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Association between cardiometabolic index and kidney stones; a systematic review and meta-analysis

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ABSTRACT

Introduction: T Kidney stone is a common urological disease, and high values of cardiometabolic index (CMI) are primarily linked with metabolic disorders, including obesity, insulin resistance and metabolic syndrome, which are associated with the formation of kidney stones (nephrolithiasis). Accordingly, our study aimed to investigate the relationship between high CMI values and the risk of kidney stones.

Materials and Methods: Databases such as Web of Science, Cochrane, Scopus, PubMed, Embase, and Google Scholar Search Engine were conducted for articles published until August 27, 2025. Data were analyzed using STATA 14. Tests with *P* values<0.05 were considered statistically significant.

Results: Results revealed that high CMI levels increased the risk of kidney stones (OR=1.39, 95% CI: 1.31, 1.47). As high CMI values in the second one-third (OR=1.38, 95% CI: 1.25, 1.52), third one-third (OR=1.35, 95% CI: 1.22, 1.49), second quartile (OR=1.31, 95% CI: 1.11, 1.56), third quartile (OR=1.45, 95% CI: 1.23, 1.71), and fourth quartile (OR=1.57, 95% CI: 1.33, 1.85) increased the risk of kidney stones. Additionally, high CMI levels increased the risk of kidney stones in men (OR=1.28, 95% CI: 1.16, 1.42), women (OR=1.28, 95% CI: 1.18, 1.39), patients with BMIs 25-30 (OR=1.21, 95% CI: 1.08, 1.35), patients with BMIs ≥ 30 (OR=1.25, 95% CI: 1.12, 1.39), patients younger than 60 (OR=1.24, 95% CI: 1.13, 1.37), patients older than 60 (OR=1.36, 95% CI: 1.26, 1.48), and diabetic individuals (OR=1.52, 95% CI: 1.36, 1.70).

Conclusion: High CMI levels increased the risk of kidney stone formation by 39%. The risk was similar in men and women; however, the risk of kidney stones increased with the patients' age. Furthermore, obese individuals were at a higher risk compared with those who were overweight.

Registration: This study has been compiled in accordance with the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD420251141496) and Research Registry (UIN: reviewregistry2044) websites.

Implication for health policy/practice/research/medical education:
Our systematic review and meta-analysis found that a high cardiometabolic index (CMI) was a serious risk factor for kidney stones. Studies that grouped CMI levels into quartiles demonstrated that the higher quartiles of CMI were associated with an increased risk of nephrolithiasis compared to the lower quartiles. The patients' gender did not affect the relationship between high CMI values and the risk of kidney stone; hence, male and female patients were equally exposed to the risk of this disease..

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Meta-analysis

Introduction

Kidney stone is a common urological disease that has affected 10% of the global population (1). In fact, a kidney stone is a chronic metabolic disorder primarily illustrated by the disrupted regulation of salt dissolution and precipitation in urine (2, 3). The incidence and frequency of this disease are increasing around the world, turning kidney stones into a critical public healthcare issue (3, 4). On the other hand, the annual costs of kidney stone diagnosis and treatment surpass billions of dollars, imposing a significant financial burden on individuals and society (5). Besides, kidney stones can cause complications, including acute attacks, urinary tract infections, renal colic, urinary obstruction, and renal failure (6).

The cardiometabolic index (CMI) is an indicator that combines the ratio of triglyceride to high-density lipoprotein-cholesterol (TG/HDL-C) and the ratio of waist-to-height ratio (WHtR) (7). Compared with traditional anthropometric measures, CMI has a closer relationship with metabolic abnormalities as it combines the indicators of abdominal obesity and dyslipidemia (8, 9). Previous studies demonstrated a strong association between high CMI levels and several diseases, including atherosclerosis, ischemic stroke, and hyperuricemia (10-12). On the other hand, high CMI levels are connected with metabolic disorders, such as insulin resistance, metabolic syndrome, and obesity, which are associated with the formation of kidney stones (13, 14).

Since previous studies presented inconsistent results, the present study aimed to examine the relationship between high levels of CMI and the risk of kidney stone using the systematic review and meta-analysis methods; for instance, a study (15) conducted in 2025 reported that, compared with the first quartile, the second quartile did not increase the risk of kidney stones. However, another study (16) in 2025 demonstrated that in the second, third, and fourth quartiles of CMI, the risk of kidney stones was significantly higher than in the first quartile.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to design the present article (17), and its protocol was registered at the websites PROSPERO (International Prospective Register of Systematic Reviews) and Research Registry.

