Cost-Effectiveness of Osteoporosis Screening in Women Over 40-Year-Old

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Abstract- Osteoporosis is a disease recognized by bone density reduction and is particularly common among older women, which imposes them to fractures. The evidence shows that if do no serious conflict with this issue, in the far little future, huge costs will be imposed on individuals, families, and the country. In this study, we studied the cost-effectiveness of osteoporosis screening in women over 40 years of age in Shiraz in 2016. This cross-sectional study was performed on 240 persons who were screened and 240 non-screened persons in the bone mineral density ward of Shiraz Namazi Hospital. The costs were identified and from the perspective of the insurer and the payer, which included only direct health care costs. To measure the effectiveness, the use of indicators as quality-adjusted life-years (QALY), the expected cost and effectiveness, and the Incremental cost-effectiveness ratio were calculated. The results showed that non-screening is the best strategy, given that the amount of ICER was obtained at $38484.56 and the threshold. As a result, the non-screening method compared to screening is cost-effective. The relevant authorities and proficients should prevent the progression of disease complications and consequently prevent the increase of the disease cost and improve the quality of life of the patients.

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Keywords: Osteoporosis; Cost-effectiveness; Screening

Introduction

Osteoporosis is a disease recognized by bone density reduction and is particularly common among older women. It is a major risk factor for fractures, often seen on the wrists, spine, and pelvis (1).

Some of the factors that contribute to reducing bone density, including a family history of osteoporosis, aging, or menopause, are unavoidable. However, lifestyle changes, including doing physical activity and increased use of supplements and foods rich in calcium and vitamin D, can prevent the occurrence and development of osteoporosis (2).

Osteoporosis is much more common than previously thought. The prevalence of the disease varies from country to country or even in different parts of a country (3), from 10 to more than 30 percent (4,5).

Osteoporosis is a major health problem in the United States, affecting about 10 million people, and it is anticipated that by 2025 the annual costs and fractures will increase by 50% (3).

Vertebra fractures caused by osteoporosis are frequent among Spanish women over 60 years old (6).

Thus, due to the high prevalence of osteoporosis, especially after menopause, and increased mortality, fractures, disabilities, and high costs of treatment, screening is highly recommended (7). Several studies pointed out the effective role of screening, increasing quality-adjusted life-years (QALY) in the women screened, and financial savings (8-12).

In Iran, various studies have also been conducted on this issue which shows the financial burden of pelvic fractures causes $588 per patient every year and should therefore be considered as a major economic-health problem (13).

Prevalence of osteoporosis in women over the age of

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50 showed that the prevalence of osteopenia and osteoporosis in the spine was 29.6% to 52.5 and 7.4% to 26%, respectively, and 29.6% and 3.9% in the femur, respectively in Iran (7,14,15).

Results of a study in Iran showed that interventions to modify two risk factors, including low serum vitamin D levels and low calcium and vitamin D intake is easy, moderate, and hard cases, reduced the burden of osteoporotic pelvic fractures by about 5%, 11% and 17%, respectively (16).

As can be seen, the studies conducted in Iran were mainly on the incidence and severity of osteoporosis, its consequences, and the prediction of its financial burden, to the knowledge of the researchers. Considering the importance of the measurement of screening costs compared to its effectiveness, which had not been studied previously, and due to the importance of osteoporosis and the need for evaluating the cost-effectiveness of screening for this disease that could play a significant role in improving the patients' quality of life and help policymakers in the health sector to choose the most effective strategy in this field, the present study aimed to investigate the cost-effectiveness of osteoporosis screening in women over 40 years of age in Shiraz in 2016.

Materials and Methods

This cross-sectional study is of economic evaluation type with cost-effectiveness calculation. The calculation of costs in this study was based on the perspectives of the patients and the insuring organizations, and the direct medical costs (hospital, physiotherapy for fractures, and drug costs) and screening costs were calculated. Due to the retrospective nature of the study data, the costs in the study year (2016) were converted to their current value using the following formula:

Cost×(price index value in the year of cost occurrence/price index value in 2015)=current value of costs in 2016

