

Original Article

Cost-Effectiveness of Mammography Screening for Breast Cancer in a Low Socioeconomic Group of Iranian Women

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Abstract

Background: Breast cancer is the most common cancer among women. Mammography screening has been used in many countries to reduce early deaths caused by breast cancer. It is important to ensure that screening programs are effective and efficient. We conducted a study to assess the cost-effectiveness of a national breast cancer screening program implemented in Iran.

Methods: The perspective of the present study was the health system. Over 26,000 women aged 35 and higher, of low socioeconomic background were recruited from ten cities in the program. We used case-finding as the outcome indicator for assessing effectiveness of the program. We measured the service provision costs, the coordination costs and supervision costs of the program that included the staff costs, and measured cost per detected case. We also conducted sensitivity analyses and calculated false-positive rates as a result of the screening program.

Results: The total cost of breast cancer screening program was estimated at \$377,797. The program resulted in the identification of 24 patients with breast cancers, not different from baseline expectations without a screening program. The cost per cancer detected was calculated \$15,742. The minimum and maximum cost per breast cancer detected were about \$13,524 and \$16,947, respectively. We observed a false-positive rate of 7.5% among the target population.

Conclusion: Our findings suggest that the mammography screening program was not cost-effective. Although there were technical efficiency issues in the conduct of the program, the findings do not support the implementation of national mammography screening programs in Iran in women aged less than 50 years. Careful studies of such programs for higher age groups are also recommended before they are rolled-out nationally.

Keywords: Breast cancer, cost effectiveness, Iran, screening

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Introduction

In women, breast cancer is the most common type of cancer as well as the most frequent cause of malignancy related death.¹ Annually, more than 1.1 million women are diagnosed with the disease around the world, and about 410,000 women die during the same period because of this malignancy.^{1,2}

Breast cancer is prevalent among Iranian women, accounting for over 21% of the total number of cancers reported in this population.³ The incidence and prevalence of the disease in Iran is reported at 22 and 120 per 100,000 women aged 15–84 years, respectively.⁴ According to the Tehran Cancer Registry, the incidence rate of breast cancer in this city was about 24.8 per 100,000 women in 1998–2001.⁵

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The burden of breast cancer is high, as it significantly lowers the health-related quality of life while increasing the need for costly healthcare interventions. Moreover, due to its high incidence and the difficulties of treating the advanced stages of the disease, breast cancer imposes a heavy burden on health systems. Some studies have suggested that mammographic screening is an effective method for reducing the negative economic and health related impacts of breast cancer.^{6,7}

In 2007–2009, Iran implemented a health assessment program aimed at low socioeconomic women who were the sole heads of households in eleven province capitals (Tehran, Shiraz, Mashhad, Isfahan, Tabriz, Kerman, Yazd, Rasht, Kermanshah, Gorgan, and Qom).⁸ In 2011, these eleven cities comprised about 29% of Iranian population.⁹ The program covered about 30,000 females heads of households and was conducted by the Iranian Ministry of Health and Medical Education's Division for Women and Family Issues.⁸ The participants in the program were recruited via active campaigning among the target groups by the Ministry of Health and Medical Education (MOHME) and two other welfare organizations (the Imam Khomeini Relief Foundation and the Welfare Organization). Conducting breast cancer screening by mammography was a major element of the program, planned to cover all women aged 35 years and above. The program also included screening for cervical cancer as well as blood examinations for fasting blood sugar, anemia and cholesterol levels. Breast cancer screening was the single most costly element of the program and

the main reason for conducting it. Other elements were added to the program to use the opportunity and gain more value for money by further assessment of the target groups. All the services were offered free of charge.

Conducting a screening program at national level would inevitably impose a financial burden on the health system. It is in no way certain that the benefits of conducting such programs would outweigh the costs, especially as the program was conducted in Iran without a priori assessment of its cost-effectiveness. It was rather based on the assumption that breast cancer screening using mammography is an effective tool to improve population health. As such, the Ministry of Health and its partners were willing to offer such services to vulnerable women.

