Exploration of Musculoskeletal Diseases

Open Exploration

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Empowering rheumatology through digital health technologies: contributions and barriers

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Academic Editor: Blanka Stiburkova, Charles University and General University Hospital, Czech Republic
Received: September 28, 2023 **Accepted:** December 5, 2023 **Published:** April 9, 2024

Cite this article: Benavent D, Carmona L, Llorente JFG, Montoro M, Ramirez S, Otón T, et al. Empowering rheumatology through digital health technologies: contributions and barriers. Explor Musculoskeletal Dis. 2024;2:92–105. https://doi.org/10.37349/emd.2024.00038

Abstract

Rheumatology, the medical specialty dealing with the diagnosis and treatment of rheumatic and musculoskeletal diseases (RMDs), is evolving with the emergence of digital health technologies, such as electronic health records (EHRs), virtual visits, mobile health (mHealth), wearable medical devices, social media, websites, digital therapeutics, artificial intelligence (AI) and machine learning. These technologies offer new opportunities to improve essential aspects of care, such as care access or disease management. They can significantly reduce the risk of errors and the workload of rheumatologists, while enhancing communication between physicians and patients, resulting in better quality of care. Moreover, digital health technologies can significantly improve research outcomes. However, digital health technologies in rheumatology also face specific barriers such as privacy, security concerns, incremental costs as well as limited digital health literacy and access. Therefore, further analysis, actions and strategies are needed to overcome these barriers. This article explores the impact of digital health technologies on rheumatology practice and highlights their contributions and challenges. By understanding the immense potential and overcoming the obstacles, the way for a future where digital health technologies are integrated into daily rheumatology care may be envisioned, in order to empower patients and healthcare providers.

Keywords

Rheumatology, digital health technologies, benefits, barriers

Introduction

The landscape of digital health technologies in patients with rheumatic and musculoskeletal diseases (RMDs) is extensive. Innovations such as electronic health records (EHRs), virtual consultations, mobile health (mHealth) applications (apps), wearable devices, and advancements in artificial intelligence (AI) and machine learning have emerged. These technologies offer significant opportunities to enhance patient care in rheumatology, improving access, outcomes, adherence, and research capabilities.

Despite these advancements, the impact of digital health on the routine delivery of rheumatologic care remains limited. Barriers such as regulatory and legal challenges, ensuring patient and clinician involvement in technology design, or addressing privacy concerns are pivotal.

In this article, a detailed examination of the current state across various sectors of digital health in medicine is provided, focusing on its developments in rheumatology, with a focus in rheumatology. Here, we present our point of view based on our personal experience and on the available evidence regarding the current contributions, barriers and possibilities of technology in rheumatology.

Overview of contributions of digital health technologies in medicine

Health information technologies (IT) have been defined as "the app of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision making" [1]. Notably, they may improve patient outcomes by reducing medication errors, adverse drug reactions, and enhancing compliance with practice guidelines. Research indicates that hospitals with more clinical IT apps tend to have lower rates of adverse events in key patient safety indicators [2]. Moreover, these technologies may contribute to enhanced patient satisfaction by enabling patients to take a more active role in their healthcare and understand their treatment benefits. The facilitation of data collection through health IT serves multiple purposes, including research, improvement in patient care and outcomes, and the enhancement of overall care quality [2].

The integration of technology in healthcare has been associated with improvement in management. Modern hospitals have adopted online appointment scheduling, digital health records, and telemedicine, all of which streamline patient care and increase efficiency, thereby reducing costs [2, 3]. In rheumatology, a randomized clinical trial involving 2,197 patients with rheumatoid arthritis (RA) found that using a smartphone app to assess patient-reported outcomes (PRO) led to a significant increase in the rate of controlled disease activity [3].

In addition to these advantages, the efficacy of healthcare delivery is significantly bolstered by technological advancements. Clinical decision support systems (CDSSs), enable physicians to rapidly verify the applicability of new research findings or recommendations to specific diseases and treatment plans. These systems include the latest updates from leading life science journals, providing a consolidated resource for medical professionals. As an example, the Rheuma Care Manager (RCM), provides a valuable tool in rheumatology, assisting physicians with treatment decisions and managing RA. The RCM includes an AI-powered flare risk prediction tool, and has demonstrated effectiveness in improving treatment decision confidence and reducing variability in physicians' assessments [4].