The study population consisted of 30,000 women over 40 years of age who had been referred to Namazi Hospital in Shiraz for bone mineral densitometry during the years 2001-2011. In order to calculate the sample size, due to the lack of a similar study, in a pilot study on a population of 30 people, a fracture ratio of 7% in the screened group was found. It should be noted that in the present study, the patients were divided into two groups: those who underwent screening and those who did not. Hence, given a confidence coefficient of 95%, 80% power, and fracture ratio of 7% in the screened group (P1) and 15% in the unscreened group (P2), at least 240 samples were needed for each group based on the following formula:

$$n_1 = n_2 = \frac{(z_{1-\alpha/2} + z_{1-\beta})^2 \left[p_1(1-p_1) + p_2(1-p_2)\right]}{(p_1 - p_2)^2}$$

In this study, the convenience sampling method was used, as the subjects were available at the time of the study. It should be noted that the patients in the screening group were those who had been referred to Namazi Hospital for bone densitometry during 2001-2011, and the non-screening group included the patients who were the same age in 2017 as those who were screened during 2001-2011, but did not undergo screening tests in that decade.

The inclusion criteria were as follows

1. Female patients over 40 years of age who had been referred to Namazi Hospital's bone densitometry center for screening tests during 2001-2011 (screening group).

2. Female patients over 55 years of age who were referred to Namazi Hospital's bone densitometry center for screening tests for the first time in 2017 who was 40 years old during 2001-2011 (non-screening group).

The exclusion criteria included the following

1. Female patients aged 40-55 years who were referred to Namazi Hospital's bone densitometry center for screening tests in 2017.

2. Patients who had osteoporotic bone fractures at least five years after bone densitometry.

3. Patients who refused to participate in the study for personal reasons.

The data gathering tool was a researcher-made data collection form, comprising demographic information such as first name, last name, age, height, weight, occupation, age of menopause, drugs used and underlying diseases, cost information, and other information including fractures, family history of osteoporosis, using cigarettes or hookah and doing physical activity. The data were collected using the patients' medical records or through phone calls. Due to the objectivity of the data, there was no need to measure the validity and reliability of the data collection tool.

In this study, the decision tree model (Figure 1) was used, and we also used the quality-adjusted life years index (QALY) to measure the effectiveness. To calculate the QALY, once the utility was determined using the European Quality of Life-5 Dimensions (EQ5D), the time

elapsed was multiplied by a particular situation and the utility associated with that situation, and the QALY was obtained.

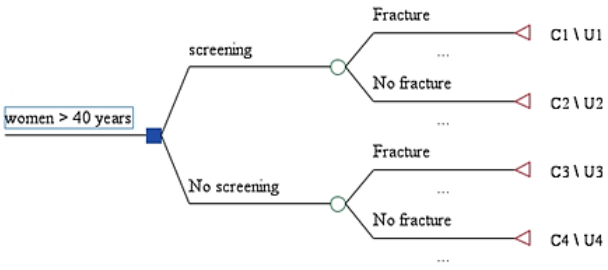

Figure 1. Decision tree for osteoporosis screening and non-screening groups of women over 40 years of age

The EQ5D questionnaire, which is a general quality assay tool, contained six questions that covered six domains of mobility, self-care, routine activities, pain or discomfort, anxiety or depression, as well as health status rating figure Questions 1 to 5 had three scales each. Scale 1: The patient has no specific problem, Scale 2: The patient somewhat has a problem, Scale 3: The patient has a serious problem. The health rating figure was also graded from zero to 100, on which the person determined her current health status. Previous studies reported the validity and reliability of the questionnaire to be 0.77 to 0.88 for various parts. Also, the Cohen's kappa coefficient of 0.61 to 1 for different parts was obtained through the re-evaluation of the questionnaire (17). The questionnaire was also localized for Iran by Goodarzi *et al.*, (18).

In order to analyze the data, the statistical methods, the Chi-square test for comparing the ratio of qualitative variables, and the independent t-test for comparing the ratio of quantitative variables in the two groups were used at a significance level of P=0.05. Then, in order to provide the results of the cost-effectiveness analysis, the incremental cost-effectiveness ratio calculated by dividing the cost difference by the effectiveness difference was used.

Having calculated the incremental cost-effectiveness, we used the one-way and probabilistic sensitivity analyses to increase the precision and accuracy.

All stages of this research were conducted in accordance with the principles of ethics in research, and the names of all the participants remained confidential. Besides, necessary permissions were obtained from the relevant authorities.

Results

According to the results of this study, 42.5% of the 480 patients studied were aged 60-69 years, 54.4% had menopausal age of <50, 84% were housewives, 87.7% lived in urban areas and 42.3% had elementary education.

Regarding the use of medications that might exacerbate osteoporosis, 47.5% were gastric drugs, and 39.4% were corticosteroids. 38.3% of the subjects had a family history of osteoporosis, and the highest incidence of underlying diseases was that of rheumatism (37.1%).