The MOHME was keen to assess the cost-effectiveness of the program it had implemented in order to use the findings for improving the design of breast cancer screening programs, and to justify the budget and resources required for them.¹⁰ We conducted the study with the aim of assessing the cost-effectiveness of the breast cancer screening program that was implemented nationally for low socioeconomic women in Iran. We focused on breast cancer screening, as it was the main element of the program.

Materials and Methods

Perspective

The present study assessed the cost effectiveness of breast cancer screening program from the perspective of the health system or the healthcare provider, which in this case is the MOHME that has paid the direct costs of the program.

Population and setting

The women were sole heads of their household and at the same time, received financial support from Iran's Welfare Organization or the Imam Khomeini Relief Foundation. The participants were recruited into the program via active campaigns by the two above mentioned organizations. Table 1 outlines the demographic data of the 26,606 women aged 35 years and higher who were recruited in the study from ten cities of Iran. We could not obtain any cost or effectiveness data from the city of Isfahan. However, for certain variables with no data reported from these cities, we estimated the values using data collected from other cities participating in the second phase of the program.

All participants who volunteered to participate and met the criteria were recruited and no sampling technique was used. In each city, the women were invited to attend specific hospitals that had been prepared for offering the screening program. In these hospitals, each woman was first visited by a general physician and then offered the diagnostic tests (including mammography) as identified in the protocol.

Assessing effectiveness

We used case-finding (the number of detected cancer cases) as the primary outcome for assessing effectiveness of the program. We used the reported cases of breast cancer diagnosed via this program as an indicator of its effectiveness.

In order to compare the number of cases diagnosed during the screening program with those identified routinely (in the absence of such a program), the expected incidence of the disease in the screened population was used as the comparator. Ideally, we should have obtained the expected incidence from the whole country; how-

ever, the national cancer registry did not provide a full enumeration of cancer cases. Considering the lack of an appropriate population based cancer registry in Iran, we used data from Tehran Cancer Registry that accounts for 10% of the country's total population. People from different socioeconomic backgrounds live in Tehran metropolis, and it was used as representative of the whole country.⁵

Assessing costs and cost-effectiveness

The program costs were calculated based on reports of the actual expenses of different aspects of the program as offered at the hospitals that provided the screening program. For certain variables with uncertain actual monetary values (e.g., meeting costs), the cost was calculated based on the results of technical sessions attended by the technologists working in this field and other stakeholders of the program. The costs were reported based on Iranian Rials (IRR) and were converted to USD using the exchange rates at the time of the intervention (2008).¹¹

Health care provision costs included mammography costs for all participating women. As part of the screening program, further assessments were also warranted for a fraction of women based on mammography outcomes. These included a re-visit by the physician, repeat mammography, sonographic assessment of the breast, breast biopsy, fine needle aspirations, ultrasound-guided fine needle aspirations, and visits by a specialist. For the cities that did not provide further assessment data, we used the estimates obtained from the six cities with adequate data. All the services have established price tariffs, set by the MOHME, implemented in all public hospitals. The total cost of the services was based on the actual tariffs (unit costs) at the time of the program (2008) multiplied by the number of times the services were offered.

We also estimated the program coordination and non-clinical costs. Given the duration of the screening intervention in each province, we estimated that on the average, 50 women were screened each week. As each participating university had assigned one program coordinator for the conduct of the intervention, we estimated that for each 50 participants, one week of basic governmental salary at the time (about 100 US\$) had been paid as personnel costs. The cost-effectiveness ratio was calculated as the intervention costs (all the incremental costs incurred by the program) per each case identified during the program. As the study was conducted over one calendar year, no discounting was incorporated in the analyses.

Sensitivity analysis

We conducted sensitivity analyses to assess the effects of uncertainty in the study parameters. Sensitivity analysis was used to estimate the effects of change in the model's certain parameter on the results of the study. We included variables in the sensitivity analyses where there were uncertainties about the true value of the variable in different settings or there were substantial variations in the data. We developed two additional scenarios to deal with uncertainties in the analysis models: minimum cost scenario and maximum cost scenario.

