HIV/AIDS - Research and Palliative Care

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REVIEW

Cost-Effectiveness of HIV Prevention Strategies: A Systematic Review of Economic Evaluations

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Background: HIV/AIDS continues to pose a significant global health challenge, especially in low- and middle-income countries. Economic evaluations are essential to identify cost-effective prevention strategies and allocate limited healthcare resources efficiently.

Objective: This systematic review aimed to assess the cost-effectiveness of HIV prevention interventions across various populations and settings, and to evaluate the methodological quality of the included studies.

Methods: A comprehensive literature search was conducted in PubMed, Embase, Web of Science, and Scopus for English-language studies published between January 2003 and November 2023. The PRISMA guidelines were followed for the review process. The quality of the included studies was assessed using the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist.

Results: Thirteen studies met the inclusion criteria, exhibiting diverse methodologies, target populations, and healthcare perspectives. The majority of studies reported that primary prevention methods—such as prenatal screening, harm reduction programs for drug users, and pre-exposure prophylaxis (PrEP) for high-risk groups—were more cost-effective than secondary or tertiary interventions. Study populations included pregnant women (38.4%), injection drug users (23.1%), men who have sex with men (23.1%), and general populations (15.4%). Overall, most studies demonstrated medium to high methodological quality.

Conclusion: Primary prevention strategies for HIV are generally cost-effective, especially when tailored to specific high-risk populations. However, more robust, context-specific evaluations are needed to support policy-making across diverse healthcare systems. Decision-makers should prioritize investment in early detection and preventive programs to optimize outcomes and resource use.

Keywords: cost-effectiveness, economic evaluation, HIV, prevention, public health

Introduction

Human immunodeficiency virus (HIV) continues to be one of the most serious public health threats worldwide. Since its emergence, it has caused widespread health, social, and economic burdens. As of 2023, approximately 39.9 million people were living with HIV, with the majority (65%) residing in the WHO African Region.[1] Although significant progress has been made in diagnosis, treatment, and prevention, HIV still accounts for hundreds of thousands of deaths annually and a growing number of new infections, especially in low- and middle-income countries.[1,2]

HIV is a retroviral infection that leads to acquired immunodeficiency syndrome (AIDS), a clinical syndrome characterized by progressive immune system failure, opportunistic infections, cancers, and neurological degeneration.[3,4] Over the last three decades, the disease has spread rapidly and remains a major cause of mortality globally.[5,6] Despite global commitments such as the 95–95-95 targets by UNAIDS,[7] a large proportion of infected individuals still do not receive appropriate treatment.

Received: 28 May 2025
Accepted: 9 August 2025
Published: 18 August 2025

In many settings, particularly resource-limited ones, rising health care costs and the growing demand for HIV services have created a critical need for economic prioritization. Therefore, evaluating the cost-effectiveness of HIV prevention interventions is essential to ensure efficient allocation of limited health resources.[8,9] Economic evaluations, such as cost-effectiveness analysis (CEA), cost-utility analysis (CUA), and cost-benefit analysis (CBA), are essential tools for comparing the costs and outcomes of different preventive strategies, including screening, pre-exposure prophylaxis (PrEP), and harm reduction.[10–15]

Although numerous individual economic evaluation studies have been conducted, the evidence is fragmented and methodologically variable. Previous analyses differ in terms of study population, design, outcome measurement, modeling approaches, and regional focus. For example, some studies target pregnant women or injection drug users, while others focus on men who have sex with men or general populations.[16–28] In addition, recent literature suggests that geographic, economic, and epidemiological heterogeneity significantly affects both costs and effectiveness of HIV interventions.[12,24,29]

Despite the availability of such data, a comprehensive and up-to-date systematic review of economic evaluations of HIV prevention strategies is lacking. This gap makes it difficult for decision-makers and health planners to synthesize findings across studies and draw evidence-based conclusions. Moreover, no recent work has systematically assessed the methodological quality of these evaluations using established tools such as the CHEERS checklist,[30] which can help identify potential biases and improve future research design.