Transitioning from health IT, it is imperative to consider the broader spectrum of technological innovations in healthcare. These advancements encompass a range of areas, each contributing uniquely to the enhancement of healthcare delivery and patient care.

Telemedicine

Telemedicine has become increasingly used in rheumatology, allowing patients to virtually consult healthcare professionals. These consultations are particularly beneficial for patients living in remote areas or those with mobility limitations [5–7]. In addition, remote monitoring and wearable devices can also help track disease activity, medication adherence, and PRO, providing valuable data for decision-making [5].

Digital platforms facilitate the communication between the patients and their healthcare providers. Secure messaging and videoconferencing allow patients to contact their rheumatologists, strengthening the patient-healthcare provider relationship [8].

Another potential benefit of telemedicine is that it provides a pre-assessment before the face-to-face consultation with the rheumatologist. Short virtual consultations or other means of asynchronous communication between a dedicated healthcare professional and the patient may help prioritize referrals and order the necessary lab tests and examinations in advance. Several studies have found a high concordance level between the diagnosis during telemedicine consultations and that established in a subsequent face-to-face rheumatology consultation [6]. Therefore, telemedicine can speed up the diagnostic process and optimize the use of health resources. Besides, patient satisfaction regarding telemedicine has been reported to be high in some studies [7].

Remote monitoring and mobile apps

Remote monitoring with electronic patient-reported outcome measures (ePROMs) is another tool that can improve the management of patients with inflammatory arthritis. A recent systematic review reported that this monitoring was significantly associated with reduced disease activity in these patients [9]. Likewise, the REmote MOnitoring of Rheumatoid Arthritis (REMORA) study demonstrated that ePROMs tools help provide a better picture of RA by capturing fluctuating symptoms more accurately [10]. For example, patients can record their pain, joint inflammation or fatigue through a mobile app or a web page. ePROMs tools can also enable patient-centered consultations by providing a relevant and compelling dialogue, as well as a better recognition of health aspects, such as emotional well-being and coping, which are not regularly detected during clinical visits. Other studies have shown that ePROMs can facilitate shared decision-making, increase patient knowledge, and improve patient self-efficacy and satisfaction [11].

There are several mobile apps and online tools specifically designed for patients with RMDs. These apps can help patients track their symptoms, medication schedules, or physical activity [12]. Additionally, they may offer educational resources and support communities to improve patient engagement [12]. As an example, a pilot study successfully demonstrated that daily data collection using smartphones for health research is feasible and achievable with high levels of ongoing engagement over 2 months. This result reveals important opportunities for large-scale longitudinal epidemiological research [13].

Due to the widespread use of smartphones among patients and their willingness to use mHealth, this technology could effectively improve rheumatic care. The 2021 European Alliance of Associations for Rheumatology (EULAR) recommendations for implementing self-management strategies in inflammatory arthritis explicitly recommended mHealth in order to achieve this goal [14]. mHealth provides easy and low-burden patient access, as well as continuous on-demand support between routine rheumatology consultations. Tight health monitoring using sensors and ePROMs also allows for personalized and ongoing treatment adjustments and improves patients' self-efficacy [12]. Physicians can also use these data to better understand patients' clinical status better and make more data-driven decisions.

Big data, predictive analytics, and AI

Integrating big data and predictive analytics can enable researchers and healthcare professionals to analyze patient data (big data). This can improve patient stratification, early detection of disease flares, and treatment plans tailored to the patients' needs [15]. Various registries have accumulated large amounts of data from RMD patients and are increasingly used in clinical research [15]. The emergence of big data and big data analytics in rheumatology seems extremely promising, especially as it is a necessary step towards precision medicine.

AI can help rheumatologists make accurate diagnoses and take appropriate treatment decisions [16]. These apps, such as machine learning algorithms, can analyze medical images, laboratory results and patient records to provide information and support evidence-based decision-making [16]. The ability of AI to process multidimensional data and discover data associations and combinations can be beneficial in complex chronic diseases, such as RMDs, due to the high heterogeneity of patient characteristics,

treatments and outcomes. AI methods help improve our understanding of RMDs, patient and risk stratification, and outcome prediction. They can also guide new avenues of research to identify new drug targets and treatment options for RMDs [17].

