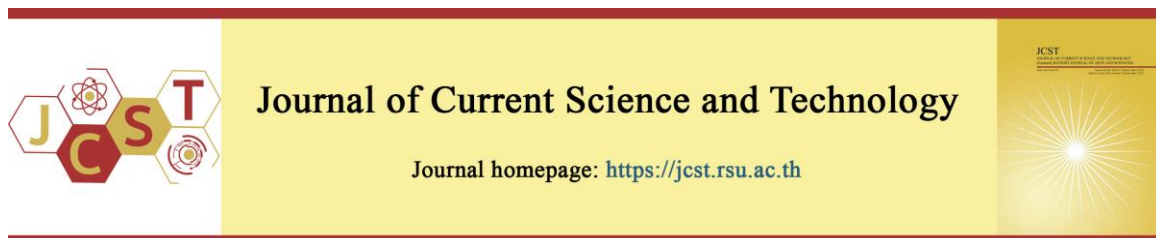


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Population-based Incidence and Incidence Trends by Age Group of Female Breast Cancer in Khon Kaen Province, Thailand, 2002-2021

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Abstract

This study aimed to delineate the age-specific incidence and temporal trends of female breast cancer in Khon Kaen Province, Thailand, between 2002 and 2021. We conducted a descriptive study using longitudinal data from the Khon Kaen Population-Based Cancer Registry. Incidence was reported using Crude Incidence Rates (CIR) and Age-Standardized Rates (ASR). Temporal trends were evaluated using the Average Annual Percentage Change (AAPC) derived from Joinpoint regression. A total of 5,800 cases were analyzed. The overall incidence showed a consistent upward trend, peaking in 2020 (ASR = 31.38 cases per 100,000 women-years). The overall AAPC was 4.71% for CIR (95% CI 4.0, 5.4, $p < 0.001$) and 3.57% for ASR (95% CI 3.2, 4.0, $p < 0.001$). Age-stratified analysis revealed a rising incidence across all age groups. When measured by ASR, the <40 years age group experienced the most rapid increase (AAPC = 5.12%). Conversely, when measured by CIR, the 55-69 years age group showed the greatest increase (AAPC = 3.80%), reflecting an increasing proportion of elderly individuals. The rising incidence, coupled with an aging population, necessitates a two-pronged approach to public health policy. These findings support further evaluation of age-appropriate screening, awareness programs, stage distribution, mortality, and cost-effectiveness.

Keywords: age-standardized rate, breast cancer, incidence, population-based cancer registry, trends, Joinpoint regression, Thailand

1. Introduction

Breast cancer is the most prevalent cancer in females worldwide. According to a global cancer database, the age-standardized incidence rate (ASR) of breast cancer was calculated to be approximately 46.8 per 100,000 women-years in 2022 (Bray et al., 2024). Furthermore, the current incidence of breast

cancer has risen steadily, with an annual percentage change (APC) of 0.33% between 1990 and 2019 (Xu et al., 2023).

Breast cancer is also the most common female cancer in Southeast Asia (Dee et al., 2025; Kristina et al., 2025). The incidence trends were projected to rise significantly, consistent with studies conducted in

Yogyakarta, Indonesia, and Hanoi, Vietnam (Huong et al., 2025; Ng et al., 2023). However, the increase in incidence observed in Brunei Darussalam was not statistically significant (Leong et al., 2023). Consistent with global trends, breast cancer is the most common cancer among women in Thailand, with an ASR of 34.9 per 100,000 women-years (TNCI, 2025), and a sharp increase in incidence calculated as an average annual percentage change (AAPC) of 3.1% (Virani et al., 2017). Various studies have reported elevated incidences of breast cancer in different regions of Thailand. In the Northern, Central, Southern, and Northeastern regions of Thailand, the incidences of breast cancer, reported as cases per 100,000 women-years, are 38.1, 40.6, 33.7, and 29.1, respectively (TNCI, 2025). The Northeastern region exhibits the lowest overall incidence of breast cancer compared to all other regions; however, its incidence is increasing most rapidly, with an AAPC of 7.1% between 1988 and 1999 and 4.2% between 1999 and 2012 (Virani et al., 2017).

In accordance with the clinical practice guidelines regarding recommendations for breast cancer screening in Thailand, age is one of the main factors when determining the eligibility for mammography, which is considered the gold standard of breast cancer screening (The Royal College of Radiologists of Thailand (RCRT), 2020; Lapkittichot, 2023; The Royal College of Surgeons of Thailand (RCST), 2024). The guidelines recommend that women aged 40 and above should be screened annually for breast cancer using mammography in accordance with the international recommendations (Oeffinger et al., 2015; National Comprehensive Cancer Network (NCCN), 2025). While there were various age-specific population-based studies in Thailand (Lalitwongsa et al., 2015; Sangkittipai boon et al., 2015; Sripan et al., 2017; Tassanasunthornwong et al., 2015; Virani et al., 2014), most of these studies stratified the population into only two groups. Moreover, to date, no study has reported breast cancer incidence data beyond 2012.

Thailand became an upper-middle-income country in 2011 (World Bank Group, 2011) and is currently undergoing numerous demographic changes. In 2023, the population was 71,702,435 and was declining, with a projected reduction of 7.4% by 2050. The population structure was also predicted to change, with a rising number of individuals aged 65 and older (World Health Organization, 2026), coupled with a progressive decline in birth and fertility rates (United Nations, 2024). Moreover, obesity, another risk factor for breast cancer, has become more prevalent (World

Obesity Federation (World Obesity, 2025). These changes may alter the future epidemiological picture of breast cancer in Thailand. Therefore, evaluating breast cancer incidence trends by age group will help determine if existing clinical guidelines align with shifting demographic patterns. Furthermore, this study provides vital insights into the changing epidemiology of breast cancer in Thailand, driven by the country's aging population.

2. Objectives

This study aimed to describe the population-based incidence and incidence trends of female breast cancer by age group in Khon Kaen Province, which is located in the Northeastern region of Thailand, using Joinpoint regression. The results are reported as Crude Incidence Rates (CIR), Age-Standardized Rates (ASR), and Average Annual Percentage Change (AAPC), with corresponding 95% confidence intervals (CIs) for the observed trends.

3. Materials and Methods

3.1 Ethical Approval

This study was reviewed and approved by the Human Research Ethics Committee, under announcement number 1579/2567, with approval number HE671654 on November 21st, 2024, for the use of cancer registry data. All data usage was permitted by Khon Kaen Cancer Registry Unit (KKCRU).

