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Cost-effectiveness of HIV pre-exposure prophylaxis among female sex workers in Iran

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The Iranian government does not fund pre-exposure prophylaxis (PrEP), and it is not used in Iran due to uncertainties in its cost-effectiveness. In this study, we examined the cost-effectiveness of PrEP among female sex workers (FSWs) in Iran. The cost-effectiveness analysis compared only PrEP, a combination of PrEP with harm reduction (HR) with only HR scenario among FSWs over a 10-year time horizon. The perspective of the healthcare provider was used in the analysis. The primary outcome was disability-adjusted life year (DALY) averted. Analyses included health and cost outcomes, as well as the incremental cost-effectiveness ratio (ICER), which was reported as the cost per DALY averted. Only PrEP was not cost-effective at a willingness to pay threshold of 4669.6 USD per DALY averted in Iran. In contrast, PrEP and HR strategies were cost-effective at the same willingness to pay threshold. The ICER was 868.47 USD per DALY averted for PrEP and HR compared to HR alone. Compared to HR, combining PrEP with HR is a cost-effective intervention among Iranian FSWs for reducing the clinical and economic burden associated with HIV over a 10-year time horizon. Iran should add PrEP to current HR programs for FSWs.

Keywords Pre-exposure prophylaxis, HIV infections, Harm reduction, Sex workers, Cost-effectiveness analysis, Iran

Pre-exposure prophylaxis (PrEP) is an effective biomedical intervention for preventing HIV acquisition. The World Health Organization (WHO) has recommended using PrEP as a part of the HIV prevention strategy[1]. PrEP can play an important part in changing the HIV pandemic[2,3]. PrEP was also shown to be effective in reducing the risk of HIV infection among key populations at high risk for HIV, such as female sex workers (FSWs)[4–6]. Several studies investigated its use in various populations and settings. The effectiveness of Tenofovir Disoproxil Fumarate (TDF) or TDF plus Emtricitabine among men who have sex with men in high-income countries was 86% [3], among heterosexual adults in Botswana was 62%, in people who inject drugs in Thailand was 49%, and among FSWs in Uganda was 67% [7–9].

The increase in PrEP availability has substantially increased its implementation in recent years. The effectiveness of PrEP implementation in real-world contexts among vulnerable populations, particularly those facing significant health disparities, still requires further examination[10,11]. The cost-effectiveness of PrEP significantly varied among different populations[12]. For example, some PrEP users might be involved in sex work[13,14], and adherence to a daily preventive regimen may vary greatly[4,15], resulting in varying levels of clinical effectiveness. Similarly, the cost-effectiveness of PrEP can differ by geographic region, depending on baseline HIV prevalence and community antiretroviral therapy use[16].

Around the world, FSWs are disproportionately affected by HIV, making them an eligible population for PrEP. It is estimated that FSWs are at 30 times higher risk of acquiring HIV compared to the general female population[17]. FSWs are more likely to acquire HIV and other sexually transmitted infections (STIs) due to structural risk factors such as poverty, stigma, discrimination, violence, and the criminalization of sex work, all

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of which limit their access to HIV prevention, care, and treatment services[18]. In Iran, while the HIV epidemic has been mostly driven by injection drug use, studies indicate that sexual transmission of the virus is increasing in Iran[19]. Given the increased risk of HIV among FSWs, as well as their potential role in HIV transmission to the general population, FSWs play an important role in controlling HIV in Iran[19,20].

Iran's government has not yet accepted, funded, or recommended PrEP as a cost-effective intervention. Variations in HIV risk across different populations, local cost elements, adherence to PrEP, and heterogeneity in PrEP dosage and efficacy[3,7,8] were among the reasons for uncertainties in the cost-effectiveness of PrEP in Iran. To address this knowledge gap, this study aimed to assess the cost-effectiveness of implementing a PrEP program for FSWs in Iran.

Method

A decision tree modeling in TreeAge 2022 was used to perform the cost-effectiveness and sensitivity analysis on three strategies: (1) only routine HR, (2) only PrEP, and (3) PrEP and HR (Fig. 1).

Intervention and comparator

Three strategies were used, including implementing HR, PrEP, and combination of PrEP with HR. The second strategy focused solely on PrEP, while the third strategy combined PrEP with the HR program. The two strategies were compared with standard HR without access to PrEP. The HR program involved providing free sterile syringes, condoms, lubricants, and counseling services.

Target population

We ran our model for 1000 HIV-negative FSWs. We defined FSWs as women who exchanged sex for money, food, or gifts; had a history of inconsistent or no condom use with their sexual partner(s) within the previous 12 months. Also, women who had an HIV-positive partner were eligible for inclusion in the study[21,22].

Economic model

In the decision tree model, the case-averted and the Disability Adjusted Life Years (DALY) averted were considered as the outcomes and effectiveness of three strategies over a 10-year time horizon. The willingness-to-pay threshold was chosen based on the gross domestic product (GDP) of 4669.6 USD per DALY averted. In each approach, after initiating PrEP, individuals were reassessed after 12 months. Based on their HIV infection status, they were categorized into two groups: positive and negative. The negative group was monitored over the remaining period, with regular assessments to detect potential infections. Consequently, the 10-year HIV risk for 1,000 FSWs who commenced an initial high HIV incidence period of one year on PrEP was compared with the 10-year risk for the control cohort under the only HR strategy (Fig. 1). As economic evaluation studies are secondary studies and rely on primary study data, the parameters for this model were chosen based on a comprehensive literature review, expert opinions, and local data.

