long-term data storage.

*The interface subsystem* is responsible for the application logic, interactions with personal messenger APIs (specifically the use of the Telethon V2 library for the Telegram API), and data presentation in the personal messenger for both patients and physicians. An illustration of how patient data is displayed on the Telegram mobile app is provided in Fig. 2.

*The internal API subsystem* effectively regulates data management in the DBMS (standard operations of record generation, updating, and removal). Redis is used for caching, and PostgreSQL secures the long-term storage of patient data, questionnaires, and outcomes. Patient data are stored anonymously, with a unique code (nickname) assigned to each patient when creating a new patient account. Consequently, only the physician who created the account can identify the patient.

*The backup subsystem* ensures that data are regularly uploaded and saved to an external independent object storage service called S3 (Simple Storage Service).

All subsystems run in independent Docker containers and are managed using Docker Compose. All Telemedbot messenger components are located on a virtual server in Russia.

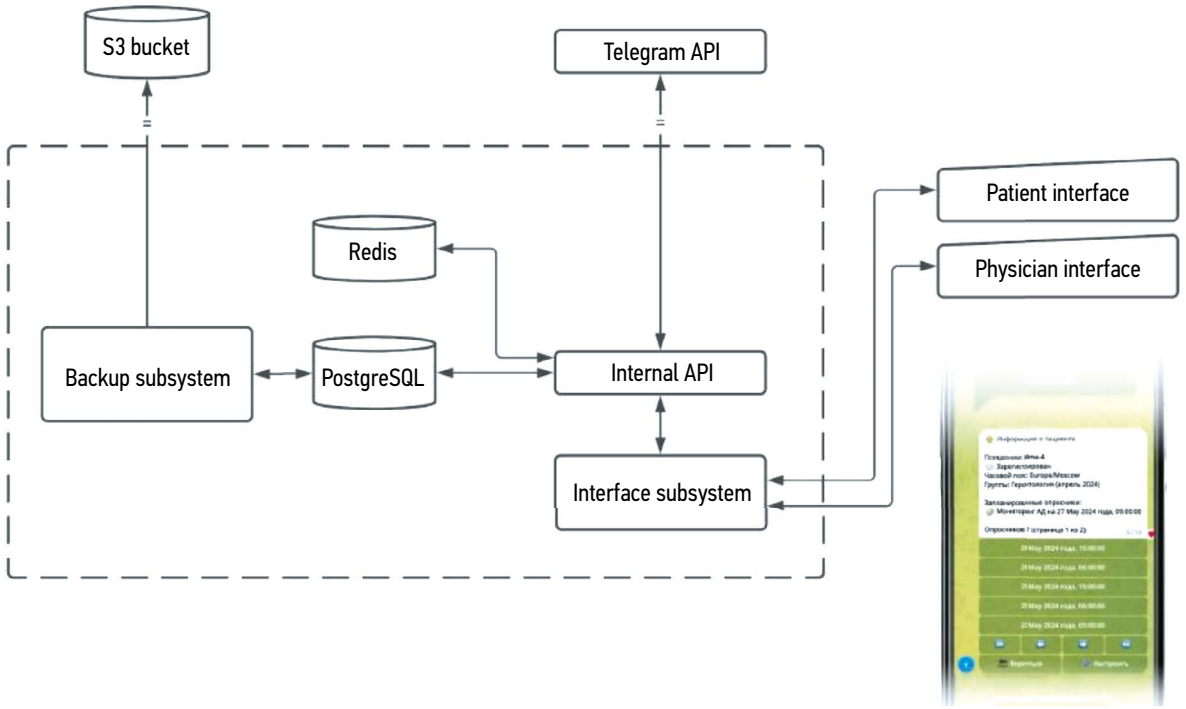


**Fig. 2.** Layout of the personal messenger-based software for remote monitoring.

To use Telemedbot, patients and physicians only need an IOS or Android smartphone installed with a personal messenger.