Therefore, the present systematic review aims to address this gap by synthesizing economic evaluations of HIV prevention interventions published between 2003 and 2023. The study assesses both the cost-effectiveness results and the methodological rigor of the included studies and provides policy-relevant recommendations for the design, implementation, and funding of future HIV prevention programs.

Materials and Methods

Search Strategy and Study Selection

A systematic literature review was conducted to identify economic evaluations related to HIV prevention. The search was carried out across four major databases—PubMed/MEDLINE, Embase, Web of Science, and Scopus—from November 21 to December 21, 2023. Keywords including "economic evaluation", "cost-effectiveness analysis", "cost-utility analysis", "cost-benefit analysis", "prevention", "primary prevention", and "HIV" were used in the search strategy, targeting article titles and abstracts.

The records retrieved were imported into Mendeley software, where duplicates were removed. In the first screening phase, two independent researchers reviewed the titles and abstracts according to predefined inclusion and exclusion criteria. Eligible full-text articles were then assessed independently by the same two reviewers. Disagreements were resolved by discussion with a third researcher. The overall selection process is illustrated in the PRISMA flow diagram (Figure 1).

Inclusion and Exclusion Criteria

Studies were included if they met the following criteria:

1. Published between 2003 and 2023;
2. Economic evaluations using decision-analytic models, clinical trials, or cohort studies related to HIV/AIDS;
3. Complete economic evaluations (ie, cost-effectiveness, cost-utility, or cost-benefit analyses);
4. Full-text availability;
5. Published in English or Persian;
6. Use of decision tree modeling techniques.

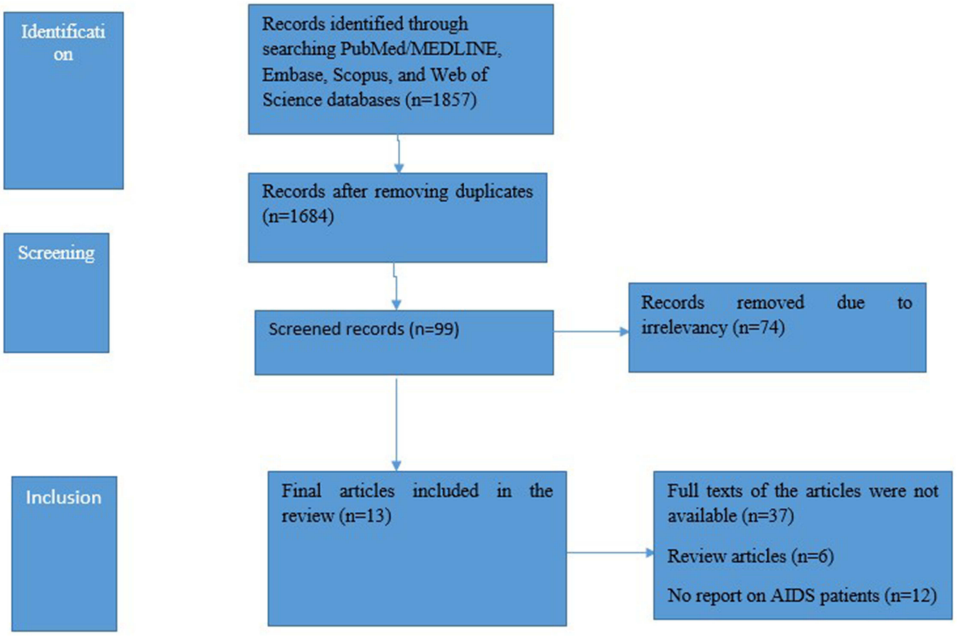

Figure 1 PRISMA diagram and how to select final articles for systematic review.

Studies were excluded if:

1. They were published in languages other than English or Persian;
2. They were unrelated to HIV/AIDS;
3. Their full text was not available.