Search strategy

The databases such as Web of Science, Cochrane, Scopus, PubMed, Embase, and Google Scholar Search Engine were conducted to search for articles published by August 27, 2025, without any language or publication time restrictions. The Medical Subject Headings (MeSH) and their equivalents were used during the searching process. Operators (AND, OR) were used to combine the keywords. In the end, the process included a manual search. The search strategy in the Embase database was as follows: 'cardiometabolic index' AND ('kidney calculi' OR 'kidney stone' OR Nephrolithiasis OR 'renal calculi)

PECO framework

- Population: Articles that aimed to investigate the relationship between high CMI and the risk of kidney stones.
- Exposure: High CMI.
- Comparison: People without kidney stones.
- Outcomes: Risk of kidney stones.

Inclusion criteria

Articles that aimed to investigate the relationship between high CMI and the risk of kidney stones.

Exclusion criteria

Case reports, abstracts published in conferences, studies with low qualitative score, duplicate studies, studies that did not have full text, and those that did not provide our required data were excluded.

Quality assessment

The quality of observational studies was assessed using the Newcastle-Ottawa Scale. This tool assigns a maximum of one star to each question, except for the comparative question. Therefore, a score of zero indicated the lowest quality, and a score of ten showed the highest quality. Then, studies with scores lower than five were considered low-quality (18).

Data extraction

Two researchers extracted data, including age, stage, number of samples, type of study, country, year, duration of study, and the author's name. Then, the third researcher addressed the discrepancies.

Statistical analysis

The odds ratio (OR) logarithm was used for data analysis, and the studies were combined. The I^2 index was employed to examine the heterogeneity between studies. A randomized effects model was used to combine the studies. Data analysis was conducted using STATA 14 software. Tests with P values lower than 0.05 were considered statistically significant.

Results

Overall, 175 articles were found during the search stage. Then, 83 duplicate studies were identified and removed. The abstracts were reviewed, and 21 studies without accessible full texts were removed. Out of the 71 remaining articles, 45 lacked the required data for analysis and were excluded. Among the 26 articles that entered the next step, 21 studies were removed due to other exclusion criteria, and five articles remained (Figure 1).

As Table 1 shows, five cross-sectional studies with a total of 48625 individuals were investigated, all of which