3.2 Population and Sampling

This population-based retrospective study aimed to describe female breast cancer incidence and trends across different age groups. Data were retrieved from the historical and electronic medical records of the Khon Kaen Cancer Registry Unit (KKCRU), spanning from 1985 to 2025. The KKCRU contains data from Khon Kaen Hospital, Srinagarind Hospital, 25 community hospitals, and 3 private hospitals within the Khon Kaen province. The inclusion criteria of this study were: (1) patients who have been diagnosed with breast cancer, as classified by the specific International Classification of Disease for Oncology - Third Edition (ICD-O) codes C50.0 - C50.9, excluding code C44.5 (skin of breast), (2) patients whose data were recorded between January 1st, 2002 and December 31st, 2021. The exclusion criteria of this study were: (1) patients who were assigned male at birth, (2) patients whose recorded address and postal code were not in Khon Kaen Province, (3) patients lacking any of the following data: sex, age at diagnosis, or year of diagnosis.

3.3 Statistical Analysis

All data were derived from the KKCRU. Population denominators were obtained from the 2000 and 2010 Population and Housing Censuses conducted by the Thai National Statistical Office (TNSO). For the intercensal years, annual population estimates were derived using linear interpolation between census years and were used to calculate age-specific incidence rates (TNSO, 2000; TNSO, 2012).

The study evaluates the incidence of female breast cancer in four age groups, as follows: < 40 years old, 40-54 years old, 55-69 years old, $\geq$ 70 years old. The division of age groups was based on Thailand's breast cancer screening recommendations (RCRT, 2020; Lapkittichot, 2023; RCST, 2024), all of which recommend annual screening with mammography in women aged 40 and above. Women aged more than 54, according to the Thai National Cancer Institute (TNCI) (Lapkittichot, 2023), may reduce the screening frequency to every other year, or may continue annually, similar to the recommendations of the American Cancer Society (Oeffinger et al., 2015). Most screening guidelines suggest that screening can be stopped at 70-75 years of age; therefore, we selected age 70 as the lower bound of the oldest group (Ren et al., 2022).

The data are analyzed and reported statistically using the following parameters:

1. Data quality was assessed using the percentage of microscopically verified cases (MV%), defined as a diagnosis confirmed by histology or cytology of primary or metastatic tumors, and the percentage of death certificate only cases (DCO%), defined as a diagnosis based solely on death certification.

2. Incidence of female breast cancer in the Khon Kaen Province is reported as follows:

- 2.1 Crude Incidence Rate (CIR) is the total number of new cases calculated as a proportion of the entire population at risk during a one-year period. This rate is appropriate for comparing annual local trends and estimating the true disease burden.

- 2.2 Age-standardized Rate (ASR) is the incidence rate adjusted to the world standard population, as defined by Segi et al. (1960), and later modified by Doll et al. (1966). This rate is appropriate for international comparisons.

3. Trends of female breast cancer for the entire study population and each age group are reported as average annual percentage change (AAPC). Temporal

trends were analyzed using Joinpoint regression. The maximum number of joinpoints was set to zero to estimate the overall trend and calculate the Average Annual Percent Change (AAPC) across the study period. With zero joinpoints, AAPC equals the single-segment APC. Statistical significance was assessed using the permutation test, with $p < 0.05$ considered statistically significant. A Poisson regression model with robust standard errors was used to compare significant differences across age groups. The number of cases was specified as the outcome variable, with age group included as a categorical predictor and population size included as an exposure term.

4. Age-period-cohort (APC) analysis was performed using a Poisson regression model with the logarithm of person-years as an offset term. Female breast cancer incidence data were analyzed using the `apc.fit` function from the `Epi` package in R. The Age-cohort-period (ACP) parameterization was selected as the primary model because it provides direct estimates of cohort-specific relative risks with respect to a reference birth cohort and facilitates interpretation of generational patterns in breast cancer incidence. The analysis included women aged 20-90 years, with the 1960 birth cohort specified as the reference cohort. This age range was selected, as recommended for APC modeling, to ensure sufficient observations across age, period, and cohort dimensions while minimizing instability at extreme ages. No cases occurred in patients younger than 20 or older than 90 years.

This study used the following software for statistical analysis:

1. Microsoft Excel was used to prepare the initial diagnostic dataset.

2. SPSS version 29 was used for analysis of the general characteristics of the population, data quality, and the Poisson regression test.

3. Joinpoint regression program version 5.4.0 was used for calculating the incidence in the forms of CIR and ASR, as well as the incidence trends in the form of AAPC.

4. R version 3.6.2 running in RStudio version 2023.06.2 was used for age-period-cohort (APC) analysis. The APC models were fitted using the `apc.fit` function from the `Epi` package version 2.40 to estimate age, period, cohort, and drift effects on breast cancer incidence.

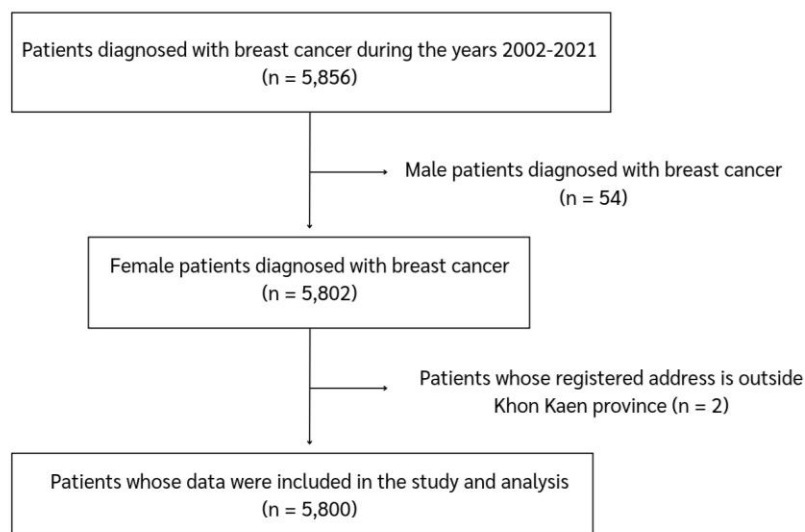


Figure 1 Flow diagram demonstrating the selection of patients. Drawn by the authors

Table 1 General information of the study population (N = 5,800)

General Information		n	%
Age groups	< 40	671	11.57
	40-54	2616	45.10
	55-69	1945	33.53
	≥ 70	568	9.79
Stages	0	5	0.09
	1	730	12.59
	2	1891	32.60
	3	1264	21.79
	4	541	9.33
	Unknown	1369	23.60
Subtypes	Squamous cell carcinoma	9	0.16
	Papillary carcinoma	19	0.33
	Adenocarcinoma	145	2.50
	Infiltrating duct carcinoma	4,891	84.33
	Unspecified	736	12.68
Patient's addresses	Mueang district	1820	31.38
	Other districts	3976	68.55
	Unknown	4	0.07
Basis of diagnosis	Death certificate only	28	0.48
	History & physical exam	151	2.60
	Endoscopy & radiology	140	2.41
	Surgery & autopsy	129	2.22
	Specific biochemical/immunology test	1	0.02
	Cytology	53	0.91
	Histology of metastasis	43	0.74
	Histology of primary	5255	90.60

4. Results

4.1 General Information of the Study Population

During 2002-2021, the number of breast cancer patients in the Khon Kaen Province was 5,856. This study excluded people who met the exclusion criteria, which included 54 male patients diagnosed with breast cancer and 2 patients whose address and postal code were outside the study area. This resulted in a study population of 5,800 patients (Figure 1).