Model assumptions

We exclusively focused on modeling FSWs under the presumption that all prospective PrEP users would be part of this group. It was assumed that PrEP would only be offered to high-risk FSWs, following PrEP eligibility criteria. Additionally, it was assumed that the risk status of individuals who initiate PrEP did not change during

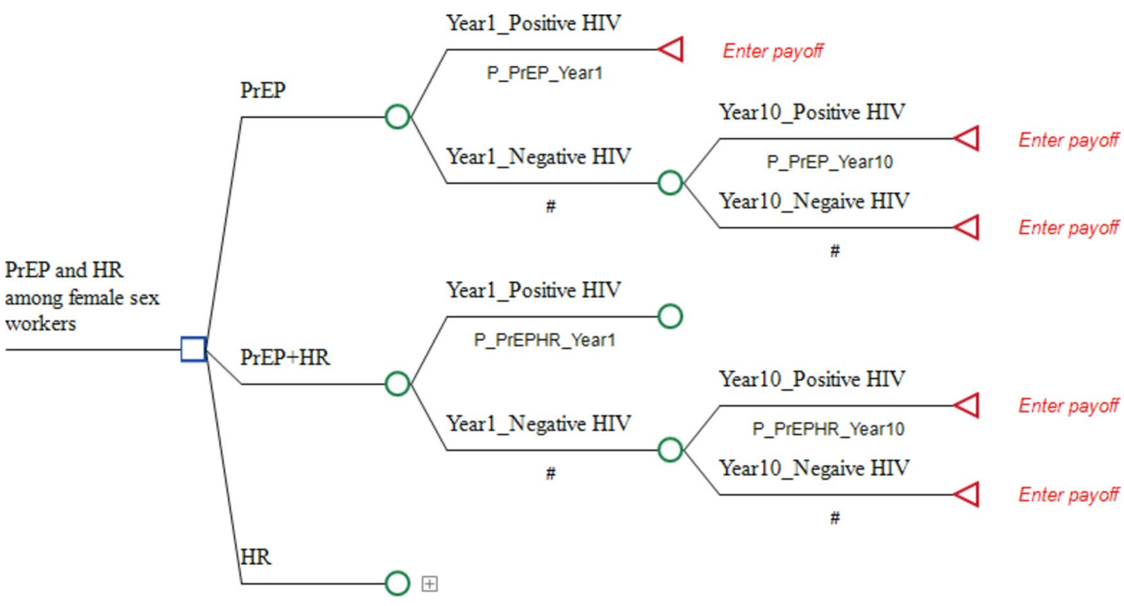

Fig. 1. Decision analytical model structure comparing PrEP, PrEP + HR with HR in 1,000 female sex workers at high HIV risk, Iran, 2023.

the modeling period. From a study in Australia[23], we use a one-year adherence rate of 76% (with a 95% confidence interval of 74–77). We also assessed how our results would depend on PrEP adherence by a sensitivity analysis.

We assumed that the infections occurred uniformly over time, and so the median time was considered for the group that became positive during the modeling. The cost of the group who became HIV positive was multiplied by five years instead of 10 years. In addition, the percentage of people who receive the HR program but do not use it was considered when calculating the costs. According to the national data, this percentage was calculated and applied to the costs of the HR program. If the cost of the HR program is the percentage of people using it (40%), some people may receive the services but not use them. Therefore, some of the costs are not considered, and they are underestimated. Consequently, we also calculated the percentage of people who receive the service but do not use it (20%), and we calculated the final cost based on the percentage of people receiving the service.

(20%+40%) *HR cost = annual HR program costs.

Model input data

Epidemiological parameter estimates

Epidemiologic data and probabilities were collected from reports by the Joint United Nations Programme on HIV/AIDS (UNAIDS), scientific literature, and national and international sources[4,23–26]. This included factors such as HIV incidence among FSWs in Iran, DALY averted, cases averted, PrEP adherence, HR adherence, and the probability of disease transmission to subsequent stages. The model utilized baseline scenarios, ranges for each probability, and the extent of each parameter for sensitivity analysis (Table 1).

Risk compensation

Some studies showed an increase in condomless sex and diagnoses of other STIs after people started PrEP[13]. This risk compensation can potentially increase the risk of HIV exposure[27]. Also, the expansion of the PrEP program may decrease adherence to PrEP and potentially result in increased HIV transmission. To investigate these risk compensations, our scenarios considered a 20% increase in HIV incidence among individuals receiving PrEP[28]. For instance, at a PrEP effectiveness rate of 70%, the annual HIV incidence can be calculated as (100% − 70%) * H = 30%, where H represents the HIV incidence among FSWs . If H is increased by 20% due to risk compensation, the annual HIV incidence becomes (100% − 70%) * (100% + 20%) * H = 36%.