The patient interface communicates with Telemedbot by sending and receiving messages using a dedicated account in a personal messenger. Depending on the physician's treatment strategy, the patient was reminded to complete a questionnaire on a regular basis (e.g., once a month). Once the patient agreed to complete the questionnaire, the Telemedbot would send successive messages with various questions (single- or multiple-choice, free- or semifree-form responses; in the latter case, the response was checked for conformity with the set regular expression). The questionnaire results, including the partially completed questionnaires, were immediately reported to the physician.

The physician interface also interacts via a personal messenger. Physicians can create and update new accounts as well as review patient data and questionnaire results.

## Main study outcomes

The following parameters were assessed during an in-person visit after six months:

- Clinical treatment outcomes;
- Level of patient satisfaction with software-based remote monitoring;
- Time spent by healthcare personnel on remote monitoring.

## Additional study outcomes

Assessments were conducted on the self-monitoring skills during treatment, technical difficulties, and willingness to continue monitoring.

## Outcomes registration

Treatment efficacy (clinical outcome) was assessed based on RA activity changes from baseline using DAS28.

After six months, to assess overall satisfaction with the messenger-based medical care, patients were asked to rate the technique using the following parameters:

- Convenience and user-friendliness of the software;
- Time needed per month to utilize the software;
- Physician's time to respond;
- Convenience of format;
- Satisfaction with treatment outcomes over six months.

Each parameter was assessed on a five-point scale, where 1 = very bad, 2 = rather bad than good, 3 = satisfactory, 4 = rather good than bad, and 5 = excellent.

## Ethical review

The study was approved by the local ethics committee of the Sechenov First State Medical University (Minutes No. 22-22 of November 3, 2022).

## Statistical analysis

Statistical analysis was performed using the StatTech v. 4.2.6 software (StatTech LLC, Russia). Based on the effect size determined in previous studies, an expected minimal significance level of 5%, and a statistical power of 90%, the sample size was estimated to be a minimum of 30 patients in each group. The descriptive statistics for the quantitative parameters are presented as median (Me) and interquartile range [Q1; Q3]. The Pearson's chi-square test was used for intergroup comparisons of the categorical variables. Differences were considered significant at a *p-value* <0.05.

# RESULTS

The two study groups were matched based on sex, age, serological parameters (rheumatoid factor [RF] and anti-cyclic citrullinated peptide antibody [anti-CCP] levels), and RA activity parameters at baseline (Table 1).

After six months, RA activity was assessed in both groups using DAS28 (Table 2). To achieve optimal RA control, disease activity must be minimal, or the patient should be in remission. By the end of the follow-up, Group 1 patients who used Telemedbot attained a state of low disease activity or remission more frequently than those in Group 2 (see Table 2, Fig. 3). In the remote monitoring group, 9 (30.0%) and 11 (36.7%) patients achieved remission and low disease activity, respectively, compared to 3 (10.0%) and 8 (26.7%) patients in the in-person monitoring group (see Table 2). Thus, the disease was effectively controlled in 20 (66.7%) patients in Group 1, compared to 11 (36.7%) patients in Group 2 (see Fig. 3).

**Table 1.** Clinical characteristics of the patients

| Parameter | Remote monitoring | In-person monitoring |
|---|---|---|
| Number of patients, *n* | 30 | 30 |
| Male, *n* (%) | 6 (20.0) | 4 (13.3) |
| Female, *n* (%) | 24 (80.0) | 26 (86.7) |
| Age, years, M ± SD | 52.20 ± 15.23 | 54.10 ± 12.62 |
| DAS28, Me [Q1–Q3] | 4.46 [3.76–5.62] | 4.70 [4.12–5.59] |
| Moderate RA activity* (%) | 20 (66.7) | 17 (56.7) |
| High RA activity (%) | 10 (33.3) | 13 (43.3) |
| RF*+, *n* (%) | 25 (83.3) | 22 (73.3) |
| anti-CCP*+, *n* (%) | 10 (33.3) | 10 (33.3) |

*Note.* RA, rheumatoid arthritis; RF, rheumatoid factor; anti-CCP, anticyclic citrullinated peptide antibody.

