香港乳癌資料庫
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Mammogram screening saves lives, saves treatment cost

Editor's message

This issue complements "Hong Kong Breast Cancer Registry Report No. 15" on the benefits of mammogram (MMG) screening. Our findings suggest that MMG could detect breast cancer at earlier stages, improve overall survival, and lower the treatment cost. The study aims to expand understanding of the economic impact of MMG, in addition to its clinical implications, and provide insights for better breast cancer control plans.

Introduction

Breast cancer is a significant health concern worldwide, and early detection plays a crucial role in improving patient outcomes. MMG has been widely acknowledged as an effective method for the early detection of breast cancer.[1] Numerous studies have demonstrated its ability to downstage breast cancer at the time of diagnosis, leading to improved treatment options and increased survival rates.[1,2]

In previous research, the Hong Kong Breast Cancer Registry (HKBCR) has provided valuable insights into survival outcomes of breast cancer patients in Hong Kong. There remains, however, a need for further investigation into specific factors that may impact relapse rates and survival outcomes, particularly in relation to self-detected breast cancer versus MMG-detected cases.

In addition to the clinical implications, understanding the economic impact of different breast cancer detection methods is essential for healthcare resource allocation and policy-making. Utilising data from the HKBCR, the current study aims to evaluate the cost of treatment associated with the two detection methods for breast cancer: self-detection and MMG.

To provide a comprehensive assessment of the economic implications, an additional simulation model study was conducted to estimate the cost of treatment in a cohort of 100,000 women aged 40 with an average risk of breast cancer. By considering both clinical and economic aspects, this study intends to contribute further insights into the benefits and challenges associated with different breast cancer detection methods, ultimately informing decision-makers and healthcare professionals in optimising breast cancer screening strategies.

Methods

This study evaluated the impact on stage of cancer on presentation, treatment and survival, and economic impact of using MMG as a breast cancer detection method, utilising data from the HKBCR. A retrospective cohort study was conducted using data available in the HKBCR, with inclusion criteria as: (1) self-detected or MMG-detected cases, and (2) no missing data on cancer stage and biological subtype. A total of 15,144 eligible HKBCR participants, diagnosed between 2006 and 2018, were included for analysis. Baseline characteristics, including stage and biological subtype of breast cancer at the time of diagnosis, were obtained for the cohort. Furthermore, a subgroup consisting of 6,359 breast cancer patients diagnosed between 2006 and 2011 from the HKBCR was selected for survival analysis. This subgroup provided information regarding breast cancer mortality and relapse rates.

Based on results obtained from the survival analysis, an economic analysis was conducted to evaluate the difference in the cost of treatment between self-detected and MMG-detected breast cancer cases. To achieve this, a Markov model was designed, considering the perspective of the healthcare service provider. The model commenced at the time of breast cancer diagnosis and followed patients until the end of life, utilising annual cycles. The annual cost of stage- and subtype-specific breast cancer treatment was estimated using standard breast cancer treatment protocols, with the unit cost of each treatment item obtained from the Hong Kong Gazette. All costs calculated in this study were in Hong Kong Dollars. Additionally, a separate analysis was performed to estimate the overall economic impact of using MMG as a breast cancer detection method at the population level. For this purpose, a lifelong Markov model was developed, employing a hypothetical population of 100,000 female individuals aged 40 with an average risk of breast cancer. The model compared the cost of treatment between self-detected and MMG-detected breast cancer cases from the perspective of the healthcare service provider. Multiple sets of analyses were conducted, considering different starting ages for MMG implementation (40, 45, and 50), to evaluate the impact of MMG at various age groups on the cost of treatment. Background annual mortality rates were obtained from the Hong Kong Census and Statistics Department, assuming that all subjects would pass away at the age of 100, whereas age-specific incidence of breast cancer was obtained from the Hong Kong Cancer Registry.

