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NARRATIVE REVIEW

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Digital games for rehabilitation of speech disorders: A scoping review

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Abstract

Background and Aims: Digital games are among the treatment methods for speech disorders that serve purposes other than mere entertainment. These games have been used for different speech disorders at any age. This study aims to review articles that have used digital games for rehabilitating speech disorders.

Methods: This study was a scoping review. PubMed, Scopus, and Web of Science were searched on February 28, 2022, to access the articles on digital games used in rehabilitation of speech disorders without any date restrictions. The search strategy was as follows: ("video game [MeSH term]" OR "computer game" OR "mobile game" OR "serious game" OR gamification [MeSH term]) AND ("speech pathology" OR "speech therapy [MeSH term]" OR "speech disorder [MeSH term]" OR stuttering [MeSH term]). Original interventional and observational studies in English were included. The data were extracted from the relevant articles, including the first author's name, year of publication, country, target group, participants, mobile device/computer-based, type of game design, language level, number of sessions, and outcome. Descriptive statistics were used to analyze the data.

Results: Of 693 retrieved articles, 10 articles were included in this study. Digital games were used for different speech disorders such as apraxia (20%), dysarthria (10%), articulatory hypokinesia in Parkinson's disease (10%), dysphonic disorder (10%), hearing disability (10%), phonological impairment (10%), and speech disorder in autism (10%). Most of the articles (60%) used a mobile device-based game. Phonemes (30%), words (30%), and sentences (20%) were the most frequently used language levels in designing digital games. All the reviewed articles reported the positive effect of digital games on speech and the patients' motivation in therapy.

Conclusion: Digital games can improve patients' speech and motivation in therapy. Although studies showed the positive impact of digital games on speech disorders, personalized speech therapy should be considered in designing these games.

KEYWORDS

digital game, rehabilitation, speech disorder

1 | INTRODUCTION

Speech is a dynamic, complex, and unique motor and neurological activity allowing a person to exchange thoughts and feelings, and helping the process of learning and growth. Communication through speech plays a major role in a person's social and psychological well-being.[1] This powerful tool significantly impacts the quality of life and personality expression.[2]

Any disorder in speech can disrupt people's role in society, discourage them from constructive interactions in social activities and, in some cases, even lead to their social isolation.[1] People with speech disorders often know exactly what they want to say or what is appropriate in any situation, but have difficulty communicating effectively in producing sounds.[3] The most common types of speech disorders include childhood apraxia of speech, dysarthria, orofacial myofunctional disorders, speech sound disorders, and stuttering.[4] These disorders occur at all ages for a variety of possible reasons, including autism spectrum disorder, dyslexia, cerebral palsy, hearing loss, and Parkinson's disease.[5,6] Studies have shown that speech disorders are prevalent in 89% of people with Parkinson's disease, and many of these patients do not have adequate access to speech rehabilitation services.[7,8] An effective speech rehabilitation process could ultimately promote a person's quality of life.[9]

Rehabilitation of speech disorders is often done to improve the motor output of speech and, ultimately, enhance the ability to communicate effectively in the everyday life. A speech therapist tries to evaluate, diagnose, and treat patients' communication problems and speech disorders based on the cause of their problems.[10] They use a variety of rehabilitation techniques that significantly differ for each patient, depending on the type of speech disorder, including articulation therapy, language intervention therapy, oral motor therapy, and Lee Silverman voice treatment.[11–14] Each of these techniques is used for specific disorders and differs in terms of effectiveness. Despite the high effectiveness of speech rehabilitation in many cases,[9,15,16] conventional rehabilitation methods are not always adequately effective[17] and, thus, newer methods need to be applied.

With the increasing advance in computer systems, electronic speech rehabilitation techniques such as natural language processing and speech processing technologies have become popular,[18] thanks to their accessibility, controllability, and portability.[19,20] Digital games are among the treatment methods for speech disorders. These games are used for purposes other than just entertainment.[21] Today, digital games are utilized in numerous applications, for example, military, government, education, corporate, and healthcare domains. If combined with the healthcare process, digital games can be a powerful tool for effective patient participation due to their cost-effectiveness, wide access, fun, and attractiveness for all ages.[22] Digital games have a strong potential to meaningfully engage with patients and enhance the enjoyment of education.[23] These games can also encourage patients to participate in high-frequency and self-based training. Digital speech rehabilitation games can positively lead to higher-intensity practice in patients and effectively help rehabilitate speech disorders.[24]

