

Review Article



Educational Interventions for Waste Separation in Iran: A Systematic Review

Abdollah Dargahi,^{1,2} Mohammad Heidari,³ Fateme Samiee,^{4*} Farnam Mokhtarkoureh,⁵ Mehdi Vosoughi²

¹Department of Environmental Health, Khalkhal University of Medical Sciences, Khalkhal, Iran

²Social Determinants of Health Research Center, School of Health, Ardabil University of Medical Sciences, Ardabil, Iran

³Department of Epidemiology and Biostatistics, School of Medicine, Urmia University of Medical Sciences, Urmia, Iran

⁴Social Determinants of Health Research Center, Institute of Health Sciences and Technology, Hamadan University of Medical Sciences, Hamadan, Iran

⁵Student of the Research Committee, Khalkhal University of Medical Sciences, Khalkhal, Iran

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***Corresponding author:**

Fateme Samiee,

Email: samiee_fateme@yahoo.com

and Farnam

Mokhtarkoureh, Email: farnam.mokhtari@yahoo.com

Abstract

Source separation is one of the most cost-effective and sustainable approaches to urban waste management. This approach increases the recycling of useful materials, reduces environmental pollution, and improves the quality of life for residents of urban communities. This systematic review was conducted to identify and explain interventions related to source separation of waste by reviewing published research in Iran from 1980 to 2024, providing a comprehensive view of the current situation in the country. The systematic search and review procedure was conducted according to the PRISMA guidelines. Up-to-date data were obtained by executing queries in international databases, including Google Scholar, PubMed, Scopus, and Embase, as well as domestic databases such as Magiran and SID, from their inception up to July 28, 2024. Ultimately, 33 studies that met the inclusion criteria were reviewed; these were conducted between 2012 and 2023 across 20 provinces of Iran and focused on source separation education methods. Of the 33 studies, 15 (45.45%) were descriptive, while 18 (54.54%) were interventional. The total number of participants included in these studies was 15,588.

Keywords: Waste management, Educational interventions, Environmental pollution, Iran

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Introduction

Urban waste management is a key component of sustainable development, including collection, transportation, recycling, and disposal. Effective waste management minimizes environmental pollution, enables resource recovery, and improves quality of life.¹⁻³ Source separation—sorting of waste at the point of generation—enhances recycling efficiency and minimizes landfill loading.^{2, 4} Ineffective urban waste management leads to serious environmental issues, including contamination of water, soil, and air, increased greenhouse gas emissions, and accelerating climate change.⁵ Inefficient disposal of waste also propagates infectious diseases, including cholera and respiratory infections. Globally, post-consumer waste accounts for nearly 5% of greenhouse gas emissions,⁶ and municipal solid waste is estimated to increase from 2.01 billion tons in 2016 to 3.40 billion tons by 2050.⁷ Recycling rates globally are low, with merely 38.2% of municipal solid waste having been recycled or composted in 2018.⁸ Waste reduction, source segregation, reuse, recycling, and

recovery play major roles in sustainability.⁷ In developing countries, domestic solid waste offers opportunities for recycling and employment generation.^{9, 10} Low public involvement in decision-making may limit participation in recycling activities.¹¹ In Iran, over 83.6% of urban waste is not safely dumped, whereas recycling is carried out for only 8% of waste.¹² Food waste accounts for approximately 75% of municipal waste, showing enormous potential for composting and energy utilization. Design shortcomings, weak management, educational policies, and lack of incentive schemes are key barriers.^{13, 14}

Education is one of the main strategies to improve municipal solid waste management. Curriculum-based educational programs aim to reduce waste generation and improve source separation practices.^{15, 16} Education supports efficient waste management, cost reduction, environmental impact reduction, increased recycling rates, and employment generation.¹⁷ Wet waste can be used to generate compost and biogas, promoting sustainability and socio-economic development. Recyclable materials



are utilized by numerous industries, including the tire and lighting sectors.¹⁸ Public education is a cost-effective method to expand participation in waste reduction and recycling. Environmental education influences attitudes, knowledge, social norms, accessibility, and economic incentives, fostering sustainable behavior. For example, public education in Thailand increased recycling participation. Without public participation, waste management initiatives would likely fail.¹⁹

Effective source separation requires civic participation, knowledge, and appropriate infrastructure. However, insufficient coordination, infrastructure deficits, and limited public awareness continue to impede progress. Comparing past interventions and analyzing their strengths and limitations provide a foundation for planning effective waste management strategies. Despite the positive impact of educational interventions on source separation rates, comprehensive and rigorous evaluations are still scarce.¹⁵ The aim of this systematic review was to synthesize interventions in Iran between 1980 and 2024 and provide a scientific foundation for effective waste separation decision-making and policy development.

