BMC Public Health

RESEARCH

Socioeconomic inequalities in uptake of outreach mammography before and after accessibility improvement of Taiwan's national universal breast cancer screening policy

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Abstract

Background Taiwan implemented the Cancer Screening Quality Improvement Program (CAQIP) in 2010. The program sought to enhance mass breast cancer screening accessibility. This study aimed to examine socioeconomic disparities in outreach screening utilization pre-CAQIP (2005–2009) and post-CAQIP (2010–2014).

Method We conducted a nationwide population-based observational study in Taiwan, analyzing four population databases to evaluate socioeconomic disparities among women aged 50 to 69 years undergoing their first mammography screening pre-CAQIP. Multivariate logistic regression was used to examine changes in utilization of outreach screening pre- and post-CAQIP implementation, and to estimate the Slope Index of Inequity (SII) and Relative Index of Inequity (RII) values.

Results Utilization of outreach screening through mobile mammography units (MMUs) increased from 6.12 to 32.87% between the two periods. Following CAQIP, a higher proportion of screened women were older, less educated, and from suburban or rural areas. The SII and RII for age, income, and urbanization levels decreased post-CAQIP. However, regarding education level, SII was −0.592 and RII was 0.392 in the pre-CAQIP period, increasing to -0.173 and 0.804 post-CAQIP, respectively.

Conclusions Our study observed that utilization of outreach screening through MMUs increased after CAQIP. The MMUs made outreach screening services more accessible in Taiwan. Expanding outreach screening services and educational programs to promote mammography uptake in local communities could help reduce the potential effect of socioeconomic disparities, and thus may enhance early detection of breast cancer. Further study could focus on the accessibility of outreach screening and breast cancer outcomes.

Keywords Breast Cancer Screening, Outreach Screening, Mobile Mammography units, Mammography, Socioeconomic inequalities

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Introduction

Female breast cancer, with 2.3 million new cases every year, is the most common female cancer worldwide according to the estimates of GLOBOCAN 2020 [1]. In Taiwan, female breast cancer is also the leading cause of cancer incidence among women, and the age-standardized incidence rate was 80.99 per million per year in 2019 [2]. Mammography is the most common screening modality utilized for early identification of pre-clinical disease, and for reducing breast cancer mortality among women aged 50 years or older [3, 4]. The strategies in mammography screening differ between countries. Several countries, such as the United Kingdom, France, and Italy, have population-based screening programs which invite eligible women individually to attend each round of screening [5, 6]. The opportunistic screening is dependent on the individual's decision or the offer of health professionals. For example, in addition to the population-based screening among women aged 50 years or older in the US, selected screening is provided to women aged 40–49 years according to individual and clinician decision making [3]. Currently, mobile screening units have been implemented in many countries to expand access to screening services, including settings in rural or urban regions for elderly and medically underserved populations [7, 8].

Taiwan implemented a single-payer health system with universal National Health Insurance (NHI) in 1995, encompassing the entire population of Taiwan. Taiwan's government implemented a nationwide population-based breast cancer screening program to eliminate accessibility barriers to promote women's mammography screening participation [9, 10]. The breast cancer screening policy has subsequently been reformed several times. Taiwan's Ministry of Health Promotion Administration first implemented a nationwide screening service with free biennial mammography screening for eligible women aged 50 to 69 years in 2004 [11]. Initially, fewer hospitals were equipped to provide mammography screening, and the limited availability of mobile mammography units (MMUs) led to an overall screening rate of only 11.6% in 2009 [12, 13]. Before 2010, numbers of MMUs were very limited, and these numbers increased with greater access to outreach screening services after implementation of a new Cancer Screening Quality Improvement Program (CAQIP) [12] in 2010. CAQIP aimed to improve the accessibility of breast cancer screening through both inreach and outreach screening services. The age range for women participating in mammography screening has been extended to 45 to 69 years, and 40 to 44 years for those with family history, since 2010. CAQIP contracts with nearly 230 qualified hospitals annually, providing financial support for health staff, gifts, MMU rentals, and health advertisement and marketing costs to improve mammography capacity and accessibility. In turn, hospitals are required to offer both inreach mammography screenings in the hospital outpatient setting and outreach mammography screening services across the country through MMUs in local communities. They are also required to regularly report their performance metrics, such as screening volume and cases with positive results. The biennial mammography screening rate then gradually increased to 36% in 2013 [4, 12, 14].

Existing literature suggests that socioeconomic-related barriers may affect women's participation in mammography screening. For example, a systematic review and meta-analysis in 2022 found that factors such as a low household income, low education levels, greater distance from place of residence to screening unit, and immigrant status were associated with a lower rate of screening participation [15]. Furthermore, several previous studies have discussed socioeconomic inequalities in screening participation, finding that more deprived women were less likely to participate in screening [16–18]. Palència et al. (2010) conducted a study in European countries that reported that greater population socioeconomic disparities were more likely to result in opportunistic screening rather than nationwide population-based screening programs [5]. Choi et al. (2018) investigated inequalities in breast cancer screening among Korean women from 2005 to 2015, and found that income-related socioeconomically deprived women were most adversely affected [19].