Patients were stratified into four age groups, < 40 years, 40-54 years, 55-69 years, $\geq$ 70 years, comprising 671 (11.6%), 2,616 (45.1%), 1,945 (33.5%), and 568 (9.8%) patients, respectively. The 40-54 years age group had the highest number of cases between 2002 and 2021. The mean age of the patients was 53.18 years (standard deviation [SD] = 11.734), and the median age was 52 years. The most common type of breast cancer was infiltrating ductal carcinoma (Table 1).

4.2 Data Quality

Of the 5,800 cases of female breast cancer which were analyzed, 92.26% had their diagnosis microscopically verified (MV% = 92.26) by either

cytology, or histology of primary or metastatic tumor, exceeding the 80% standard recommended by the International Agency for Research on Cancer (IARC). In contrast, only 0.48% had their diagnosis confirmed by death certificate only (DCO% = 0.48), which was also well below the 10% threshold recommended by the IARC.

4.3 Overall Incidence

The incidence of breast cancer was lowest in 2002 (CIR 16.59, ASR 14.6), and the overall trend was upward. The highest incidence was found in 2020 (CIR 45.13, ASR 31.38). It is noteworthy that the CIR was higher than the ASR in every year throughout the study period (Table 2; Figure 2).

4.4 Overall Incidence Trends

From the analysis of overall incidence, we found that the incidence of female breast cancer increased throughout the study. Trend analysis revealed an AAPC of 4.71% when calculated using CIR (95% CI 4.0, 5.4) (Figure 3), and an AAPC of 3.57% (95% CI 3.2, 4.0) when using ASR (Figure 4).

Table 2 Overall incidence of breast cancer among women in Khon Kaen

Year	Crude incidence rate	Age-standardized rate (ASR)	Standard Error of ASR
2002	16.59	14.60	1.23
2003	19.35	16.72	1.30
2004	21.98	18.44	1.34
2005	23.67	19.03	1.33
2006	23.72	18.64	1.30
2007	25.13	19.61	1.33
2008	26.96	20.36	1.33
2009	30.21	22.37	1.38
2010	33.30	23.93	1.41
2011	31.34	22.20	1.35
2012	34.13	23.99	1.40
2013	33.62	23.70	1.40
2014	37.52	25.94	1.45
2015	41.90	28.85	1.53
2016	39.54	27.41	1.52
2017	41.38	28.76	1.57
2018	42.67	29.65	1.60
2019	44.20	29.89	1.61
2020	45.13	31.38	1.69
2021	42.66	29.72	1.66

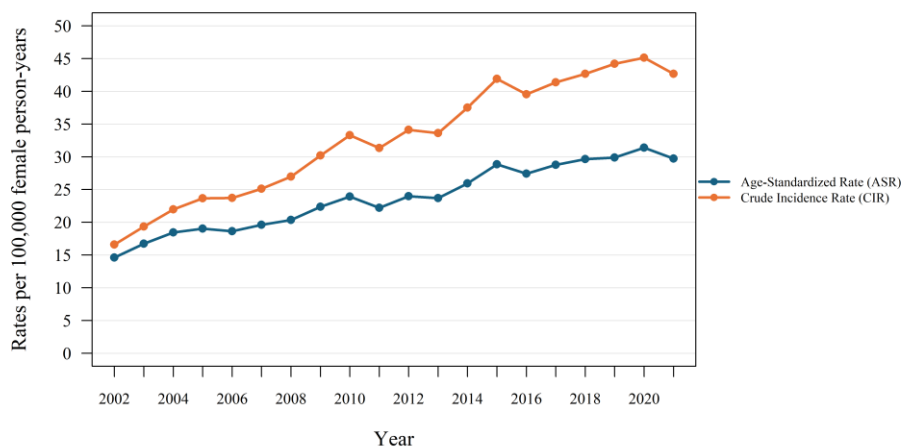


Figure 2 Overall incidence of breast cancer among women in Khon Kaen, reported as CIR and ASR. Drawn by the authors

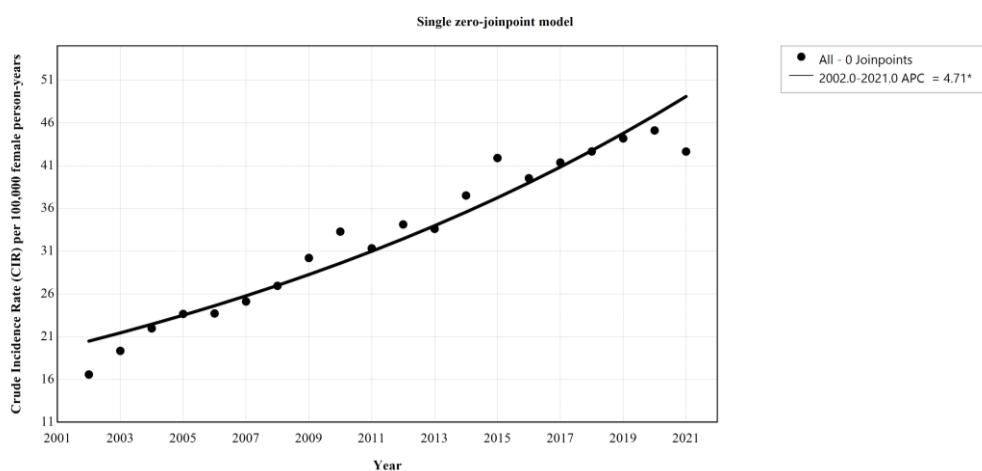


Figure 3 Average annual percentage change (AAPC) calculated using CIR. Drawn by the authors

