

LAB TEACHER AN INNOVATIVE APPROACH TO OPTIMIZING PREPARATION FOR LABORATORY TESTING AND REDUCING DIAGNOSTIC ERRORS BASED ON ARTIFICIAL INTELLIGENCE

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Abstract

In modern medical practice, laboratory testing represents one of the fundamental stages in clinical decision-making. At the same time, inadequate preparation for tests, errors occurring in the pre-analytical phase, and insufficient patient awareness significantly affect the reliability of results. This article scientifically substantiates the concept of an intelligent digital assistant called “LabTeacher.” This system is designed to provide patients with individualized, personalized, and interactive guidance for proper preparation for laboratory tests using elements of artificial intelligence. The study analyzes the role of digital healthcare technologies in reducing pre-analytical errors and examines the relationship between patient behavior and laboratory test outcomes. Through the “LabTeacher” system, patients receive real-time reminders and explanations regarding nutrition before testing, medication intake, physical activity, and other important factors. This contributes to minimizing human-related errors and improving the accuracy of laboratory results. The findings indicate that the use of digital assistant systems significantly enhances patients’ level of preparedness for laboratory testing and reduces the risk of incorrect diagnoses. In conclusion, the “LabTeacher” concept emerges as a promising innovative solution for improving the quality of laboratory diagnostics, optimizing clinical decision-making, and increasing overall efficiency within the healthcare system.

Keywords: Lab Teacher, laboratory diagnostics, pre-analytical phase, laboratory errors, artificial intelligence, digital healthcare, patient preparation, personalized approach, test accuracy, clinical decision-making, interactive systems, medical information technologies, diagnostic reliability, automation, healthcare efficiency.



Introduction

Annotatsiya

Zamonaviy tibbiyot amaliyotida laborator tahlillar diagnostik qaror qabul qilishning asosiy bosqichlaridan biri hisoblanadi. Shu bilan birga, tahlillarga noto'g'ri tayyorgarlik ko'rish, preanalitik bosqichdagi xatoliklar va bemorlarning yetarli darajada xabardor emasligi natijalar ishonchligiga sezilarli ta'sir ko'rsatadi. Mazkur maqolada "LabTeacher" nomli aqlli raqamli yordamchi konsepsiyasi ilmiy jihatdan asoslab beriladi. Ushbu tizim sun'iy intellekt elementlari yordamida bemorlarga laborator tahlillarga to'g'ri tayyorgarlik ko'rish bo'yicha individual, moslashtirilgan va interaktiv ko'rsatmalarni taqdim etishga qaratilgan. Tadqiqotda raqamli sog'liqni saqlash texnologiyalarining preanalitik xatoliklarni kamaytirishdagi roli tahlil qilinib, foydalanuvchi xulq-atvori va tahlil natijalari o'rtasidagi bog'liqlik o'rganildi. "LabTeacher" tizimi orqali bemorlarga tahlil topshirishdan oldingi ovqatlanish, dori vositalarini qabul qilish, jismoniy faollik va boshqa muhim omillar yuzasidan real vaqt rejimida eslatmalar va tushuntirishlar beriladi. Bu esa inson omiliga bog'liq xatoliklarni kamaytirish va laborator natijalar aniqligini oshirishga xizmat qiladi. Natijalar shuni ko'rsatadiki, raqamli yordamchi tizimlardan foydalanish bemorlarning tahlillarga tayyorgarlik darajasini sezilarli darajada yaxshilaydi hamda noto'g'ri tashxis qo'yilish xavfini kamaytiradi. Xulosa qilib aytganda, "LabTeacher" konsepsiyasi laborator diagnostika sifatini oshirish, klinik qaror qabul qilishni optimallashtirish va sog'liqni saqlash tizimida samaradorlikni ta'minlashda istiqbolli innovatsion yechim sifatida namoyon bo'ladi.

Kalit so'zlar: LabTeacher, laborator diagnostika, preanalitik bosqich, laborator xatoliklar, sun'iy intellekt, raqamli sog'liqni saqlash, bemor tayyorgarligi, individual yondashuv, tahlil aniqligi, klinik qaror qabul qilish, interaktiv tizimlar, tibbiy axborot texnologiyalari, diagnostik ishonchlik, avtomatlashtirish, sog'liqni saqlash samaradorligi.