Few empirical studies investigated the association between enhanced accessibility and changes in the extent of socioeconomic inequalities. Guillaume et al. (2017) used cross-sectional data from 2003 to 2012 among women who first participated in breast cancer screening in Orne, France, to evaluate the association between MMUs and population geographic variations. They found that MMUs may reduce the impact of social and geographic inequities in participation in cancer screening [20]. Li et al. (2018) conducted an observational study using data from the 2001, 2005, 2009, and 2013 National Health Interview Surveys in Taiwan, and found that income-related inequality in mammography screening was higher in 2001 but decreased in 2013 when breast cancer screening rates were higher [21]. However, to the best of our knowledge, no studies specifically examine the effect of socioeconomic inequalities on outreach mammography utilization before and after breast cancer screening policy reform. To address this gap, this study evaluated socioeconomic inequalities in the uptake of outreach screening services and mammography screening utilization during 2005–2009 and 2010–2014, the periods before and after CAQIP implementation in 2010. Specifically, we calculated the slope index of inequity (SII) and relative index inequity (RII) to assess changes in socioeconomic inequity associated with implementation of CAQIP in 2010 among women aged 50 to 69 years undergoing mammography screening for the first time.

Methods

We conducted an observational population-based study using four nationwide population databases in Taiwan. The first database was a nationwide breast cancer screening registry collecting participants' information at the time of each mammography screening, including personal identification, screening date, education level, family history, related hormone risk factors, and the screening service (inreach vs. outreach screening). The second was the National Health Insurance Research Database (NHIRD), which enrolled more than 99% of Taiwan's population; information includes birth year, sex, monthly payroll, and place of residence. The third database was the Taiwan Cancer Registry tracked from 1979 to 2017, which contains the diagnoses and dates of all types of cancer. The fourth was the National Death Registry, which records accurate death causes and dates for all populations in Taiwan, tracked from 1971 to 2017. We analyzed all data in 2022 in the Health and Welfare Data Science Center of the Ministry of Health and Welfare, which is a government-operated national data warehouse. Encrypted identifiers were linked through the four population-based databases for the study population and variables for investigating the study question.

Ethical aspects

The study followed the Helsinki Declaration of the World Medical Association and the ethical standards of the Institutional Review Board of the Kaohsiung Medical University Hospital (IRB number: KMUHIRB-E(I)-20190177). Given that these three population-based datasets were all encrypted and de-identified when analyzed under the patient privacy protection regulation of the Health and Welfare Data Science Center of the Ministry of Health and Welfare in Taiwan, individual patient informed consent was waived.

Study population

To make the comparison between the pre- and post-CAQIP periods, we first identified women aged 50–69 years with their first-time mammography screening using the nationwide breast cancer screening registry from January 1, 2005, to December 31, 2014 (n=2,181,769). The exclusion criteria included any cancer diagnosis or death event before the index date, incomplete personal data or any error in the record (e.g., sex missing), or age younger than 50 years or older than 69 years. Finally, 542,602 women aged 50–69 years were identified from 2005 to 2009 including 509,387 who underwent inreach screening and 33,215 who underwent outreach screening; 948,082 women aged 50–69 years were identified from 2010 to 2014, including 636,471 who underwent inreach screening and 311,611 who underwent outreach screening. Figure 1 presents the inclusion and exclusion criteria among the study population in 2005–2009 and 2010–2014.

Measures of outcome of interests and Health inequities

To address the main objectives of this study, we examined whether women utilized outreach screening services, and created a binary dependent variable to indicate preference for screening service (outreach screening=1; inreach screening=0). Individual socioeconomic characteristics included age categories (50–54, 55–59, 60–64, 65–69 years), education level (no education, elementary school, junior high school, senior high school, university and above), average monthly income level (dependent, less than NTD 20,000, 20,000–40,000, more than 40,000), and urbanization level (urban, suburban, and rural).

To measure health inequities related to socioeconomic characteristics, following previous studies [22], we first conducted a logistic regression as Eq. (1) and then estimated the SII in Eq. (2) and the RII in Eq. (3) for each socioeconomic covariate, as follow:

$$\mu_j = \beta_0 + \beta_1 R_j \tag{1}$$

$$SII = \beta_1 = \frac{\sum_{j=1}^{J} p_j R_j \left(\mu_j - \mu\right)}{\sum_{j=1}^{J} p_j R_j^2 - \left(\sum_{j=1}^{J} p_j R_j\right)^2} \tag{2}$$

$$RII = \frac{SII}{\mu} = \frac{\beta_1}{\mu} \tag{3}$$

Where μ_j is the average outreach screening utilization rate of socioeconomic group (SEG) for individual j; p_j is the population share of SEG j; R_j is the relative rank of SEG j; μ is the average outreach screening utilization rate in the population; β_0 is the estimated outreach screening utilization at the bottom of the SEG hierarchy; β_1 is the difference in average outreach screening utilization between individuals at the bottom and the top of the SEG distribution.