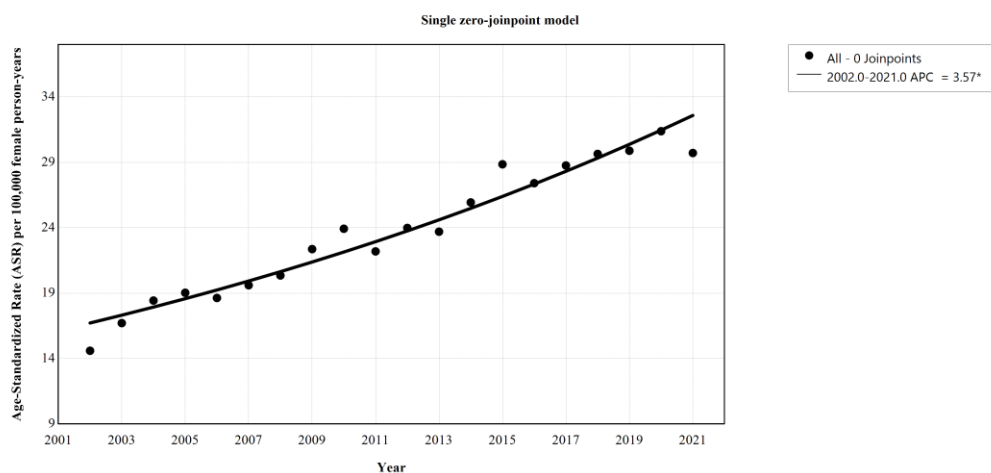


Figure 4 Average annual percentage change (AAPC) calculated using ASR. Drawn by the authors

Table 3 Incidence of female breast cancer between years 2002-2021, stratified by age groups

Year of diagnosis	< 40 years		40-54 years		55-69 years		≥ 70 years	
	Crude	ASR	Crude	ASR	Crude	ASR	Crude	ASR
2002	4.45	2.19	42.64	7.24	35.66	4.01	28.04	1.17
2003	6.54	3.15	45.40	7.86	38.22	4.38	31.79	1.33
2004	2.96	1.33	50.68	8.78	59.81	6.46	47.55	1.87
2005	5.85	2.74	55.66	9.57	50.88	5.45	33.09	1.27
2006	5.58	2.59	59.83	10.25	39.92	4.44	35.72	1.36
2007	7.06	3.34	50.79	8.72	60.40	6.62	23.19	0.92
2008	8.40	3.81	53.34	9.14	55.47	6.01	33.83	1.41
2009	8.35	3.63	54.77	9.38	66.49	7.43	46.97	1.93
2010	7.26	3.40	63.91	10.97	73.52	7.99	42.55	1.57
2011	4.65	2.53	67.46	11.49	63.63	6.87	35.53	1.32
2012	5.58	2.81	66.33	11.28	77.73	8.51	34.15	1.39
2013	9.13	4.60	60.77	10.28	60.34	6.61	54.35	2.22
2014	7.72	3.99	71.01	12.00	67.59	7.41	60.92	2.55
2015	7.14	3.95	83.41	14.06	83.17	9.13	42.80	1.72
2016	8.59	4.98	72.98	12.27	70.32	7.74	59.95	2.41
2017	9.85	5.97	70.00	11.68	79.64	8.70	58.82	2.40
2018	8.56	5.39	69.62	11.94	94.03	10.34	47.68	1.99
2019	7.96	5.24	73.89	12.21	90.02	9.84	62.35	2.60
2020	8.72	5.91	74.45	12.74	97.12	10.67	49.83	2.06
2021	8.08	5.44	81.50	13.64	75.44	8.29	55.62	2.35

4.5 Incidence by Age Groups

When calculating the incidence rate of female breast cancer for each age group, we found that the year with the maximal incidence was 2017 for the < 40 year age group (CIR 9.85, ASR 5.97), 2015 for the 40-54 year age group (CIR 83.41, ASR 14.06), 2020 for the 55-69 year age group (CIR 97.12, ASR 10.67), and 2019 for the ≥ 70 year age group (CIR 62.35, ASR 2.6) (Table 3). By the end of the study period, breast cancer incidence had increased across all age groups.

4.6 Incidence Trends by Age Groups

When calculating the incidence trends of breast cancer during 2002-2021 using CIR, we found that the incidence of breast cancer increased in every age group. The age group with the highest increase was the 55-69 years age group with an AAPC of 3.80% (95% CI 2.3, 6.0), followed by the ≥ 70 years age group with an AAPC of 3.27% (95% CI 1.4, 5.9), and the 40-54 years age group with an AAPC of 2.81% (95% CI 1.9, 3.8). The < 40 years age group had the smallest increase in incidence, with an AAPC of 2.77% (95% CI 0.9, 4.8). When analyzed using the Poisson regression test, we found statistically significant differences between the AAPCs of all groups ($p < 0.001$), except between the 40-54 years and the 55-69 years age groups ($p > 0.999$) (Figure 5).

When calculating the incidence trends using ASR, the incidence of breast cancer also increased in every group. Interestingly, unlike the trend calculated from CIR, the < 40 years age group had the highest increase in incidence, with an AAPC of 5.12% (95% CI 3.4, 7), followed by the 55-69 years age group, with an AAPC of 3.79% (95% CI 2.3, 5.9) and the ≥ 70 years age group, which had an AAPC of 3.61% (95% CI 1.6, 6.6). The 40-54 years age group had the smallest increase in incidence, with an AAPC of 2.67% (95% CI 1.8, 3.6), despite its high incidence of breast cancer. When analyzed with the Poisson regression test, we found statistically significant differences between all groups ($p < 0.001$) except for between the < 40 years age group and the ≥ 70 years age group ($p > 0.999$); and between the 40-54 years age group and the 55-69 years age group ($p = 0.353$) (Figure 6).

The incidence of breast cancer increased significantly in every age group, regardless of the incidence measure used. However, a pronounced difference exists between the two methods regarding the magnitude of the incidence increase (Table 4). In the < 40 years age group, the increase in incidence measured by CIR was relatively small compared with that measured by ASR.

Table 4 Incidence trends reported as AAPC, calculated by CIR and ASR

Age group	AAPC (by CIR)			AAPC (by ASR)		
	AAPC	95% CI	p-value	AAPC	95% CI	p-value
<40	2.8	0.9-4.8	0.003	5.1	3.4-7	< 0.001
40-54	2.8	1.9-3.8	< 0.001	2.7	1.8-3.6	< 0.001
55-69	3.8	2.3-6	< 0.001	3.8	2.3-5.9	< 0.001
≥70	3.3	1.4-5.9	< 0.001	3.6	1.6-6.6	0.001
Overall	4.7	4.0-5.4	< 0.001	3.6	3.2-4	< 0.001

