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Mobile Applications in Patients with Chronic Kidney Disease: A Systematic Review

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Abstract. Justification: Worldwide, 850 million people suffer from chronic kidney disease (CKD), and in Mexico it is the tenth cause of mortality with 13,167 deaths per year. CKD patients undergoing hemodialysis present challenges in following the prescribed treatment and managing care; Therefore, different health strategies have been proposed to address those challenges, including mobile health applications. Objective: Analyze the scientific evidence available worldwide on mobile health applications for patients with CKD on hemodialysis that have been validated, evaluated, implemented or in the process of development. Methods: Systematic review of the literature following the PRISMA statement and search question with the PICOT-D format. Databases with keywords in 12 languages were consulted. Results: Of 474 manuscripts, seven met the inclusion criteria. Mobile health applications were designed using different methodologies. Mobile health applications were found mainly aimed at self-monitoring and/or self-management, including health literacy, of patients with CKD.

Keywords. mobile health applications, chronic kidney disease, hemodialysis, self-care.

1. Introduction

More than 850 million people suffer from Chronic Kidney Disease (CKD) in the world, causing around 2.4 million deaths per year [1]. A total of 85% of these cases are found in low- and middle-income countries [2] where Mexico leads the highest mortality rate in the world [3]. According to the National Institute of Statistics and Geography (INEGI), [4] CKD affects around 12.2% of the Mexican population, ranking tenth in mortality with 13,167 deaths by year.

CKD is classified as a rapidly evolving and progressive disease, and treatment primarily requires the replacement of kidney function, which is mainly performed with hemodialysis [5]. Likewise, patients with CKD present challenges in following the

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prescribed treatment and low Treatment adherence is associated with disease progression. and development of complications. That said, strategies have been proposed to address these challenges through the development of technological tools, such as mobile health interventions, which have shown positive results [1,2] to promote self-management, self-monitoring, and self-care in this population [6].

According to the World Health Organization (WHO), mobile health (mHealth) is the practice of medicine and public health supported by mobile devices, such as phones and other wireless devices, all of which include mobile health applications [7].

Despite the importance of mobile applications in health, it is necessary to investigate applications specifically developed for CKD patients (and used by patients) on hemodialysis that have been designed and validated by multidisciplinary teams to determine which are reliable for use in the practice [8].

Considering the diverse literature on mobile health applications for CKD patients around the world and in different languages, and the current increasing adoption of technology for healthcare applications, it is essential to determine how these applications were designed, from conceptualization to evaluation [9]. Therefore, this study aimed to conduct a systematic review to analyze the scientific evidence available worldwide on mobile health applications for patients with CKD on hemodialysis that have been validated, evaluated, implemented or are in the process of being developed. development for use.

2. Methods

A systematic review of the literature was carried out following the Preferred Reporting Items for System reviews and Meta-Analyses (PRISMA) guidelines statement [10]. The search strategy was performed using the Population, Intervention, Comparison, Outcomes, Time and Data (PICOT-D) format [11]. The research question was "What are the mobile health applications for patients with CKD on hemodialysis that have been designed and validated or evaluated in the last five years worldwide?" (Table 1).

Table 1. PICOT-D question.

P **Population**	**I** **Intervention**	**C** **Comparison**	**O** **Outcomes**	**T** **Time**	**D** **Data**
Patients with CKD	Mobile health applications for patients with CKD on hemodialysis	Make a comparison between mobile health applications, methodological and scientific consistency in the world.	Reliable mobile health applications for CKD patients on hemodialysis	2017-2022	Electronic databases

Note: search strategy with the PICOT-D question

The eligibility criteria for the selected articles are described in continuation:

Inclusion criteria: Articles published between 2017 and 2022, where mobile applications have been designed, evaluated, implemented, or are under development for use in patients with chronic kidney disease undergoing hemodialysis.

Exclusion criteria: Articles from mobile applications that did not go through an evaluation or validation process, or that had missing information on their design and validation process, articles on mobile applications intended for use by health professionals (i.e., not by patients) and duplicate articles.

Database searches in the following languages were included: Spanish, Portuguese, English, French, Italian, German, Simplified Chinese, Japanese, Korean, Arabic, Thai, and Dutch. The search keywords in Spanish were: “mobile applications”, “chronic kidney disease”, “hemodialysis” or “Hospital Hemodialysis Units”, “telenursing”, “self-care”. The same keywords were used for all languages by using the translator DeepL®. The boolean operators "and" and "or" were used.

Searched databases were Pubmed, Cochrane Library, Science Direct, SciELO, EBSCO and REDALyC. Additionally, the Google Academic search engine was used to capture any additional publication not indexed in the databases, using the same keywords. The procedures for the selection of the included articles were as follows: 1) search of the Descriptors in Health Sciences (DeCS) [12]. and Medical Subject Headings (MeSH) [13]. keywords in Spanish, English, Portuguese, and French; 2) boolean operators for searching in databases; 3) title screening; 4) screening and review of the abstract; and 5) analysis of the full text.

The process of searching the articles in the different databases was made independently by two authors. Following the search criteria, the same authors screened the titles and abstracts of the articles and selected the ones for full-text screening.

The articles were analyzed, and data were captured according to the following guidelines: for the study designs, articles were analyzed using the IMRYD format (introduction, methods, results and discussion) format [14]. where each of these components was screened.