Materials and Methods

Study Design

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines⁽¹⁾. The purpose was to identify and synthesize evidence regarding educational interventions that promote waste segregation at the source level in Iran.

Protocol and Registration

Although the review protocol was not registered on PROSPERO, all study selection phases, data extraction, and quality assessment were conducted according to the PRISMA standards.

Search Strategy

The following databases were searched: PubMed, Scopus, Embase, Google Scholar, Magiran, and SID (up to July 28, 2024). The following keywords were used: “waste,” “recycling,” “waste separation,” “household waste,” “source separation,” “behavior,” “intervention,” “education,” “Theory of Planned Behavior,” “students,” and “citizenship education.” Boolean operators (AND/OR) were used to combine search terms.

Eligibility Criteria

Inclusion Criteria

- Studies conducted in any region of Iran, regardless of race or place of residence.
- Studies implementing an intervention related to waste management education.
- Studies that met population, intervention, and comparison (PIC) criteria.
- Studies providing models and strategies for waste management education without implementing an

educational intervention.

Exclusion Criteria

- Non-original studies, including reviews, systematic reviews, and meta-analyses.
- Interventions conducted in other countries.
- Articles reporting data only from books, theses, conferences, symposiums, or congress poster abstracts.

Study Selection

Titles and abstracts retrieved from electronic searches were independently screened by two authors. Articles were imported into EndNote 20, duplicates were removed, and each article was coded as “included,” “excluded,” or “uncertain.” Full texts of relevant studies were reviewed based on inclusion and exclusion criteria. The PRISMA flowchart illustrates the selection process (Figure 1).

Quality Assessment and Risk of Bias

Methodological quality of interventional studies was assessed using the Cochrane Risk of Bias Tool, addressing randomization, blinding, completeness of outcome data, and reporting bias. Descriptive studies were assessed using the STROBE checklist. Risk of bias was graded as low, moderate, or high.

Data Synthesis

Due to heterogeneity in study designs, interventions, and outcome measures, a meta-analysis was not performed. Results were synthesized descriptively and grouped into thematic areas: knowledge, attitude, behavior, and awareness. Regional, demographic, and methodological differences were analyzed narratively. A summary table of intervention effects was prepared for policymakers (Table 1).

Results and Discussion

From national and international databases, including Google Scholar, PubMed, Scopus, Magiran, and SID, 109 articles were initially identified. After removing duplicates and screening according to inclusion and exclusion criteria, 33 studies conducted between 2012 and 2023 in 20 provinces of Iran were included. Of these, 15 were descriptive and 18 were interventional, involving 8,934 participants aged between 5 and 75 years (Figures 2 and 3). The interventional studies were predominantly quasi-experimental, while the descriptive studies were mainly cross-sectional.

These studies provide an overall impression of educational measures for waste segregation across different Iranian settings, from major cities such as Tehran, Isfahan, and Mazandaran to smaller cities such as Ardabil, Yazd, and Hormozgan.²⁴ Strategies included face-to-face training sessions and workshops, which were most effective with adult participants, e.g., housewives and employees. Maleki et al¹³ and Sadeghi et al²⁴ reported that direct training with brochures