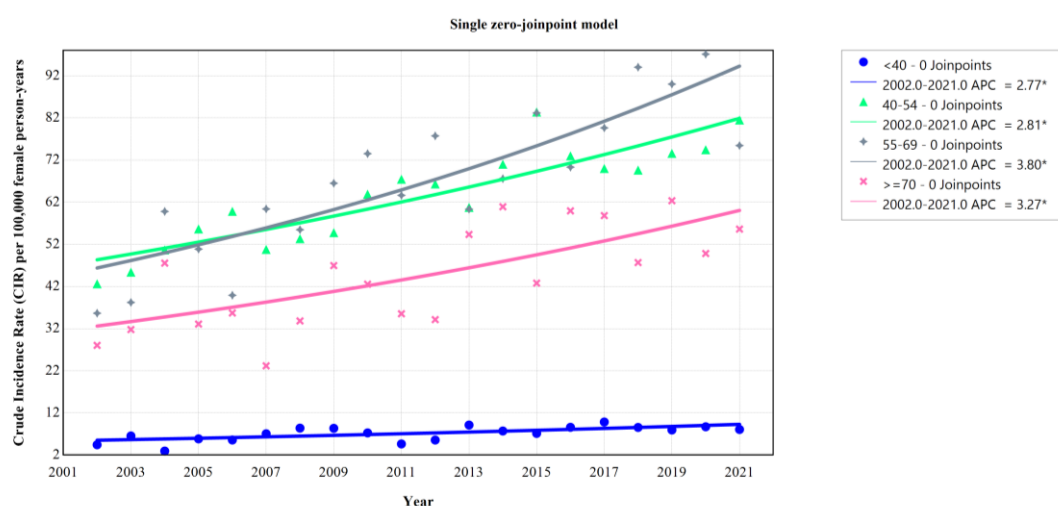


Figure 5 Trend of breast cancer by age groups, calculated using CIR. Drawn by the authors

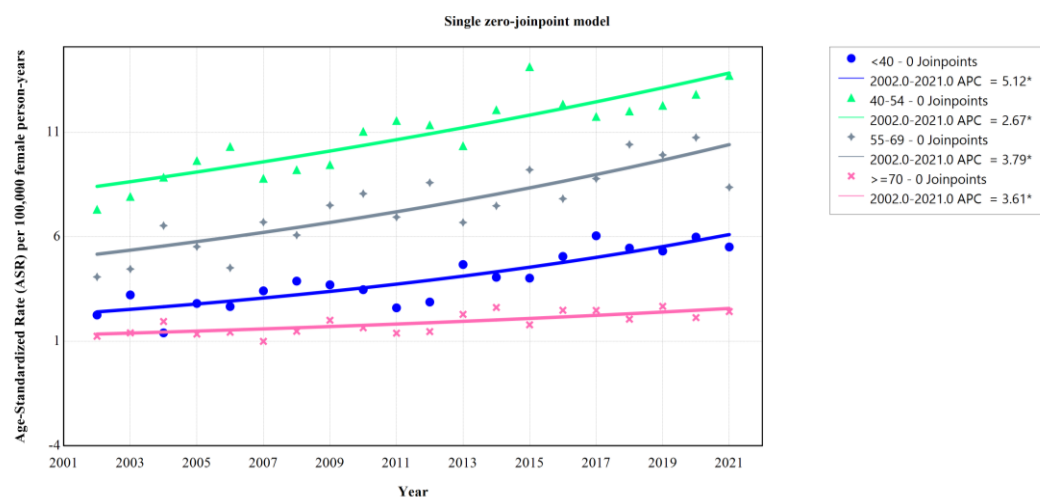


Figure 6 Trend of breast cancer by age groups, calculated using ASR. Drawn by the authors

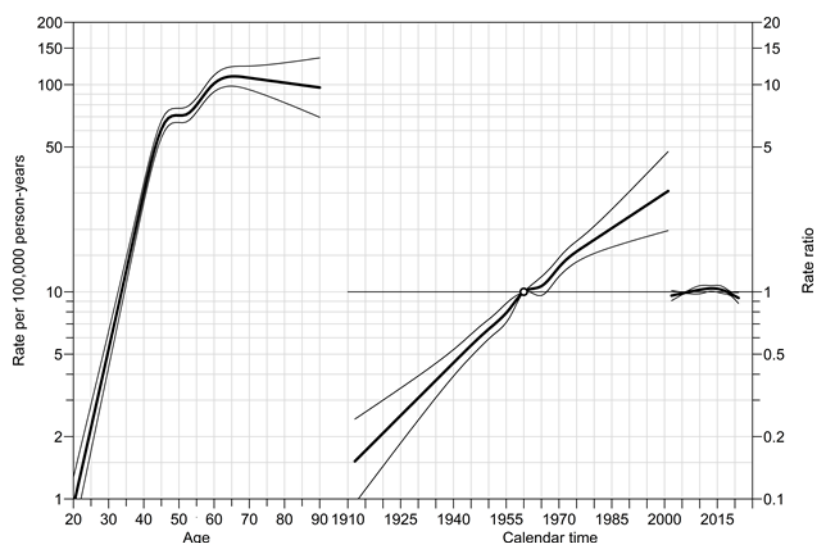


Figure 7 Age-period-cohort (APC) graphs using ACP parameterization model for analyses. Drawn by the authors

4.7 Age-Period-Cohort (APC) Analysis

The APC model demonstrated that breast cancer incidence increased substantially with age. Age-specific incidence rates rose rapidly from approximately 1 case per 100,000 women-years at age 20 years to more than 100 cases per 100,000 women-years after age 60 years, peaking at approximately 65-70 years of age before declining slightly among older women. An increasing trend was observed across successive birth cohorts. Compared with the reference birth cohort (born in 1960), women born before 1950 had substantially lower risks of breast cancer, whereas women born after 1960 experienced progressively higher risks. Relative risks increased from approximately 1.32 among women born in 1970 to 1.78 among those born in 1980, 2.31 among those born in 1990, and approximately 3.06 among those born in 2001. In contrast, period effects remained relatively stable around unity throughout the study duration.

Formal model testing demonstrated a significant net drift in breast cancer incidence over time ($\chi^2=195.13$, $df=1$, $p < 0.001$). However, cohort deviations beyond the overall drift were not statistically significant ($\chi^2=5.63$, $df=5$, $p = 0.344$). Similarly, period deviations beyond cohort effects showed only borderline statistical significance ($\chi^2=5.83$, $df=2$, $p = 0.054$). Consistent findings were observed in the Age-Period model: cohort deviations were not statistically significant ($p = 0.360$), whereas period deviations beyond drift remained borderline significant ($p = 0.051$) (Figure 7).

5. Discussion

From the analysis of female breast cancer data between years 2002-2021, we found that the incidence of female breast cancer continued to increase in every age group, with an AAPC of 4.71% (calculated from CIR), and 3.57% (calculated from ASR). When calculating the trends from CIR, the group with the fastest increase in incidence was the 55-69 years age group, followed by the ≥ 70 years age group, whereas the group with the smallest increase in incidence was the < 40 years age group. However, when the trends were calculated from ASR, we found that the < 40 years age group had the fastest increase in incidence.