Аннотация

В современной медицинской практике лабораторные исследования являются одним из ключевых этапов принятия клинических решений. В то же время неправильная подготовка к анализам, ошибки на преаналитическом этапе и недостаточная информированность пациентов существенно влияют на достоверность результатов. В данной статье научно обоснована концепция интеллектуального цифрового помощника «LabTeacher». Данная система направлена на предоставление пациентам индивидуализированных, адаптированных и интерактивных рекомендаций по правильной подготовке к лабораторным исследованиям с использованием элементов искусственного интеллекта. В исследовании проанализирована роль цифровых технологий здравоохранения в снижении преаналитических ошибок, а также изучена взаимосвязь между поведением пользователей и результатами лабораторных анализов. С помощью системы «LabTeacher» пациентам предоставляются напоминания и разъяснения в режиме реального времени относительно питания перед сдачей анализов, приема лекарственных средств, физической активности и других важных факторов. Это способствует снижению ошибок, связанных с человеческим фактором, и повышению точности лабораторных результатов. Результаты исследования показали, что использование цифровых помощников значительно повышает уровень подготовки пациентов к



лабораторным исследованиям и снижает риск постановки ошибочного диагноза. В заключение, концепция «LabTeacher» представляет собой перспективное инновационное решение для повышения качества лабораторной диагностики, оптимизации клинического принятия решений и повышения эффективности системы здравоохранения.

Ключевые слова: LabTeacher, лабораторная диагностика, преаналитический этап, лабораторные ошибки, искусственный интеллект, цифровое здравоохранение, подготовка пациентов, индивидуальный подход, точность анализов, клиническое принятие решений, интерактивные системы, медицинские информационные технологии, диагностическая надежность, автоматизация, эффективность здравоохранения.

In modern medicine, laboratory diagnostics is considered an integral and decisive component of the clinical decision-making process. According to various sources, a significant proportion of clinical diagnoses rely on laboratory test results, which makes ensuring their accuracy and reliability a top priority. From this perspective, all stages of the laboratory process—especially the pre-analytical phase—hold particular scientific and practical importance. Errors occurring at this stage can significantly compromise overall diagnostic accuracy.

Problems in the pre-analytical phase are often associated with improper patient preparation for laboratory tests. These include factors such as inappropriate dietary habits, uncontrolled medication intake, excessive physical activity, and failure to comply with required timing protocols. In addition, the complexity of medical instructions and their insufficient clarity for patients further aggravate the issue. As a result, laboratory findings may become distorted or misinterpreted, increasing the risk of inappropriate clinical decisions and ineffective treatment strategies. In recent years, the rapid advancement of digital technologies and artificial intelligence has introduced new opportunities into the healthcare system. In particular, intelligent systems that enable interactive communication with patients offer the potential to improve the quality of medical services, reduce errors, and enhance personalized care. In this context, the development of digital solutions aimed at optimizing patient preparation for laboratory testing represents a highly relevant scientific and practical challenge. This article examines the concept of an intelligent assistant system called “LabTeacher,” analyzing its role in laboratory diagnostics, its significance in reducing pre-analytical errors, and its potential for integration into clinical practice from a scientific perspective.

In the modern healthcare system, laboratory diagnostics serves as one of the primary sources of clinical decision-making and plays a crucial role in establishing diagnoses, selecting treatment strategies, and evaluating disease dynamics. Nevertheless, the reliability of laboratory tests largely depends on the pre-analytical phase, where errors can significantly reduce overall diagnostic accuracy. Scientific evidence indicates that a substantial proportion of laboratory errors are directly associated with improper patient preparation for testing. At present, insufficient medical literacy among patients, the complexity and often generalized nature of instructions, and the lack of individualized approaches further intensify this issue. As a result, inaccurate or compromised laboratory results may lead to misdiagnosis, inappropriate prescription of medications, and increased economic burden on the healthcare system. Therefore, this problem should be considered not only a medical concern but also a socio-economic challenge. The rapid development of digital technologies



and artificial intelligence offers new opportunities to address these issues. In particular, intelligent systems can provide patients with personalized, adaptive, and real-time guidance, thereby reducing pre-analytical errors. In this context, the development of innovative solutions aimed at digitizing and automating the process of preparation for laboratory testing represents a highly relevant scientific and practical task. The implementation of intelligent assistant systems such as “LabTeacher” can enhance patient awareness, improve the accuracy of laboratory results, and increase overall diagnostic efficiency. Consequently, research in this area is not only of scientific importance but also holds significant practical value in addressing real-world challenges in modern medicine.