It is crucial to note that applying big data and AI across various RMDs pose challenges. Not all RMDs are represented equally in existing datasets, with some having more extensive data than other infrequent conditions. This disparity limits the effective use of AI in certain RMDs, where smaller patient datasets prevail. Addressing this challenge emphasizes the need for larger, more comprehensive datasets that can reliably inform AI models and enable equitable advancements across all RMDs. Strategies to overcome these limitations, such as collaborative data sharing and the integration of multi-center studies, are essential [18].

Virtual reality and augmented reality

Virtual reality (VR) and augmented reality technologies are being explored as tools for patient education and care. VR has also been investigated as an alternative delivery tool for traditional non-pharmacological treatments such as cognitive behavioral therapy, biofeedback and mindfulness [19].

VR has great potential in the field of RMDs, given its unique ability to remotely deliver immersive and individualized treatments [19]. There is consistent evidence that VR significantly reduces subjective experiences of acute pain [19]. However, caution is needed when extrapolating these findings to chronic pain. As an example in this regard, a study by found a 60% reduction in subjective pain ratings in chronic pain patients during a VR experience featuring a nature landscape, with some participants reporting lasting analgesia [20]. A randomized controlled pilot study compared a VR program incorporating cognitive behavioral therapy, biofeedback, and mindfulness to an audio-only comparator in patients with chronic low back pain and fibromyalgia. The VR group experienced significant reductions in pain intensity and improvements in sleep, mood, and stress [21].

EHRs and interoperability

The digitalization of health systems led to further advances in medical documentation. With the transition from paper to electronic databases, EHRs have become standard practice for clinical record keeping, but they might also have a central role in the healthcare organization. Digital health systems streamline patient records, making them easily accessible to all healthcare providers and facilities. This promotes care coordination, reduces duplication of tests, and improves the continuity of care for RMD patients [22]. Moreover, EHRs can also be a tool for clinical decision-making [5].

Digital biomarkers

Digital health technologies or digital biomarkers have traditionally supported clinical research in rheumatology by reorganizing remote patient recruitment, data collection, and monitoring. However, these technologies also have the potential to enhance the efficiency of new drug development and approval processes. An example example is the use of medical imaging technology for the development and the deployment of biomarkers in clinical trials [23].

Clinical imaging studies assessing parameters such as receptor occupancy or a target engagement pathway in mechanism-proof studies provide invaluable insights. This knowledge helps mitigate the risks that can be encountered during new drug development. They ensure target coverage throughout the dosing interval or verify that a specific pathway has been modulated according to its mechanism of action [23].

Technology selection and rigorous validation, encompassing both analytical (sometimes referred to as technical) and clinical validation, are typically guided by the “fit-for-purpose” principle. A biomarker is only beneficial when valid within its specific usage context. In the case of imaging biomarkers, this means evaluating the biomarker’s technological performance at the clinical level. This evaluation can also be strengthened by preclinical or tissue studies. Features like the cross-sectional signal difference between patients and healthy subjects, a signal correlated with a disease stage, or a short test-retest, as the simplest

method to gauge longitudinal variability, are essential to instil confidence in the imaging biomarker's performance. Pragmatic considerations are of equal importance [23].

Barriers to the implementation of digital health technologies in rheumatology

The implementation of digital health technologies in rheumatology faces several barriers that must be addressed to release their full potential. Some of these barriers include the following:

Regulatory and legal challenges

Digital health technologies must frequently adhere to specific regulations and standards to ensure patient safety and data privacy. Navigating these intricate regulatory frameworks can be time-consuming and expensive, especially for smaller businesses or startups pioneering such technologies.

Numerous complex questions surrounds the regulation of medical AI, such as striking a balance between investment and transparency or between accuracy and explainability. These value conflicts will complicate the development of a reliable new regulatory framework for Ais, reminiscent of the challenges encountered with Europe's General Data Protection Regulation (GDPR). Nevertheless, establishing this framework is crucial to reach a consensus among member states on high-risk AI apps and to avoid a fragmented single market. Unfortunately, rapid advances in AI and competition from other nations might render this process either too slow or overly hasty, potentially leading to counterproductive regulatory gaps [24].

Data privacy and security concerns in digital health

The sensitive nature of health-related information inherently raises concerns about its privacy and security. Both patients and healthcare providers might hesitate to embrace digital health solutions if they are uncertain about the protection and privacy of their data.