We observed that CIR was always higher than ASR in every year throughout the study. This is attributable to the fact that the population being studied had a significantly higher proportion of elderly people compared with the world standard population described by Segi et al. (1960), in which older adults accounted for only 11% of the total population. As reported by the Thai National Statistical Office (TNSO) (2025), in 2021, Thailand's elderly female population made up 21.1% of the country's entire female population, while Khon Kaen province had 23% of its female population older than 60, slightly higher than the national average; this proportion continued to rise to 25.6% in 2024, resulting in a higher CIR than ASR. We believe that for the same reason, but in the reverse direction, the ASR in the < 40 years age group showed a greater increase in incidence than the CIR. CIR can better reflect the disease burden of breast cancer within the

province, whereas the ASR allows the results of this study to be compared with other regions or countries.

The age-period-cohort analysis identified age as the strongest effect associated with breast cancer incidence. Age-specific incidence rates increased markedly with advancing age, peaking at approximately 65-70 years before declining slightly in older age groups. An increasing trend across successive birth cohorts was observed, with women born after 1960 exhibiting higher relative risks than earlier generations. However, formal model testing indicated that cohort deviations beyond the overall drift were not statistically significant ($p = 0.344$), suggesting that the observed cohort pattern largely reflected the underlying long-term temporal trend. Period effects remained relatively stable throughout the study period, and period deviations demonstrated only borderline statistical significance ($p = 0.054$). Overall, the APC model findings indicate that the increasing incidence of breast cancer was characterized primarily by a significant long-term net drift, whereas independent cohort- and period-specific deviations were comparatively modest.

The results of this study are similar to those of many other studies conducted in Thailand, which also found a significant increase in incidence. Our finding, AAPC = 3.57% by ASR, was higher than the national AAPC (AAPC = 3.1%) (Virani et al., 2017), but lower than that of previous studies in the entire Northeastern region (AAPC = 4.2%) (Virani et al., 2017) and in Khon Kaen (AAPC = 4.5%) (Virani et al., 2018). However, this study found a significant difference in the age group with the highest increase in incidence, with the youngest group showing the greatest increase in incidence, while previous studies in Thailand found that the incidence rose fastest in females aged more than 40 (Sripan et al., 2017), or more than 50 (Virani et al., 2014; Sangkittipai boon et al., 2015; Tassanasunthornwong et al., 2015; Lalitwongsa et al., 2015) when compared to other groups. This also contrasts with studies published in different regions of Asia, such as Taiwan (Chen et al., 2022) and India (Mathew et al., 2016), both of which found that the incidence of breast cancer predominated in postmenopausal females.

Various countries are undergoing an epidemiological transition, with a decrease in communicable diseases and an increase in non-communicable diseases (NCDs) including malignancy. Data from the Global Cancer Observatory (Ferlay et al., 2024) generally demonstrated a higher incidence of breast cancer in high-income countries (ASR = 83.9)

compared with upper-middle-income (ASR = 40.8), lower-middle-income (ASR = 33.2), and low-income countries (ASR = 30.6). This implies that the incidence of breast cancer may be related to the country's socioeconomic status. Thailand, which became an upper-middle-income country in 2011, had a breast cancer incidence similar to that of low- and lower-middle-income countries, which is lower than that of countries with comparable income.

Obesity is one of the modifiable risk factors of breast cancer (NCCN, 2025). The Global Obesity Observation (World Obesity, 2025) found that the obesity rate in Thailand and the Southeast Asia region has risen continuously. This might be one of the reasons Thailand has seen an increase in breast cancer incidence in recent years. However, the prevalence of obesity in northeastern Thailand was found to be the second lowest out of all the regions, with the Northern region having the lowest prevalence (Patanavanich & Aekplakorn, 2025). Nulliparity, a reproductive risk factor for breast cancer (NCCN, 2025), was also low in the northeastern region, since it had a high proportion of women who had never been pregnant (Patanavanich & Aekplakorn, 2025; TNSO, 2025); this might explain the relatively lower incidence of breast cancer in this region (Virani et al., 2017). Recently, the average age at menarche has declined in Thailand (Patanavanich & Aekplakorn, 2025), which would contribute to the rising trend of breast cancer in the near future (NCCN, 2025).

Current screening guidelines recommend that females aged 40-54 years should be screened for breast cancer by mammography annually, and females aged more than 54 can either choose to be screened annually or every other year (RCRT, 2020; Lapkittichot, 2023; RCST, 2024). From the results of this study, considering that the CIR of breast cancer increased the most in the 55-69 years age group, followed by the ≥ 70 years age group, we believe that females older than 54 should continue to be screened annually, because the incidence is still rising in females aged 55 years and above. When considering the ASR, the incidence in the < 40 years age group was still low but increased continuously. Coupled with the low prevalence of breast self-examination (BSE) in young women (Thotong et al., 2019), particularly those aged 20-29 years (Patanavanich & Aekplakorn, 2025), it is necessary to promote age-appropriate screening modalities for young women, such as breast self-examination, clinical breast examination, and breast ultrasound.

In 2023, Thailand's Universal Coverage Scheme (UCS) was extended to include breast cancer screening exclusively for high-risk women aged 40–70 years who have a first-degree family history of the disease, using biennial mammography and ultrasound (TNCI, 2024). However, average-risk women aged > 40 years are still not included in this program. We recommend implementing more robust health promotion strategies to encourage breast cancer screening uptake among Thai women, though the cost-effectiveness of a mass screening program should be further evaluated. A mammography fast-track program was also implemented in Ratchaburi, Thailand, in 2016–2017 (Tongyoi, 2018), which may benefit breast cancer patients, as it significantly decreased the waiting time for patients suspected of having breast cancer, and also increased the availability of mammography.

To our knowledge, this study is the first to analyze incidence trends according to the age groups that should be screened differently. Those groups are women aged < 40 years old, 40–54 years old, 55–69 years old, and ≥ 70 years old. The sample size used in this study was large enough to demonstrate differences or similarities in the incidence trends among each group. In addition, both the ASRs and the CIRs were used for the analyses, and the differences between them were discussed in the local context, such as that of an aging society.

This study used data from one provincial registry, which limits national generalizability. In addition, it lacked analysis of stage-specific trends, screening uptake data, and possible changes over time in diagnostic capacity and registry completeness. There was a high proportion (23.6%) of unknown stage, and individual-level risk factors, as well as other factors affecting breast cancer incidence, were unavailable; consequently, the interpretation of incidence trends and screening implications might be affected. Linear-intercensal population estimates might introduce systematic error in the incidence rate calculation; however, this was the standard method and the best data available to us. Although the cancer registration systems had not been changed over time, ascertainment bias from improvements in diagnostic access and mammography availability might have occurred.