Data Extraction

A structured data extraction form was used to collect information from each included study, including: author name, year of publication, country, study design, prevention type, target population, study perspective, modeling approach, time horizon, intervention and comparator, outcome measures, sensitivity analysis, discount rate, and intervention strategy. Data extraction was performed by one researcher and cross-checked by another to ensure accuracy and consistency.

Data Analysis

A narrative synthesis method was employed to analyze the collected data. Extracted variables were compiled into comparative tables. The studies were grouped by type of intervention, level of prevention, modeling method, and effectiveness measure. Trends, differences, and common findings across studies were identified. These patterns were then interpreted in the context of policy recommendations. No meta-analysis was performed due to heterogeneity in methodologies and outcome metrics.

Quality Assessment

The methodological quality of the included studies was independently evaluated by two researchers using the CHEERS (Consolidated Health Economic Evaluation Reporting Standards) checklist. This tool comprises 24 criteria assessing transparency in reporting, structure and validity of economic models, and potential limitations. Any discrepancies were resolved through consensus. Studies scoring 85% or higher were categorized as high quality and were included in the final synthesis.

Ethical Considerations

This study involved secondary analysis of published literature and did not include any human or animal subjects. The protocol was approved by the Ethics Committee of Baqiyatallah University of Medical Sciences (Approval ID: IR.BMSU.REC.1402.079). All steps were conducted in accordance with ethical standards for systematic reviews, including transparency in data selection, reviewer blinding during screening, and adherence to data integrity and reporting principles. No personal or confidential data were used.

Results

Study Selection and PRISMA Flow Diagram

The study selection process is depicted in the PRISMA flow diagram (Figure 1), illustrating the identification, screening, eligibility assessment, and inclusion stages of the systematic review.

Study Characteristics and Design

Table 1 summarizes the characteristics of the 13 included economic evaluation studies (16–288) Among these, four studies (30.77%) were conducted in Asia, and three (23.07%) in Africa. Overall, the majority of studies (53.85%) originated from low-income countries, while the remainder (46.15%) were from developed countries. The publication years ranged from 2005 to 2022.

Regarding study design, four were randomized controlled trials (RCTs), one was a cohort study, and eight were cross-sectional studies. Most employed pre-test/post-test designs and generally involved small sample sizes over extended study periods with limited interventions. All included studies performed economic evaluations, with some utilizing secondary data sources.

Study Perspectives

The perspective of analysis varied: nine studies (69.2%) adopted a healthcare provider perspective, two (15.4%) employed a community perspective, and two (15.4%) analyzed from the payer's viewpoint.

Population and Intervention Characteristics

Regarding target populations, 38.4% (n=5) of the studies focused on pregnant women. Injecting drug users and men who have sex with men (MSM) were each the focus in 23.07% (n=3) of the studies. Two studies (15.46%) compared cost-effectiveness across different subgroups, such as adults versus adolescents or high-risk populations within specific groups.

The interventions evaluated primarily included oral treatment regimens and preventive tools, which demonstrated higher cost-effectiveness compared to other methods.

Specifically, 38.4% (n=5) of the studies assessed interventions aimed at preventing mother-to-child HIV transmission during pregnancy and breastfeeding. These studies showed that active use of dietary and treatment regimens alongside preventive tools significantly reduced pediatric HIV incidence and were generally cost-effective.[19,23,25,27,28]

Screening and pharmacological interventions among injecting drug users were examined in 23.07% (n=3) of the studies, demonstrating that active screening strategies were cost-effective compared to passive or no interventions.[16–18]

Similarly, 23.07% (n=3) of the studies focused on MSM populations, indicating that active screening and preventive drug use were cost-effective strategies for reducing HIV transmission in these groups.[20,22,24]

Lastly, 15.46% (n=2) of studies analyzed oral treatment regimens in the general population, suggesting that some regimens were cost-effective for HIV treatment and should be considered by health policymakers.[21,26]

Quality Assessment

The quality of included studies was appraised using the CHEERS checklist (Table 2). All studies met at least 50% of the checklist criteria. Nine articles (69.2%) achieved an "excellent" quality rating with scores above 85%, while four (30.8%) were rated "very good" with scores between 70% and 85%. Notably, more recently published studies tended to score higher than earlier ones.

