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REVIEW ARTICLE

Use of Health Technologies in Liver Transplantation: Integrative Review

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ABSTRACT

This study aims to analyze the available evidence in the literature on the use of mobile health technologies aimed at the self-management of candidates and recipients of liver transplantation. An integrative review method was used, which consisted of the following steps: development of the research question, literature search for primary studies, data extraction, evaluation of the studies included in the review, analysis and synthesis of the results, and presentation of the review. The LILACS, PubMed, CINAHL, and Embase databases were searched for primary studies that reported the use of mobile health technologies in candidates and recipients of liver transplantation, published in English, Portuguese, and Spanish, in the last five years. Six of the 248 records submitted for title and abstract reading answered the research question. The use of mobile applications was highlighted, followed by text messages and telephone support. The analyzed evidence indicates positive outcomes regarding mobile technologies for self-management in liver transplant candidates and recipients. Therefore, with the evidence pointed out, professionals can explore a wide range of technologies. Encouragement of their use and subsequent studies evaluating the impact of this approach on the lives of candidates and liver transplant recipients are essential to standardize the use of these resources in the pre-and postoperative phases faced by this population.

Descriptors: Liver Transplantation; Immunosuppressive Agents; Telemedicine; Wireless Technology; Mobile Applications.

Uso de Tecnologias Móveis de Saúde no Transplante de Fígado: Revisão Integrativa

RESUMO

O objetivo é analisar as evidências disponíveis na literatura sobre o uso de tecnologias móveis de saúde direcionadas para a autogestão de candidatos e receptores de transplante de fígado. O método de revisão integrativa foi utilizado e pautado nas seguintes etapas: elaboração da pergunta de pesquisa, busca na literatura dos estudos primários, extração de dados, avaliação dos estudos incluídos na revisão, análise e síntese dos resultados e apresentação da revisão. Para a busca dos estudos foram acessadas as bases de dados LILACS, PubMed, CINAHL e Embase. Foram incluídos estudos primários que retrataram o uso de tecnologias móveis de saúde em candidatos e receptores de transplante de fígado, publicados em inglês, português e espanhol, no período compreendido dos últimos cinco anos. Dos 248 registros submetidos à leitura de título e resumo, seis responderam à questão norteadora. Ressalta-se o uso de aplicativos, seguido pelo uso de mensagens de texto e suporte telefônico. As evidências analisadas indicam resultados positivos sobre o uso de tecnologias móveis direcionadas para a autogestão de candidatos e receptores de transplante de fígado. Portanto, com as evidências apontadas conclui-se que existe uma ampla gama de tecnologias disponíveis a serem exploradas pelos profissionais. É necessário apenas incentivar seu uso e, posteriormente, realizar estudos que analisem o impacto que essa abordagem pode trazer para a vida de candidatos e transplantados de fígado, com o intuito de normalizar a utilização desses recursos no pré e pós-operatório enfrentado por essa população.

Descritores: Transplante de Fígado; Imunossupressores; Telemedicina; Tecnologia sem Fio; Aplicativos Móveis.

INTRODUCTION

Liver transplantation is a therapeutic option that should be considered in cases of progressive and irreversible liver disease in which the available therapeutic alternatives cannot control the disease's progression or improve the patient's quality of life.[1] In Brazil, the Associação Brasileira de Transplantes reported that in 2022, approximately 2,118 patients underwent liver transplantation, while approximately 2,880 patients entered the waiting list, with a mortality rate of approximately 26.88% before the transplant.[2]

Despite advances in surgical techniques and immunosuppressive treatment over the years, liver transplantation remains a complex procedure that requires the active participation of the transplant recipient and rigorous, lifelong follow-up by a multidisciplinary transplant team.[3]In addition, many lifestyle and lifestyle changes are necessary to maintain health after transplantation, including taking prescribed medications, managing possible complications, and adopting healthy habits. In the face of treatment success, liver recipients are at risk for long-term health complications, including metabolic, cardiovascular, and renal changes, malignancies, infections, and rejection of the transplanted organ, many of which are related to immunosuppressive therapy.[4]