Both SII and RII provide valuable insights into inequalities by accounting for the entire distribution of the utilization of outreach screening services across different socioeconomic groups. The SII was the regression coefficient which acted for the relation between the frequency of health behaviors in each socioeconomic category and the lined-up hierarchical ranking of social groups. As a result, SII represented an absolute difference in the frequency of health behaviors between the individuals with the highest and lowest socioeconomic status. In addition, RII could be estimated by dividing the frequency

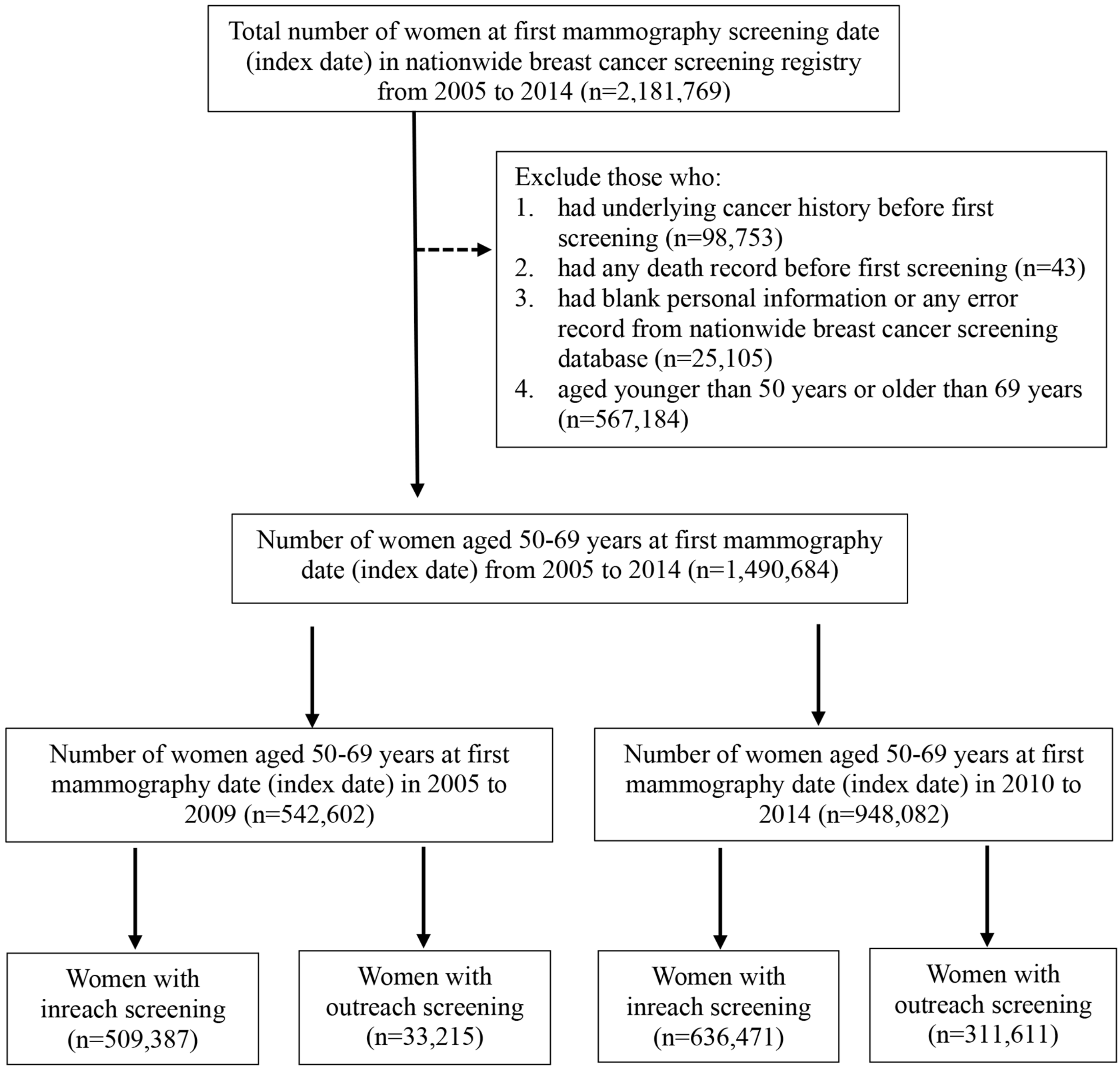

Fig. 1 Flow chart of inclusion and exclusion criteria for the study population between 2005–2009 and 2010–2014

of health behaviors in the highest socioeconomic status by that of the lowest with the identical equation, reflecting relative disparity. SII focuses on absolute differences, while RII focuses on relative differences in the outcome of interest concerning the socioeconomic spectrum (SII and RII) [19, 23]. A positive SII value indicates inequality associated with socioeconomic status; the larger the SII, the larger the inequalities [22, 24]. A negative SII indicates an increase in women's participation in outreach mammography in the group with low socioeconomic status [22, 24]. An SII value of zero and an RII value of 1 indicate no difference in women's participation in outreach screening between the highest and lowest socioeconomic groups. An RII greater than 1 suggests a greater level of inequity between the groups in the worst and best socioeconomic conditions [22, 24].