This study was designed to evaluate the impact of the “LabTeacher” intelligent digital assistant on patient preparation for laboratory testing, using a mixed-methods approach that combined both quantitative and qualitative research designs. Participants were recruited on a voluntary basis and divided into two groups: a control group (patients who followed traditional written instructions) and an intervention group (patients who used the “LabTeacher” system). The study materials included data from patients undergoing various laboratory tests, such as complete blood count, biochemical analyses, and hormonal assessments. The “LabTeacher” system provided users with personalized instructions, reminders, and alerts based on individual characteristics, including age, gender, type of test, and medication use. The system operated using real-time algorithms, enabling interactive communication with users. The primary evaluation criteria included the level of correct test preparation, the frequency of pre-analytical errors, the rate of repeated testing, and user satisfaction. Data were collected through questionnaires, analysis of laboratory results, and system log records. Statistical analysis was performed using modern biostatistical methods. Comparative analyses were applied to determine differences between groups, with statistical significance assessed at $p < 0.05$. Both descriptive and inferential approaches were used to analyze qualitative indicators. This methodological framework enabled a comprehensive assessment of the effectiveness of the “LabTeacher” system, its impact on the laboratory diagnostic process, and its potential for implementation in clinical practice.

The results of the study demonstrated that the “LabTeacher” intelligent assistant system significantly improves the quality of patient preparation for laboratory testing. In the intervention group (patients using the digital system), the level of correct test preparation was notably higher compared to the control group, with a marked improvement in patients’ adherence to given instructions. In particular, significant positive changes were observed in key factors such as compliance with dietary restrictions, temporary discontinuation of medications when required, and adherence to the appropriate timing of testing. A substantial reduction in pre-analytical errors was identified in the intervention group, which directly contributed to improved accuracy of laboratory results. While the control group showed a higher frequency of repeated testing due to improper preparation, such cases were significantly reduced among users of the “LabTeacher” system. This, in turn, enabled more efficient utilization of time and healthcare resources. Additionally, a high level of user satisfaction was observed. The majority of respondents evaluated the personalized instructions provided by the system as clear, convenient, and practically useful. Interactive reminders and real-time notifications were found to have a positive influence on patient behavior. Statistical analysis confirmed that the differences between the groups were significant ($p < 0.05$), thereby scientifically supporting the effectiveness of the “LabTeacher” system. Overall, the findings indicate that the use of intelligent digital assistant



systems plays a crucial role in improving the quality of laboratory diagnostics, reducing pre-analytical errors, and optimizing clinical decision-making processes.

The findings of the study indicate that the implementation of the “LabTeacher” intelligent digital assistant in the laboratory diagnostic process significantly reduces errors in the pre-analytical phase and improves the reliability of test results. Enhancing patients’ level of preparation for laboratory examinations increases diagnostic accuracy and reduces the risk of incorrect clinical decisions. The study also revealed that personalized and tailored instructions, real-time reminders, and interactive communication elements positively influence patient behavior. This contributes to minimizing human-related errors and enables the standardization of laboratory processes. As a result, more efficient use of time and healthcare resources is achieved. Furthermore, the “LabTeacher” concept represents a clear example of the practical integration of digital medicine and artificial intelligence technologies, strengthening a patient-centered approach. The widespread implementation of this system has the potential to improve the quality of laboratory services, enhance the efficiency of medical care, and optimize overall healthcare outcomes. In conclusion, the “LabTeacher” intelligent assistant system emerges as an innovative and promising solution in laboratory diagnostics, offering an effective approach to addressing one of the key challenges in modern medicine.

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