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Research Article

Cost-effectiveness analysis of breast cancer screening by mammography in average-risk women in China

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Abstract

Breast cancer is the most common form of cancer among women worldwide and is often at an advanced stage when clinical diagnosis. Fortunately, mammography could increase the detection rate of early-stage breast cancer. In this study, we conducted a cost-effectiveness analysis of breast cancer screening compared with no screening for average-risk women aged 45-69 every two years in China. Parameters about screening, costs, and utilities were taken from previous studies. Compared with no screening, mammography screening cost $1566.12 more with a reduction of 0.0088 Quality-Adjusted Life Years (QALYs), which was absolutely dominated. In summary, breast cancer screening by mammography was more recommended to high-risk women rather than average-risk women in China.

Introduction

Breast cancer is a continuing major global public health concern for all women. As a result, breast cancer screening was recommended for high-risk women aged 40 to 69 every year and for average-risk women aged 45 to 69 every 2 years according to China Guideline for the Screening and Early Detection of Female Breast Cancer [1]. Current methods of screening involve clinical breast examination, mammography, ultrasonic examination as well as Magnetic Resonance Imaging (MRI), during which mammography was the most recommended according to clinical practice guidelines [2,3]. Previous study in China has shown that compared with no screening, annual screening for high-risk women is cost-effective [4]. However, further exploration is needed for average-risk women. In this study, we aimed to develop a Markov model to evaluate the cost-effectiveness of breast cancer screening by mammography for average-risk women in China. The time horizon was 45 years (from 40 to 85 years) and the cycle length was one year.

Methods

We compared the current recommended strategy for average-risk women with no screening. The screening process is shown in Figure 1. Breast Imaging Reporting and Data System (BI-RADS) I and II represent negative results. BI-RADS IV and V represent positive results, and BI-RADS 0 and III represent insufficient and suspicious results [5]. Those with positive results, and insufficient or suspicious results will undergo a biopsy, others repeat screening 2 years later.

A Markov model was developed using TreeAge software as shown in Figure 2. The model consisted of twelve states. Women who develop breast cancer could remain in the current stage, progress to a higher stage, be diagnosed by symptoms or screening, or expire due to breast cancer or other cause. The age-specific invasive breast cancer incidence was taken from the Chinese Cancer Registry Annual Report [6]. The transition probability of natural history was obtained from previous studies [4,7,8]. After diagnosis, stage-specific mortality rates

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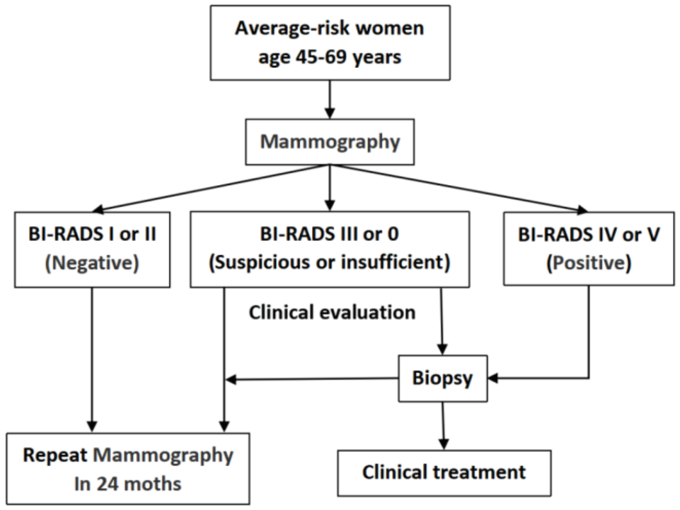

Figure 1: Screening process. BI-RADS; Breast Imaging Reporting and Data System.

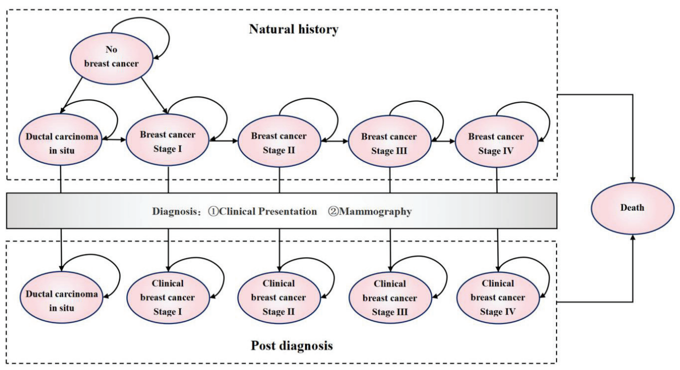

Figure 2: Markov model.

were estimated from Surveillance, Epidemiology and End Results (SEER) Program data [9,10].

The effectiveness of screening came from a system review which included 56 studies [1]. The distribution characteristic of BI-RADS was from a breast cancer screening in Guangdong province in 2021 [11].

The cost of screening was taken from the rural breast cancer screening programme, during which the cost of mammography and biopsy were $29.75 and $23.80, respectively [7,12]. Moreover, we derived the treatment cost from the Urban Cancer Early Detection and Treatment Program in Hebei province [13].