With the rise of electronic health systems, portable devices, and apps collecting and storing patient data, ensuring adherence to data protection laws becomes paramount. This also applies to platforms facilitating patient-healthcare provider communications. As digital healthcare evolves, legislation such as the GDPR might need modifications or refinements to address specific concerns.

However, a challenge arises when local, regional, and national administrations lack a unified vision regarding digital health. Sometimes, they might even appear to take a hesitant or defensive stance toward innovation. While their intentions might be to preserve rights, this can lead to stricter regulations for new digital tools than their traditional counterparts, as it has been observed with certain new drugs.

For the European health data space, many members of the scientific community stress the importance of valuing the benefits of health data use above overly restrictive regulations. After all, rights are already protected by the existing laws within the health ecosystem, including those governing medical research. The European health data space also has the distinctive feature that patients own their data. This sometimes goes against the interests of researchers, which must be considered when developing approaches in this respect, and provide clear explanations to users.

Some of the issues that also need to be addressed by the European health data space are problems arising from the lack of care or legislation that is not yet adapted to IT systems. Thus, we have listed some problems that need to be addressed through framework legislation in order to provide security for users (professionals and patients): poorly encrypted communication channels between healthcare providers and patients can lead to the interception of sensitive information (such as medication lists or test results); sharing patient records with unauthorized individuals, potentially for financial gain or other malicious proposes; wearables devices may lack robust security measures, making them vulnerable to hacking, potentially exposing sensitive patient information or providing inaccurate data to healthcare providers [25].

Big data management for machine learning approaches

In addition to ethical and regulatory implications, methodological challenges must be overcome, including data pre-processing, data integration, model training, or system refinement concerning the actual clinical problem [26]. When managing big data, several challenges emerge, including computational dilemmas regarding the optimal storage of vast data quantities, and operational complexities related to the efficient processing of this data and identification of responsible personnel for these tasks.

Rheumatology data can be noisy, inconsistent, and error-prone due to the intricacies of RMDs and the complex and chronic follow-up of patients [27–29]. Incomplete or inaccurate data can negatively impact the performance of machine learning models. Furthermore, rheumatology data are often collected from various sources, including EHRs, laboratory tests, imaging, PROMs, and wearable devices. Integrating and harmonizing different data types can be a significant challenge [30].

Interoperability challenges in digital health

Many digital health tools come from various companies, and their compatibility with each other or with the existing EHR systems is often uncertain. This lack of interoperability can fragment data and prevent smooth communication between healthcare providers.

The success in integrating data into EHRs varies widely. Data must be usable to be of practical value. For instance, by integrating ePROMs data directly into the EHRs, clinicians would receive timely and accurate information during the clinical visit. This integration would also enable to track other clinical information in the EHR, such as laboratory tests and medications. In contrast, using stand-alone apps during clinical visits might require physicians to exit the EHR to access data. Alternatively, staff might manually enter information into the EHR, like calculated disease activity scores from these apps. This adds extra steps to the workflow.

Major EHR systems, such as Epic and Cerner, develop interfaces supporting and integrating external apps. However, rheumatology still lacks successful demonstration projects, and writable interfaces for the EHR (beyond just read-only access) remain hard to achieve. It is also important to note that despite the growing use of EHRs, health data and extensive data analysis do not occur in isolation. The extent of their use is influenced by organizational and professional involvement, which varies depending on each socio-technical context.

Although notes contain data from different sources regarding different topics, they are generally stored as indivisible units, primarily written by a single author, and are rarely edited after initial creation. In their current form, notes organize information according to time, clinical thread (subject matter or team ownership, e.g., primary team *vs.* consultant), and responsibility (the writer of a note simultaneously attests to the veracity of all assertions it contains and takes responsibility for them). Notes are a poor organizational framework for the individual clinician, but they may be even worse for a collaborative medical team. Although little of a patient's medical information changes depending on the team or physician reviewing it, different teams usually redocument the same information (e.g., the history of the present illness) in separate notes, representing another large source of duplicated information [31]. When information does differ between teams (e.g., different physical exam results or a more in-depth cardiological history), it can only be identified by navigating between separate notes. Such practices contribute to the scattering and overloading of information, waste time because efforts are duplicated, and limit optimal collaborative potential within the EHR [32]. Thus, this apparently modern system, such as the use of an EHR, is a simple legacy of the previous system (manual note-taking on paper) and does not translate into a truly modern and efficient EHR.

