RESEARCH ARTICLE

Editorial Process: Submission:08/21/2024 Acceptance:12/07/2024

Analysis of the Effectiveness and Coverage of Breast, Cervical, and Colorectal Cancer Screening Programs in Kazakhstan for the Period 2021-2023: Regional Disparities and Coverage Dynamics

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Abstract

Background: Cancer screening is a crucial component in the fight to reduce cancer incidence and mortality. Currently, the WHO recommends highly effective cancer screening programs, including screening for cervical cancer (CC), breast cancer (BC), and colorectal cancer (CRC). Despite the implementation of a cancer screening program since 2014, an evaluation of the effectiveness of BC, CC, and CRC screening in the Kazakhstan has not yet been conducted. Study aimed to assess the effectiveness and coverage of BC, CC, and CRC screening in the Republic of Kazakhstan during the period from 2021 to 2023. **Methods:** Data for the retrospective analysis were extracted from the "Healthcare Statistics" database. Data on participants eligible for screening (n=8,167,184) for BC, CC, and CRC were included in the analysis. **Results:** In 2023, there was a noticeable decrease in the number of detected cases of CC (1.7) compared to previous years. The detection rates for BC (14) and CRC (around 1) per 100,000 population in 2023 remained almost at the same level as in previous years. The detection rate for BC was 0.74% in 2021, followed by a decline to 0.59% in 2022. In 2023, there was an increase to 1.69%. As for CC, the detection rate was 0.70% in 2021, it increased to 0.77% in 2022, but then decreased again to 0.53% in 2023. CRC shows a steady decline in detection rates. In 2021, the detection rate was 4.23%, then it dropped to 3.64% in 2022, and continued to decrease to 3.28% in 2023. **Conclusions:** The data for 2021-2023 underscore the necessity for continuous monitoring, analysis, and adaptation of screening strategies, taking into account regional peculiarities and new challenges, such as the pandemic. Ensuring high screening coverage for BC, CC, and CRC is a key factor for the early detection and effective treatment of these diseases.

Keywords: Neoplasms- national cancer screening- screening coverage- efficiency

Asian Pac J Cancer Prev, **25 (12)**, 4371-4380

Introduction

Non-communicable diseases are currently the leading cause of death worldwide, and cancer is expected to become the primary cause of death and the single most significant barrier to increasing life expectancy in every country in the 21st century [1]. Cancer screening has long been an important component in the fight to reduce cancer incidence and mortality [2]. Screening tests are generally considered secondary cancer prevention, as they indicate the presence of precancerous conditions or early-stage signs of the disease [3]. Currently, the WHO recommends cancer screening programs, such as those for cervical cancer (CC), breast cancer (BC), and colorectal cancer (CRC), which have been proven to be the most effective for different groups of countries [4]. Worldwide, BC is the most frequently diagnosed type of cancer in women [5]. Meanwhile, CRC is the third most frequently diagnosed type of cancer globally [6]. The most successful cancer screening programs lead to the detection of precursor lesions (e.g., cervical intraepithelial neoplasia (CIN) in CC screening, where the treatment of these precursor lesions over time results in a reduction in the incidence of invasive cancer [7], and more than half of CC cases are diagnosed in patients who have not participated in regular screening [8]. A key feature of screening for CC and CRC is the ability to directly access the target tissue and conduct an adequate screening test [7].

According to the data, high-quality cancer registry information, which is essential for planning and implementing evidence-based cancer control programs, is not available in most low- and middle-income countries

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[1]. In the Republic of Kazakhstan, as in many Central Asian countries, screening for BC has been conducted since 2008 [9], and screening for CC and CRC has been conducted since 2011 [10, 11]. It is well known that in some cases, the harm from cancer screening arises from subsequent events, such as the diagnostic workup of false-positive screening results and the diagnosis and treatment of cancers that might never have manifested clinically without screening (overdiagnosed and overtreated cases) [2]. For example, prostate cancer (PC) screening was introduced in 2013 [12], but due to the occurrence of false-positive results and controversial cases [13], the widespread use of PC screening was discontinued in 2017 [14].

Despite the implementation of screening programs, there has been no evaluation of the effectiveness of screening for commonly detected cancers (BC) and cancers that are accessible for targeted diagnosis during screening (CC, CRC) in the Republic of Kazakhstan. Additionally, it is important to note that during the COVID-19 pandemic, cancer screening, similar to other types of medical care, sharply declined [15-18] and the registered statistical data on screening outcomes during the pandemic period may not reflect the actual figures.

In this regard, the aim of this study is to evaluate the effectiveness of screening for BC, CC, and CRC in the Republic of Kazakhstan during the period from 2021 to 2023.

Materials and Methods

Data collection

In this study, data from the "Health Statistics" database of the S. Kairbekova National Research Center for Health Development for the period from 2021 to 2023 were used for conducting a retrospective analysis [19]. Access to these data was granted with the approval of the relevant authorities, adhering to all confidentiality and personal data protection requirements. All data were anonymized and used in an aggregated form for analysis purposes.

The study included patients who were diagnosed with BC (ICD-10 code C50), CC (ICD-10 code C53), or CRC (ICD-10 codes C18, C19, C20). Additional inclusion criteria were age over 18 years and documented participation in screening from 2021 to 2023. Patients with incomplete data, lack of diagnosis confirmation, or other contraindications for screening participation were excluded from the study.

For the analysis of regional differences, data on patients' place of residence were categorized according to the administrative regions of the Republic of Kazakhstan. Regional differences in screening coverage, availability of medical services, and infrastructure were considered. These factors were analyzed to identify potential influences on the outcomes of the screening programs.