In this sense, the preventive approach is fundamental for the patient's and the graft's survival, and self-management is a relevant issue.[4] The prevention and management of potential health problems in the transplant recipient are supported by evidence in the literature and include adherence to drug treatment, symptom management, adoption of healthy behaviors, such as physical exercise, follow-up of treatment with the transplantation and stress management.[5]

Therefore, the liver recipient's quality of life depends on active cooperation, therapeutic regimen adherence, and necessary care compliance. Lack of adherence can adversely affect the function and survival of the newly transplanted organ.[6] According to data from the literature, the lack of adherence to the immunosuppressive regimen can affect 20 to 62% of patients undergoing liver transplantation.[7] Thus, although the transplant significantly improves the quality of life, this is a chronic and permanent condition, making health technologies essential, particularly mobile technologies, which can help post-transplant self-management.

Mobile and wireless technologies can revolutionize how healthcare is delivered, driven by the rapid advancement of mobile technologies and applications and the increased accessibility and coverage of cellular networks.[8] According to 2020 data, 94% of the Brazilian population owned a smartphone, while 97% had access to mobile internet connections.[9]

In this sense, mHealth (mobile health) stands out as a public health practice supported by mobile devices, such as cell phones, patient monitoring devices, personal digital assistants (PDAs) and other wireless devices. mHealth involves the use of mobile phone voice and short message services (SMS) as well as more complex functionalities and applications that include general packet radio service (GPRS), third and fourth-generation mobile telecommunications (3G and 4G), global positioning system (GPS) and Bluetooth technology.[8]

Thus, this approach is a promising alternative to minimize health problems and improve the health care provided. Among the areas of application of mHealth, adherence to treatment, health promotion and disease prevention, awareness of health problems, health monitoring, communication, data collection, telemarketing, disease surveillance, decision support, and emergency medical response.[10]

Given the above, an analysis of the evidence available in the literature on the use of mobile technologies for the self-management of liver transplant candidates and recipients is justified, given the absence of similar studies and the contribution to the planning of methods and systems that can be used in clinical nursing practice. It is important to emphasize that this professional is primarily involved in the care of these patients, making knowledge about this topic relevant and fundamental for planning interventions to prevent complications after liver transplantation. Thus, the objective of the present study is to analyze the evidence available in the literature on the use of mobile health technologies aimed at the self-management of liver transplant candidates and recipients.

METHOD

The integrative review (IR) method was used to perform the search, critical evaluation and synthesis of evidence available in the literature on the proposed topic. Such an approach allows the portrayal of the current state of knowledge and detects gaps for future studies. From the synthesis of primary studies, general conclusions are drawn to supporting decision-making and improving clinical practice.[11]

In this study, the following steps were followed: elaboration of the research question, search in the literature of primary studies, data extraction, evaluation of studies included in the review, analysis and synthesis of results and presentation.[11]

Elaboration of the research question

The PICO strategy guided the research question, based on the acronym patient, intervention, comparison and outcomes[12], as follows: "What evidence is available in the literature on the use of mobile health technologies aimed at self-managing liver transplant candidates and recipients?", as shown in Table 1.

Table 1. Elements of the PICO strategy.

Acronym	Definition	Description
P	Patient or problem	Liver transplant candidates and recipients
I	Intervention or topic of interest	Use of mobile health technologies
C	Comparison or control	Not applicable
O	Outcome or results	Self-management

Source: Elaborated by the authors.

Literature search

In the search stage of primary studies, the internet was used to access the databases: *Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS)*, National Library of Medicine and the National Institutes of Health (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Embase. Medical Subject Headings (MeSH) controlled descriptors from CINAHL Headings, the *Descritores em Ciências da Saúde (DeCS)*and the Emtree, were delimited according to each database, in addition to keywords identified in articles on the subject. The single strategy adapted for each database listed, using Boolean operators AND and OR, were used in the combination of crosses between the elements of the PICO strategy.