In the minimum costs scenario, only the costs of care provision were considered while the personnel costs related to supervision and coordination activities were ignored. In the maximum costs scenario, the costs of care provision, program coordination and non-clinical costs, as well as the personnel costs related to supervision activities were included. Supervision costs occurred at three levels: in hospitals and healthcare centers, at medical uni-

Table 1. Number of women screened by mammography in different cities stratified by age group.

Cities	Number of Screened women				Total
	35–40 yr. (%)	41–50 yr. (%)	51–60 yr. (%)	Above 60 yr. (%)	
Tehran	918 (16)	2482 (43)	1823 (31)	569 (10)	5792
Mashhad	1135 (15)	3385 (43)	2672 (34)	601 (8)	7793
Shiraz	592 (14)	1606 (37)	1396 (32)	749 (17)	4343
Tabriz	272 (19)	537 (38)	361 (26)	243 (17)	1413
Gorgan	345 (16)	502 (23)	575 (27)	715 (33)	2137
Rasht	189 (14)	537 (41)	471 (36)	107 (8)	1304
Kerman	207 (22)	411 (43)	247 (26)	91 (10)	956
Kermanshah	226 (17)	520 (39)	517 (39)	57 (4)	1320
Yazd	213 (17)	414 (32)	408 (32)	249 (19)	1284
Qom	55 (21)	109 (41)	70 (27)	30 (11)	264
Total	4152 (16)	10503 (39)	8540 (32)	3411 (13)	26606

versities and at the welfare and other collaborating organizations. The number of individuals (who were usually senior staff) attending the meetings was estimated, using actual data provided to us by the universities. It was then multiplied by an average cost per individual attending the meeting (covering the staff and meeting costs and overheads - about 20 US\$). In these meetings, issues relevant to the breast cancer screening program were discussed alongside other screening activities. Based on expert opinion, 80% of the cost of these meetings was considered to be related to the breast cancer screening program.

False-positive rate in breast cancer screening program

False positive rates are important for both patients and physicians. The personal and psychological side effects of such diagnoses, regardless of the screening program used, are hard to calculate quantitatively.¹² False-positive results have been defined in different ways. A general approach is to consider a mammography result false positive if it is followed by further investigations (imaging, assessing tissue samples) but not yielding a breast cancer diagnosis after one year of follow up. The clinical effects of false positive results mainly include recommendations for unnecessary tests and diagnostic techniques in a woman who is not suffering from breast cancer.¹³ In the present study, false positive was considered as cases referred for further follow-up (repeated mammogram, physical examination, sonography, biopsy, fine needle aspiration, sonography-guided fine needle aspiration and visits by a specialist) based on the first mammogram results which were not ultimately diagnosed with breast cancer. The number of suspicious cases who were not diagnosed with breast cancer (false positives) was divided by the number of primary mammograms, and then multiplied by 100 in each of the cities to compute the total false positive rate in the screening program.

Results

Twenty six thousand six hundred and six (26,606) women aged 35 year or higher were included in the study from the 10 capital cities

which participated in breast cancer screening program. The percentage of women in the age groups 35–40, 41–50, 51–60 and above 60 years was 16, 39, 32, and 13%, respectively; in other words, over 50% of those participating in the program were below 50 years of age.

Table 2 shows the number of diagnostic services after the primary mammography and the cost of the services. The total cost of services was estimated at \$324,585. Adding non-clinical personnel costs (i.e., \$53,212) raised the total cost to \$377,797.

Based on available data, 24 cases were diagnosed with breast cancer during the screening program (Table 3). The incremental cost per identified cancer case under the screening program was \$15,742. As the counterfactual, using the Tehran Cancer Registry's expected age specific incident rate of breast cancer, we would have expected 24 cancer cases per 100,000 women to be identified under routine care (i.e., without the screening program). This calculation was based on the distribution of the screened women in different age groups as presented in Table 4.