Table 1 Overview of 13 Economic Evaluation Studies

ICER	Sensitivity Analysis	Time Horizon	Perspective	Effectiveness Measurement Result(s) Unit	Intervention	Intervention Implementation Strategy	Type of People Involved in Interventions	Study Design	Country	Author's name Publication year
$855/39 $1528/90	Tornado Diagram (one-way sensitivity)	One year	Provider	Number of people with HIV after screening and the costs	Conducting AIDS screening tests for injecting drug users	Injection drug users are checked with screening tests.	Injection drug users referring to active (with AIDS) and inactive screening centers	CEA	Iran	Bordbar[16] 2021
13,248.5$	Tornado Diagram (one-way sensitivity	Lifetime	Governmental service provider	Number of HIV-prevented cases and costs	Effectiveness was based on high-risk behaviors before and after research	Injection drug users before and after intervention	Injection drug users	CEA	Iran	Majdzadeh et al[17] 2018
$2856	-	One year	Governmental service provider	Number of HIV-prevented cases and costs	Cost-effectiveness of methadone in not contracting AIDS	Comparison of use and non-use of methadone by Injection drug users in AIDS	Injection drug users	CEA	Iran	Pourkhajoei et al[18] 2017
$13,200 $7400	Tornado Diagram (one-way sensitivity	Lifetime time	Governmental service provider	Life quality and costs	Use of three Treatment regimens: ARVs—AZT, 3TC, and efavirenz; and AZT, 3TC, and lopinavir/ritonavir	Treatment regimens that lead to non-transmission of HIV to their children	Pregnant mothers and their breast-feeding period	Economic Evaluation	Thailand	Werayingyong et al[19] 2015
-	Non	One year	Provider	Number of people correctly diagnosed and the costs	Three screening methods: elective HIV testing/screening	Comparison of three common screening methods in Australia	Screening recipients (first, male homosexuals)	Economic evaluation	Australia	Williams et al[20] 2021
$3098	Tornado diagram (one-way sensitivity analysis) & PSA	10 years	Government	Number of people correctly diagnosed and the costs	Performing PITC, SU-PITC, and POC-NAAT tests and comparing them	Investigating cost effectiveness of screening in HIV diagnosis	Suspected HIV patients	CEA	Kenya	Babigumira et al[21] 2022
EUR 32,000	Univariate sensitivity analyses & Multivariate sensitivity analyses	Lifetime	Healthcare provider	Number of people with HIV-positive test and the costs	Use and non-use of pre-exposure prophylaxis method	HIV prevention and non-prevention	HIV prevention in people at risk (male homosexuals)	Economic evaluation	England	Ong et al[22] 2017

(*Continued*)

Table 1 (Continued).

ICER	Sensitivity Analysis	Time Horizon	Perspective	Effectiveness Measurement Result(s) Unit	Intervention	Intervention Implementation Strategy	Type of People Involved in Interventions	Study Design	Country	Author's name Publication year
US$ 455	One-way sensitivity analyses	Ten-years	Ministry of Health	Number of babies not affected, costs, DALYs	Use three prevention methods	Use of three methods for preventing the transmission of HIV to baby through mother	Prevention of mother-to-child HIV transmission	CEA	Malawi	Fasawe et al[23] 2013
-	One-way and probabilistic sensitivity analyses	Lifetime	Government health care payer	Quality of life, DALYs and costs	Use of circumcision for HIV prevention	Use of circumcision for HIV prevention compared with no circumcision	Prevention of HIV transmission in male homosexuals	Cost-utility analysis	Sub-Saharan African countries	Uthman et al[24] 2011
-	Univariate sensitivity analyses & Multivariate sensitivity analysis & Monte Carlo simulation	Lifetime	Societal	Quality of life, AIDS RNA levels in body, and costs	Prenatal care	Prevention of HIV transmission to baby during pregnancy	Pregnant women with HIV	CEA	USA	Avram et al[25] 2019
-		48 weeks	The payer perspective (National Health System)	Number of patients in whom the disease did not emerge, costs	Use of various treatment regimens	Using a variety of treatment regimens to reduce the effects of HIV	HIV prevention in adults	CEA	Spain	Berenguer et al[26] 2015
$11,546	Univariate and multivariate sensitivity analyses	100 years	Payer	Quality of life, HIV positive test, and costs	General screening and use of different treatment regimens to prevent transmission of the disease	Prevention of HIV transmission to the baby during pregnancy	Pregnant women with HIV	Economic evaluation	Israel	Chowers et al[27] 2016
-	Test sensitivity, test specificity, positive predictive value	Lifetime	Societal	Detection power of experimental tests, costs	Comparison of Oraquick rapid testing with other methods for screening pregnant women	Prevention of HIV transmission to the baby during pregnancy	Pregnant women with HIV	CEA	USA	Doyle et al[28] 2005