Once the descriptors were identified for building the search strategy, a literature search was implemented, the results of which were exported to the bibliographic reference manager (EndNote, version X7.8).[13]

After organizing the studies, the exclusion of duplications was performed, in which the final result was exported to the Rayyan web application for the selection of studies. Notably, this application allows the creation of labels and the description of each study's reasons for exclusion or inclusion during the reading of the title and abstract (first phase) and during the reading in full (second phase) of the selection process.[14] In both phases, a consensus meeting was held between the reviewers, with the participation of a third reviewer to resolve possible conflicts.

Primary studies that portrayed mobile health technologies aimed at liver transplant candidates and recipients were included, published in English, Portuguese and Spanish in the last five years (2017 to 2021). Part of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations were used to ensure rigor in conducting this review.[15]

Data extraction

Data from the selected primary studies were extracted in a standardized way, based on a script, which allowed the identification of the study, as well as the methodological characteristics and main results.

Evaluation of studies

The methodological approach (quantitative or qualitative) and the strength of the evidence were identified for the critical evaluation of the studies. Thus, the terminology indicated by the authors themselves was used to define the research design of the included studies. When this reference was unavailable, the concepts described by Polit and Beck (2018) were adopted.[16] Concerning the strength of evidence, the hierarchy of evidence classification by Melnyk and Fineout-Overholt (2019) was used in which for each type of clinical question (meaning, prognosis/prediction or etiology, and intervention/treatment or diagnosis / diagnostic test), a different classification as to the hierarchy of evidence was identified.[17]

Analysis and synthesis of results

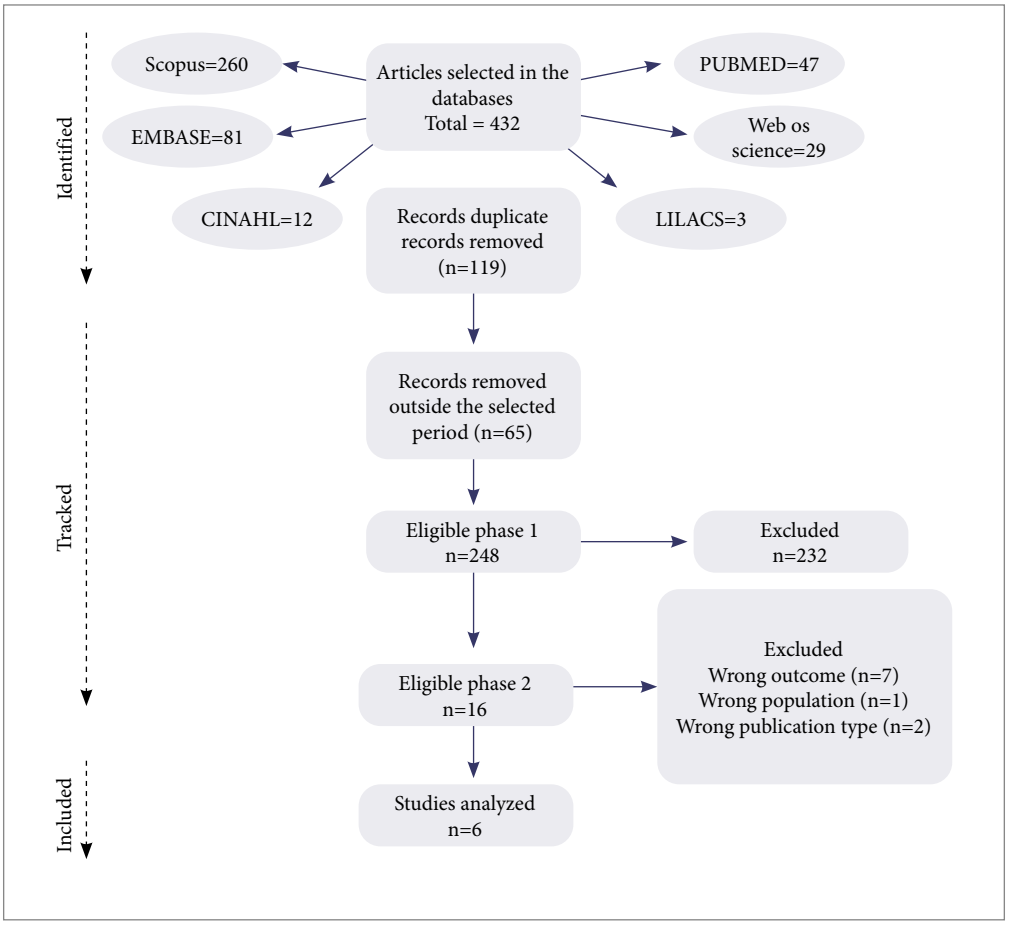
The analysis and synthesis of results were descriptive, covering the characteristics and results of each primary study included in the IR. A summary table containing identification data, objectives and main results found in each study was also elaborated.