Many review studies have been performed on the use of digital game in healthcare. Chan et al. evaluated the impact of the video games on the lifestyle of youth.[25]

Jiménez-Muñoz et al. reviewed video games for the management of autism spectrum disorder.[26] The other review study conducted by Abd-alrazaq et al. considered the impact of digital games on improving executive functions of the elderly with cognitive impairments.[27] To the best of our knowledge, there is no review study investigating the use of digital games for different speech disorders at any age. The only systematic review study in this field has been conducted by Saeedi et al. This study has reviewed the digital games developed to treat speech disorders and their challenges in children.[28] Conducting a comprehensive review study in this field will provide more knowledge for researchers about the capabilities of digital games in helping patients with speech disorders, and also help to the better move toward designing and using a game for the treatment of speech disorders. Therefore, this study aims to review studies on digital games for rehabilitating speech disorders. We wanted to answer the following questions in this study:

- In what year was the article published?
- In which country the study was done?
- What group of patients was the digital game designed for?
- How many patients participated in the study?
- On what devices was the digital game installed?
- What was the type of digital game design?
- Which language levels (phoneme, syllable, word, phrase, and sentence) were considered for developing the digital game?
- How many sessions did participants use the digital game?
- What was the outcome of the study?

This study was formulated based on the population, concept, and context (PCC) components.

This scoping review study evaluated original articles that used digital games:

- For the patients with speech disorders (population),
- To improve patients' speech in different settings (context),
- and provided the outcomes of using these games (concept).

2 | METHODS

The Joanna Briggs Institute's guideline was adopted for conducting this scoping review study.[29] This guideline has nine levels, including defining and aligning the aim and question; developing and aligning the inclusion criteria with the aim and question; reporting the planned approach to study search, selection, data extraction, and presentation of the result; searching for the study; selecting the study; extracting the data; analyzing the data; presenting the results; summarizing the results in relation to the aim of the review, making conclusions, and noting any implications of the findings.[29] The PRISMA extension of

scoping reviews (PRISMA-ScR) checklist was used to report the results.[30] This study was approved by Kerman University of Medical Sciences Ethics Committee (Approval Code IR.KMU.REC.1400.700).

2.1 | Search strategy

PubMed, Scopus, and Web of Science were searched on February 28, 2022, to access articles without any date restrictions. The search was performed by S. H. using the ("video game [MeSH term]" OR "computer game" OR "mobile game" OR "serious game" OR gamification [MeSH term]) AND ("speech pathology" OR "speech therapy [MeSH term]" OR "speech disorder [MeSH term]" OR stuttering [MeSH term]) search strategy.

2.2 | Inclusion criteria

Original interventional and observational studies in English that used digital games for managing speech disorders were included.

2.3 | Exclusion criteria

Protocol studies, review studies, letters, conference articles, books, articles that used digital games for other conditions such as language disorders, and articles that did not use digital games were excluded.

2.4 | Articles review

In the first phase, the articles retrieved from different databases were entered into the Endnote reference manager software version X8, and the duplicates were removed. The remaining articles were reviewed separately in the second phase based on their titles and abstracts by two authors (S. H. and S. G.). In the next phase, the same authors reviewed the full text of the selected articles from the previous step. Disagreements between the two reviewers were resolved by reaching a consensus. In the last phase, the required data were extracted.

2.5 | Data extraction

The data extraction form contained the first author's name, year of publication, country, target group, participants, mobile device/computer-based, type of the game design, language level, number of sessions, and outcome. In this study, language level refers to five levels, including phoneme, syllable, word, phrase, and sentence, which were considered for developing the games. The number of sessions means the number of times and the duration of each time the desired game is used to rehabilitate speech disorders.

2.6 | Data analysis

Descriptive statistics, including frequency and frequency percentage were used to analyze the data using the Microsoft Excel version 2016.

3 | RESULTS

In total, 693 articles were retrieved from PubMed, Scopus, and Web of Science. The titles and abstracts of 663 articles were assessed after removing 30 duplicates. Subsequently, the full text of the 52 remaining articles was reviewed. Finally, 10 articles were included in this review study (Figure 1).