Effectiveness

We employed a meta-analysis of trials to ascertain the effectiveness of PrEP among FSWs. Under the standard scenario, we applied the trial-based PrEP effectiveness estimate of 70% [4]. Moreover, to assess the effect of the HR program on HIV incidence among young FSWs, we analyzed the HIV incidence in this group between 2010 and 2014 and between 2014 and 2019. We estimated the potential effect of the HR program by focusing on the under-25 age group to control for other factors. Additionally, we cross-checked our findings with international research to validate the program's effectiveness, yielding closely aligned results (70% efficacy)[24,29].

If the effectiveness of PrEP is 70%, the annual incidence of HIV can be determined by calculating the remaining 30% (i.e., 70 − 100%), representing the incidence of HIV in the target population. To convert this

Variable	Base Case Value	Range in Sensitivity Analysis	Distribution	Reference
HIV incidence[a]				
Incidence among FSW with PrEP[b]	1.84	0.92–3.66	Poisson	[6]
Incidence among FSW with HR[c]	2.88	1.42–5.73	Poisson	Local data and[29]
Incidence among FSW with PrEP + HR	1.73	0.84–3.46	Poisson	Local data and[6]
PrEP adherence	68%	60 – 75%	Beta	[23]
HR adherence	50%	40 – 60%	Beta	Local data and[25]
Transition probability per year				
Probability of getting HIV for those with PrEP	0.0018	0.0091–0.0359	Beta	[6]
Probability of getting HIV for those with HR	0.0028	0.0014–0.0556	Beta	Local data
Probability of getting HIV for those with PrEP + HR	0.0017	0.0083–0.0340	Beta	Local data and[6]
Effectiveness (Clinical efficacy)				
Efficacy of PrEP to prevent HIV	70%	55 – 79%	Beta	[4]
Efficacy of Harm Reduction to prevent HIV	70%	58 – 79%	Beta	[24]
Cost parameter estimates				
Annual cost of PrEP drug	182.72	146.17–219.26	Gamma	Local data
Annual cost of screening for HIV and other STIs in the HIV-negative population	170.21	136.16–204.25	Gamma	Local data
Annual cost of Harm Reduction	40.91	32.73–49.10	Gamma	Local data
Discount rate, %/year	6%		Gamma	[46]
HIV-positive people DALY	1.08		Poisson	[32]

Table 1. Parameter values for the decision tree model and cost-effectiveness analysis. a: per 1000 population. b: Pre-exposure prophylaxis. c: Harm reduction.

proportion into a probability, the following formula was applied, which indicates a probability of 1 year of transmission at each node[30]:

$p = 1 - e^{-rtp}$.

Where:

e is the base of the natural logarithm (approximately 2.7182818).

r is the index ratio.

t represents the time period.

In addition, to calculate the incidence combination of PrEP with HR strategy, the following procedure was used:

P(Disease) = P(A) + P(B) + P(C) + P(D).

A (Probability of disease occurrence if both strategies are received).

B (Probability of disease occurrence if only the pre-exposure prophylaxis strategy is received).

C (Probability of disease occurrence if only the harm reduction strategy is received).

D (Probability of disease occurrence if neither strategy is received).

$I_{(PrEP+HR)} = A + B + C + D$.

Cost estimates

Our analysis was conducted from a healthcare provider viewpoint, consistent with national health evaluation protocols. Costs were inflated using the Iranian Consumer Price Index (CPI) for healthcare to adjust for inflation[31]. Total yearly PrEP program-related costs (annual cost of PrEP drug, annual cost of screening for HIV and other STIs in the HIV-negative population) and annual HR program-related costs were calculated (Table 1). Top-down gross costing approach was used to estimate mean costs for the HR program. Bottom-up micro-costing approach was used to estimate costs for the annual cost of the PrEP drug and the annual cost of screening for HIV and other STIs.

Outcome estimates

The model outcome included the number of HIV infections averted, the number of DALYs averted, and the incremental cost-effectiveness ratio (ICER), representing the cost incurred per DALY averted compared to only HR. Given the absence of validated Iranian data, DALY estimates for FSWs were obtained from Global Burden of Disease (GBD) assessments for the general population[32]. Additionally, international data were utilized when Iranian-specific information, such as the effectiveness of PrEP, was unavailable.

Cost-effectiveness analysis

For the primary economic endpoint, the ICER was estimated for each scenario using this equation:

ICER= [(Cost $_{\text{PrEP Strategy}}$ – Cost $_{\text{HR Strategy}}$) / (DALY averted $_{\text{PrEP Strategy}}$ – DALY averted $_{\text{HR Strategy}}$)]

To interpret cost-effectiveness, we defined a cost-effectiveness threshold per DALY averted (4,669.60 USD).

The ICER for each strategy was calculated relative to both the status quo and the next best strategy. Since there was no comprehensive study in this field in Iran, we referred to the WHO guidelines for developing countries. In the economic evaluation of healthcare, the WHO recommends that countries consider a healthcare technology cost-effective if its ICER is between 1 and 3 times GDP per capita[33]. Therefore, strategies with an ICER below the per capita gross domestic product (GDP) threshold (4,669.6 USD for Iran in 2022) were classified as cost-effective[34]. Furthermore, the net monetary benefit was calculated by initially assuming a willingness-to-pay threshold, followed by converting health benefits (DALY averted) into the common metric of US dollars. Subsequently, the cost linked to each strategy was deducted, resulting in the net benefit of each strategy expressed in monetary terms.