Presentation of the integrative review

It is intended to present the synthesis of knowledge about mobile technologies used for liver transplant care and methodological limitations, knowledge gaps and directions for future investigations on the subject.

RESULTS

The research carried out in the selected databases revealed the existence of 432 records. After eliminating duplicates, 248 records remained, in which titles and abstracts were read. After a consensus meeting, it was possible to select 16 studies for a complete reading, culminating in a final sample of six studies. This selection aimed to answer the central question of this research, which asks about the evidence available in the literature regarding the use of mobile health technologies for the self-management of candidates and recipients of liver transplantation. Figure 1 visually presents the selection process of primary studies included in this integrative review.



Source: Elaborated by the authors.

Figure 1. Flowchart of the selection process of primary studies included in the integrative review.

Regarding the year of publication, two were published in 2018,[18,19], one in 2020,[20] and three in 2021,[21,22,23], demonstrating visible repercussions of the COVID-19 pandemic on the need for mobile technologies, with a significant increase in publications in 2020 and 2021. As for the country of origin, three are from the United States of America,[18,19,22] and the rest come from Russia,[20] from spain[23] and Belgium,[21]all of which were published in English. Table 2 presents the main characteristics of the analyzed studies.

Table 2. Characterization of studies included in the integrative review.

Authorship	Year	Language	Country	Approach
Sayegh et al.,[19]	2018	English	United States of America	Medical
DeMartini et al.,[18]	2018	English	United States of America	Medical
Malinovskaya et al.,[20]	2020	English	Russia	Multidisciplinary
Melilli et al.,[23]	2021	English	Spain	Multidisciplinary
Koc et al.,[21]	2021	English	Belgium	Medical
Lieber et al.,[22]	2021	English	United States of America	Medical

Source: Elaborated by the authors.

Concerning the design of the included studies, three clinical trials were observed, two of which were pilots[18, 19]and one non-randomized[23], a descriptive study[20], a qualitative study[22] and a prospective cohort study[21]. Table 3 summarizes the evidence identified in this study.

Table 3. Summary of studies included in the integrative review.