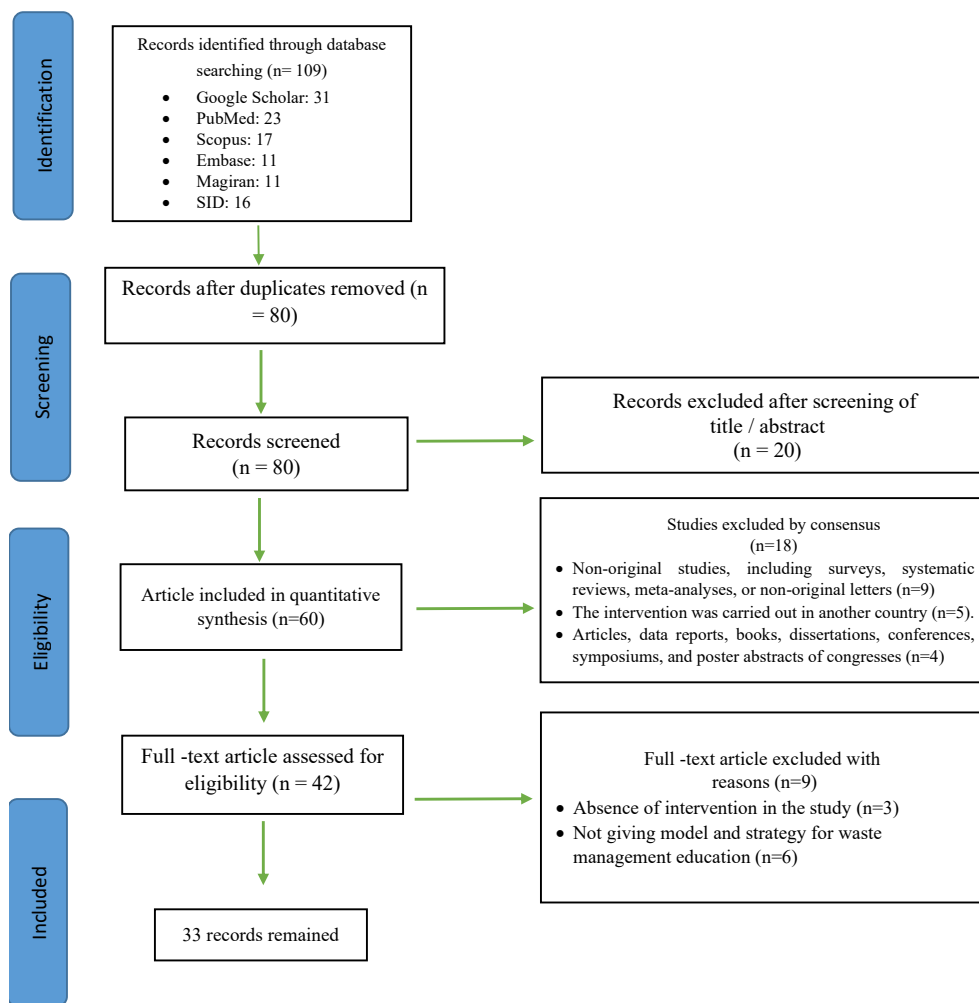


Figure 1. Flow Diagram for Identification, Screening, Eligibility, and Inclusion of Studies in the Systematic Review Process

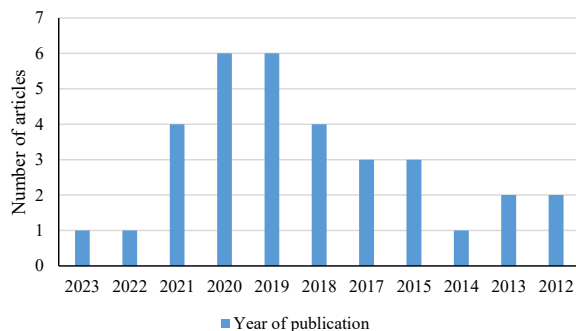


Figure 2. Number of Articles Found on Investigating the Impact of Interventions on Waste Separation Behavior at Source in Iran from 2013 to 2024 in Databases

significantly improved community awareness, attitudes, and behavior. For younger participants, activity-based methods such as educational games, storytelling, and craft activities enhanced learning retention. Shobeyri et al²¹ preschool children subjected to game-based interventions significantly improved both knowledge and practical ability in waste segregation. Hybrid interventions combining theory-based models such as the Theory of Planned Behavior (TPB) or the Integrated Behavior Model (IBM) with interactive and web-based tools provided the highest long-term behavioral impact. Virtual classrooms and mobile apps were successful

depending on engagement and accessibility.