The utility was extracted from a previous study and we assumed that those with Ductal Carcinoma in Situ (DCIS) have the same utility as those without breast cancer [14,15]. A disutility lasted for 3 months for false positive was also assumed in our model.

Cost and QALYs would be discounted by 5% per year. A half-cycle correction was also applied. The key input parameters are presented in Table 1. Finally, the incremental cost, incremental QALY, and Incremental Cost-Effectiveness Ratio (ICER) were calculated. The Willingness-to-Pay (WTP) threshold was considered to be 3 times the Gross Domestic Product (GDP) per capita in China in 2022, $38223 per QALY.

Results

The base-case result is described in Table 2. Compared with no screening, breast cancer screening for average-risk women yielded lower QALYs with higher cost which was absolutely dominated, indicating that screening should focus on high-

Table 1: Key parameter of the model.

Variables	Value	Reference
Data about transition probability		
Progression rate		
Stage I–Stage II	0.06	[4,7]
Stage II–Stage III	0.11	[4,7]
Stage III–Stage IV	0.15	[4,7]
Stage IV–death	0.23	[4,7]
Stage-specific probability of symptoms		
Stage I	0.004	[4,7]
Stage II	0.014	[4,7]
Stage III	0.38	[4,7]
Stage IV	0.98	[4,7]
Fatality rate after treatment		
Stage I	0.002	[9]
Stage II	0.016	[9]
Stage III	0.039	[9]
Stage IV	0.233	[9]
Ratio of DCIS incidence to invasive breast cancer incidence	0.12	[8]
RR of invasive cancer from DICS	2.02	[9]
Screen Parameters		
Sensitivity	80%	[1]
Specificity	96%	[1]
Proportion of BI-RADS 0 and III	38.72%	[11]
Proportion of BI-RADS IV and V	6.61%	[11]
Utilities		
Without clinical breast cancer	0.95	[14,15]
DCIS	0.95	[14,15]
Stage I	0.90	[14,15]
Stage II	0.80	[14,15]
Stage III	0.70	[14,15]
Stage IV	0.30	[14,15]
Dis-utility (false positive)	0.001	Assume
Cost ($)		
Mammography	29.75	[7,12]
Biopsy	23.80	[7,12]
Treatment costs per cycle		
DCIS	1723.58	[13]
Stage I	7755.91	[13]
Stage II	7928.37	[13]
Stage III	9996.58	[13]
Stage IV	14822.56	[13]

RR: Relative Risk; DICS: Ductal Carcinoma in Situ; BI-RADS: Breast Imaging Reporting and Data System.

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Table 2: Base-case result.

Strategy	Costs ($)	QALYs	Incremental costs ($)	Incremental QALYs	ICER
No screening	333.24	17.4840			
Screening at age 45-69 every 2 years	1899.36	17.4752	1566.12	-0.0088	-177968

QALY: Quality-Adjusted Life Year; ICER: Incremental Cost-Effectiveness Ratio.

risk women rather than average-risk ones. Our result was consistent with a previous study that evaluated the economics of mammographic screening for women in rural China [7].

Discussion

Breast cancer is usually diagnosed at an advanced stage with a poorer survival rate because people in the early stage usually remain asymptomatic. Mammography is now the most promising tool for breast cancer screening [1,2]. According to a previous study, breast cancer screening was cost-effective compared with no screening for specific high-risk populations [4]. However, it was not recommended for average-risk women according to our study.

In our study, the Markov model consisting of natural history and post-diagnosis was adopted to simulate the screening programme as performed by the previous study about cancer screening [4,7,16-18]. In natural history, the average-risk population without breast cancer first transited to DCIS or stage I, followed by remaining or progressing to a higher stage. After diagnosis, the stage-specific breast cancer mortality rate was calculated based on SEER Program data. In addition, the distribution characteristic of BI-RADS was considered clearly and used to calculate the proportion of repeating mammography in 24 months or directed biopsy. We also assumed that a biopsy should be done for 50 percent of those with BI-RADS 0 and III. Moreover, similar to previous research, a little decrement in quality of life from false positives was assumed in our study.

Several important limitations still existed in our study. First, we just did a simple cost-effectiveness analysis. Uncertain analysis such as one-way and probability sensitivity analysis should also be done in the future to ensure the robustness of the results. Second, perfect attendance and perfect adherence to screening were assumed in our analysis. However, screening focused on the asymptomatic population, some people may decide not to seek medical treatment if they were still asymptomatic which also influenced the result. Finally, further research is required to estimate the heterogeneity of screening effects for the reason that the screening benefits and the cost-effectiveness of mammography screening may be varied for populations with different characteristics. However, compared with no screening, mammography screening for average-risk women aged 45-69 every two years was absolutely dominated in China.

Conclusion

In conclusion, we should pay more attention to high-risk women if screening and should also ensure prompt diagnosis and treatment of symptomatic women at an early stage at the same time.

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