Sensitivity analyses and false-positive rates

The cost of identifying each case was \$13,524 minimally. At the maximum cost scenario, supervisory and coordination meeting raised the total costs by \$36,154, 80% of which (i.e., \$28,923) was allocated to the mammography screening. 23% of these costs were related to the meetings at hospitals and centers, 32% to the meetings at medical universities, and 45% to the meetings at the welfare and other collaborating organizations. Adding the meeting costs, the total costs of the program increased to \$406,720, and the cost per case identified increased to \$16,947.

Detailed data from four cities demonstrated 579 suspicious cases among 7720 primary mammographies, giving a false-positive rate of about 7.5% (range: 1–32%). The city of Yazd, with a high incidence of detecting cases (Table 3), also had a very high false-positive rate.

Discussion

Diagnostic services costs (i.e., primary mammography, physi-

Table 2. The cost of diagnostic services in breast cancer screening program, 2008.

Services	The number of services	Service tariffs (\$)	cost of the services (\$)
Mammography	26606	11.8	313641
Re-visit by the physician	262.1	2.5	652
Repeat Mammography	137.8	11.8	1624
Ultrasound	1481.3	4.7	6991
FNA	89	9.6	855
Biopsy	69.4	9.6	664
Ultrasound-guided FNA	5.5	17	94
Visit by a specialist	21.5	3	64
Total			324585

Table 3. The number of breast cancers detected in the screening program.

Cities	Screened population	Cases of cancer detected	Incidence rate per 100000
Tehran	5792	7	120.9
Mashhad	7793	3	38.5
Shiraz	4343	6	138.2
Tabriz	1413	1	70.8
Gorgan	2137	0	0
Rasht	1304	1	76.7
Kerman	956	1	104.6
Kermanshah	1320	0	0
Yazd	1284	4	311.5
Qom	264	1	378.8
Total	26606	24	90.2

Table 4. The expected incidence rate of observed breast cancers in the screened population in the current conditions based on Tehran registry data, if there were no screening intervention.

Age group	35–40 yr.	41–50 yr.	51–60 yr.	Above 60 yr.	Total
Incidence rate per 100,000 in Tehran registry data	55.11	97.41	92.49	97.3	85.68
The population screened in this study	4152	10503	8540	3411	26606
Expected incidence in this population with no mammography screening	2.29	10.23	7.9	3.32	23.74

cian assessment, and follow-up procedures such as repeat mammography etc.) comprised the biggest fraction (about 86%) of the screening program's total cost; and primary mammography costs accounted for 97% of the diagnostic services care. This study suggests that the total costs of the screening program were considerable compared to its effects. While the specific program we assessed here might not be an optimal program, the results suggest that the screening program might not have been cost-effective.

There are studies that have assessed cost-effectiveness of other screening programs in Iran, suggesting a wide range of cost-effectiveness for them.^{14–17} Cost per case detected in these studies ranged from \$17 per detected case in an opium use screening program in Kerman¹⁶ to \$6,639 per detecting a case of syphilis among pregnant women in Shiraz.¹⁴

Our findings are comparable to similar studies conducted in other countries. A recent systematic review of studies remarked that very few studies in low- and middle-income countries had previously focused on cost effectiveness of mammography screening programs.¹⁸ In high-income countries, the cost per cancer detected ranged from \$8,424 (age 50–65 in Spain) to \$100,007 (triennial screening age 45–65 in Korea).¹⁸

In 2010, Denewer et al. conducted a pilot breast cancer screening project in Egypt. The project was implemented on volunteer women; all aged 25 to 65 years, from three urban areas of one of the country provinces. The cost of screening, apart from that of treatment, for each cancer detected was \$415. Also, the cost of treating each cancer patient was \$600–800, indicating that the total fee for diagnosing and treating each cancer patient is about \$1015–1215. As for those suffering from symptomatic advanced forms of cancer, treatment costs were about \$2000–2500. Thus, they estimated that the breast cancer screening program saved approximately \$985–1285 per cancer case compared to no screening.²¹