Intervention effects were observed in four domains: knowledge, attitudes, behavior, and awareness. Training programs increased waste management knowledge in both adults and children. Recycling and source separation attitudes improved significantly in TPB-based interventions, enhancing motivation and intention. However, attitude and knowledge did not automatically translate into behavior unless interactive or theory-based reinforcement was added. Gamified, face-to-face, or hybrid interventions most effectively induced real-world behavioral outcomes.²⁹ Variability among studies depended on target population, intervention, and measurement strategies. Housewives, students, and working individuals were primary targets; some studies included only one gender. Measurement tools varied, from structured questionnaires and behavior observation checklists to in-depth interviews. Intervention durations also varied, with most studies focusing on short-term responses. Geographically, most interventions occurred in densely populated urban areas with higher economic and educational infrastructure, such as Tehran, Mazandaran, and Isfahan. Coastal provinces like Gilan and Mazandaran were included due to environmental concerns related to tourism Rural or less-developed provinces, e.g., Ilam and

Table 1. Integrated Waste Separation Interventions at Source Studies

ID	Year / Location / Time	Study	Method	Age Range / Average	Sample	Population under Education	Intervention / Education	Effect of Intervention	Ref.
1	2021/Nowshahr County/1 month	Quasi-experimental	In-person training classes	34	60	Housewives	TPB-based educational program	Improved waste separation behavior	20
2	2015 / Mashhad	Quasi-experimental	Educational games and traditional teaching	5-6	30	Preschool boys	Games + traditional methods	Enhanced learning and motivation for recycling and reuse	21
3	2022 / Khalkhal / 1 week	Case study	Face-to-face + brochures	-	380 / 100 households	Heads of households	General training	Effective in motivating waste reduction at source	13
4	2019	Case study	Multi-objective optimization model	-	-	Households	New model	Reduced supply chain costs and environmental risks	22
5	2013 / Tehran / 3 weeks	Cross-sectional	Workshop + brochure training	-	300	Households	Workshop & brochures	Workshops more effective in motivating separation; brochures less impact	2
6	2019 / Bushehr / 4 months	Quasi-experimental	CBSM five stages	11-13	1453	4th-6th grade students	CBSM approach	Raised awareness, reduced waste, increased recyclables	14
7	2018 / Tehran	Analytic Hierarchy Process (AHP) + Fuzzy Theory	Mobile applications	-	100	Civic education	Mobile app engagement	Facilitated participation, faster, more efficient waste recycling	1
8	2023 / Lahijan / 6 weeks	Quasi-experimental	Virtual classes	18-60	144	Housewives	ISCM-based intervention	Increased awareness and performance in waste management	4
9	2015 / Kalaleh / 2 months	Quasi-experimental	Face-to-face + packaged training	16-72	240	Households	Combined training	Face-to-face increased awareness, attitude, performance more than packaged	23
10	2019 / Sanandaj / 2 months	Quasi-experimental	IBM-based education	34-35	144	Housewives	IBM intervention	Improved attitude, norms, perceived control, self-efficacy; changed behavior	24
11	2021	Cross-sectional survey	Minimization education model	-	13	Managers/ instructors	Model-based education	Educational needs assessment led to environmental responsibility	25
12	2021 / Khorramabad / 1 month	RCT	In-person classes	10-11	200	Elementary students	In-person training	Increased awareness, attitude, sense of responsibility, cost reduction	26
13	2018 / Sabzevar / 2 months	Quasi-experimental	In-person classes	25-47	128	Hospital staff	Training model	Promoted behavioral intention, improved waste management	27
14	2019 / Shiraz / 2 months	Quasi-experimental	Multi-modal in-person	33	202	Hospital staff	TPB-based intervention	Improved performance in hospital waste management	28
15	2018 / Tabriz	Quasi-experimental	In-person classes	15->40	60	Citizens	Environmental education	Positive impact on urban environment quality	29
16	2013 / Esfahan	Quasi-experimental	In-person classes	14	50	Female students	Environmental education	Improved value perception in green space & energy; no impact on waste perception	30
17	2015 / Maraqeh / 3 weeks	Controlled intervention	In-person + games	-	413	Elementary students	Interactive educational programs	Empowered students to increase waste separation	31
18	2014 / Kermanshah / 6 months	-	Brochures	25-75	200	Citizens	Brochure education	Increased awareness and willingness to pay for park ecosystem protection	32
19	2020 / Amol	Survey	Questionnaire	-	445	Citizens	Descriptive	Highest separation for high-value waste; low separation for low-value waste	33
20	2017 / 12 cities in Iran	Descriptive	Municipal info	-	12 cities	Citizens	Descriptive	Awareness high but participation low; need to examine other factors	34
21	2020 / Genaveh	Cross-sectional	Questionnaire	16-54	300	Women	Descriptive	Low participation; need policies, programs, infrastructure	35
22	2017/Kohgiluyeh, Boyer-Ahmad, Fars	Cross-sectional	Questionnaire	18-50+	562	Married women	Descriptive	Attitude & responsibility positively impacted HWS; demographic factors significant	36
23	2012 / Tehran	-	Checklist & data	-	500	Households	Descriptive	Public participation requires education + infrastructure; repetition emphasized	37
24	2020 / Tehran, Saveh, Khomein, Shiraz	Exploratory	Semi-structured + Fuzzy Delphi	<35-45+	13	Professors & managers	Descriptive	Curriculum & educational objectives critical; proper content organization	25