However, these findings support further evaluation of age-appropriate screening, awareness programs, and their effects on stage distribution, mortality, and, finally, cost-effectiveness. Future research should investigate stage distribution trends

and modifiable risk factors to obtain more comprehensive and generalizable data that can be further used to develop or implement comprehensive national prevention programs. This information may be beneficial for developing more adequate guidelines regarding breast cancer screening and prevention.

6. Conclusion

The incidence of female breast cancer in Khon Kaen Province increased continuously, with an AAPC of 4.71% (calculated by CIR) and 3.57% (calculated by ASR). This trend is similar to that in other regions around the world. The year of highest overall incidence was 2020 (CIR 45.13, ASR 31.38). The incidence in each age group peaked in 2017, 2015, 2020, and 2019 for the < 40, 40–54, 55–69, and ≥ 70 years groups, respectively. CIR was higher than ASR in every year throughout the study, reflecting the rise of the aging population in Khon Kaen. The incidence trends were rising in every age group, regardless of the analysis method. Trends by CIR exhibited a larger increase in incidence in women > 55 years of age compared with younger women, with the maximal increase in the 55–69 years group, followed by the ≥ 70 years group. In contrast, trends by ASR displayed a larger increase in women aged below 40 years. Reliance on passive registry data was the study's primary limitation.

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8. Abbreviations

Abbreviation	Full Term
AAPC	Average Annual Percentage Change
ACP	Age-cohort-period (parameterization)
APC	Annual Percentage Change or Age-period-cohort (model)
ASR	Age-Standardized Rate
BSE	Breast Self-Examination
CI	Confidence Interval
CIR	Crude Incidence Rate
DCO%	Percentage of Death Certificate Only

IARC	International Agency for Research on Cancer
ICD-O	International Classification of Disease for Oncology
KKCRU	Khon Kaen Cancer Registry Unit
MV%	Percentage of Microscopically Verified
NHES	The National Health Examination Survey
SD	Standard Deviation
UCS	Universal Coverage Scheme

9. CRediT Statement

Putsaya Yospaiboon: Conceptualization, Writing – Original Draft, Investigation.

Kandit Anukunananchai: Writing – Original Draft, Formal Analysis.

Napat Wiruchongsanon: Writing – Original Draft, Data Curation.

Pimyada Anuruxwongsri: Writing – Original Draft, Visualization.

Thanabordee Somanawat: Writing – Original Draft, Validation.

Chalongpon Santong: Resources, Validation, Data Curation, Software, Statistical Analysis.

Bandit Chumworathayi: Methodology, Supervision, Funding Acquisition, Writing – Review & Editing, Project Administration.

10. References

- Bray, F., Laversanne, M., Sung, H., Ferlay, J., Siegel, R. L., Soerjomataram, I., & Jemal, A. (2024). Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: A Cancer Journal for Clinicians*, 74(3), 229-263. <https://doi.org/10.3322/caac.21834>
- Chen, Y. C., Su, S. Y., Jhuang, J. R., Chiang, C. J., Yang, Y. W., Wu, C. C., ... & Lee, W. C. (2022). Forecast of a future leveling of the incidence trends of female breast cancer in Taiwan: An age-period-cohort analysis. *Scientific Reports*, 12(1), Article 12481. <https://doi.org/10.1038/s41598-022-16056-y>
- Dee, E. C., Laversanne, M., Bhoo-Pathy, N., Ho, F. D. V., Feliciano, E. J. G., Eala, M. A. B., ... & Bray, F. (2025). Cancer incidence and mortality estimates in 2022 in southeast Asia: A comparative analysis. *The Lancet Oncology*, 26(4), 516-528. [https://doi.org/10.1016/S1470-2045\(25\)00017-8](https://doi.org/10.1016/S1470-2045(25)00017-8)
- Doll, R., Payne, P., & Waterhouse, J. (1966). *Cancer incidence in five continents: A technical report*. Berlin, Germany: Springer-Verlag.
- Ferlay, J., Ervik, M., Lam, F., Laversanne, M., Colombet, M., Mery, L., et al. (2024). *Global cancer observatory: Cancer today*. Retrieved from <https://gco.iarc.who.int/media/globocan/factsheets/populations/900-world-fact-sheet.pdf>
- Huong, G. N., Nguyen, H. L., Goldberg, R. J., Epstein, M. M., Allison, J. J., Pham, L. Q., ... & Huong, T. T. (2025). Thirty-year trends (1991-2020) in breast cancer incidence rates: Hanoi, Vietnam. *JCO Global Oncology*, 11, Article e2400570. <https://doi.org/10.1200/GO-24-00570>
- Kristina, S. A., Krisnadewi, K. I., Trung, V. Q., Ramadhani, A., Verdiana, A. S., & Aryasatya, M. D. (2025). Cancer Burden Across The South East Asia Nation (ASEAN) in 2022. *Asian Pacific Journal of Cancer Prevention*, 26(9), 3377-3388. <https://doi.org/10.31557/APJCP.2025.26.9.3377>
- Lalitwongsa, S., Pongnikorn, D., Daoprasert, K., Sriplung, H., & Bilheem, S. (2015). Breast cancer in Lampang, a province in Northern Thailand: Analysis of 1993-2012 incidence data and future trends. *Asian Pacific Journal of Cancer Prevention*, 16(18), 8327-8333. <https://doi.org/10.7314/APJCP.2015.16.18.8327>
- Lapkittichot, S. (2023). *Breast imaging*. In: Supaporn S, Sampatanukul P, Vassanasiri W, Kongdan Y, Chirappapha P, Asanprakit W, & Rattadilok C. Editors. *Guidelines for diagnosis and treatment of breast disease and breast cancer*. Bangkok, Thailand: National Cancer Institute. Retrieved from https://www.nci.go.th/doc/cpg/1768966645_cpgรักษาโรคเต้านมและมะเร็งเต้านม.pdf
- Leong, E., Ong, S. K., Si-Ramlee, K. A., & Naing, L. (2023). Cancer incidence and mortality in Brunei Darussalam, 2011 to 2020. *BMC Cancer*, 23(1), Article 466. <https://doi.org/10.1186/s12885-023-10962-8>
- Mathew, A., George, P., Arjunan, A., Augustine, P., Kalavathy, M. C., Padmakumari, G., & Mathew, B. (2016). Temporal trends and future prediction of breast cancer incidence across age groups in Trivandrum, South India.