Net monetary benefit = (DALY averted * Willingness-to-pay threshold) – Cost.

Sensitivity analysis

Deterministic sensitivity analysis and probabilistic sensitivity analysis were conducted to address the uncertainty of model parameters and assess the model's robustness.

Deterministic sensitivity analysis

A one-way tornado diagram was generated to conduct sensitivity analysis, depicting the parameters with the most impact on cost-effectiveness analysis. Based on this diagram, one-way and two-way sensitivity analyses were conducted for the parameters exerting the greatest impact on cost-effectiveness (Fig. 2). For the one-way deterministic sensitivity analysis, we changed one parameter at a time by its published variance or ± 20% of its base values if variance data were unavailable. Furthermore, we conducted a two-way analysis to assess the concurrent impact of the parameters. The deterministic sensitivity analysis findings are depicted in a tornado diagram, highlighting the most influential parameters impacting the ICER (Fig. 2 and Additional File 1: Supplementary Material). Because entering all the variables together in the model did not provide an accurate estimate of the impact of the variables, we decided to put variables that are of the same type (we had one category of cost, which included cost and discount rate, and one category of effect, which included effects and probabilities). This category provides an accurate estimate of the impact of the variables on the cost-effectiveness outcome.

We examined a scenario involving different levels of PrEP adherence. In the adherence scenario, we considered adherence to HR as the baseline and modified PrEP adherence to assess its influence on the ICER.

Probabilistic sensitivity analysis (PSA)

Using a Monte-Carlo simulation method, multiway sensitivity analyses were conducted to delineate the degree of certainty regarding the cost-effectiveness of PrEP under varying levels of PrEP adherence (Table 2). In the

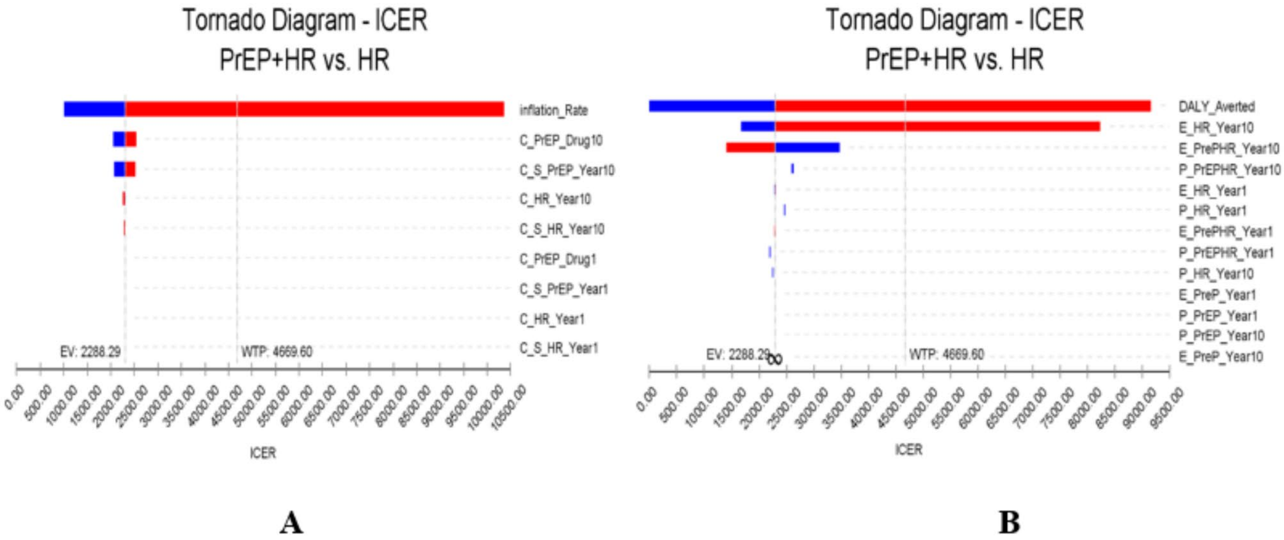

Fig. 2. One-way sensitivity analyses. The tornado diagram displays the sensitivity of the incremental cost-effectiveness ratio (ICER) of PrEP + HR compared to HR to variation in a large number of input parameter values (Chart **A** includes costs and inflation rates, and Chart **B** includes DALYs, effects, and probabilities).

PrEP[a] adherence	Strategy	Incremental costs ($)	Incremental DALY[b]	Incremental costs / DALY
68% (Baseline)	**HR[c]**	**0**	**0**	**0**
	PrEP	6236.04	0.23	27110.84
	PrEP + HR	6698.68	7.71	868.47
85%	**HR**	**0**	**0**	**0**
	PrEP	6412.85	0.32	20103.62
	PrEP + HR	7116.30	7.89	902.06
75%	**HR**	**0**	**0**	**0**
	PrEP	6323.68	0.29	21586.22
	PrEP + HR	6929.67	7.81	886.97
60%	**HR**	**0**	**0**	**0**
	PrEP	5968.10	0.19	31979.95
	PrEP + HR	6571.25	7.70	853.25
50%	**HR**	**0**	**0**	**0**
	PrEP	5733.86	0.14	40651.27
	PrEP + HR	6387.81	7.63	837.39
40%	**HR**	**0**	**0**	**0**
	PrEP	4789.37	0.10	50160.97
	PrEP + HR	6151.05	7.55	814.49

Table 2. Multivariate sensitivity of incremental cost-effectiveness ratio for different levels of pre-exposure prophylaxis adherence in female sex workers in Iran. a: Pre-Expusour prophylaxis. b: per 1000 population. c: Harm Reduction.