Table 1. Continued.

ID	Year / Location / Time	Study	Method	Age Range / Average	Sample	Population under Education	Intervention / Education	Effect of Intervention	Ref.
25	2021 / Dastja village / 2 months	Cross-sectional	Questionnaire + in-person/ virtual	18-41+	60	Housewives	Descriptive	Increased knowledge, attitude, and performance; interactive approach effective	38
26	2019 / Tabriz / 5 months	Cross-sectional	Questionnaire + interviews	-	360	Citizens	Descriptive	Perceived control, moral obligation, policy effectiveness influenced intention	39
27	2020 / Yazd	Cross-sectional	Questionnaire	-	386	Households	Descriptive	Ecological factors significantly related to participation & proper separation	40
28	2020 / Yazd	Descriptive-analytical	Questionnaire	18+	410	Citizens	Descriptive	Awareness low in some areas; overall health/environmental awareness adequate	41
29	2019 / Babol	Cross-sectional	Questionnaire	-	476	Households	Descriptive	Weak performance due to insufficient municipal facilities & space	42
30	2018 / Mashhad	Descriptive	Questionnaire	19-34+	420	Students	Descriptive	Motivation strongest effect on intention; other factors follow	43
31	2012 / Mashhad	Descriptive	Questionnaire + interview	-	391	Households	Descriptive	Positive effect of perspective on city cleanliness; economic incentives impact separation	44
32	2020 / Tehran	Cross-sectional	Face-to-face + questionnaire	15-60+	384	Women	Descriptive	Face-to-face training positively impacted recycling performance	45
33	2017 / Tehran / 1 month	Descriptive	Questionnaire + checklist	-	100	Households	Descriptive	Reduced organic waste improved recyclable material quality	46