The extracted data from included articles have been shown in Table 1.

3.1 | Year of publication

The included articles were published from 2008 to 2021. Most of the articles ($n = 6$, 60%) were published in 2017[31,36] and 2018[24,32,34,39] (Figure 2).

3.2 | Country

Half of the articles ($n = 5$, 50%) were conducted in European countries, including Slovenia ($n = 2$, 20%),[31,39] the Netherlands ($n = 1$, 10%),[32] Spain ($n = 1$, 10%),[36] and the UK ($n = 1$, 10%).[38] The remaining studies were conducted in other countries, including Australia ($n = 2$, 20%),[24,33] Canada ($n = 1$, 10%),[34] Bangladesh ($n = 1$, 10%),[35] and Colombia ($n = 1$, 10%).[37]

3.3 | Target group

The digital games were mostly used for apraxia ($n = 2$, 20%),[24,33] followed by dysarthria ($n = 1$, 10%),[32] articulatory hypokinesia in Parkinson's disease ($n = 1$, 10%),[34] dysphonic disorder ($n = 1$, 10%),[36] hearing disability ($n = 1$, 10%),[37] phonological impairment ($n = 1$, 10%),[38] and speech disorder in autism ($n = 1$, 10%).[35] Two articles (20%) did not determine the type of speech disorder.[31,39]

3.4 | Participants

In total, 153 patients with speech disorders participated in 10 included articles. The sample size ranged from 1[35] to 44 patients.[39]

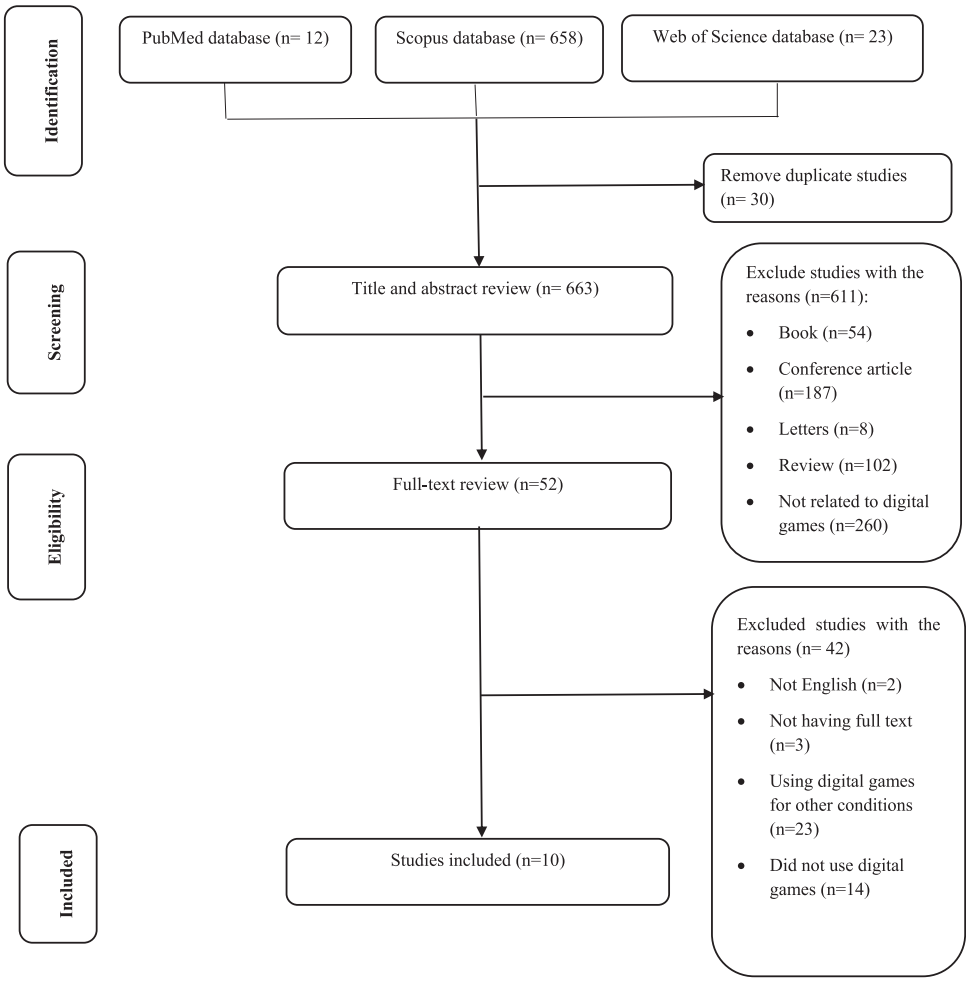

FIGURE 1 The PRISMA flowchart to find relevant articles.