PSA, parameters were randomly sampled from selected distributions over 10,000 iterations, and the range for parameters was determined either from existing studies or through a ± 20% change in parameter values[35].

Ethical approval
The protocol and procedures of the present study were reviewed and approved by the research ethics committee of Kerman University of Medical Sciences (Ethics Code: IR.KMU.REC.1401.443).

Result
Base case analyses
Assuming baseline levels of PrEP adherence (68%), we estimated that over the next 10 years, 7 new HIV infections will be prevented among 1000 FSWs in Iran, resulting in 7.71 additional DALYs averted in the strategy combination of PrEP with HR compared to the HR strategy alone (Table 2). Moreover, implementing the PrEP

strategy alone would prevent 0.23 DALYs compared to the HR strategy alone. The annual cost of PrEP was 352.9 USD.

Combining PrEP with HR approach (without altering HR adherence) was the most cost-effective measure, with an ICER of 868.47 USD per DALY averted compared to only HR. Over 10 years, PrEP and HR would have an additional cost of 6698.68 USD. Over 10 years, using PrEP and HR was associated with an average incremental net monetary benefit of 140647.58 USD. Only PrEP was not a cost-effective measure under the baseline scenario (Fig. 3). Purple line (undominated) shows that among the options, "HR" and "PrEP + HR" are the undominated options, and they are on the efficiency frontier. The points on this line offer the best balance between cost and effectiveness. The PrEP point is dominated because it has a higher cost than HR and is less effective than PrEP + HR (Fig. 3).

Sensitivity analysis

Deterministic sensitivity analysis

Our results showed that ICER is very sensitive to the cost of PrEP drugs, inflation, case averted, and DALY averted (Fig. 2, A and B). If the inflation rate remains approximately below 30%, implementing PrEP and HR will be cost-effective. However, only the HR strategy would be more cost-effective if the inflation rate surpasses this threshold. Other parameters did not notably affect the ICER. Furthermore, the two-way sensitivity analysis indicated that if the DALY averted is below 0.5, the approach that integrates PrEP with HR programs will remain cost-effective for any new cases averted. However, if the DALY averted is greater than approximately 0.5, the cost-effectiveness of the strategies will depend on the number of new cases averted. In certain conditions, the combined PrEP and HR program will be cost-effective, whereas, in other circumstances, the HR program alone will be cost-effective (Fig. 2 and Additional File 1: Supplementary Material).

Scenario analyses

Scenario analyses demonstrated that reducing PrEP adherence from the baseline level of 68% resulted in a decrease in the proportion of HIV infections averted, as well as reductions in costs and incremental DALY. Nevertheless, across all scenarios of PrEP adherence, the PrEP and HR strategies were cost-effective. If PrEP adherence is reduced by 40%, the ICER decreases from 868.47 USD to 814.49 USD per DALY averted (Table 2).

Probabilistic sensitivity analysis

The results of the probabilistic sensitivity analysis were presented as a scatterplot illustrating cost-effectiveness, with incremental DALY and incremental cost plotted for each iteration (Fig. 4). PrEP and HR strategy with a threshold of 4,669.60 USD was a cost-effective strategy with a probability of 77.1%. In contrast, only PrEP was not cost-effective when compared to HR for any scenario (Fig. 5).