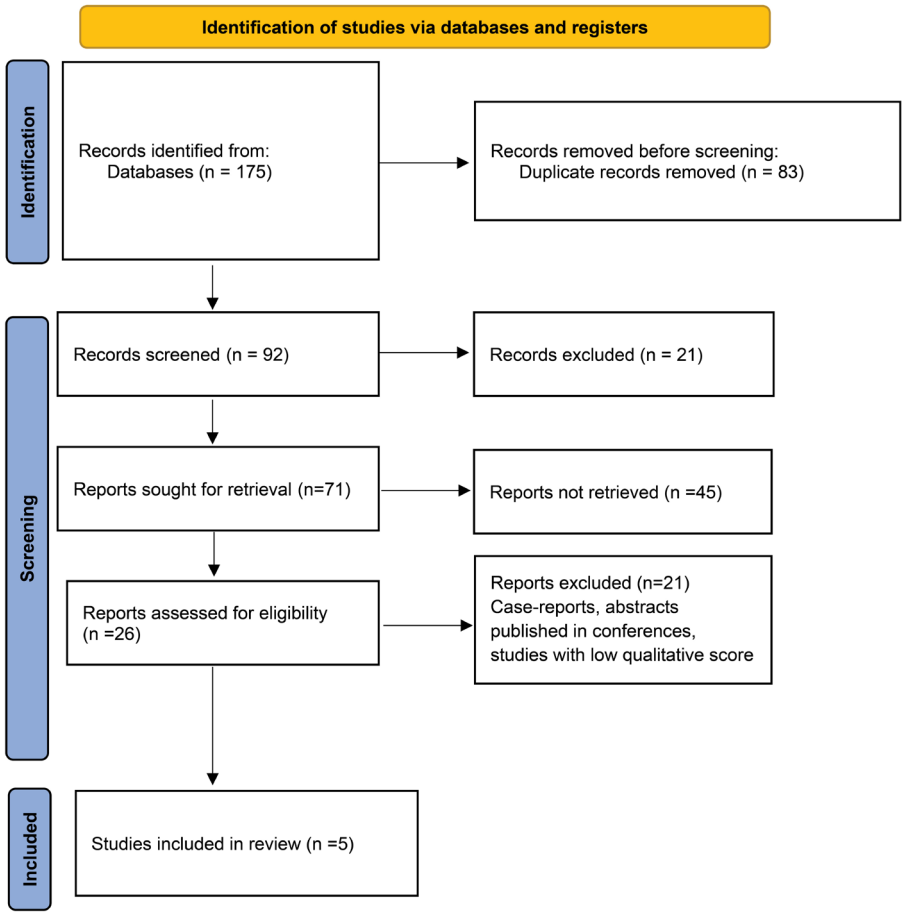

Figure 1. The flow chart of study selection (PRISMA).

Table 1. Summarized information of the studies

Author, year	Country	Type of study	Duration of study	Sample size	Compared with	Stage	OR	Low	Up
Zhong S, 2025 (15)	USA	Cross-sectional	2007–2018	14200	People without kidney stones	Total	1.19	1.06	1.32
						Quartile2	1.16	0.87	1.55
						Quartile3	1.40	1.03	1.91
						Quartile4	1.46	1.08	1.97
Bi J, 2025 (16)	USA	Cross-sectional	2007-2020	18043	People without kidney stones	Total	1.07	1.02	1.12
						Quartile2	1.32	1.01	1.73
						Quartile3	1.44	1.13	1.82
						Quartile4	1.50	1.18	1.92
Liu H, 2024 (19)	USA	Cross-sectional	2007–2018	2714	People without kidney stones	Total	1.17	1.06	1.30
						Quartile2	1.55	1.10	2.18
						Quartile3	1.54	1.09	2.19
						Quartile4	1.88	1.33	2.67
Wang Q, 2024 (20)	USA	Cross-sectional	2011-2018	3059	People without kidney stones	Tertile2	1.39	1.24	1.56
						Tertile3	1.31	1.17	1.47
Yin G, 2024 (21)	USA	Cross-sectional	2007–2018	10609	People without kidney stones	Total	1.29	1.16	1.44
						Tertile2	1.34	1.11	1.62
						Tertile3	1.46	1.20	1.78

OR: Odds ratio.

were conducted in the United States.

The results revealed that high CMI levels increased the risk of kidney stones (OR=1.39, 95% CI: 1.31, 1.47). As high CMI levels in the second one-third (OR=1.38, 95% CI: 1.25, 1.52), the third one-third (OR=1.35, 95% CI: 1.22, 1.49), the second quartile (OR=1.31, 95% CI: 1.11, 1.56), the third quartile (OR=1.45, 95% CI: 1.23, 1.71), and the fourth quartile (OR=1.57, 95% CI: 1.33, 1.85) increased the risk of kidney stone formation (Figures 2 and 3).

Moreover, high CMI levels increased the risk of kidney stones in men (OR=1.28, 95% CI: 1.16, 1.42), women (OR=1.28, 95% CI: 1.18, 1.39), patients with body mass indexes of 25 to 30 kg/m^2 (OR=1.21, 95% CI: 1.08, 1.35), and in patients with body mass indexes of ≥ 30 kg/m^2