3.5 | Mobile device/computer-based game

More than half of the articles (n = 6, 60%)[24,31–33,36,39] used a mobile device-based game, while the remaining articles (n = 4, 40%)[34,35,37,38] used a computer-based one.

3.6 | Type of the game design

In most of the articles (n = 6, 60%),[31,33,35–38] the game was designed by the researchers; however, a predesigned game was used in the other articles (n = 4, 40%).[24,32,34,39]

3.7 | Language level

Different language levels such as phonemes (n = 3, 30%),[31,38,39] words (n = 3, 30%),[24,33,36] sentences (n = 2, 20%),[32,34] and syllables (n = 1, 10%)[37] were considered in the employed digital games. The game used in 1 article (10%)[35] considered both words and sentences.

3.8 | Number of sessions

The number of sessions for using digital games ranged from 1[37,38] to 4[32,33] per week, and the duration of each session was from 5[24,36] to 45 min.[34,37] The number of sessions was not mentioned in the 2 articles.[31,39]

3.9 | Outcome

Although the reviewed articles revealed the positive impact of digital games on speech[32–34,36,38] and the patients' motivation during the therapy,[24,31,32,37,39] 2 articles (20%) mentioned that personalized speech therapy should be considered in designing digital games.[32,35]

4 | DISCUSSION

This study aimed to review the digital games used for the rehabilitation of speech disorders. The results showed that digital games could improve patients' speech and motivation in therapy.

TABLE 1 Characteristics of the included articles.

Author	Year of publication	Country	Target group/ participants	Mobile device/ computer-based	Type of game design	Language level	Number of sessions	Outcome
Ahmed et al.[24]	2018	Australia	Apraxia/10 children 6–11 years old	Android and iOS mobile-based	Predesigned games (WordPop, Speech Worm, Asteroid, Whack-A-Mole and Memory)	30 words ranging from one to four syllables	5 min per game	Speech-controlled games are interesting and fun, and can engage children in therapy.
Gačnik et al.[31]	2017	Slovenia	Speech sound disorders/27 children aged 5–8 years old	Android-based tablets	Researcher designed game in libGDX environment	6 phonemes	Not reported	The game increases children's motivation and engagement in the therapy.
Ganzeboom et al.[32]	2018	The Nether-lands	Dysarthria/3 patients with Parkinson's disease and 2 patients with a stroke	iOS-based tablet	Predesigned game (Treasure Hunters)	30 sentences containing a word with/p/ ,/t/, or/k/	15 min four times a week for 4 weeks	Game-based speech training can improve speech intelligibility and user satisfaction; however, personalized speech training is needed.
Hair et al.[33]	2021	Australia	Apraxia/10 children aged 5–12 years old	Android tablet-based	Researcher-designed game with Unity Game Engine (Apraxia World)	1000 words	30 min four times a week for 8 weeks	This speech therapy game can significantly improve speech.
Kearney et al.[34]	2018	Canada	Articulatory hypokinesia in Parkinson's disease/5 patients	Computer-based	Predesigned games (Dragon World and Fish World) Unity Game Engine	6 sentences	45 min, 10 times for 5 weeks	A gamified augmented visual feedback can improve articulatory hypokinesia in Parkinson's patients.
Rahman et al.[35]	2011	Bangladesh	Speech disorder in autism/1 child	Windows computer-based	Researcher-designed games with Microsoft Visual Studio 2008, Microsoft Speech Engine for English Speech SDK 5.1, Microsoft Windows XP Service Pack 2	Word, sentence	Three sessions in 5 months	Because there are various types of autism, personalized speech therapy is needed.
Lv et al.[36]	2017	Spain	Dysphonic/3 patients (stroke, Parkinson's, elderly)	Windows tablet-based	Researcher-designed game with Windows Presentation Foundation (WPF) library with C# programming language	50 words	5–20 min three times a week	The quality of phonation is improved.
Navarro-Newbal et al.[37]	2014	Colombia	Hearing disability/15 children aged 4–14 years old	Windows computer-based	Researcher-designed game with a game engine which allows the system to run on Windows 7, 8, and 8.1 (Talking to Teo)	Syllable	45 min eight sessions for 8 weeks	The game has positive impacts on attention and engagement in therapy.