Table 2 Quality Assessment of Included Studies Using CHEERS Checklist

Total	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Potential conflict of interest	✓	✓	✓	✓	×	✓	✓	✓	×	✓	✓	✓	×
Funding source	✓	×	×	✓	✓	✓	✓	✓	×	✓	×	×	×
Findings and limitations	#	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	#
Heterogeneity explained	#	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	#
Sensitivity analyses	✓	✓	×	✓	×	✓	✓	✓	✓	✓	×	✓	✓
Incremental costs	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	×	✓	×
Parameters of values	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Analysis methods	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Model assumptions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Model choice described	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Currency, date and conversion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Preference based outcomes	*NA*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Measurement of effectiveness	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outcomes and relevance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Discount rate	×	✓	×	✓	×	✓	✓	✓	✓	✓	×	✓	✓
Time horizon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

(*Continued*)

https://doi.org/10.2147/HIV.S543292

Table 2 (Continued).

Comparators described	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Study Perspective	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Setting and location	✓	#	✓	#	✓	✓	✓	✓	✓	✓	✓	✓	✓
Population characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Introduction	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓
Abstract	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Title	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Study	Bordbar[16]	Majdzadeh et al[17]	Pourkhajoei et al[18]	Werayingyong et al[19]	Williams et al[20]	Babigumira et al[21]	Ong et al[22]	Fasawe et al[23]	Uthman et al[24]	Avram et al[25]	Berenguer et al[26]	Chowers et al[27]	Doyle et al[28]

Notes: ✓ Items that were completely met in the studies received a score 1. # Items that were partially met in the studies received a score of 0.5. × Items that were not fulfilled at all received a score of zero, NA: Not Applicable.

https://doi.org/10.2147/HIV.S543292

Discussion

This systematic review synthesized evidence from 13 studies evaluating the cost-effectiveness of HIV prevention interventions. Despite the considerable volume of literature initially retrieved, data on preventive methods remain limited, especially concerning geographic representation. The restricted number of studies available for each target population subgroup—fewer than ten in most cases—limits the robustness of conclusions that can be drawn across diverse populations and settings. Consequently, future research should prioritize generating comparative evidence on intervention strategies, particularly by incorporating emerging technologies and novel prevention methods, through direct head-to-head evaluations in varied contexts.

The cost associated with HIV diagnosis increases markedly as disease prevalence decreases.[31] In low-prevalence settings, screening low-risk populations using expensive, highly sensitive technologies is not cost-effective.[32] Therefore, it is advisable to employ cost-efficient and effective testing modalities when healthcare resources are constrained.