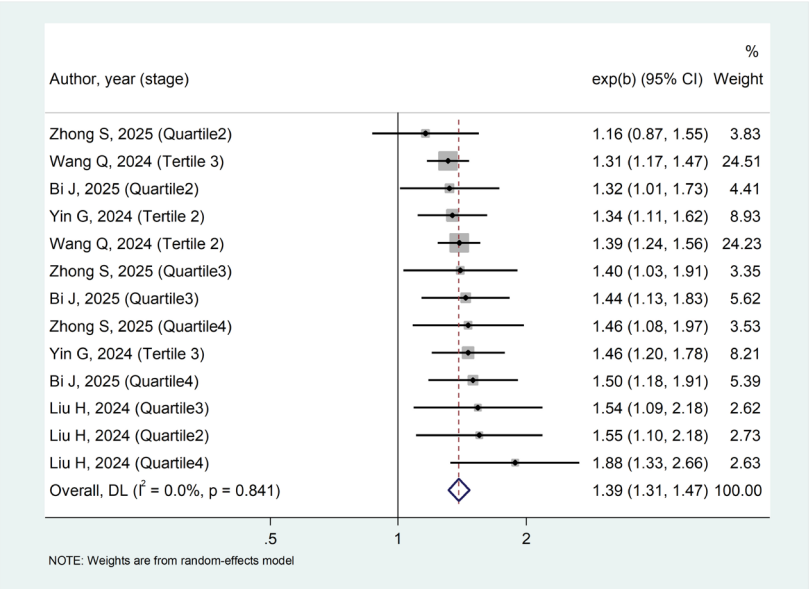

Figure 2. Forest plot showing the association between CMI and kidney stones.

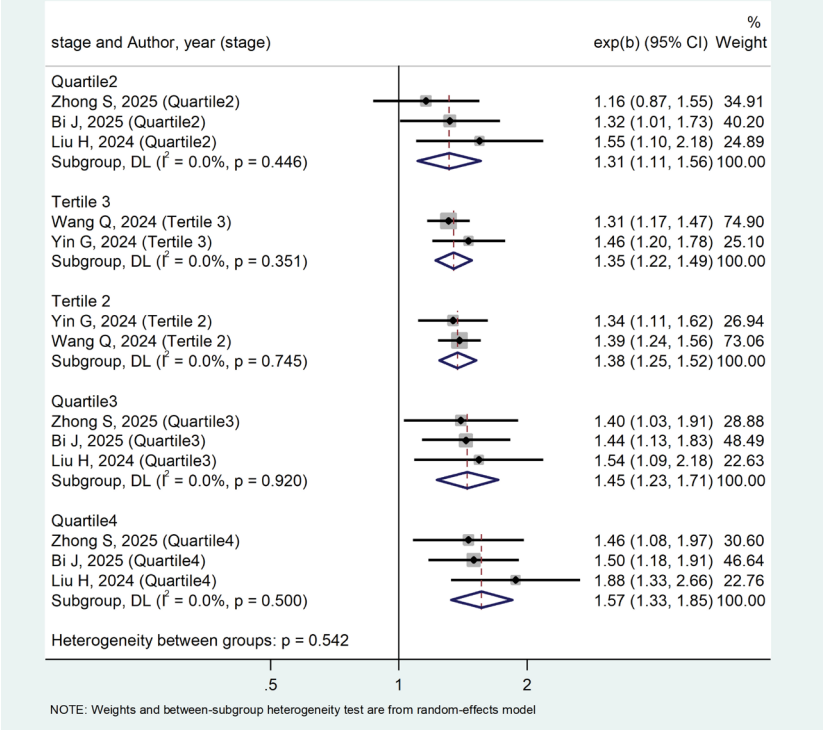

Figure 3. Forest plot showing the association between CMI and kidney stones by stage.

(OR=1.25, 95% CI: 1.12, 1.39) (Figures 4 to 7).

Additionally, high CMI levels increased the risk of patients younger than 60 years (OR=1.24, 95% CI: 1.13, 1.37), older than 60 years (OR=1.36, 95% CI: 1.26, 1.48), and diabetic individuals (OR=1.52, 95% CI: 1.36, 1.70) (Figures 8 to 10).

Discussion

Based on the findings of the current meta-analysis, high CMI levels increased the risk of kidney stones (39%). As high CMI levels in the second one-third (38%), third one-third (35%), second quartile (31%), third quartile (45%), and fourth quartile (57%) increased the risk of kidney stone formation. Besides, high CMI levels increased the risk of kidney stones in men (28%), women (28%), patients with BMIs 25-30 (21%), patients with BMIs ≥ 30 (25), patients younger than 60 (24%), patients older than 60 (36%), and diabetic patients (52%).