Statistical analysis

This study reports the percentage of inreach and outreach screening mammography among each subgroup of variables, and a chi-square test was used to compare the proportions of these variables between 2005 and 2009 and 2010–2014. Cramer's V coefficients measured the correlations among two nominal variables, and they ranged from 0 (no association) to 1 (perfect association) (Supplementary appendix eTable 1) [25]. Multivariate logistic regression was performed to investigate the preference in outreach screening before and after CAQIP implementation, as well as estimated SII and RII values. Adjust odds ratios (aOR) and 95% confidence intervals are reported. All statistical operations were performed using SAS version 9.4. P values < 0.05 were considered statistically significant.

Results

Table 1 presents the socioeconomic characteristics of women aged 50–69 years undergoing inreach or outreach mammography services before and after CAQIP implementation. Our findings reveal a rising percentage of women participating in outreach screening, increasing from 6.12 to 32.87% following CAQIP implementation. Regarding the age categories, the increase in outreach screening percentage was more prominent among elderly women aged 65 to 69 years between the two periods. Women with no education experienced a greater increase in the utilization of outreach screening, rising from 5.94 to 39.03%, compared with those with a university education or higher, whose percentage change was lower, increasing from 3.32 to 19.19%. Women with a monthly income level exceeding NTD 40,000 experienced the smallest increase in outreach screening percentage, from 5.91 to 28.52%. Moreover, women living in rural areas experienced the greatest increase in outreach screening percentage between the two periods, rising from 1.76 to 40.72%. Supplemental Appendix eTable 1 shows the Cramer's V coefficient matrix among nominal variables before and after CAQIP implementation to present significant correlations between socioeconomic characteristics and participation in outreach screening.

Table 2 presents the adjusted odds ratio results of multivariate logistic regression models followed by SII and RII of women's participation in outreach screening before and after CAQIP implementation. Before CAQIP implementation, women aged 55–69 years were less likely to participate in outreach screening compared with women aged 50–54 years. Women who were more educated or had higher incomes seemed to use less outreach screening. Additionally, those living in suburban and rural area were less likely to undergo outreach screening. After CAQIP implementation, women aged 55–69 years and those living in suburban and rural areas became more likely to participate in outreach screening. The SII and RII for age variables decreased from 0.038 to 1.030 from 2005 to 2009 to -0.032 and 0.960 from 2010 to 2014, respectively, which reflected a 184.2% decrease in SII and a 6.8% decrease in RII. Similarly, the SII and RII for income and urbanization level slightly decreased between periods. However, the SII and RII by education

Table 1 Basic characteristics and percentage of inreach and outreach screening in each subgroup among women participating in breast cancer screening pre- and post-CAQIP implementation

	2005–2009				2010–2014				P-value
	Inreach screening		Outreach screening		Inreach screening		Outreach screening		
	N	%	N	%	N	%	N	%	
N	509,387	93.88	33,215	6.12	636,471	67.13	311,611	32.87	< 0.001
Age categories									
50–54 years	204,354	93.76	13,590	6.24	274,837	69.17	122,474	30.83	< 0.001
55–59 years	147,628	93.98	9,459	6.02	171,895	66.58	86,277	33.42	< 0.001
60–64 years	87,306	94.20	5,375	5.80	118,093	64.85	64,021	35.15	< 0.001
65–69 years	70,099	93.60	4,791	6.40	71,646	64.85	38,839	35.15	< 0.001
Education									
No education	61,596	94.06	3,892	5.94	47,756	60.97	30,575	39.03	< 0.001
Elementary school	186,732	92.63	14,854	7.37	191,116	62.58	114,270	37.42	< 0.001
Junior high school	77,387	92.97	5,850	7.03	110,684	64.20	61,721	35.80	< 0.001
Senior high school	136,594	95.12	7,003	4.88	194,330	70.06	83,057	29.94	< 0.001
University and above	47,078	96.68	1,616	3.32	92,585	80.81	21,988	19.19	< 0.001
Income level (monthly)									
Dependent	169,562	94.93	11,961	5.07	173,189	70.22	86,257	29.78	< 0.001
Less than NTD 20,000	70,221	93.41	3,751	6.59	99,442	66.75	42,172	33.25	< 0.001
NTD 20,000- NTD 40,000	209,134	93.85	13,703	6.15	268,396	64.91	145,108	35.09	< 0.001
NTD 40,000+	60,470	94.09	3,800	5.91	95,444	71.48%	38,074	28.52	< 0.001
Urbanization level									
Urban	321,941	93.57	22,131	6.43	437,962	71.01%	178,802	28.99	< 0.001
Suburban	146,201	93.39	10,344	6.61	160,274	60.07%	106,545	39.93	< 0.001
Rural	41,245	98.24	740	1.76	38,235	59.28%	26,264	40.72	< 0.001