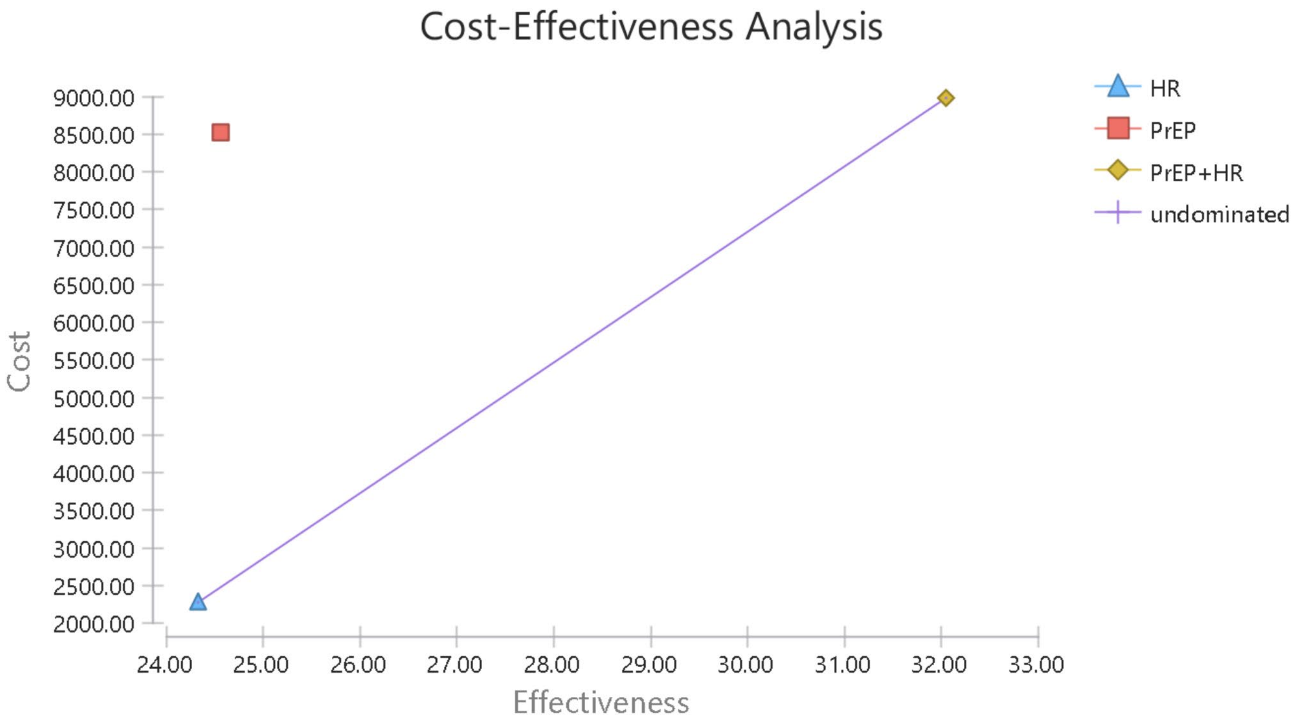

Fig. 3. Cost-effectiveness (quality-adjusted life-years versus total costs over 10 years) of 76% scale-up for single or combination programs.

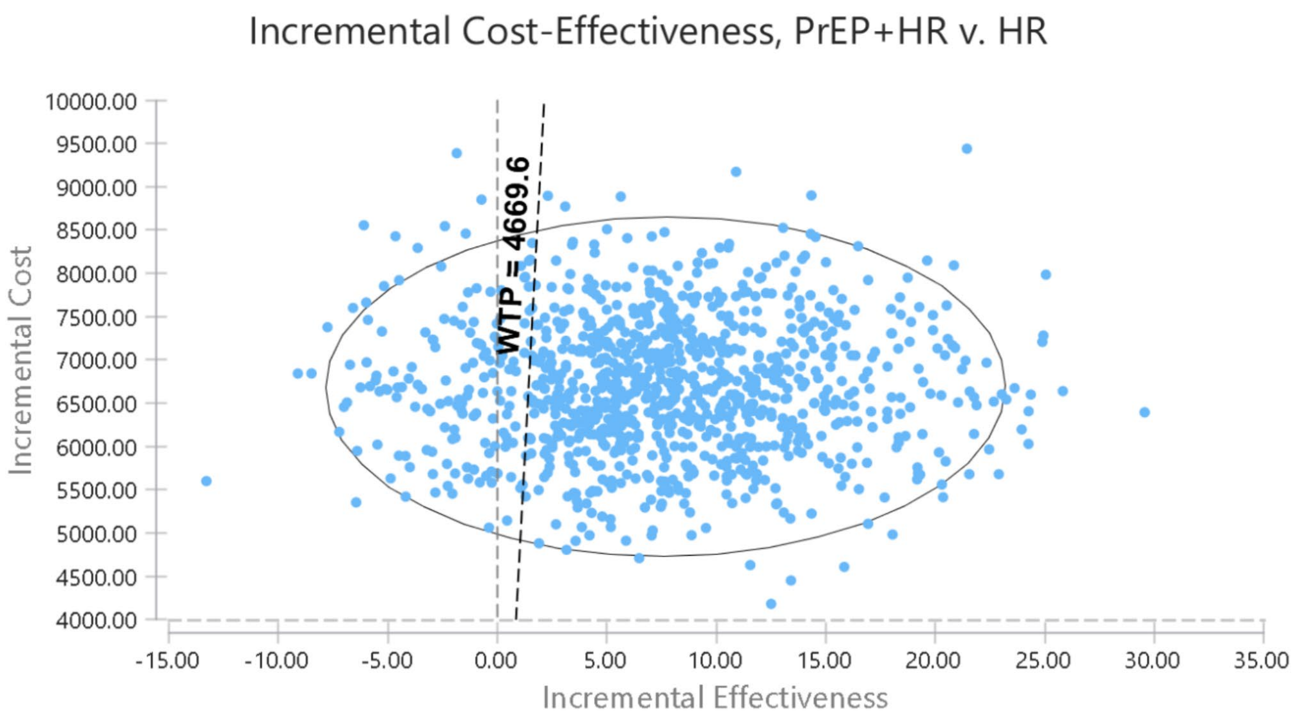

Fig. 4. Incremental cost-effectiveness, PrEP + HR, versus HR. Each dot represents an individual simulation of the Monte Carlo analysis. The x-axis represents the additional DALY averted per FSW (across all risk groups). The Y-axis represents the incremental cost per FSW (across all risk groups).