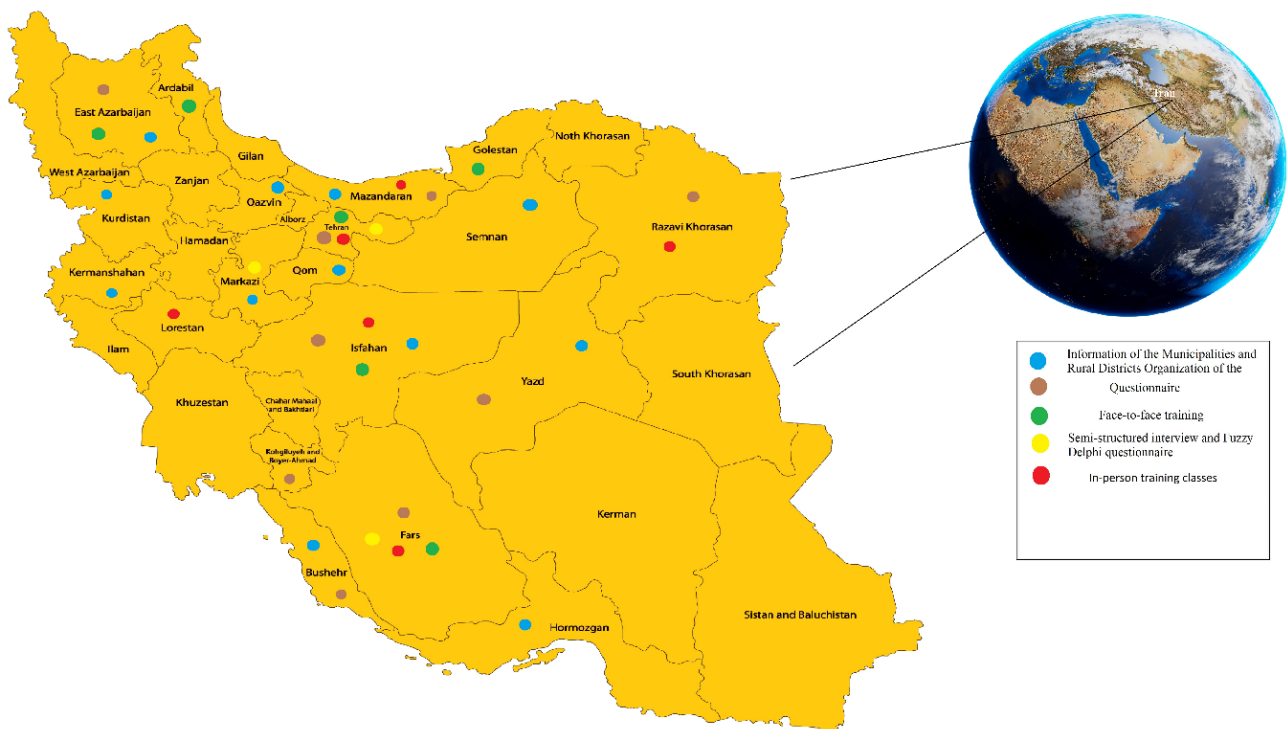


Figure 3. The Mapping Location Showing the Methods of Similar Studies in Various Provinces of Iran

Sistan and Baluchistan, were underrepresented. Cultural, social, and economic determinants were seldom studied but likely influenced intervention efficacy. Education-based interventions also had longer-term social and economic impacts. Raising awareness of economic benefits, such as disposal cost savings and potential incentives, improved participation. Interventions framed around social responsibility and environmental stewardship facilitated sustained behavior change. Theory-based interventions consistently enhanced attitudes, knowledge, and self-efficacy. Limitations include unequal outcome

measurements across studies, geographical clustering limiting generalizability, and scarcity of longitudinal assessments. Qualitative approaches were rarely used to explore barriers and facilitators.²⁸

In summary, educational interventions in Iran effectively improve knowledge, attitudes, and behavior regarding waste separation, particularly when interventions are interactive, theory-driven, and tailored to context and demographics.²⁶ Multi-modal strategies combining face-to-face instruction, gamification, printed media, and digital tools are most effective. However, rural gaps,

follow-up, and standardized outcome measurements persist, emphasizing the need for inclusive, longitudinal, and culturally sensitive approaches.

Conclusion and Policy Implications

This review shows that Iranian educational programs significantly improve waste separation knowledge, attitudes, and behaviors, especially when combining behavioral theories with interactive, digital methods. Face- to-face teaching with supporting materials boosts participation and lasting change. However, most research focuses on urban areas, with rural and disadvantaged regions less studied. Outcomes are inconsistent, and long-term data are lacking. Cultural and socioeconomic factors are often overlooked, making generalization difficult. Policymakers should adopt comprehensive, multi-dimensional strategies that include social incentives, infrastructure, and culturally relevant practices, especially in rural areas, for sustained impact.

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Authors' Contribution

Conceptualization: Abdollah Dargahi, Mohammad Heidari, Fateme Samiee.

Data curation: Fateme Samiee, Farnam Mokhtarkoureh.

Formal analysis: Mehdi Vosoughi, Abdollah Dargahi, Mohammad Heidari, Fateme Samiee.

Methodology: Fateme Samiee, Abdollah Dargahi, Farnam Mokhtarkoureh.

Project administration: Fateme Samiee, Mehdi Vosoughi.

Software: Mohammad Heidari.

Supervision: Mohammad Heidari, Fateme Samiee.

Writing—original draft: Fateme Samiee, Farnam Mokhtarkoureh, Abdollah Dargahi.

Writing—review & editing: Fateme Samiee, Farnam Mokhtarkoureh.

Competing Interests

The authors declare no competing interests.

Compliance with Ethical Guidelines

The protocol and ethics of this study were approved by the Ethics Committee of Ardabil University of Medical Science (Ethic Code of IR.ARUMS.REC.1404.051).

Consent for Publication

The manuscript does not contain data from any individual person so consent for publication is “not applicable.”

Data Availability Statement

All data generated or analyzed in this study are included in this published article.

Ethical Approval and Consent to Participate

The protocol and ethics of this study were approved by the Ethics Committee of Ardabil University of Medical Science (Ethic Code of IR.ARUMS.REC.1404.051).

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