- Asian Pacific Journal of Cancer Prevention*, 17(6), 2895-2899.
- National Comprehensive Cancer Network (NCCN). (2025). *Breast cancer (Version 5.2025)*. Retrieved from <https://nccn.org/view/journals/jnccn/23/11/article-p426.xml?content=pdf-7738>
- Ng, B., Puspitaningtyas, H., Wiranata, J. A., Hutajulu, S. H., Widodo, I., Anggorowati, N., ... & Sripan, P. (2023). Breast cancer incidence in Yogyakarta, Indonesia from 2008–2019: A cross-sectional study using trend analysis and geographical information system. *PLoS One*, 18(7), Article e0288073. <https://doi.org/10.1371/journal.pone.0288073>
- Oeffinger, K. C., Fontham, E. T., Etzioni, R., Herzig, A., Michaelson, J. S., Shih, Y. C. T., ... & Wender, R. (2015). Breast cancer screening for women at average risk: 2015 guideline update from the American Cancer Society. *JAMA*, 314(15), 1599-1614. <https://doi.org/10.1001/jama.2015.12783>
- Patanavanich, R., & Aekplakorn, W. (2025). *The National Health Examination Survey [NHES]. 7th edition 2024-2025*. Bangkok, Thailand: Faculty of Medicine, Ramathibodi Hospital, Mahidol University. Retrieved from <https://kb.hsri.or.th/dspace/handle/11228/6360>
- Ren, W., Chen, M., Qiao, Y., & Zhao, F. (2022). Global guidelines for breast cancer screening: A systematic review. *The Breast*, 64, 85-99. <https://doi.org/10.1016/j.breast.2022.04.003>
- Sangkittipaiboon, S., Leklob, A., Sriplung, H., & Bilheem, S. (2015). Breast cancer in Lopburi, a province in Central Thailand: Analysis of 2001-2010 incidence and future trends. *Asian Pacific Journal of Cancer Prevention*, 16(18), 8359-8364. <http://doi.org/10.7314/APJCP.2015.16.18.8359>
- Segi, M., Fujisaku, S., Kurihara, M., Narai, Y., & Sasajima, K. (1960). The age-adjusted death rates for malignant neoplasms in some selected sites in 23 countries in 1954-1955 and their geographical correlation. *The Tohoku Journal of Experimental Medicine*, 72(1), 91-103. <https://doi.org/10.1620/tjem.72.91>
- Sripan, P., Sriplung, H., Pongnikorn, D., Virani, S., Bilheem, S., Chaisaengkhaum, U., ... & Chitapanarux, I. (2017). Trends in female breast cancer by age group in the Chiang Mai population. *Asian Pacific Journal of Cancer Prevention*, 18(5), 1411–1416. <https://doi.org/10.22034/APJCP.2017.18.5.1411>
- Tassanasunthornwong, S., Chansaard, W., Sriplung, H., & Bilheem, S. (2015). Breast cancer in Surat Thani, a province in Southern Thailand: Analysis of 2004-2012 incidence and future trends. *Asian Pacific Journal of Cancer Prevention*, 16(15), 6735-40. <https://doi.org/10.7314/APJCP.2015.16.15.6735>
- Thai National Cancer Institute (TNCI). (2024). *National cancer control programme 2024-2032*. Bangkok, Thailand: National Cancer Institute. [in thai]
- Thai National Cancer Institute (TNCI). (2025). *Cancer in Thailand. Vol. XI*. Bangkok, Thailand: National Cancer Institute.
- Thai National Statistical Office (TNSO). (2000). *Population and housing census*. Retrieved from https://www.nso.go.th/nsoweb/main/summano/aE?set_lang=en#gsc.tab=0 [in thai]
- Thai National Statistical Office (TNSO). (2012). *The 2010 population and housing census*. Retrieved from <https://prt.parliament.go.th/items/b7ed7598-605e-4091-8496-d4c0508751b4> [in thai]
- Thai National Statistical Office (TNSO). (2025). *Number, proportion and ratio of elderly population from survey in Thailand*. Retrieved from https://www.nso.go.th/nsoweb/downloadFile/stat_impt/im/file_xls_th [in thai]
- The Royal College of Radiologists of Thailand [RCRT]. (2020). *Announcement of the royal college of radiologist of Thailand in breast cancer screening, Volume 2*. Retrieved from <https://www.rcrt.or.th/wp-content/uploads/2021/03/ประกาศราชวิทยาลัยรังสีแพทย์แห่งประเทศไทย-การตรวจคัดกรองมะเร็งเต้านม-ฉบับที่2.pdf> [in thai]
- The Royal College of Surgeons of Thailand (RCST). (2024). *Breast mass*. Retrieved from <https://www.rcst.or.th/cpg/8G98.pdf> [in thai]
- Thotong, R., Somharnwong, S., Sangrajrang, S., Pichainarong, N., Satitvipawee, P., Pitikultang, S., & Chaveepojnkamjorn, W. (2019). Factors related to breast self-examination practices among premenopausal women. *Thai Cancer Journal*, 39(1), 16–27.
- Tongyoi, P. (2018). Outcome of fast track breast cancer screening with breast ultrasonography

- in Paktho Hospital. *Region 4-5 Medical Journal*, 37(2), 184-191.
- United Nations, Department of Economic and Social Affairs. (2024). *United Nations data portal population provision*. Retrieved from <https://population.un.org/dataportal/>
- Virani, S., Bilheem, S., Chansaard, W., Chitapanarux, I., Daoprasert, K., Khuanchana, S., ... & Sriplung, H. (2017). National and subnational population-based incidence of cancer in Thailand: Assessing cancers with the highest burdens. *Cancers*, 9(8), Article 108. <https://doi.org/10.3390/cancers9080108>
- Virani, S., Chindaprasirt, J., Wirasorn, K., Sookprasert, A., Somintara, O., Vachirodom, D., ... & Wiangnon, S. (2018). Breast cancer incidence trends and projections in Northeastern Thailand. *Journal of Epidemiology*, 28(7), 323-330. <https://doi.org/10.2188/jea.JE20170045>
- Virani, S., Sriplung, H., Rozek, L. S., & Meza, R. (2014). Escalating burden of breast cancer in southern Thailand: Analysis of 1990–2010 incidence and prediction of future trends. *Cancer Epidemiology*, 38(3), 235-243. <https://doi.org/10.1016/j.canep.2014.03.003>
- World Bank Group. (2011). *Thailand economic monitor*. Retrieved from <https://documents1.worldbank.org/curated/en/818191468132279260/pdf/612320REPLACEM0or0April020110Final1.pdf>
- World Health Organization. (2026). *Thailand [country overview]*. Retrieved from <https://data.who.int/countries/764>
- World Obesity Federation (World Obesity). 2025. *World obesity atlas 2025*. London, UK: World Obesity Federation. Retrieved from https://s3-eu-west-1.amazonaws.com/wof-files/World_Obesity_Atlas_2025_rev1.pdf
- Xu, Y., Gong, M., Wang, Y., Yang, Y., Liu, S., & Zeng, Q. (2023). Global trends and forecasts of breast cancer incidence and deaths. *Scientific Data*, 10(1), Article 334. <https://doi.org/10.1038/s41597-023-02253-5>