Note: NTD, New Taiwanese Dollar

P-value was computed based on a chi-square test to compare the proportions of the variables between 2005 to 2009 and 2010 to 2014

Table 2 Socioeconomic inequalities and women's preference in outreach screening in different periods analyzed by multivariate logistic regression after adjusting the baseline variables

	2005–2009			2010–2014		
	aOR	**95% CI**	**P-value**	**aOR**	**95% CI**	**P-value**
Age categories						
50–54 years (Ref)						
55–59 years	0.901	(0.877, 0.927)	< 0.001	1.070	(1.058, 1.082)	< 0.001
60–64 years	0.845	(0.816, 0.875)	< 0.001	1.103	(1.089, 1.117)	< 0.001
65–69 years	0.934	(0.899, 0.970)	< 0.001	1.029	(1.013, 1.045)	< 0.001
SII*	0.038	(0.011, 0.065)		-0.032	(-0.044, -0.018)	
RII**	1.030	(1.008, 1.057)		0.960	(0.932, 0.989)	
Education						
No education (Ref)						
Elementary school	1.152	(1.109, 1.197)	< 0.001	0.983	(0.968, 0.999)	0.039
Junior high school	1.030	(0.985, 1.077)	0.192	0.957	(0.941, 0.974)	< 0.001
Senior high school	0.681	(0.652, 0.712)	< 0.001	0.799	(0.786, 0.812)	< 0.001
University and above	0.462	(0.434, 0.491)	< 0.001	0.494	(0.484, 0.503)	< 0.001
SII	-0.592	(-0.773, -0.409)		-0.173	(-0.269, -0.014)	
RII	0.392	(0.211, 0.539)		0.804	(0.677, 0.938)	
Income level						
Dependent (Ref)						
Less than NTD 20,000	0.867	(0.835, 0.901)	< 0.001	0.955	(0.944, 0.966)	< 0.001
NTD 20,000- NTD 40,000	0.976	(0.950, 1.002)	0.072	1.058	(1.048, 1.068)	< 0.001
NTD 40,000+	0.962	(0.925, 1.000)	0.053	0.973	(0.961, 0.985)	< 0.001
SII	0.110	(-0.315, 0.588)		0.027	(0.011, 0.038)	
RII	1.108	(0.869, 1.305)		1.013	(1.002, 1.016)	
Urbanization level						
Urban (Ref)						
Suburban	0.935	(0.912, 0.959)	< 0.001	1.531	(1.519, 1.543)	< 0.001
Rural	0.929	(0.912, 0.947)	< 0.001	1.509	(1.488, 1.530)	< 0.001
SII	-0.006	(-0.318, 0.294)		-0.012	(-0.411, 0.460)	
RII	0.987	(0.891, 0.994)		0.980	(0.973, 0.991)	

Note: aOR, adjusted odds ratio; Ref., reference group; SII slope index of inequality; RII, relative index of inequality; NTD, New Taiwanese Dollar

*SII (slope index of inequality) represents an absolute difference in women's participation in outreach screening between the highest and lowest socioeconomic groups. An SII value of zero indicates no difference between the socioeconomic groups. A positive SII value indicates larger inequality but a negative SII value means less inequality

**RII (relative index of inequality) represents a relative difference in women's participation in outreach screening between the best and worst socioeconomic conditions. An RII value of 1 indicates no difference between the socioeconomic groups. An RII value greater than 1 indicates larger inequality but an RII value smaller than 1 means less inequality

level were −0.592 and 0.392 in 2005–2009 and increased to -0.173 and 0.804 in 2010–2014, indicating a 70.8% increase in SII and a 105.1% increase in RII.

Discussion

This study evaluated the changes in screening mammography utilization among women aged 50 to 69 years before and after CAQIP implementation in 2010; CAQIP aimed to improve accessibility and utilization of outreach mammography screening. Specifically, we analyzed inequalities by accounting for the entire distribution of utilization of outreach screening services across different socioeconomic groups between the two periods. The goal of the outreach screening service was to increase the accessibility of breast cancer screening. Before 2010, numbers of MMUs were limited, and these numbers increased with greater access to outreach screening services after CAQIP implementation [12]. Consistent with the study by Hsieh et al. (2021) [12], we observed that utilization of outreach screening through MMUs was 6.12% in 2005–2009, increasing to 32.87% in 2010–2014. We found that a higher proportion of screened women utilizing outreach services were older, less educated, and residing in suburban or rural areas after CAQIP. Our study further provided real-world empirical evidence of the impact of the CAQIP policy on reducing socioeconomic and geographical disparities in access to mammography screening in Taiwan.