**Table 2.** Rheumatoid arthritis activity in the different group patients after six months

| Activity by DAS28 | Remote monitoring, *n* (%) | In-person monitoring, *n* (%) | *p-value* |
|---|---|---|---|
| Remission | 9 (30.0) | 3 (10.0) | 0.049 |
| Low activity | 11 (36.7) | 8 (26.7) | |
| Moderate activity | 10 (33.3) | 16 (53.3) | |
| High activity | 0 (0.0) | 3 (10.0) | |

*Note.* DAS28 (Disease Activity Score), rheumatoid arthritis activity score in 28 joints.

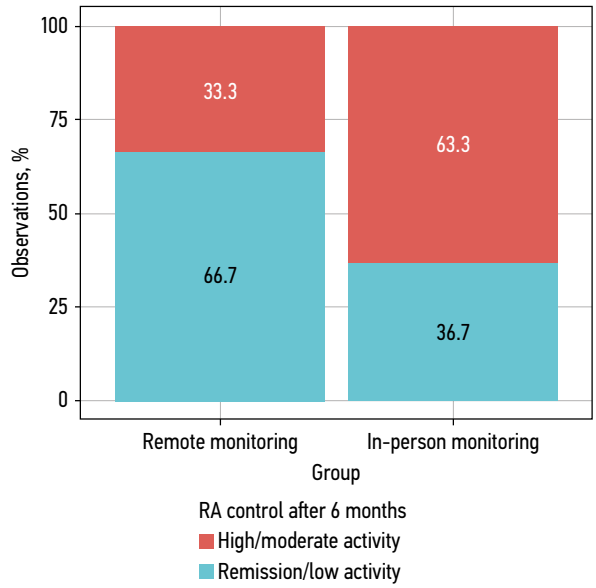


**Fig. 3.** RA control in the groups after six months.

Observed intergroup differences were likely due to earlier detection of worsening and absence of on-treatment improvements in the remote monitoring group, which enabled timely treatment modifications. During the follow-up period, 11 (36.6%) patients in the remote monitoring group had unfavorable changes, such as increasing pain and tender/swollen joint counts, which required an unscheduled consultation. One (3.3%) patient required previous prescriptions to be explained once more. Four patients (13.3%) received remote treatment adjustments, whereas six (20%) patients were recommended an unscheduled in-person appointment, follow-up examination, and inpatient treatment adjustment.

The analysis of patient satisfaction with medical care utilizing remote monitoring software indicated that most Group 1 (20 patients, 66.7%) patients were completely satisfied with treatment outcomes, comparable to the proportion of patients who achieved RA activity control. Most patients (27 patients, 90.0%) reported that the physician responded immediately. The convenience of the chatbot was rated excellent by 24 (80.0%) patients and good by five (16.7%) patients. One (3.3%) patient encountered difficulties in using the software and considered it inconvenient. One patient (3.3%) considered the time required to complete the questionnaires to be excessive, while another patient (3.3%) deemed it satisfactory. The remaining patients rated the application as good (3 patients, 10.0%) or excellent (25 patients, 83.3%) (Fig. 4). Three (10.0%) patients encountered technical issues (temporary switch-off during the software update process, patient mobile device issues) (Fig. 5).

A greater understanding of self-monitoring and self-assessment while undergoing RA treatment was reported by patients (25 patients, 83.3%) who utilized the remote monitoring program. In total, 24 (80.0%) patients consented to use the chatbot for continued monitoring (see Fig. 5).