Results and Discussion

The current study included 15,144 participants from the HKBCR, with 13,502 self-detected breast cancer and 1,642 MMG-detected breast cancer. The mean age of MMG-detected patients was slightly higher than that of self-detected patients (self-detected: 53.1; MMG-detected: 54.0; $p < 0.001$). Stage at diagnosis of MMG-detected breast cancer was lower than that of those self-detected. Stage distribution at diagnosis (stage 0/I/IIA/IIB/III/IV) was 5.4%/31.5%/28.7%/15.3%/17.1%/1.9% for self-detected breast cancer cases and 33.2%/48.3%/

12.6%/2.7%/3.0%/0.2% for MMG-detected breast cancer cases respectively (Figure 1).

In general, there was more luminal type breast cancer in MMG-detected cases (self-detected: 65.1%; MMG-detected: 74.0%; $p < 0.001$), and more triple-negative breast cancer in self-detected cases (self-detected: 11.6%; MMG-detected: 6.2%; $p < 0.001$). Details of subtype distribution within each stage of breast cancer are shown in Table 1.

The subgroup analysis included 6,359 breast cancer patients, with 5,817 self-detected and 542 MMG-detected. The 10-year overall survival was higher in MMG-detected breast cancer patients. The Kaplan-Meier estimate for 10-year overall survival was 88.4% in self-detected breast cancer patients and 95.7% in MMG-detected breast cancer patients (log-rank $p < 0.001$). Annual mortality of breast cancer increased with initial breast cancer stage, from 0.6% in stage 0 to 23.4% in stage IV (Table 2).

Relapse rate generally increased with breast cancer stage. Annual probability of locoregional relapse increased from 0.83% in stage 0 to 1.05% in stage III, while that of distant relapse increased from 0.16% in stage 0 to 2.86% in stage III (Table 3). Annual probability of distant relapse in patients with locoregional relapse also increased from 2.56% in stage 0 to 21.07% in stage III (Table 3).

Figure 1: **Stage distribution of self-detected and MMG-detected breast cancer**

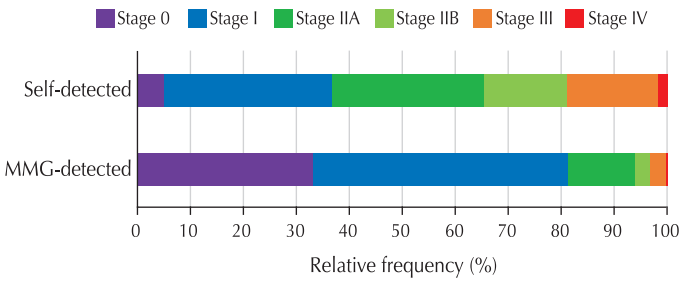


Table 1: **Stage and subtype distribution of self-detected and MMG-detected breast cancer**

	Self-detected	MMG-detected
Stage Distribution		
Stage 0	5.4%	33.2%
Stage I	31.5%	48.3%
Stage IIA	28.7%	12.6%
Stage IIB	15.3%	2.7%
Stage III	17.1%	3.0%
Stage IV	1.9%	0.2%
Subtype Distribution (luminal/HER2+ HR+/HER2+ HR-/TNBC) by stage		
Stage I	71.4%/11.0%/8.1%/9.5%	74.6%/11.4%/6.4%/7.5%
Stage IIA	62.5%/13.5%/9.2%/14.8%	77.7%/7.1%/9.0%/6.2%
Stage IIB	65.2%/13.5%/8.7%/12.5%	82.2%/11.1%/2.2%/4.4%
Stage III	58.5%/17.8%/12.4%/11.3%	60.8%/29.4%/3.9%/5.9%
Stage IV	51.3%/23.4%/13.6%/11.7%	51.3%/23.4%/13.6%/11.7% Δ

Δ Subtype distribution of stage IV MMG-detected breast cancer is assumed to be the same as that of self-detected breast cancer due to limited number of cases in the HKBCR (n=3).