Besides, 19.2% of the subjects had fractures, mainly in the wrists, with a frequency of 8.5%. About 13.8% of the participants used tobacco, 31.9% suffered from shortness due to osteoporosis, and 57.3% did not have any physical activities, such as exercise and walking.

Based on the findings of investigating the relationship between the quantitative variables in the two groups using the independent t-test, the mean age (P<0.001), body mass index (P=0.003), and menopausal age (P<0.001) of the non-screening group were higher than those of the screening group. Furthermore, the results of investigating the relationship between the qualitative variables in the two groups using the Chi-square test showed that the mean education level (P<0.001) varied, and primary education was more common in both groups. Besides, the family history of osteoporosis (P<0.001), the underlying diseases such as rheumatism (P<0.001) and hypothyroidism (P=0.019), the incidence of shortening (P<0.001), and the use of gastric drugs (P<0.001) as well as corticosteroids (P<0.001) and anticoagulants (P<0.008) were higher in the screening group than the non-screening one, but the fracture rate (P=0.037) in the non-screening group was higher than in the screening group.

The results of cost-effectiveness analysis and comparison of different interventions using the incremental cost-effectiveness indicator showed which interventions (screening and non-screening in this study) used the resources more properly. The results are shown

in Table 1. As can be seen in the table, screening, compared to non-screening, would increase costs and effectiveness by $588.43 million and 0.01, respectively. In order to make a decision, the incremental cost-effectiveness ratio was first calculated (ICER=$38484.56) and then compared with the threshold.

In order to calculate the threshold, the WHO method was used so that if the ICER indicator was below three times as much as the per capita GDP, the program would be cost-effective (19). According to the World Bank, the per capita GDP of Iran based on the purchasing power parity was $19948 (20). That's according to the exchange rate of 12000 Rials (21), the per capita GDP was $ 6393.59 dollars, and the threshold was three times as much (i.e. $19180.77). Hence, the screening method was not cost-effective with respect to the threshold.

Sensitivity analysis

Since any economic evaluation study is associated with uncertainty, the stability and generalizability of the results of this study were examined using one-way and probabilistic sensitivity analyses (22). In the one-way sensitivity analysis, the Tornado figure was plotted with an increase of 20% in the initial data. According to the results of the Tournado Figure 2, the incremental cost-effectiveness ratio had the highest sensitivity to the QALY (utility) of the patients in the non-screening group who had fractures and had the least sensitivity to the costs of the patients in the non-screening group who had no fractures. In fact, the "QALY of the patients in the non-screening group who had fractures" was the determining factor in the ICER. (Figure 3 shows probabilistic sensitivity analysis in both screening and non-screening groups).

Figure 2 shows the results of probabilistic sensitivity analysis, in which the horizontal axis is the incremental effectiveness, the vertical axis is the incremental cost, and the dotted line is the coordinate axis, showing the first, second, third, and fourth quarters. This figure was plotted using the Monte Carlo simulation for a sample of 10,000. The results showed that in 95% of the spot distributions, no screening was an optimal strategy. (95% of the spot distributions were in the accept zone and lower than the threshold in the Fourth quarter of the cost-effectiveness plan). Given the ICER index of $ 38484.56 and due to the threshold ($19180.77), the no screening method was cost-effective compared to screening.