Previous studies have indicated that women aged 55 years or older may have a lower inclination to participate in screening mammography [14, 26–28]. Older women may be concerned about the cost or the inconvenience of mammography screenings, which may influence their decision to participate [26]. Therefore, the accessibility enhancement approach (i.e., MMUs) may help alleviate such disparities by addressing the specific issues of cost and convenience for these women. Our study found that the SII and RII for age variables decreased after CAQIP implementation. The current study finding was consistent with Guillaume et al. (2017), which found that French women aged older than 70 years in remote and underserved regions preferred mobile mammograms over screening in a central radiology office suite [20].

A systematic review in 2017 mentioned that mobile screening units were predominantly utilized in North America and European countries, with 52% serving mixed rural/urban regions [8]. In previous studies conducted in France, researchers compared the use of breast cancer screening at the radiologist's office alone with the use of screening that included both radiologist's office and MMUs. They found that screening with MMUs was more cost-effective and significantly increased the uptake of mammography screening in deprived or remote areas [20, 29]. Our study also found that a greater percentage of women utilizing outreach mobile mammography resided in suburban or rural areas between 2010 and 2014 after CAQIP implementation. Rural outreach screenings increased notably from 1.76% (2005–2009) to 40.72% (2010–2014) in Taiwan, which may be related to the increased ease of access to screening using MMU's in these previously underserved areas. The significant rise in outreach screenings in rural areas may help reduce health inequality. The phenomenon may resemble the "inverse equity hypothesis", which suggests that public health interventions initially affect individuals of higher socioeconomic status before reaching those of lower socioeconomic status, but improvements occur as individuals with lower socioeconomic status gain increased access to these interventions over time [30]. Further policy initiatives should aim to expand outreach services' accessibility in rural regions, facilitating the participation in cancer screenings of women living in rural or remote areas.

Concerning income factors, in the initial period, we did not detect a significant difference in the utilization of outreach mammography services among women with different income levels. However, we did observe a decrease in the degree of income inequality across various income groups, potentially stemming from the rise in outreach MMU utilization within the middle-income range (NTD 20,000–40,000) following CAQIP implementation. Several studies specifically examined the association between income level and utilization of outreach mammography services through MMUs. One recent study by van den Bruele et al. (2022) reported the characteristics among 32,350 women who participated in mobile mammography in New York City and found that 63% of women had an annual household income less than USD 25,000, and 30% did not have health insurance [31]. Vang et al. (2018) conducted a systematic review to describe sociodemographic characteristics of mobile unit users and found results similar to van den Brule et al. (2022), that women who received mobile mammography outreach services had incomes below $25,000, or were uninsured [7]. Given that culture and social norms in different countries may affect women's preferences, future studies may investigate the association between income levels and utilization of outreach mammography services through MMUs. This would enable policymakers to target specific populations and address disparities in access to screening.

Regarding educational characteristics, to the best of our knowledge, there is still a lack of studies specifically examining the association between education level and utilization of outreach mammography services through MMUs. Our study found that women with lower education levels underwent a higher percentage of outreach screening during the initial period. Furthermore, the percentage of outreach screening service uptake increased notably among this group following CAQIP implementation, and the magnitude of social inequality by education level also increased. This suggests that outreach screening services through MMUs were more accessible to the less-educated population in Taiwan. Our findings may provide valuable insights for expanding access to outreach services and designing educational programs targeted at eligible women with lower levels of education in local communities, thereby encouraging them to participate in mammography screening.

One key strength of this study is that it is an observational cross-sectional study using four nationwide population-based databases from 2005 to 2014. This allowed us to compare the extent of socioeconomic inequalities in the utilization of outreach screening services before and after CAQIP implementation. Additionally, socioeconomic status records, including education level, income level, and urbanization level, were obtained from the nationwide breast cancer screening registry and NHIRD. This approach helped to mitigate potential recall bias and selection bias. However, there were several limitations. First, the study population was focused on women aged 50 to 69 years for comparison in two periods. This study did not analyze the utilization of screened women aged 45 to 49 years in inreach or outreach screening services in 2010–2014 with their socioeconomic status. Second, the current study did not investigate those without mammography screening and their socioeconomic status before and after CAQIP implementation due to limitations of secondary data analysis. Third, the current study focused on women with first-time mammography; those participating in second or third-time mammography screening (repeated screening) were not analyzed, and they may have different preferences in inreach or outreach screening services. Fourth, due to secondary data analysis, there were some unobservable potential factors related to receiving mammography screening, including personal factors such as immigration status, language barriers, or lack of knowledge of health access. In addition, potential confounding factors related to screening services included the sex of the technician performing the mammogram, and the public media for outreach service. Fifth, there may be geographic variations in the socioeconomic characteristics of women participating in inreach and outreach screenings. Nevertheless, the current study used the population-based registry data to analyze screening utilization, which can capture real-world inreach and outreach services across the whole country between 2005 and 2009 and 2010–2014. Finally, the findings in this study may not be generalized to other countries.