Cost and reimbursement

Implementing and maintaining digital health technologies can be challenging, especially in resource-limited environments. Moreover, not all reimbursement policies cover the use of these technologies, adding financial pressure to the organization of healthcare institutions. Integrating AI systems within the existing

EHR and healthcare IT systems can be expensive and complex. Ensuring that AI solutions are fully compatible with existing systems can result in additional costs.

While digital health technologies have enhanced healthcare outcomes, technological progress is a principal driver of healthcare costs [33]. Even when deemed cost-effective, such technologies might still increase healthcare expenses. This is because cost-effectiveness analyses attribute a monetary value to health and life based on individuals' willingness to pay. Accordingly, an intervention is deemed cost-effective when the anticipated health benefits warrant the added investment [34]. Also, healthcare providers may hesitate to invest in AI without understanding the financial benefits, including improved patient outcomes and cost savings. Demonstrating a positive return on investment can be challenging.

Readiness to change

Healthcare professionals and patients may be reluctant to adopt new digital health technologies due to a lack of knowledge or skills, concerns about disrupting established workflows, time consumption or privacy, or a lack of confidence in using digital tools [35]. They may perceive AI as a threat to their expertise or job security. Concerns about the reliability and accuracy of AI in diagnosing complex conditions like rheumatic diseases can hinder AI adoption. Clinicians may worry about AI's potential to make mistakes in critical decision-making. Finally, healthcare organizations may lack effective change management strategies to successfully introduce AI into their practices. This can lead to resistance and inefficiencies during the transition.

Engagement with health apps is a particularly relevant issue. The issue of disengagement over time was reported in eHealth studies, but also for mobile apps outside of the research setting [36]. In a recent work using a mobile solution, adherence levels decreased over the course of the study, with approximately 50% of patients interrupting their participation during the 6-month follow-up period [37].

Engagement with mHealth solutions requires substantial effort from researchers and participants [38]. In this regard, attrition might be a significant threat to the validity and generalizability of research findings, as it can lead to a biased sample. In previous studies using mobile apps to collect ePROMs, initial adherence to data reporting was high, but often declined over time. For example, a study found that adherence dropped from 88% to 62% over a 6-month period [39], while another reported that adherence rates fell from over 90% during the first week to less than 50% by the fourth week [40]. Interestingly, a more recent study reported that out of 220 consecutive patients with either RA or spondyloarthritis (SpA, including psoriatic arthritis and axial SpA) invited to telemonitor their disease activity, 64% dropped out, with a median drop-out time of 17 weeks [41]. Motivational techniques such as gamification could help users stay engaged and are generally underused in the existing eHealth systems [42, 43].

Limited digital health literacy and access

Digital health technologies require digital access (availability of appropriate devices and reliable internet connectivity) and a high level of digital health literacy. This refers to combining skills, confidence, and motivation to use the internet effectively. Digital literacy encompasses the ability to read, use computers, search for information, understand health-related data, and contextualize it.

Nevertheless, it is estimated that approximately one in five RMD patients lack access to an internet-connected device. Additionally, 15% admit they have never used the internet. Even among those with internet-connected devices, nearly one in five individuals report having inadequate digital literacy [44]. A similar observation has been noted among healthcare professionals [35]. Also, some AI tools in rheumatology require patients to provide data, such as pain levels or medication adherence, via digital devices. Patients with limited digital health literacy may struggle to enter these data accurately.

Evidence and validation

It is crucial to validate digital health technologies in rheumatology to guarantee their safety, effectiveness, and reliability in patient care. This validation involves thorough testing and evaluation, to ensure that the

technology adheres to specific standards and achieves its intended function. However, there remains a shortage of high-level clinical validation studies [5]. Validating AI tools in rheumatology requires access to real-world patient data. The availability of such data can be limited, which makes it challenging to demonstrate the effectiveness of AI solutions. Also, collecting and analyzing data to validate AI algorithms in rheumatology can be time-consuming and resource-intensive. This can delay the adoption of new technologies in clinical practice.

User experience

Poorly designed user interfaces and experiences can lead to frustration and decreased adoption rates. A lack of guidance and involvement of healthcare providers and intended users has been shown in the development process of several digital health technologies in rheumatology [45]. This has resulted in a gap between digital commercial and scientific aspects, with products often developed in response to technological innovations rather than evidence-based knowledge and user needs [45].