Based on the HKBCR data, the average cost of treatment of each MMG-detected breast cancer ($361,069) was 28.4% lower than that of self-detected breast cancer ($504,200). The main reason was the downstaging of breast cancer detected by MMG at diagnosis. Looking further to each stage, the overall cost of treatment increased from $305,866 for each stage 0 breast cancer to $1,366,634 for each stage IV breast cancer (Figure 2).

Table 2: **Annual mortality at different stages of breast cancer**

	Without relapse	With relapse	
		Locoregional	Distant
Stage 0	0.59%	0.48%	23.32%
Stage I	1.17%	1.81%	22.70%
Stage IIA	2.04%	0.68%	30.49%
Stage IIB	2.04%	4.68%	27.69%
Stage III	5.84%	5.28%	46.03%
Stage IV	23.38%	NA	NA

Table 3: **Annual probability of relapse at different stages of breast cancer**

	Relapse		
	Locoregional	Distant	Locoregional to Distant
Stage 0	0.83%	0.16%	2.56%
Stage I	0.45%	0.41%	2.29%
Stage IIA	0.67%	0.77%	6.49%
Stage IIB	0.62%	1.26%	19.37%
Stage III	1.05%	2.86%	21.07%

Despite the varying biological subtype distributions between self-detected and MMG-detected breast cancer within each stage, the cost of treatment within the same stage was similar between the two detection methods (Table 4).

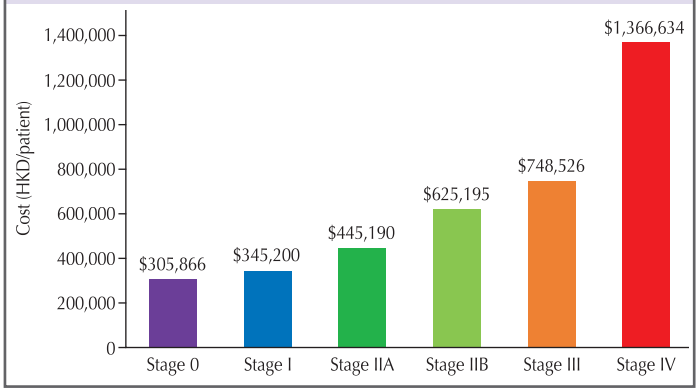
When simulating a cohort of 100,000 average-risk women aged 40, the estimated total number of breast cancer was 5,314 for both detection methods. The estimated 10-year mortality from the model was 14.5% with self-detection and 8.9% with MMG. The 10-year mortality increased to 9.4% when the age of MMG implementation increased to 45, and that increased to 10.0% when the age of implementation increased to 50. Using MMG as a breast cancer detection method from the age of 40 saved 27,932 life-years, while the benefit decreased to saving 17,723 life-years when delaying use of MMG to the age of 50 (Table 5).

The estimated total cost of treatment in the simulated cohort was $2,402.1 million with self-detection and $1,627.5 million with MMG. In other words, implementation of MMG as a detection method saved $774.6 million in a 100,000-person cohort aged 40 in the long run. If the implementation of MMG was delayed until the age of 50, use of MMG still saved $617.4 million compared to self-detection (Figure 3). Despite use of MMG

Table 4: **Cost of treatment per patient for self-detected and MMG-detected breast cancer**

	Overall Cost (HKD)	Self-detected Cost (HKD)	MMG-detected Cost (HKD)	MMG-detected Difference
Overall	488,681	504,200	361,069	-143,131 (-28.4%)
-Stage 0	305,866	306,973	296,766	-10,207 (-3.3%)
-Stage I	345,200	345,092	346,085	993 (+0.29%)
-Stage IIA	445,190	447,261	428,162	-19,099 (-4.3%)
-Stage IIB	625,195	632,974	561,229	-71,745 (-11.3%)
-Stage III	748,526	744,093	784,982	40,889 (5.5%)
-Stage IV	1,366,634	1,366,671	1,366,333	-338 (-0.03%)

Figure 2: **Overall cost of treatment per patient of each breast cancer stage**



increasing total cost of treatment in lower stages of breast cancer, it reduced cost of treatment for advanced stages. When MMG was used for breast cancer detection, starting from age of 40, it increased the cost of treatment by $347.3 million for stage 0 and $262.1 million for stage I, while there was a decrease of $530.3 million for stage III and $121.8 million for stage IV (Table 6).