(Continues)

TABLE 1 (Continued)

Author	Year of publication	Country	Target group/ participants	Mobile device/ computer-based	Type of game design	Language level	Number of sessions	Outcome
Wren et al.[38]	2008	UK	Phonological impairment/33 children aged 4–8 years old	Computer-based	Researcher-designed game with specially commissioned software Phoneme Factory	19 phonemes	30-min session per week for 8 weeks	There is no significant difference between the computer and tabletop delivery of phonology therapy and no therapy groups with regard to changes in speech output.
Zajc et al.[39]	2018	Slovenia	Speech disorder/44 children aged 3–12 years old	Tablet-based	Predesigned game in libGDX environment	6 phonemes	Not reported	The game had a positive effect on the children's satisfaction and motivation.

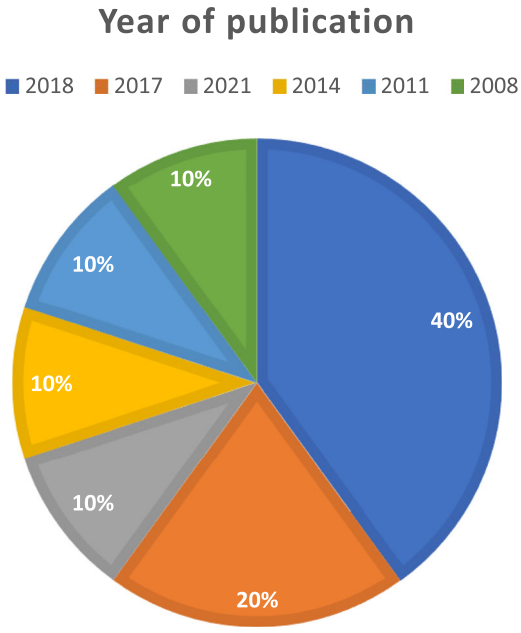

FIGURE 2 The frequency of articles based on the year of publication.

Another study that reviewed the application of digital games for speech therapy in children reported the same results.[28] Other studies conducted on the use of digital games for attention[40] and physical rehabilitation after stroke[41] also reported the positive impact of these games on the patients. Improving speech in speech disorders requires the patient's active participation in therapeutic exercises. For this purpose, using methods that are entertaining as well as therapeutic can be very useful.[33,42]

Digital games were evaluated on different speech disorders, specifically apraxia. Apraxia is a neurological speech disorder that affects the oral movements needed for speech. Approximately 1 in 1000 children are diagnosed with apraxia. The motor planning skills of the patients with apraxia are considered for the treatment.[43] Studies found that digital games could improve these patients' speech and increase their engagement in the treatment process.[24,33]

Most of the digital games used were based on mobile platforms. Compared with our study, another work showed that computer-based games had been more frequently used for speech therapy in children.[28] Mobile phones are used for the self-management of diseases in the recent years.[44] The increasing number of smartphone users leads to a growing healthcare gamification market.[45] Moreover, despite the possible benefits of computer-based games, the portability and availability of mobile devices and the faster and easier installation of games on mobile phones may increase the use of digital games by the patients in their therapy process.[46]

The designed games mostly considered phonemes and words. Words comprise semantic, lexical, and phonological information that refers to meaning, letters, and sounds, respectively. The connection between this information in memory can lead to the retrieval of the target word with the appropriate letters and meaning, and

TABLE 2 Characteristics of some digital games.