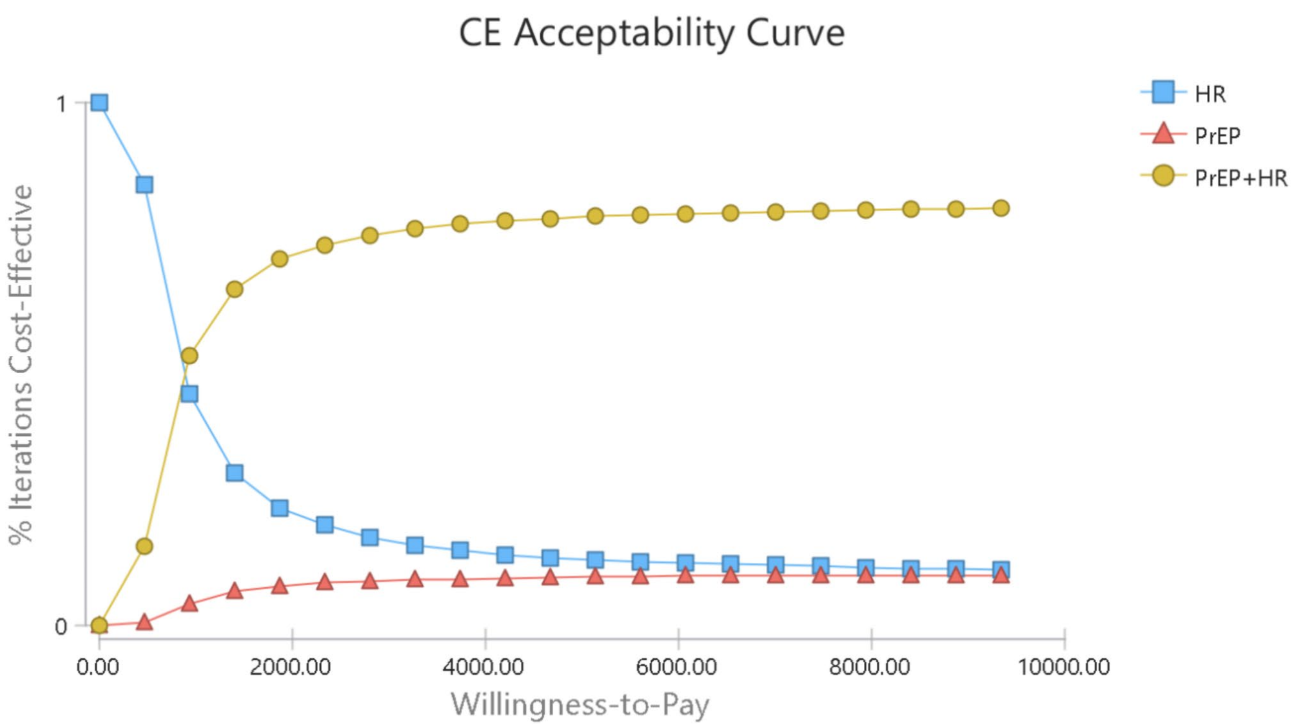

Fig. 5. Cost-effectiveness acceptability curve. The cost-effectiveness of PrEP availability for three interventions, PrEP, PrEP + HR, and HR for female sex workers, was assessed through a Monte Carlo simulation. = Willingness to pay (WTP) – US$4669.6/ DALY averted.

Discussion

We found that among FSWs in Iran, combination of PrEP with HR was cost-effective at a willingness to pay threshold of 4669.60 USD per DALY averted in Iran. The incremental costs of adding PrEP to the current HR program are minimal. Over a decade, the combined PrEP and HR strategy was projected to avert seven new infections and accrue more than 7.71 DALY compared to the current HR program (standard of care) for FSWs. Despite these benefits, the cost of this strategy increases the current program's expenses by 4-fold (8981.33 USD vs. 2282.66 USD). Sensitivity analyses highlighted the importance of PrEP drug costs and inflation rate. If the inflation rate remains below approximately 30% and the annual PrEP drug costs remain around 182 USD, implementing the PrEP strategy alongside HR would be deemed cost-effective, even with the change in adherence levels.

Our results showed that the PrEP strategy was not cost-effective compared to the HR program alone. Several factors may impact the cost-effectiveness of only PrEP. Firstly, the relatively low HIV incidence among FSWs in Iran impacts the potential impact and cost-effectiveness of PrEP compared to settings with higher incidence[36]. Secondly, the intervention costs in our study were substantial due to the resource-intensive nature of the interventions, as shown in some other studies. A study in Sub-Saharan Africa showed that combining PrEP and HR among FSWs proved to be a cost-effective strategy[37]. In addition, a study in Malawi found that integrating PrEP with HR programs may have beneficial effects on PrEP among FSWs[38]. In contrast to our results, some studies indicated that using PrEP alone was among the most cost-effective interventions in FSWs. Woods et al. showed that implementing PrEP alone was among the most cost-effective among FSWs[39]. Another study by Jamieson et al. demonstrated that using PrEP by FSWs in South Africa was cost-effective[40]. This discrepancy is primarily due to the type of PrEP (oral and injectable versus oral only) and the higher incidence of HIV in these studies compared to our study (4.8% versus 3.3%). Although the impact of the difference in HIV incidence and the costs of PrEP in these countries compared to Iran on the cost-effectiveness of PrEP is undeniable, the findings emphasize the importance of combining PrEP with Iran's HR program.