The benefits of MMG screening for reducing mortality have been extensively demonstrated in previous studies.[3,4] Consistent with these findings, our study adds further evidence to support the effectiveness of MMG as a screening tool. A cohort study conducted in Taiwan showed MMG screening resulted in a higher distribution of earlier-stage breast cancer (stage 0-I) compared to MMG performed for diagnostic purposes.[5] Additionally, the study reported better overall survival rates over an 8-year follow-up period for women who underwent MMG screening.[5] Our study aligns with these findings, which highlights the potential benefits of MMG in detecting breast cancer at an earlier stage and improving long-term survival outcomes. It is worth noting

Table 5: **Breast cancer mortality and stage distribution for self-detected and MMG-detected breast cancer in a 100,000-person cohort aged 40**

	Self-detected	MMG-detected		
		From age of 40	From age of 45	From age of 50
Total number of breast cancer	5,314	5,314	5,314	5,314
-Breast cancer with death	3,206 (60.3%)	2,250 (42.4%)	2,349 (44.2%)	2,451 (46.1%)
-Estimated 10-year mortality	14.5%	8.9%	9.4%	10.0%
Life-year saved	NA	27,932	22,550	17,723
Stage distribution				
-Stage 0	287 (5.4%)	1,764 (33.2%)	1,606 (30.2%)	1,449 (27.3%)
-Stage I	1,675 (31.5%)	2,566 (48.3%)	2,471 (46.5%)	2,376 (44.7%)
-Stage IIA	1,527 (28.7%)	670 (12.6%)	762 (14.3%)	852 (16.0%)
-Stage IIB	814 (15.3%)	144 (2.7%)	215 (4.1%)	287 (5.4%)
-Stage III	910 (17.1%)	159 (3.0%)	240 (4.5%)	320 (6.0%)
-Stage IV	101 (1.9%)	11 (0.2%)	20 (0.4%)	30 (0.6%)

that different international organizations, including the US Preventive Services Task Force (USPSTF) 2023 update and the National Comprehensive Cancer Network (NCCN) 2019 guidelines, have recommended breast cancer screening starting at the age of 40. This further supports the importance of early detection through MMG in improving patient outcomes.

Our study, however, has several limitations that should be acknowledged. Firstly, we focused solely on evaluating the cost of treatment and did not consider other costs associated with MMG, such as screening costs. Future studies should incorporate a comprehensive cost analysis that includes all

Figure 3: **Estimated total cost of treatment in a 100,000-person cohort aged 40**

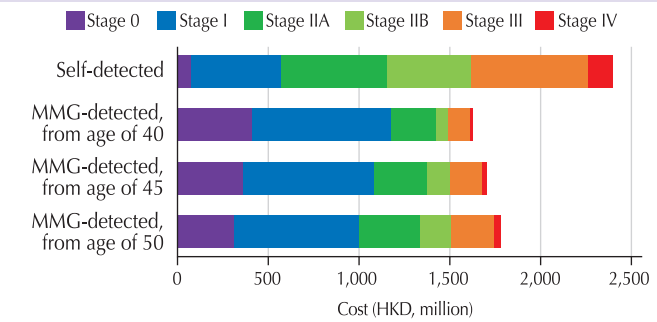


Table 6: **Estimated total cost of treatment of each breast cancer stage in a 100,000-person cohort aged 40**