In a study by Bi et al high CMI levels were associated with increased risk of kidney stones (OR= 1.07, 95% CI: 1.02, 1.12) (16). Furthermore, Liu et al demonstrated that high CMI levels were positively correlated with increased risk of kidney stones in diabetic patients (OR= 1.17, 95% CI: 1.06, 1.30) (19). According to the results of Wang et al the odds ratios for the occurrence of kidney stones in the second and the third one-third were (OR= 1.39, 95% CI: 1.24, 1.56) and (OR= 1.31, 95% CI: 1.17, 1.47), respectively (20). In another cross-sectional study by Yin et al on 10609 participants, researchers reported that high CMI levels led to the formation of kidney stones (OR= 1.29, 95% CI: 1.16, 1.44) (21). Zhong et al demonstrated a statistically significant relationship between high CMI levels and the increased frequency of kidney stone formation (OR= 1.19, 95% CI: 1.06, 1.32) (15). The mentioned studies

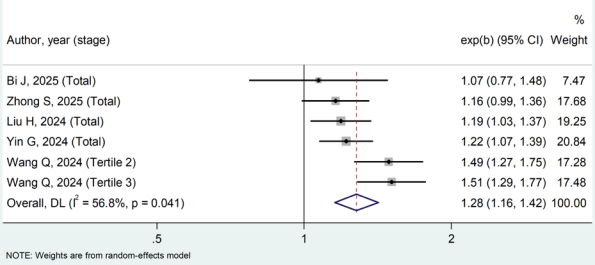

Figure 4. Forest plot showing the association between CMI and kidney stones in males.

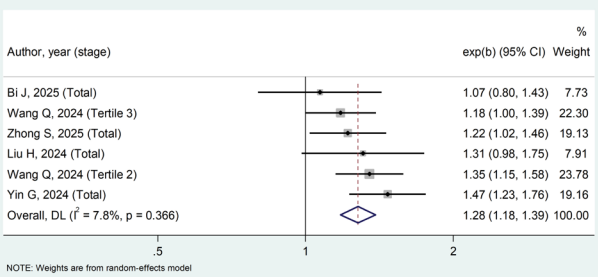

Figure 5. Forest plot showing the association between CMI and kidney stones in females.

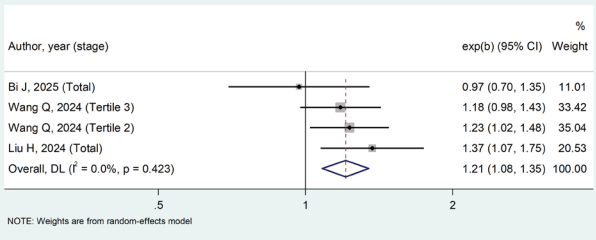

Figure 6. Forest plot showing the relationship between CMI and kidney stones in individuals with body mass index (25-30 kg/m²).

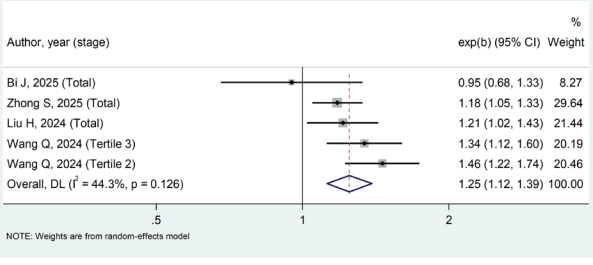

Figure 7. Forest plot showing the relationship between CMI and kidney stones in individuals with body mass index ≥30 kg/m².

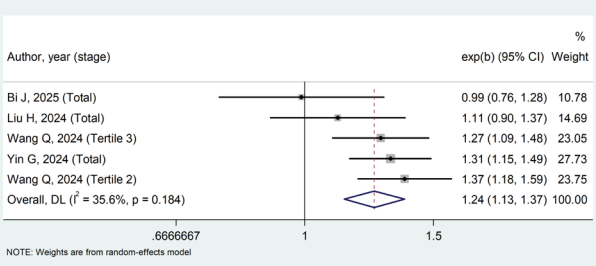

Figure 8. Forest plot showing the relationship between CMI and kidney stones in individuals with mean age <60 years.

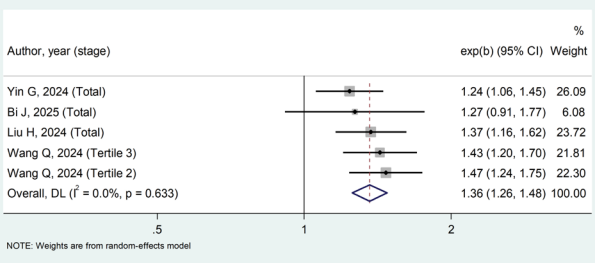

Figure 9. Forest plot showing the relationship between CMI and kidney stones in individuals with mean age ≥60 years.