Conclusion

Our study found that utilization of outreach screening through MMUs was 6.12% in 2005–2009, and increased to 32.87% in 2010–2014. We found that a higher proportion of screened women utilizing outreach services were older, less educated, and residing in suburban or rural areas after CAQIP implementation. Our study found that the impact of socioeconomic variables in age, income, and residential area on screening participation decreased after CAQIP implementation. Moreover, MMUs made outreach screening services more accessible to the less-educated population in Taiwan. Expanding outreach screening services and educational programs to promote mammography uptake in local communities could help reduce the potential effect of socioeconomic disparities, and thus may enhance early detection of breast cancer. Further study could focus on the accessibility of outreach screening and breast cancer outcomes.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-19896-7.

Supplementary Material 1

Acknowledgements

The authors also express thanks for help from the Division of Medical Statistics and Bioinformatics, Department of Medical Research, Kaohsiung Medical University Hospital, and Center for Big Data Research, Kaohsiung Medical University for providing administrative and funding support.

Author contributions

Cheng-Ting Shen: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Visualization, Software, Formal analysis, Data Curation, Project administration, Funding acquisition; Hui-Min Hsieh: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Visualization, Resources, Funding acquisition, Supervision; Yu-Hsiang Tsao: Visualization, Software, Formal analysis, Data Curation.

Funding

This study is supported by Kaohsiung Municipal Ta-Tung Hospital (KMTTH-109-002 ; KMTTH-111-R004; KMTTH-112-002) and the Ministry of Science and Technology grant (MOST 108-2410-H-037-007; MOST 111-2410-H-037-011; NSTC 112-2628-H-037 -002 -MY3). The authors also express thanks for the help from the Division of Medical Statistics and Bioinformatics, Department of Medical Research, Kaohsiung Medical University Hospital, and the Center for Big Data Research, Kaohsiung Medical University for providing administrative and funding support. None of these organizations had any role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability

The data that support the findings of this study are available from Taiwan's Health and Welfare Data Science Center, Ministry of Health and Welfare, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the corresponding author upon reasonable request and with permission of Taiwan's Health and Welfare Data Science Center, Ministry of Health and Welfare.

Declarations

Ethics approval and consent to participate

This study followed the Helsinki Declaration of the World Medical Association and was approved by the Institutional Review Board of Kaohsiung Medical University (KMUHIRB-E(I)-20190177). The requirement for informed consent was waived by the Ethics Committee of Kaohsiung Medical University because datasets were all encrypted and de-identified when analyzed under the patient privacy protection regulation of the Health and Welfare Data Science Center of the Ministry of Health and Welfare in Taiwan.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 24 April 2024 / Accepted: 27 August 2024
Published online: 08 September 2024

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer statistics 2020: GLOBOCAN estimates of incidence and Mortality Worldwide for 36 cancers in 185 countries. Cancer J Clin. 2021;71(3):209–49.