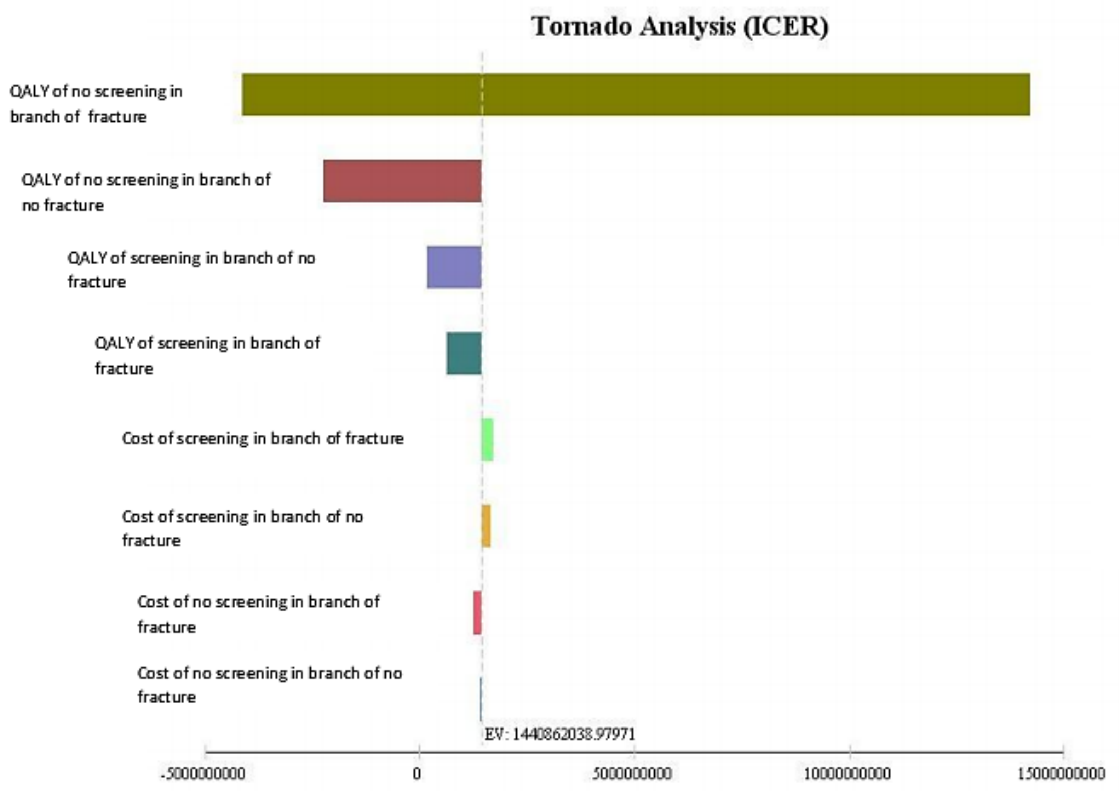

Figure 2. Tornado for one-way sensitivity analysis of both screening and non-screening groups of women over 40 years of age

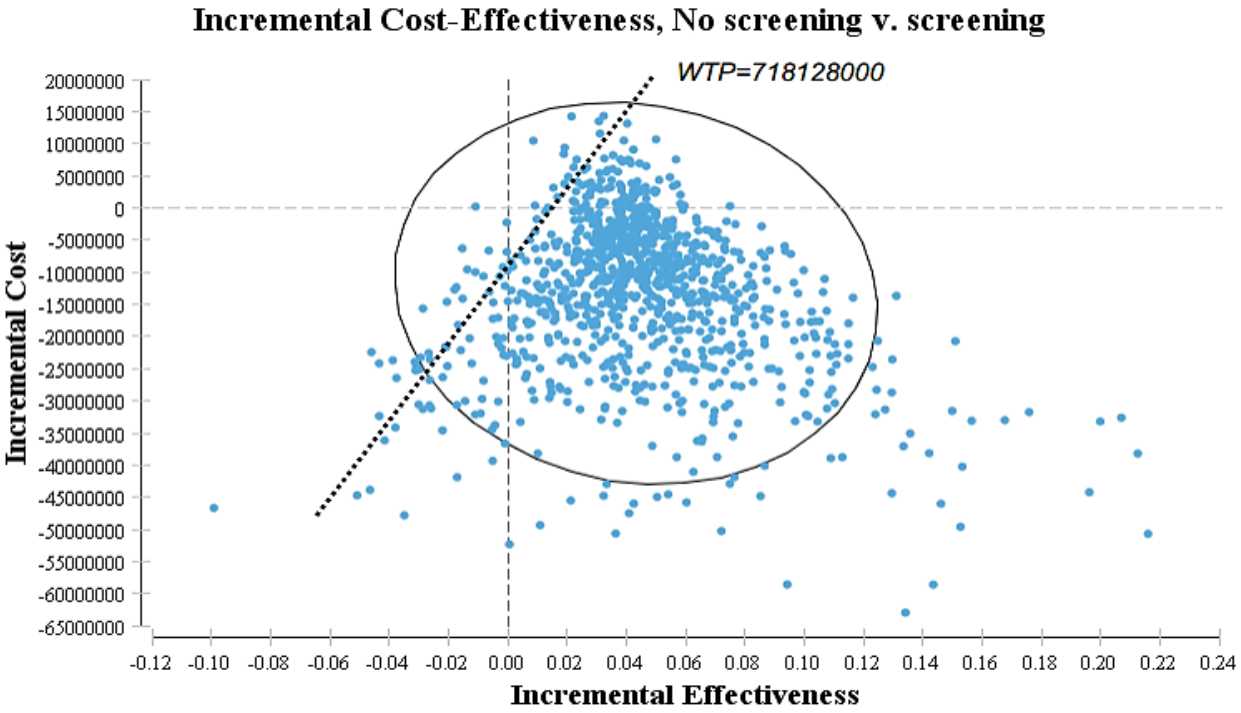

Figure 3. Cost-effectiveness dispersion related to probabilistic sensitivity analysis in both screening and non-screening groups of women over 40 years of age, 2016