	Self-detected	MMG-detected					
		From age of 40		From age of 45		From age of 50	
	Cost (HKD million)	Cost (HKD million)	Difference	Cost (HKD million)	Difference	Cost (HKD million)	Difference
Total	2,402.1	1,627.5	-774.6 (-32.2%)	1,705.7	-696.4 (-29.0%)	1,784.7	-617.4 (-25.7%)
-Stage 0	69.9	417.2	347.3 (+496.9%)	362.9	293.0 (+419.2%)	312.8	242.9 (+347.5%)
-Stage I	492.9	755.0	262.1 (+53.2%)	721.4	228.5 (+46.4%)	688.3	195.4 (+39.6%)
-Stage IIA	593.2	249.2	-344.0 (-58.0%)	294.1	-299.1 (-50.4%)	337.4	-255.8 (-43.1%)
-Stage IIB	459.4	71.6	-387.8 (-84.4%)	119.9	-339.5 (-73.9%)	166.8	-292.6 (-63.7%)
-Stage III	650.5	120.2	-530.3 (-81.5%)	179.8	-470.7 (-72.4%)	238.6	-411.9 (-63.3%)
-Stage IV	136.1	14.3	-121.8 (-89.5%)	27.6	-108.5 (-79.7%)	40.8	-95.3 (-70.0%)

relevant factors, to provide a more accurate assessment of the economic impact of MMG as a screening method for breast cancer. Another limitation is the potential of overdiagnosis associated with MMG screening for breast cancer. Despite this aspect not being specifically addressed in our study, a recent publication on the NHS breast screening program has shown only modest levels of overdiagnosis,[6] thus reassuring the benefit of implementation of MMG screening at a population level. Further research should explore potential trade-offs between the benefits of early detection and the risks of overdiagnosis to provide a more comprehensive understanding of the impact of MMG screening on breast cancer. Additionally, our study did not account for the potential effect of MMG implementation on breast cancer incidence. The assumption was made that the incidence of breast cancer would remain the same with the use of MMG detection. It is important, however, to recognize that with more downstaged breast cancer detected earlier through MMG, this strategy may lead to a reduced risk of late-stage breast cancer in later stages of life. Future studies should consider assessing the long-term impact of MMG on breast cancer incidence rates.

The strength of our current study lies in the utilisation of local real-life data obtained from the HKBCR. By using this comprehensive and reliable dataset, we were able to conduct in-depth analysis of the economic implications associated with using MMG as a breast cancer detection method. The HKBCR provides a wealth of information on breast cancer patients in Hong Kong, including baseline characteristics, stage and subtype of breast cancer at diagnosis, and long-term survival outcomes. By using local data, our study reflects the specific context and healthcare system of Hong Kong, enhancing the relevance and applicability of our findings to the local population. This local perspective is crucial for formulating healthcare policies and resource allocation decisions that are tailored to the specific needs of the Hong Kong community.

In conclusion, our study contributes to the existing body of evidence supporting the benefits of MMG screening for breast cancer. The findings from our study align with previous research, demonstrating the potential of MMG in detecting breast cancer at earlier stages and improving overall survival. However, the limitations of our study, including the focus on treatment costs without considering other associated costs and the need for further exploration of overdiagnosis and the long-term impact on breast cancer incidence, should be noted. Future research should address these limitations to provide a more comprehensive understanding of the economic and clinical implications of MMG as a breast cancer detection method.

Conclusion

MMG detection of breast cancer reduced 10-year overall mortality. The average cost of breast cancer treatment per patient was lower by 28.4% with MMG compared with self-detection, mainly driven by downstaging of breast cancer and less intensive cancer treatment at diagnosis. Implementation of MMG as a breast cancer detection method, in a 100,000-person cohort aged 40, saved $774.6 million on total cost of treatment in the long run. Screening of breast cancer with MMG should be encouraged.

References

(Please refer to Chinese version)

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