Thus, for example, the use of the app by patients may also present limitations. Doumen et al. [46] found that rheumatologists are worried that mHealth-based symptom monitoring could increase their workload, since an app for symptom reporting may increase the number of assessments. Therefore, mHealth apps should aim to streamline the responsibilities of healthcare professionals, by providing more data for example, and should not lead to additional tasks. Secondly, patients, nurses, and rheumatologists are concerned that frequent assessment of disease symptoms carries a risk of disease reinforcement. Patients were also worried that this would confront them more often with the chronic nature of their disease [46].

Similarly, in a recent study [40], patients interviewed after testing a new mHealth app indicated that it reminded them too much of their illness, leading to internal resistance. The stakeholders of the study were also concerned about the use of subjective patient data, such as pain and fatigue levels. This illustrated the need to carefully consider how and with what intensity should patients interact with the app.

Finally, rheumatologists are sensitive to the fact that the use of apps cannot be generalized to all patients and is only indicated in a subset of patients (which needs to be evaluated and described in detail in future studies).

Overcoming barriers to the uptake of digital health technologies in rheumatology

Several actions and strategies can be designed and implemented to efficiently increase the use of digital health technologies efficiently.

Concerns regarding data privacy and security concerns

Data privacy and protection stand as fundamental rights of every individual. In the healthcare sector, ensuring robust data protection is of paramount importance. By implementing stringent encryption measures, enforcing strict access controls, and ensuring compliance with relevant regulations, trust can be fostered between patients and healthcare professionals.

Privacy considerations must be integrated from the start when designing digital health technologies. Moreover, a "privacy by design" approach must be adopted, which emphasizes data protection as a fundamental principle of system development. Due to EHR, implementing a role-based access control system restricting the access to patient data based on the user's role and need to know should be crucial. It must be ensured that only authorized staff can access specific data.

Regular security audits and penetration testing should be carried out to identify vulnerabilities in the system. Identified issues must be promptly addressed to enhance security. Finally, transparency and patient education should be taken into account. Being transparent with patients about how their data will be used, and the security measures taken is essential. It is an obligation to educate patients about their rights and the steps taken to protect their data.

Big data management

In 2020, EULAR published guidelines regarding the use of big data in RMDs [47]. This publication offers a comprehensive framework for processing large amounts of data, highlighting key components such as data sources, storage (with an emphasis on ethical considerations), data analysis, interpretation, and implementation. Adopting EULAR's recommendations could enhance the use of such data.

A comprehensive data governance framework is needed to define data ownership, access control, as well as data lifecycle management and compliance. This framework should include policies and procedures to manage data effectively. Implementing data deduplication and cleansing processes removing duplicate or irrelevant data is necessary to improve data quality and reduce storage and processing overheads.

Investing money in AI could also help to build computing infrastructure to improve processes and analyze large datasets, as well as to accelerate research and clinical decision-making. This could help develop efficient data indexing and retrieval systems to access specific information within large datasets quickly.

Interoperability

Efficient data exchange between digital health systems is crucial for holistic patient care. By creating standardized data formats and embracing interoperable EHR systems, we can better integrate digital health technologies into rheumatology practices.

Although technical formats for specific clinical and administrative data have already been standardized by Health Level Seven (HL7) [48], there has been a significant development in the recent years. A new standard, known as Fast Healthcare Interoperability Resources (FHIRs), has been introduced by HL7. This new standard promises to streamline data exchanges between healthcare apps, offering developers more straightforward and adaptable solutions. Consequently, these standards will empower EHRs to communicate efficiently with a broader array of digital health technologies [5].

Participating in or establishing regional or national health information exchange networks facilitating the secure sharing of patient data among healthcare providers and institutions may be another possible solution. This would help to implement data mapping and translation tools to convert data from one format to another, allowing different systems to understand and process data from each other.