To extract and synthesize the included studies, a table was created to capture the key components of the included studies. This process was performed by one investigator and revised by all co-investigators and compared for agreement on the key components. The key elements extracted were: publication information, aim, method, key results, strengths and limitations, and the risk for bias. The risk for bias assessment was based on the Cochrane collaboration tool to evaluate the “bias risk”, where a detailed description of what happened in the study was made to consider the possible effects of biases and the cautiousness at the time to interpret the results [15].

3. Results

The initial search strategy resulted in a total of 474 articles. Figure 1 provides a complete description of the search strategy. A total of 16 full-text articles were included for analysis, where nine articles were excluded for not describing the validation or evaluation process in their methodology, giving a total of seven articles included for the present review.

From the included articles, seven articles reported on mobile health applications for CKD patients on hemodialysis and dialysis for self-control and self-management. These articles aimed primarily in fostering health literacy, patient education, self-care, and health management for patients. Among the applications, mobile health topics covered patient’s activities and actions impacting CKD, such as food and fluids intake, medication management (e.g., reminders), medical appointments, laboratory results monitoring, physical activity, allergies, educational material, and physical well-being. Out of the reported applications, seven were designed in Brazil, Australia, Chicago, Dubai and Malaysia, and one study was a systematic review.

Risk of bias assessment for individual studies was jointly and comprehensively performed by the authors, which was analyzed using the Cochrane Collaboration Tool. Based on the analysis of individual articles, all articles were judged to be at risk of bias.

Thus, according to the risk of bias assessment domains, in the blinding of investigators and participants domain, 57.2% of the articles had reported unclear risk of bias and 42.8% had low risk of bias. For the domains of blinding of outcome assessment or measurement and selective description of outcomes, 100% of the studies were at low risk of bias.

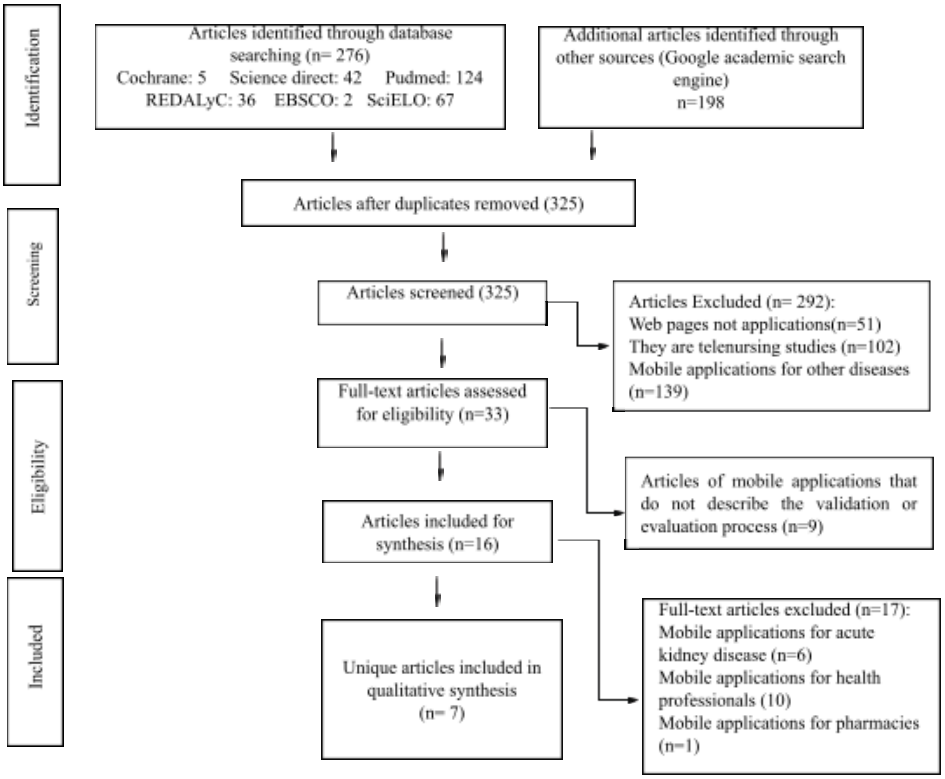

Figure 1. *Flowchart diagram of the search strategy for the included publications about mobile health applications used by patients with chronic kidney disease on* hemodialysis.

Note: *published evidence of the year 2017 to 2022.*

4. Discussion

This systematic review aimed to analyze the scientific evidence available on valid and reliable mobile health applications for (and used by) patients with CKD on hemodialysis. The included articles encompassed six manuscripts reporting on specific

mobile health applications and one systematic review [16, 17, 18, 19, 20, 21]. The majority of included studies adopted a user-centered design approach with multidisciplinary professionals involved in the design and/or evaluation and use of the mobile applications aimed at promoting self-monitoring, self-care and self-management of health. the patients.

5. Conclusions

Reliable mobile applications have been designed and evaluated for patients with CKD undergoing hemodialysis in the period between 2017 and 2022 worldwide. Mobile health applications reported in the included studies were mainly aimed at the self-control and self-management of patients; thus, showing the impact of the use of these technological tools on the study population.

These findings can be used to promote the future design and validation of mobile health applications aiming at the self-care of patients with CKD undergoing hemodialysis by the multiprofessionals, specifically by nurses in Mexico, since there is no scientific evidence of the development and use of mobile health applications for patients with CKD in that country.

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