Study design, objective and level of evidence (LE)	Characteristics of the participants	Inclusion criteria	Intervention	Main results
-Clinical trial pilot study -Assess improvement in adherence after the mobile phone support intervention. [19] LE = III (clinical issue of intervention/ treatment)	N=8 non-adherent adolescent and young adult recipients. Mean age of 16.76 years, post-transplantation from 101 to 5548 days.	Patients with a level of medication adherence lower than 80% and blood levels of the immunosuppressant lower than the stipulated parameter also participated in the study.	The team provided Telephone support daily, in which they were asked about the time the immunosuppressant, Tacrolimus, was taken. In case of non-adherence, the reason was asked to justify it. In addition, daily reminders were sent about the doses, which could be adjusted according to the level of the drug in the bloodstream, with notifications being sent to the team about the altered levels.	On average, 12.63 (SD = 14.41) blood levels of immunosuppressants were taken in the 24 weeks prior to intervention enrollment, and 6.88 (SD = 4.45) were taken in the 24 weeks after registration, excluding the levels taken during a period of hospitalization. Pre-post analysis indicated an improvement in adherence, social support and depression rates.
-Clinical trial pilot study. -Develop SMS-based mobile intervention to reduce the incidence of alcohol relapse and decrease stress in liver transplant candidates. (18) LE = III (clinical issue of intervention/ treatment)	N=15 transplant candidates. Mean age of 50.8 years.	Have alcoholic liver disease and at least 1 episode of alcohol consumption in the previous year. Being on the waiting list and providing urine samples to assess alcohol levels.	For 8 weeks, participants in the intervention group, in addition to weekly consultations with psychologists, received daily text messages, 3 text messages per day in the first four weeks of the study and 3 messages per week in the last four weeks, containing encouragement for sobriety, and they demanded a response. The responses were analyzed according to five domains, namely, (1) identification of desires; (2) humor; (3) identification of high-risk situations; (4) coping strategies, and the fifth domain, "general" data were compared to the control group (usual care).	According to the self-report satisfaction survey, the improvement in stress levels and the ease in maintaining abstinence (M = 3.67, SD = 1.51), dealing with cravings (M = 3.67, SD = 1.51) and stress (M = 3.67, SD = 1.37). Only 1 participant tested positive on the breathalyzer, demonstrating that the intervention helped maintain sobriety in most participants.
- Descriptive study. -Describe the use of a remote monitoring system to monitor transplant recipients during the pandemic. (20) LE = IV (clinical question of intervention/treatment)	N=63 transplant recipients.	It included all participants who voluntarily registered in the application.	The TRANSPLANT.NET application made it possible to remotely control the clinical conditions of the patients, making it possible for the medical assessment to be made through indicators reported daily (dose of medication taken, signs and symptoms, subjective symptoms such as itching, weakness, etc.). The application has a personal library with themes customized according to the needs of patients.	During 10 months of analysis of the TRANSPLANT.NET application, 63 participants were evaluated. There was a decrease in the number of errors in the medication regimen, and patients reported greater ease in finding reliable information about their condition, in addition to contacting the medical team online, improving communication between the group and patients.
- Non-randomized clinical trial. -Evaluate the degree of involvement and use of the Track Your Med® application; TYM, as a method of controlling and promoting adherence to immunosuppressive treatment[23] LE = III (clinical issue of intervention/ treatment)	N=90 receivers. Participants with 6 months of stable graft function after transplantation were included.	Outpatients from two transplant centers in Barcelona. The only requirement was to own a smartphone.	The patient received several QR-CODE labels pasted on the medication boxes and should be scanned daily using the TrackYourMed application, which automatically generated reminders for the doses for the next few days. By scanning the code and registering the day's adherence, it was possible to include additional information such as taking the dose late, medication not taken or medication in a different dose.	61 (68%) used the app regularly. During the 6-month follow-up, correct doses (CIN), mistimed entries (OUT), and missed doses (MIS) varied between 69%-76%, 12%-19%, and 9%-12%, respectively.

Continue...

Table 3. Continuation.