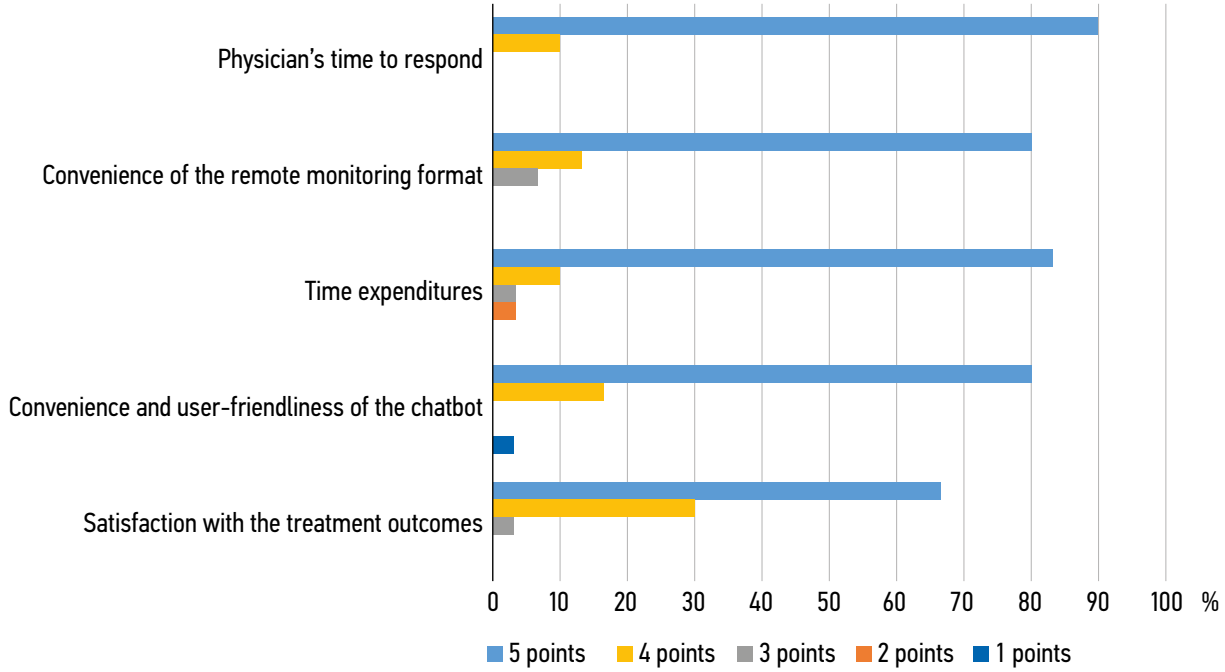


**Fig. 4.** Subjective patient assessment of the remote monitoring software: 1 = very bad, 2 = rather bad than good, 3 = satisfactory, 4 = rather good than bad, and 5 = excellent.