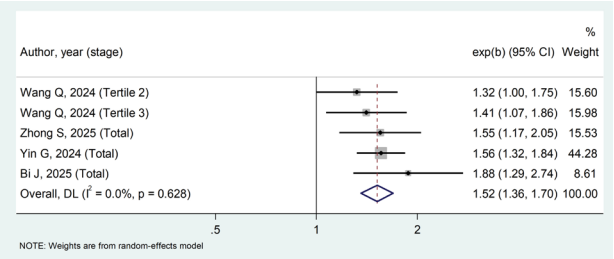

Figure 10. Forest plot showing the relationship between CMI and kidney stones in diabetic individuals.

were consistent with our results and demonstrated that increased CMI level was a risk factor for the formation of kidney stones.

Zuo et al in their cross-sectional study, aimed to examine the connection between CMI and hyperuricemia. They showed that the odds ratio for hyperuricemia in the highest CMI quartile was (OR=16.67, 95% CI: 4.42, 62.84) (12). In another cross-sectional study by Kong et al on 6540 diabetic patients, results revealed that high CMI levels increased the risk of diabetic kidney disease (OR= 1.11, 95% CI: 1.05, 1.17) (22). Xu et al conducted a cross-sectional study and indicated that high CMI levels were a significant risk factor for the incidence of albuminuria (OR= 2.26, 95% CI: 1.58, 3.23) (23). According to the results of cross-sectional research by Guo et al the highest one-third of CMI (OR= 1.08, 95% CI: 1.03, 1.13) increased the risk of chronic kidney disease (24). In a recent cross-sectional study by Zhu et al aiming to examine the relationship between CMI and renal dysfunction, the researchers demonstrated that the possibility of the reduction in eGFR in the highest one-fifth of CMI was 2.16 times higher than the lowest one-fifth (OR= 2.16, 95% CI: 1.27, 3.69) (25). These studies were consistent with the present research and indicated that high CMI levels were a risk factor for the occurrence of various kidney diseases (i.e., hyperuricemia, diabetic kidney disease, albuminuria, chronic kidney disease, and renal dysfunction).

In another cross-sectional study by Guo et al researchers revealed that high CMI levels and the increased frequency of hypertension were correlated (OR= 1.30, 95% CI: 1.25, 1.35) (26). In addition to the renal diseases, high CMI levels increase the risk of hypertension, which is consistent with the result of the present study.

Conclusion

High CMI was a serious risk factor for kidney stones. Studies that grouped CMI levels into quartiles demonstrated that the higher quartiles of CMI were associated with an increased risk of kidney stones compared to the lower quartiles. The patients' gender did not affect the relationship between high CMI values and the risk of kidney stone; hence, male and female patients were equally exposed to the risk of this disease. However, the risk of kidney stones in patients increased with age. Additionally, diabetic patients with high CMI levels were significantly more susceptible to kidney stones than nondiabetic patients.

Limitations of the study

Subgroup analysis based on the variables study type, country of origin, examined indicator, and comparison group was not possible as the reviewed studies were similar in this regard. The number of examined studies was low, and additional research on this subject is necessary. The studies did not group the CMI levels using the same method. Some studies reported the CMI in quartiles and others in one-third.

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Authors' contribution

Conceptualization: Sina Salem Ahim, Sara Rashki Ghalehno, and Mohammad Rostamzadeh
Methodology: Amir Heidari, Roozbeh Roohinezhad, and Leila Ashrafi.
Data curation: Sina Salem Ahim, Roozbeh Roohinezhad, and Zahra Eydizadeh.
Formal analysis: Abdolmohammad Ranjbar, Amir Heidari and Leila Ashrafi.
Investigation: Sara Rashki Ghalehno, Rasoul Jafari Arismani, and Negar Jafari.
Project management: Sara Rashki Ghalehno and Mohammad Parsa Mahjoob.
Supervision: All authors.
Validation: Mohammad Rostamzadeh and Negar Jafari.
Visualization: Zahra Eydizadeh and Rasoul Jafari Arismani.
Writing–original draft: All authors.
Writing–review and editing: All authors.

Conflicts of interest

There are no competing interests.

Ethical issues

This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO website (ID: CRD420251141496) and the Research Registry website with (Unique Identifying Number (UIN) reviewregistry2044). Besides, ethical issues (including plagiarism, data fabrication, and double publication) have been completely observed by the authors.

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