Digital health literacy and access

Efforts must be made to remedy disparities regarding the access to digital health technologies, especially within underserved communities. Overcoming systemic differences demands both structural reforms and actions at the community level. A promising strategy to alleviate these disparities is to increase minority participation in research and design at the healthcare system level. Through such inclusive practices, we can move closer to eliminating inequalities and improving outcomes for all.

mHealth apps show great potential in facilitating clinical research within minority patient groups. These apps allow investigators to precisely record patient outcomes by tracking longitudinal data remotely [49]. Notably, these populations frequently face financial barriers regarding access to healthcare and have difficulties attending appointments in person [50]. In the current healthcare paradigm, patients are often encouraged, if not expected, to play an active role in their health and disease management decisions. Therefore, it is imperative that our strategies and interventions, whether related to information delivery, decision-making, or support, are tailored to meet patients' health literacy requirements. It is crucial that these efforts especially reach those with limited health literacy [51]. Healthcare professionals must also adhere to the same principles. Grasping how to use and interpret digital health data is pivotal for effective disease management and treatment decisions. Hence, comprehensive training and education are essential to guarantee effective adoption and app by patients and healthcare professionals [44].

Collaboration and knowledge sharing

Promoting collaboration between digital health technology companies, healthcare institutions, patients, and healthcare professionals can accelerate the development and implementation of digital health technologies in rheumatology. Sharing knowledge and best practices will lead to better outcomes for patients.

As an example, the HIPPOCRATES initiative [18], focusing on psoriasis and psoriatic arthritis (PsA), aims to improve early identification and outcomes in PsA. Funded by the EU's Horizon 2020 program, it involves leading clinicians, researchers, and patients. Key areas include developing diagnostic tools, predictive models, and personalized treatment strategies, supported by AI-driven data analysis. HIPPOCRATES exemplifies the benefits of collaborative, multidisciplinary efforts in healthcare, demonstrating the potential of integrating diverse expertise to advance patient care in rheumatology [18].

In our opinion, establishing virtual platforms or online communities where rheumatologists, researchers, and healthcare professionals can collaborate, discuss cases, and share knowledge in real-time could be helpful. These platforms can include forums, chat rooms, or social networking for professionals.

User experience

Incorporating feedbacks and considerations from end-users throughout the development process can encourage the final product's adoption and success among patients and healthcare professionals. For optimal patient engagement, it is essential to investigate user experience thoroughly. Moreover, features empowering users, such as educational and interactive content, should be rigorously tested and implemented to support patient engagement [52].

Digital health technologies aiming for widespread adoption need user-friendly interfaces that appeal to everyone, including patients and healthcare professionals. Adopting user-centric design principles is crucial in crafting intuitive apps and devices that users find easy to navigate and understand. A truly user-centered design approach mandates the early involvement of all stakeholders in the design and development processes. This includes patients, healthcare professionals, caregivers, pain and eHealth researchers, designers, and IT developers.

Conclusions

In conclusion, digital health technologies offer transformative potential in the field of rheumatology, from optimizing patient care to improving research outcomes. However, challenges such as data privacy and digital literacy remain. Tackling these barriers is crucial to fully integrate these technologies into rheumatology practice, benefiting patients and healthcare providers.

The increasing adoption of digital health solutions in practice, often driven by entrepreneurs, highlights a gap with academic research. This rapid innovation, while promoting progress, also challenges the alignment with evidence-based medical practice. The interplay between entrepreneurial agility and the rigor of medical research underlines the need for more studies to bridge this gap. Balancing innovation with validated methodologies is crucial for a responsible digital health evolution, ensuring that improvements are based on scientific evidence.

Abbreviations

AI: artificial intelligence

Apps: applications

EHRs: electronic health records

ePROMs: electronic patient-reported outcome measures

EULAR: European Alliance of Associations for Rheumatology

IT: information technologies

mHealth: mobile health

RA: rheumatoid arthritis

RMDs: rheumatic and musculoskeletal diseases

VR: virtual reality

Declarations

Author contributions

DB, LC, JFGL, and AGC: Conceptualization, Investigation, Writing—review & editing. MM and SR: Conceptualization, Methodology, Investigation, Writing—review & editing. TO and EL: Conceptualization, Investigation, Writing—review & editing Writing—original draft, Supervision. All authors have read and approved the submitted version.

Conflict of interest

Diego Benavent, Loreto Carmona, Jose Francisco García Llorente, Teresa Otón, Estíbaliz Loza, Antonio Gómez-Centeno were paid consultants to Pfizer in connection with the preparation of this manuscript and for their participation in the steering committee. María Montoro and Susan Ramirez are employees of Pfizer.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Availability of data and materials

Not applicable.

Funding

This work was sponsored by Pfizer. The concept of this study and the decision to publish comes from Pfizer, and have no role in other aspects.

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