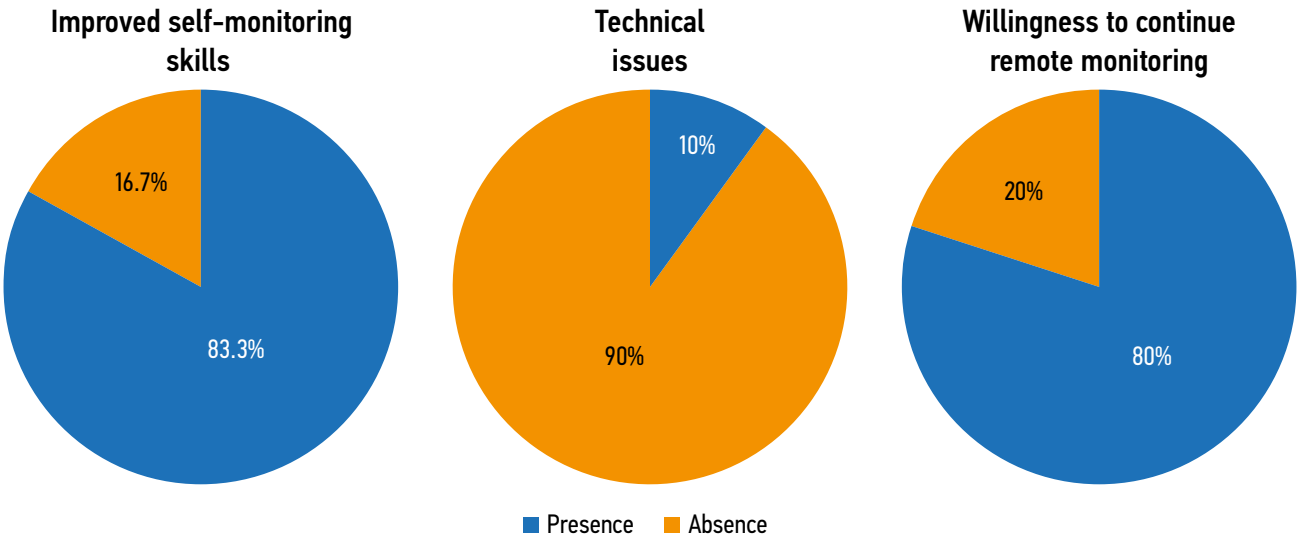


**Fig. 5.** Subjective patient assessment of the remote monitoring software (2).

## DISCUSSION

In recent years, remote monitoring in RA patients has become a convenient and accessible tool for enhancing treatment outcomes. Although the number of available monitoring applications and software is rapidly expanding, only a few of them have been scientifically proven to be effective and safe. A systematic review of mobile applications for RA patients by Luo et al. revealed that only seven of the 20 assessed applications were designed in consultation with healthcare professionals [16]. Very few applications are assessed in clinical studies prior to release, and software proven to be effective in clinical studies is not widely available. The lack of information on data transfer and storage makes it challenging to evaluate the confidentiality of the available mobile applications. There have been few studies on technical solutions for the remote diagnosis of relapses [17]. According to most studies in a systematic review by Marques et al., the management of RA patients employing dedicated applications provides comparable or superior outcomes compared to conventional in-person appointments in terms of efficacy, safety, compliance, and user experience. Publication bias cannot be excluded in more than half of the analyzed randomized clinical studies, as positive outcomes are more likely to be published than negative ones [15]. Remote monitoring applications can boost patient engagement in therapy. Greater awareness of the disease and treatment modalities,

confidence in the outcome from following physician advice, and improved self-assessment skills contribute to favorable treatment outcomes [18]. Notably, all remote monitoring studies in RA patients focused on clinical safety. However, the lack of knowledge on the storage and transfer of patient data makes it nearly impractical to evaluate cybersecurity, especially personal data security.

Our study demonstrates that monitoring RA patients with moderate or high disease activity using the Telemedbot personal messenger facilitates the timely accomplishment of treatment goals: remission or minimal disease activity. The treatment efficacy after six months, as determined by evaluating RA activity using DAS28, was significantly greater in the remote monitoring group than in the conventional in-person monitoring group. One significant advantage of telemonitoring is the possibility to maintain the obtained results via regular monitoring of patients for deterioration and inadequate improvements while on treatment. The method has demonstrated high patient satisfaction with treatment outcomes, increased patient engagement in therapy, and boosted the user-friendliness of the messenger.

### Study limitations

Despite the reliability of the findings, the study exhibits several limitations. Although the study sample can be considered representative, the sample size precludes a multivariate analysis of the impact of individual patient characteristics, such as drug therapy variations, on treatment efficacy. The study findings can serve as a basis for future, more extensive randomized controlled studies of remote digital monitoring in RA patients.

## CONCLUSION

This study confirms the efficacy of the RA treatment monitoring program developed at Sechenov University. Telemedbot exhibits the potential to enhance access to medical care by facilitating direct communication with physicians and providing patients with information support. The software promotes more frequent monitoring of changes in the condition, early detection of elevated RA activity, and timely treatment. Moreover, remote monitoring mitigates the need for in-person appointments, which is especially crucial for patients with mobility issues and those residing in remote areas.

## ADDITIONAL INFORMATION

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