Study design, objective and level of evidence (LE)	Characteristics of the participants	Inclusion criteria	Intervention	Main results
-Prospective cohort study. -Evaluate the safety, feasibility and beneficial clinical effects of a remote monitoring program (TRMP). [21] LE = IV (clinical issue of intervention/ treatment)	N=115 participants Use of an online platform (via a website or mobile application) for communication with participants (Mynexuzhealth) and Wintermute (clinical decision support system). Mean age of 59.1 years.	Participants aged ≥ 18 years Recipients transplanted more than 12 months ago and under outpatient follow-up during the study data collection period.	The Mynexuzhealth application allowed communication with patients (access to consultation dates and test results). The Wintermute system allowed monitoring, according to the values entered by the patient, such as daily adherence to the Tracrolimus medication, signs and symptoms. The information was transmitted to the medical team to maintain a pre-established ideal parameter. Every four months, new blood tests were requested for possible readjustments in the dosage, which were also communicated to the patient through the application. Patients were interviewed about challenges and coping strategies experienced after liver transplantation. The interviews were conducted using a semi-structured script and were digitally recorded and transcribed. Dedoose software was used for analysis. A descriptive analysis was also performed in addition to the qualitative one.	The remote program decreased the need for outpatient consultations (P< 0.001), decreasing the risk of the transplanted patient being exposed to COVID-19. When analyzing blood concentrations of Tracrolimus, it was possible to maintain lower serum levels by having fewer missed doses with fewer corrections (P = 0.038 and P = 0.002) with no effect on the rejection rate in the pre-and post-intervention analysis. The program allowed rigorous monitoring of serum levels of Tacrolimus.
- Qualitative study. -Assess liver receptor challenges and survival strategies used to overcome challenges. [22] LE = VI (clinical issue of intervention/ treatment)	N=20 liver transplant recipients.	- Age ≥ 18 years old At least 3 to 6 months post-transplant period	The Mynexuzhealth application allowed communication with patients (access to consultation dates and test results). The Wintermute system allowed monitoring, according to the values entered by the patient, such as daily adherence to the Tracrolimus medication, signs and symptoms. The information was transmitted to the medical team to maintain a pre-established ideal parameter. Every four months, new blood tests were requested for possible readjustments in the dosage, which were also communicated to the patient through the application. Patients were interviewed about challenges and coping strategies experienced after liver transplantation. The interviews were conducted using a semi-structured script and were digitally recorded and transcribed. Dedoose software was used for analysis. A descriptive analysis was also performed in addition to the qualitative one.	90% of the participants had a smartphone, with alarm reminders to take medication (65%) being the most used function. 65% used the Epic MyChart system to communicate with the team. 80% were interested in apps to help with their recovery. The study supported the development of the LiveRight Transplant application to improve patient education, facilitate adherence and improve coordination of post-transplant care.

Source: Elaborated by the authors.

Concerning the leading mobile technologies identified in this study, applications are highlighted, used in four studies,[20-23] followed by text messages[18,19] and phone support.[19] All analyzed studies indicated positive results regarding the use of mobile technology aimed at the self-management of liver transplant candidates and recipients.

DISCUSSION

This integrative review aimed to examine the available evidence on mobile technologies' role in managing health care for transplant recipients. In a context in which technological advances are increasingly present in people's daily lives, especially in times of pandemic and post-pandemic, it is natural for new tools to emerge, such as applications that aim to promote adherence to the self-care necessary after transplantation, covering pharmacological, psychological, nutritional and physical aspects.

In this sense, adherence to immunosuppressive treatment is highlighted, a fundamental condition for the patient's survival. As defined by the World Health Organization (WHO), adherence refers to the patient's agreement with the recommendations of physicians or other health professionals regarding medication intake, diet adherence and lifestyle changes.[24] This agreement can be considered an agreement between the health team and the transplant recipient, aiming to maintain the postoperative pharmacological regimen throughout life to prevent complications. Thanks to technological advances, strategies to monitor adherence were becoming more and more present and were addressed in this study.