In comparison, our findings suggest that the costs of launching a breast cancer screening program using mammography in a middle-income country such as Iran are rather high. The costs per

case detected observed in our study were even higher than what is reported in some high-income countries such as Norway.²² The following possible reasons might explain the high cost of detecting cancer in this program in Iran. Firstly, the program did not seem to select the 'right' target population for screening. The cost of a screening program will be reasonable when it is carried out on a population at an appropriate risk of developing the disease. Therefore, selecting an appropriate target population is of great importance. In our study, the program was conducted on women aged over 35 years, while similar screening programs in other countries targeted older women.¹⁸ As a result, the cost of detecting a new case of cancer was rather high. Also, the target population consisted of women with low socioeconomic status, who are at relatively lower risk of breast cancer than women with higher socioeconomic status.

Secondly, the screening program might have suffered from technical inefficiency. It seems that lack of trained personnel (to conduct breast mammography according to standards) and a specific protocol might have reduced the sensitivity of the screening tests. The total number of detected cases as a result of the program was almost equal to that of the expected cases when no screening program was carried out in Iran,⁵ whereas the number of cases is expected to increase after a screening program is conducted.

Thirdly, the findings might be due to errors and omissions in data recordings, preventing all detected cases of breast cancer from being recorded. Since we used the data collected via routine follow-up of the program, this is unlikely to be the case as the provincial screening teams were expected to report the detected cases to the national steering body.

In the present study, we measured the costs based on the public sector tariffs, as the screening service was offered in public hospitals. The costs would have been considerably higher if the private sector tariffs were used in calculating the program costs.

The minimum and maximum cost of one detected breast cancer case were about \$13,524 and \$16,947, respectively, indicating that the costs of conducting and coordinating the collaborating

agencies in the program did not have a substantial influence on the cost effectiveness of the program.

Apart from the sensitivity and specificity of a test, its false positive rate is also important for both patients and physicians. Because of the low specificity of the mammography and the low prevalence rate of breast cancer, false positive rate is higher among young women. As a result, fewer individuals are detected with cancer after additional tests were performed in younger women. Moreover, routine breast cancer screening over short intervals will increase the false positive rate.¹³ In the US, the risk of being diagnosed incorrectly with the disease is 10.7% for women after each mammography.²³ The Advisory Committee on Breast Cancer Screening in NHS has reported that the false positive rate after breast cancer screening differs considerably in different countries and even different centers in the UK. It also adds that the false positive rate after the NHS Breast Screening Program has been fairly steady about 4–5%.²⁴ Compared to what has been reported in previous studies, the observed false positive rate in the present study was not particularly high, although it varied greatly from one city to another.

The results of this study strongly suggest that future breast cancer screening programs should avoid the limitations of the current study, focusing on older age groups (e.g., over 50 years) while improving the technical efficiency of the program. Also, other payment approaches might be considered for remunerating radiology departments. A screening program increases the load of patients on the department in a given period. As such, it may be possible to reduce the cost per mammography if appropriate plans for implementation of the screening program are in place.

The adoption of national mammography screening programs in many countries, including in Europe, North America, Australia and Japan, was the result of conducting randomized controlled trials of mammography screening that suggested a decline in deaths from breast cancer.²⁵ On the other hand, recent systematic reviews of randomized controlled trials of breast cancer screening programs have cast doubts on the effectiveness of such interventions.²⁶ Still, such screening programs are conducted, or being introduced in several countries. Our study suggests that careful considerations are required before introducing national mammography screening programs in a country.

The study results demonstrate that assessing the cost-effectiveness of national programs are necessary and useful tools for decision making. Ideally, such assessments should be conducted before a program is nationally rolled-out. Assessing the cost-effectiveness of the mammography screening program in pilot studies should help national decision makers with revising and re-visiting their screening program before implementing them on a national scale.

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