Table 1. Results of decision tree for screening and non-screening groups of women over 40 years of age in 2016

Group	Cost	QALY	Cost difference	Effectiveness difference	Result
Screening	$1003.77	0.63	$ 588.43	0.01	Needs a comparison of ICER and threshold
Non-screening	$415.35	0.62			

Discussion

The aim of any economic evaluation study, especially in the field of medical decision-making, is to raise awareness among policymakers about the costs and effectiveness of technologies, interventions, and therapeutic methods. Therefore, the present study aimed to offer policymakers to choose of the most cost-effective method from among screening and non-screening ones for osteoporosis patients.

The findings of this study showed that the mean direct medical costs of the screening and non-screening groups were $1003.77 and $415.35, respectively. The mean cost of surgery (fracture) in the screening group was $492.70, which was 49.08% of the direct costs. But the mean cost of surgery (fracture) in the non-screening group was $346.65, which was 83.46% of the direct costs. Besides, the fracture rate in the screening and non-screening groups was 15.4% and 22.9%, respectively. Therefore, considering the fracture rate, it could be said that clinically, screening reduced the fracture rate and, consequently, the costs, compared to no screening. In their study, Nshimyumukiza *et al.*, stated that screening and treatment for women aged 40-64 was the most cost-effective intervention and caused cost saving, too (11).

The results of the study by Soheili Azad.et al (2005) in Iran showed that high fracture costs and estimated total treatment costs were about $2549889.14 per year (13).

Winzenberg *et al.*, (2016) also stated in their study in China that treatment and screening strategies led to cost saving. They also emphasized the need for screening at the age of >65 years (23).

According to the results of this study, the mean QALY (utility) of the screening and non-screening groups was 0.63 and 0.62, respectively. Meanwhile, the mean QALY of the screened patients in the two groups who had

fractures and those who did not was 0.60 and 0.64, respectively. However, the mean QALY of the non-screened and screened patients was 0.58 and 0.63, respectively. According to the findings of this study, it could be said that the quality of life of the patients who underwent screening was better than that of those who did not. The difference in the quality of life could be due to pain, discomfort, anxiety, and depression in the patients who were not screened. Capatina *et al.,* (2017) also pointed out that the quality of life of osteoporosis patients was affected by pain and fear of falling down and breaking their bones (24).

Kown *et al*., (2016) found in their study that compared to other fractures, vertebral ones strongly affected the quality of life of osteoporosis patients (25). Similarly, Hallberg *et al.,* (2009) found that non-pharmacological interventions for women with osteoporotic fractures had to be prioritized in order to increase or maintain their quality of life (26).

Altinda *et al.,* (2007) argued that physical, emotional, and psychological disorders, as well as increased pain due to osteoporotic fractures, had affected the patients' quality of life (27).

The results of the study by Park (2018) indicated that women with osteoporosis had significantly higher disabilities in EQ5D dimensions, especially mobility, pain/discomfort, and activity rates, compared to healthy subjects. This significant relationship between osteoporosis and health-related quality of life in 60-year-old Korean women indicated that prevention and treatment of osteoporosis were necessary for improving older women's quality of life (28).

As observed, various studies suggested those osteoporotic fractures or the probable fear of it might lead to inappropriate mobility of the people at risk and affect their quality of life.

The findings of the cost-utility investigation in the present study showed that, compared to no screening, the screening method was not cost-effective according to the WHO threshold.

But in their studies, Hiligsmann *et al.,* Nayak *et al.*, Kingkaew *et al*., and Ito *et al*., concluded that screening was the best strategy with an incremental cost-effectiveness ratio per QALY (8,10,29,30).

The results of this study emphasized their effect on improving the patients' quality of life. Therefore, it is recommended that authorities and specialists recognize the disease early, especially for more prone people who take certain medications that can exacerbate the disease or cause its early onset and those with a family history of osteoporosis.

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