Our estimated ICER for the expansion of combining PrEP with HR strategy was 868.47 USD per DALY averted, which was lower than estimates for interventions aimed at FSWs in New York City (31,970.00 USD)[41]. A projected implementation of PrEP within the Iranian sex worker population, based on current population estimates and PrEP eligibility, is expected to avert 351 DALYs over 10 years[26]. This strategy could result in saving of more than $46 million over that same period, accounting for the annual financial burden associated with each HIV-positive case in Iran[42]. In contrast to our results, a study indicated that expanding PrEP among South African FSWs and women aged 15–24 was deemed cost-effective at a willingness-to-pay threshold of 1,175 USD per DALY averted[39]. Moreover, Jamieson et al. found a cost of 858 USD per HIV infection averted by delivering PrEP to FSWs in South Africa, a country with a much higher incidence of HIV than Iran[40]. Notably, the costs of delivering PrEP in that study were markedly lower than those estimated in our study, amounting to 134 USD per FSW in the first year. This disparity primarily arose from the substantially lower costs of HIV screening and PrEP drugs (3.85 USD) in their study compared to ours (352.93 USD). Furthermore, a comprehensive study spanning 42 countries across the African continent demonstrated that the implementation of PrEP alongside HR programs proved to be a cost-effective strategy, with HIV infections averted per 100,000 adults ranging from 500 in Lesotho to 10 in Somalia. The ICER ranged from 5,800 USD per DALY averted to 44,600 USD per DALY averted[37]. These variations may be attributed to setting differences, PrEP targeting strategies, or underlying model assumptions.

Our results showed that the annual cost of PrEP was 352.9 USD. In a 2016 study, Eakle et al. investigated the annual cost associated with PrEP among FSWs. They found the annual cost of PrEP delivery in South Africa to be 126 USD[43]. The cost of delivering PrEP in that study was lower than that estimated in our study per FSW in the first year. Jamieson et al. found that the cost of PrEP delivery in South Africa was 134 USD per FSW in the first year, which was much lower than those estimated in our study. This is because the costs of tests and drugs were lower than those in our study[40]. One other study in Benin in 2014 found that the mean initiation cost for PrEP was 268 USD[44]. In addition, a study conducted in Zimbabwe in 2018 revealed lower annual PrEP provision costs compared to the present study's findings[45]. These differences may be attributed to variations in drug costs and the number of visits in different contexts.

Our study had seven main limitations. First, our model used the available data from multiple sources for HIV incidence, transmission probabilities, and other demographic data. While this approach allows for comprehensive integration of available epidemic knowledge, it can be challenging to calibrate all datasets simultaneously. Second, due to the lack of similar studies conducted in Iran, data from studies in other countries were used as a reference for our research. However, the context in these countries may differ from that of Iran, which could influence the results of this study. Therefore, we recommend conducting original studies within Iran to better capture the local context and ensure more accurate and relevant findings. Third, we did not account for the PrEP utilization or HR program status of participants' sexual partners. If PrEP were targeted towards individuals whose partners were less likely to use HR, we would anticipate PrEP to be more cost-effective. Conversely, if individuals on PrEP were more inclined to form sexual partnerships with HR users than non-users, this would reduce the estimated cost-effectiveness of PrEP. Fourth, we assumed uniform PrEP coverage, regardless of risk or age, across the entire population. This assumption was made for simplicity and due to the lack of available data regarding age- and risk-specific contact patterns. If PrEP coverage is higher among individuals within the FSW group who are at a high risk of infection, then PrEP would likely be more cost-effective. In contrast, if high-risk groups are also challenging to reach with PrEP, its cost-effectiveness would be lower than estimated. Fifth, we used annual cost data, which is appropriate for evaluating the PrEP intervention and aligns with established norms in health economic evaluations, enabling comparisons with other studies. However, this approach may obscure cost variations over shorter timeframes, such as monthly or seasonal. Despite this limitation, it offers a suitable overview of the long-term costs associated with PrEP implementation within the study population.

Sixth, given the sample size of 1,000 individuals per each branch, it may not be large enough to capture the true effect of changes in adherence accurately. Lastly, many of the estimates and assumptions that were used were from global data due to the lack of these data in Iran. For more precise cost-effectiveness outcomes, future original studies would need to determine these estimates (e.g., the efficacy of PrEP to prevent HIV) for Iran.

Conclusion

In brief, we showed that combination of PrEP with HR in Iran is a cost-effective intervention. It is projected to decrease HIV incidence and contribute over 7.71 DALYs to the population within a decade. Adding PrEP to HR is anticipated to demonstrate cost-effectiveness at a threshold equivalent to one GDP per capita. Iran's HIV program should consider adding PrEP as a prevention measure for FSWs, carefully implementing and monitoring PrEP adherence to ensure the benefits.

Data availability

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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Author contributions

"MH Collected the data, performed the analysis, and wrote the paper, HS designed the study, made final decisions on the inclusion of journal articles, and revised the manuscript, RG designed the study and performed the analysis, AAH assisted with the design and writing of the study, AMM conceived the study and revised the manuscript, PS conceived the study and revised the manuscript, MG designed the study and revised the manuscript and PM revised the manuscript. All authors reviewed the manuscript."

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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