Game	Characteristics
WordPop	A single-interaction mobile game that shows the target word and the player read the word. If the word is read correctly, then the word pops and letters float toward the screen edge and points are added.
Speech Worm	A word search game that shows a target word. The players pass their fingers on the letters in the network to make the word and then record their production of the word by clicking the SPEAK button. If the word is read correctly, points are added.
Asteroid	A game in that players should shoot asteroids before they hit spaceship. When players touch the yellow asteroids with their fingers, a target word is shown and the color of the asteroid changes to green. Then players should read the word. If the word is read correctly, the asteroid breaks into smaller pieces, and points are added.
Whack-A-Mole	A game that uses 10 cards in two rows. Each card shows a picture the player should say its name within 2 min. If the word production corresponds with the picture, the user is awarded a star.
Memory	An interactive game with five pairs of pictures hidden behind bubbles. The player should click on a bubble to uncover it and then click on the record button. Then, players say the name of the uncovered picture. This game cannot automatically detect the correct word. Another person such as a speech-language pathologist can manually score the accuracy of each word production by clicking on stars at the bottom of the game screen.
Treasure Hunters	A two-player cooperative game in that players should navigate a map with each other to find the treasure. Players should help each other to find their purpose by speaking. Players receive automatic feedback on their voice loudness and pitch.
Dragon World	A game that shows the player's tongue movements with the extent of fire breathed by a dragon. This game had five levels and at the end of each level, a cumulative score from all levels was shown.
Fish World	A game that shows the player's tongue movements with a fishing net and different types of fish. This game had five levels and at the end of each level, a cumulative score from all levels was shown.

pronouncing it with a strong sound.[47] As the smallest part of speech, phonemes help one word be distinguished from another. In speech disorders, unlike language disorders, in which the patient has difficulty with the meaning and grammar of words and sentences, patients cannot pronounce the words and letters correctly.[48]

European countries conducted more studies on the use of digital games in speech rehabilitation. However, another study that reviewed digital games in speech therapy for children showed that the United States had designed the most games in this field.[28] This difference may be because the mentioned study focused on speech therapy in children and included conference papers, unlike the present study. Generally, the healthcare gamification market in Europe is expanding because of the growing prevalence of chronic diseases, emerging health consumerism, and rising acceptance of gamified models.[49]

Four articles used predesigned games.[24,32,34,39] Ahmed et al. used five predesigned games, including WordPop, Speech Worm, Asteroid, Whack-A-Mole, and Memory.[24] Ganzeboom et al. used Treasure Hunters predesigned game.[32] Dragon World and Fish World were the other predesigned digital games used by Kearney et al.[34] Zajc et al.[39] also used the digital speech game that was designed by Gačnik et al.[31] The characteristics of some mentioned games have been shown in Table 2. Although using a predesigned game is more economical in terms of cost and time, designing a digital game based on the purpose of the study is more efficient.

Using guidelines to design digital games can help use them effectively. A guideline was published in 2017 focusing on the design of therapeutic serious games for children with speech and language delays. The information in this guideline was obtained from relevant literature and interviews with speech pathologists. This guideline offers advice in 15 groups: "identification with the game, interface design, layout, demonstrations, reward/encouragement, performance feedback and guidance, personalization, adaptive games and challenges, social interaction, mobility, time management/restriction, repetition and rehearsal of skills, motivation and engagement, motor skill, and cognitive development."[50]

To the best of our knowledge, this was the first study that reviewed digital games for speech rehabilitation. However, this study has some limitations. The study protocol was not written and registered. We did not have access to the full text of some articles. Conference articles were excluded, which may have led to some relevant studies being missed. Probably, if researchers consider these limitations in their future studies, they will achieve more accurate results.

5 | CONCLUSION

Digital games can be used for the rehabilitation of different speech disorders. These games can improve patients' speech and increase their motivation in therapy. Digital games can be used by patients in their homes in conditions like the COVID-19 pandemic, in which access to face-to-face visits and provision of treatment sessions by speech pathologists has been limited. Although studies showed the positive impact of digital games on speech disorders, personalized speech therapy should be considered in designing these games.

AUTHOR CONTRIBUTIONS

Sadrieh Hajesmaeel-Gohari: Conceptualization; data curation; formal analysis; investigation; methodology; project administration;

supervision; writing—original draft; writing—review and editing. **Saeideh Goharinejad**: Data curation; investigation; methodology; writing—review and editing. **Elaheh Shafiei**: Writing—original draft; writing—review and editing. **Kambiz Bahaadinbeigy**: Conceptualization; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT

This study was approved by Kerman University of Medical Sciences Ethics Committee (Approval Code IR.KMU.REC.1400.700).

TRANSPARENCY STATEMENT

The lead author Kambiz Bahaadinbeigy affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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