Our findings indicate that prevention interventions are cost-effective among pregnant women. Several studies demonstrated significant reductions in mother-to-child HIV transmission, especially when maternal viral load was low and cesarean delivery was employed.[33–35] Furthermore, studies by Patrick and Graves support the cost-effectiveness of prenatal HIV screening even in populations with low prevalence.[36,37]

Although rapid HIV tests may be less cost-effective in low-prevalence populations, they offer earlier and cheaper results compared to conventional laboratory assays.[38] Policymakers should thus consider the cost-effectiveness balance of various screening approaches when formulating HIV prevention strategies.[39]

Cost-effectiveness of prevention methods was also confirmed among men who have sex with men (MSM). For instance, Williams reported that HIV diagnosis in a general practice setting cost approximately $900,000, whereas point-of-care (POC) testing in community clinics cost less than $7000. Early diagnosis and prevention were also found to be cost-effective in this group.[20]

Hutubessy et al's meta-analysis of sub-Saharan African studies demonstrated that circumcision significantly reduced HIV transmission and was cost-effective compared to no intervention.[29] Similarly, Han et al showed that acute HIV infection (AHI) testing was cost-effective among high-risk populations with prevalence exceeding 0.4%, such as MSM and injection drug users in the US and China.[40]

While widespread HIV risk assessment may be cost-effective in large populations, intensive screening in smaller high-risk groups like MSM may not be.[41–43] Targeted combined approaches that cover multiple at-risk groups simultaneously may help overcome this limitation.

Active prevention and screening programs were effective and cost-saving among people who inject drugs. For example, a 2008 Canadian study estimated the cost per HIV infection averted at $20,100.[44] Another Canadian evaluation reported prevention of 24 HIV cases over five years following harm reduction implementation, yielding a cost saving of $4 for every dollar spent.[45]

Given the cost-effectiveness of addiction treatment centers and their role in HIV prevention, sustained financial support for these programs is essential. Continuous engagement of individuals in treatment is crucial for effectiveness, with benefits extending to the broader community by reducing transmission.[46,47] Additionally, such programs have demonstrated cost-effectiveness for abused women.[48–50]

In the general population, prevention and screening interventions exhibited favorable cost-effectiveness profiles compared to other approaches. Studies using mathematical simulation and economic modeling consistently confirmed the benefits of rapid HIV testing over conventional methods.[51–53]

Venkatesh et al found that early screening facilitated faster identification of high-risk individuals and increased average survival times.[54] Similarly, Yazdanpanah et al reported that one-time screening in France improved patient survival compared to standard screening practices in Western Europe.[55]

In summary, the available economic evaluations of HIV prevention interventions demonstrate systematic and transparent methodologies that can inform researchers, clinicians, and policymakers. These findings emphasize the importance of economic analyses in identifying cost-effective interventions and optimizing resource allocation for

sustainable healthcare systems. Nonetheless, this review reveals a paucity of comprehensive economic evaluations addressing HIV prevention, underscoring the urgent need for further research in this critical area.

One limitation of this review is the relatively small number of included studies, which resulted from our decision to restrict the inclusion criteria to economic evaluations using decision tree modeling. This approach was intended to ensure methodological consistency and enable direct comparisons across studies, although it may have excluded relevant research employing alternative analytic frameworks.

Conclusion

The evidence from this systematic review supports the effectiveness and cost-efficiency of HIV prevention methods. However, the available data pertain primarily to a limited number of countries and do not adequately account for differences in healthcare system characteristics and demographic contexts. This limitation makes it challenging to generalize the findings to countries with varying income levels and HIV prevalence rates.

Despite these limitations, the costs and outcomes associated with different prevention methods suggest that cost-effective approaches to HIV prevention do exist. Policymakers should consider deploying various prevention and screening strategies as effective means to combat HIV, especially in communities with relatively high disease prevalence.

Acknowledgments

This study is part of the military service project conducted by Hamid Talebianpour. The research was supported and approved by Baqiyatallah University of Medical Sciences (ID number: 4022000166). The research proposal (ID: IR.BMSU.REC.1402.079) has been approved by the Ethics Committee of Baqiyatallah University of Medical Sciences. The authors express their gratitude to Baqiyatallah University of Medical Sciences for their support.

Funding

This study was conducted as part of the military service project supported by Baqiyatallah University of Medical Sciences.

Disclosure

The authors declare that there is no conflict of interest in this work.

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