2. CANCER REGISTRY ANNUAL, REPORT., 2019 TAIWAN [https://www.hpa.gov.tw/Pages/Detail.aspx?nodeid=269&pid=14913].
3. Nelson HD, Fu R, Cantor A, Pappas M, Daeges M, Humphrey L. Effectiveness of breast Cancer screening: systematic review and Meta-analysis to Update the 2009 U.S. Preventive Services Task Force recommendation. Ann Intern Med. 2016;164(4):244–55.
4. Su SY. Nationwide mammographic screening and breast cancer mortality in Taiwan: an interrupted time-series analysis. Breast Cancer. 2022;29(2):336–42.
5. Palència L, Espelt A, Rodríguez-Sanz M, Puigpinós R, Pons-Vigués M, Pasarín MI, Spadea T, Kunst AE, Borrell C. Socio-economic inequalities in breast and cervical cancer screening practices in Europe: influence of the type of screening program. Int J Epidemiol. 2010;39(3):757–65.
6. Altobelli E, Rapacchietta L, Angeletti PM, Barbante L, Profeta FV, Fagnano R. Breast Cancer Screening programmes across the WHO European Region: differences among countries based on National Income Level. Int J Environ Res Public Health 2017, 14(4).
7. Vang S, Margolies LR, Jandorf L. Mobile Mammography Participation among medically Underserved women: a systematic review. Prev Chronic Dis. 2018;15:E140.
8. Greenwald ZR, El-Zein M, Bouten S, Ensha H, Vazquez FL, Franco EL. Mobile Screening units for the early detection of Cancer: a systematic review. Cancer Epidemiol Biomarkers Prev. 2017;26(12):1679–94.
9. Chou CK, Chen SL, Yen AM, Chiu SY, Fann JC, Chiu HM, Chuang SL, Chiang TH, Wu MS, Wu CY, et al. Outreach and Inreach Organized Service Screening Programs for Colorectal Cancer. PLoS ONE. 2016;11(5):e0155276.
10. Luckmann R, Costanza ME, White MJ, Frisard CF, Rosal M, Sama S, Landry MR, Yood R. A 4-year randomized trial comparing three outreach interventions to promote screening mammograms. Translational Behav Med 2018.
11. Yen AM-F, Tsau H-S, Fann JC-Y, Chen SL-S, Chiu SY-H, Lee Y-C, Pan S-L, Chiu H-M, Kuo W-H, Chang K-J, et al. Population-based breast Cancer screening with risk-based and Universal Mammography Screening compared with clinical breast examination: a propensity score analysis of 1 429 890 Taiwanese women. JAMA Oncol. 2016;2(7):915–21.
12. Hsieh HM. Effect of accessibility improvement in a national population-based breast cancer screening policy on mammography utilization among women with comorbid conditions in Taiwan. Soc Sci Med. 2021;284:114245.
13. Chou HP, Tseng LM. Outcome of mammography screening in Taiwan. J Chin Med Assoc. 2014;77(10):503–4.
14. Shen C-T, Chen F-M, Hsieh H-M. Effect of a national population-based breast cancer screening policy on participation in mammography and stage at breast cancer diagnosis in Taiwan. Health Policy. 2020;124(4):478–85.
15. Ding L, Wang J, Greuter MJW, Goossens M, Van Hal G, de Bock GH. Determinants of Non-participation in Population-based breast Cancer screening: a systematic review and Meta-analysis. Front Oncol. 2022;12:817222.
16. Menvielle G, Richard JB, Ringa V, Dray-Spira R, Beck F. To what extent is women's economic situation associated with cancer screening uptake when nationwide screening exists? A study of breast and cervical cancer screening in France in 2010. Cancer Causes Control. 2014;25(8):977–83.
17. Jack RH, Robson T, Davies EA. The varying influence of socioeconomic deprivation on breast cancer screening uptake in London. J Public Health (Oxf). 2016;38(2):330–4.
18. Kurani SS, McCoy RG, Lampman MA, Doubeni CA, Finney Rutten LJ, Inselman JW, Giblon RE, Bunkers KS, Stroebel RJ, Rushlow D, et al. Association of Neighborhood Measures of Social Determinants of Health with breast, cervical, and Colorectal Cancer Screening Rates in the US Midwest. JAMA Netw Open. 2020;3(3):e200618.
19. Choi E, Lee YY, Suh M, Lee EY, Mai TTX, Ki M, Oh JK, Cho H, Park B, Jun JK, et al. Socioeconomic inequalities in cervical and breast Cancer screening among women in Korea, 2005–2015. Yonsei Med J. 2018;59(9):1026–33.
20. Guillaume E, Launay L, Dejardin O, Bouvier V, Guittet L, Dean P, Notari A, De Mil R, Launoy G. Could mobile mammography reduce social and geographic inequalities in breast cancer screening participation? Prev Med. 2017;100:84–8.
21. Lee CB, Lee M-C. Assessing inequalities in breast and colorectal cancer screening-testing the inverse equity hypothesis. Taiwan J Public Health. 2018;37(1):50–62.
22. Pamuk ER. Social class inequality in mortality from 1921 to 1972 in England and Wales. Popul Stud (Camb). 1985;39(1):17–31.
23. Chiou ST, Wu CY, Hurng BS, Lu TH. Changes in the magnitude of social inequality in the uptake of cervical cancer screening in Taiwan, a country implementing a population-based organized screening program. Int J Equity Health. 2014;13:4.
24. Maria Cristina Schneider CC-S, Bacallao J, Loyola E, Mujica OJ. Manuel Vidaurre, and Anne Roca: Methods for measuring health inequalities (Part II). *Epidemiological Bulletin* 2005, 26(March 2005).
25. Akoglu H. User's guide to correlation coefficients. Turk J Emerg Med. 2018;18(3):91–3.
26. Trivedi U, Omofoye TS, Marquez C, Sullivan CR, Benson DM, Whitman GJ. Mobile Mammography Services and Underserved women. Diagnostics (Basel) 2022, 12(4).
27. Vyas A, Madhavan S, Sambamoorthi U. Association between persistence with mammography screening and stage at diagnosis among elderly women diagnosed with breast cancer. Breast Cancer Res Treat. 2014;148(3):645–54.
28. Nari F, Park J, Kim N, Kim DJ, Jun JK, Choi KS, Suh M. Impact of health disparities on national breast cancer screening participation rates in South Korea. Sci Rep. 2023;13(1):13172.
29. De Mil R, Guillaume E, Launay L, Guittet L, Dejardin O, Bouvier V, Notari A, Launoy G, Berchi C. Cost-effectiveness analysis of a Mobile Mammography unit for breast Cancer screening to Reduce Geographic and Social Health Inequalities. Value Health. 2019;22(10):1111–8.
30. Victora CG, Vaughan JP, Barros FC, Silva AC, Tomasi E. Explaining trends in inequities: evidence from Brazilian child health studies. Lancet. 2000;356(9235):1093–8.
31. van den Bruele AB, Sevilimedu V, Jochelson M, Formenti S, Norton L, Sacchini V. Mobile mammography in New York City: analysis of 32,350 women utilizing a screening mammogram program. NPJ Breast Cancer. 2022;8(1):14.

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