However, when analyzing the results presented, it is observed that most of the investigated studies are limited to measuring only the frequency of users' access to the applications, not covering the evaluation of the impact of these interventions on self-care. Of the six studies analyzed, four[20-23] had the main objective of evaluating whether the intervention used, in this case, an application, was used daily by at least 50% of the participants. Although these platforms use the information entered by the patient himself about his health status, there is little data on how this information was used to develop robust evidence on the level of self-care, which makes it difficult to assess the impact of interventions based on mobile technologies in the life of the transplanted patient..[25]

Differing from other studies, an American publication from 2018[19] aimed to evaluate the impact of daily telephone calls (cell phones) on the medication adherence of the participants. The inclusion criterion for this study was the participation of individuals with adherence below 80% of the recommended level. Participants received a daily telephone call in which they were asked about using immunosuppressants that day, including the time of ingestion. In addition, daily reminders were sent close to the medication prescription times. When looking at the effects after 24 weeks, there was a significant decrease in blood levels compared to the 24 weeks before the intervention. Baseline levels indicated an average of 12.63 (SD = 14.41), while final levels evolved to 6.88 (SD = 4.45), reducing the need for hospitalizations due to the effectiveness of immunosuppressant adherence.

It is important to emphasize that, among the six studies analyzed, only one focused on using mobile technologies in the pre-transplant period.[18] This pilot study, carried out in the United States of America (USA), used motivational messages to maintain sobriety about alcoholic beverages as a requirement for patients to remain on the waiting list for organ transplantation. In this intervention, participants in the online group responded to daily reminders about their desire to consume alcoholic beverages and received a specific score based on their responses. At the end of the study, the results were compared with those of a control group that underwent the same intervention in person. Results demonstrated efficacy in maintaining sobriety (M = 3.67, SD = 1.51), coping with cravings (M = 3.67, SD = 1.51) and managing stress (M = 3.67 , SD = 1.37).

Considering the evidence presented, it is clear that the main findings identified highlight the need for further studies on the use of mobile technologies as a tool to help maintain self-care. It is worth investing in new interventions that use mobile devices, such as cell phones, patient monitoring devices, apps, and text messages (SMS), among others, to ensure a transition of care with quality and safety.[26]

Regarding methodological limitations, it is crucial to recognize the restrictions related to the number of studies analyzed since there is a certain scarcity in the literature on the use of mobile health technologies aimed at the self-management of liver transplant candidates and recipients. Despite the search in six databases, the restriction to a single type of transplant and the inclusion of studies published from 2017 onwards may need more understanding of the theme proposed in this study.

In addition, it is essential to emphasize the importance of using mobile health technologies for the self-management of liver transplant candidates and recipients in a multidisciplinary way. Integrating different health professionals, such as doctors, nurses, psychologists and nutritionists, can enhance the benefits of these technologies, allowing for a more comprehensive and personalized follow-up. Future investigations are needed to deepen knowledge in this area, exploring aspects such as the effectiveness of specific interventions, the cultural and linguistic adaptation of technological tools, data security and privacy, and the inclusion of other transplants. These studies can provide subsidies for developing more effective and targeted approaches, contributing to improving the quality of life and prognosis of patients undergoing liver transplantation.

CONCLUSION

Some mobile technologies were identified to provide effective support for liver transplant candidates and recipients' self-management, such as using applications, text messages, and telephone support. The evidence analyzed so far points to positive results concerning using these mobile technologies aimed at self-management. However, it is essential to emphasize the need for further in-depth studies in the future to understand how the currently available mobile technologies can impact the survival and quality of life of liver transplant recipients. Knowing how these technologies can influence lifestyle changes is crucial, especially adherence to immunosuppressive therapy, which plays a key role in preventing complications and achieving successful treatment. With more comprehensive research in this area, we will gain valuable insights that will contribute to significant improvements in the care and health outcomes of liver transplant patients.

CONFLICT OF INTEREST

The authors declare that there are not conflict of interest.

AUTHOR'S CONTRIBUTION

Substantive scientific and intellectual contributions to the study: Barreto YE, Galvão CM, Mendes KS; **Conception and design:** Barreto YE, Mendes KS; **Data analysis and interpretation:** Barreto YE, Mendes KS; **Article writing:** Barreto YE; **Critical revision:** Barreto YE, Mendes KS; **Final approval:** Barreto YE, Mendes KS.

DATA AVAILABILITY STATEMENT

All datasets were generated/analyzed in the current study.

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