Screening procedures

The screening was conducted based on Order of the Acting Minister of Health of the Republic of Kazakhstan [20]. Target groups of individuals subject to screening examinations: 1.For early detection of BC (once every 2 years):women aged 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70 years, who are not under dynamic observation for malignant breast tumors. 2. For early detection of CC (once every 4 years): women aged 30, 34, 38, 42, 46, 50, 54, 58, 62, 66, 70 years, who are not under dynamic observation for malignant cervical tumors. 3. For early detection of CRC (once every 2 years): men and women aged 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70 years, who are not under dynamic observation for benign or malignant tumors of the colon. Scope of screening examinations for the target groups subject to screening: 1. For BC screening: mammography of the breasts. 2. For CC screening: smear collection for oncocytology/cytological examination of the cervical smear (PAP test) using a liquid-based cytology apparatus. 3. For CRC screening: detection of occult blood in stool (hemoccult test) using the rapid test method.

Covariates

The analysis included the following covariates: age and region of residence. The determination of regions of residence was based on data from the state registry, and it was performed to account for potential regional differences in access to screening and its effectiveness.

Statistical analysis

All statistical calculations were performed using SPSS software version 22.0 (IBM SPSS Inc., Chicago, Illinois, USA). The Shapiro-Wilk and Kolmogorov-Smirnov tests were used to assess the normality of data distribution and its accuracy. To evaluate the relationship between screening coverage and the number of detected cases of diseases (BC, CC, and CRC), a correlation analysis was conducted using Pearson's correlation coefficient. A p-value of <0.05 was considered statistically significant.

Regression analysis was performed to identify factors influencing the number of detected cases of diseases. For each type of cancer (BC, CC, and CRC), a linear regression model was constructed where screening coverage was considered an independent variable, and the number of detected cases was considered a dependent variable. The regression models assessed the coefficients of determination (R^2) to determine the extent to which the variation in the dependent variable was explained. The cancer detection rate was calculated as the percentage ratio of the number of cancer cases detected through screening to the total number of diagnosed conditions (both benign and malignant) among the screened patients.

Results

Over the period from 2021 to 2023, a total of 8,167,184 people in the Republic of Kazakhstan were eligible for examination for BC, CC, and CRC (Figure 1).

In the BC screening program, 2,170,181 individuals participated. A total of 521,501 cases of breast conditions were detected, of which 420,366 cases (80.6%) were benign neoplasms, and 4,294 cases (0.82%) were diagnosed as BC.

In the CC screening program, 1,992,655 individuals participated. A total of 125,868 cases of cervical conditions

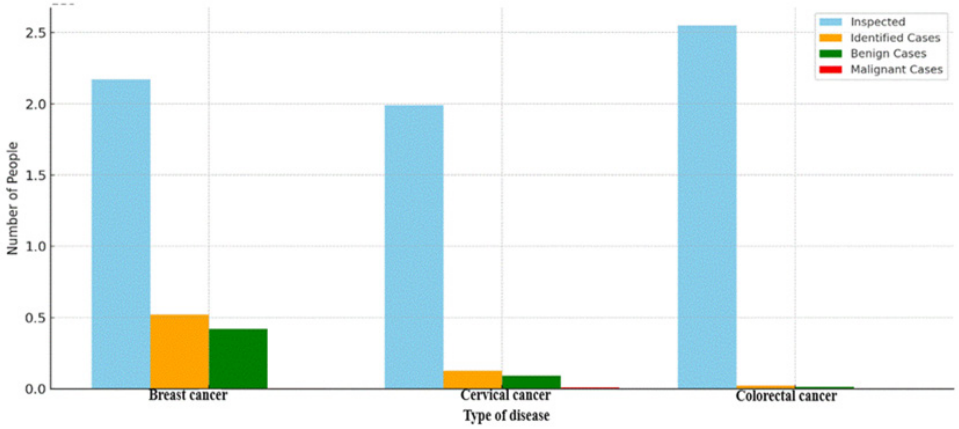

Figure 1. Quantitative Indicators for BC, CC, and CRC Screening During the Period 2021-2023.

Table 1. Results of BC Screening from 2021 to 2023, n (%).

Period	Eligible for Screening	Screened	Cases Detected	Benign Breast Neoplasms	BC
2021	923892 (100)	787619 (85.2)	186334 (20.1)	184949 (20.02)	1385(0.15)
2022	880613 (100)	808483 (91.8)	250517 (28.4)	207243 (23.5)	1478 (0.1)
2023	926467 (100)	574079 (61.9)	84650 (9.1)	28174 (3.0)	1431 (0.1)

were detected, of which 89,991 cases (71.5%) were benign neoplasms, and 7,993 cases (6.35%) were diagnosed as CC.

In the CRC screening program, 2,548,068 individuals participated. A total of 20,686 cases of colorectal conditions were detected, of which 14,025 cases (67.8%) were benign neoplasms, and 752 cases (3.64%) were diagnosed as CRC.

BC screening (Table 1) from 2021 to 2023 covered over 2.7 million women. In 2021, 85.25% of the 923,892 women eligible for screening were examined, with 20.17% of them diagnosed with conditions, including 0.15% of cancer cases. In 2022, screening coverage reached 91.81% of the 880,613 women, with a detection rate of 28.45% for conditions and 0.17% for cancer cases. In 2023, coverage decreased to 61.96% of the 926,467 women, with a detection rate of 9.14% for conditions and 0.15% for cancer cases.

CC screening (Table 2) from 2021 to 2023 covered over 2.4 million women. In 2021, 92.9% of the 815,617 women eligible for screening were examined, with 5.4% diagnosed with conditions, including 0.04% of CC cases. In 2022, screening coverage was 92.0% of the 838,000 women, with 6.0% diagnosed with conditions and 0.05% of CC cases. In 2023, coverage decreased to 54.9% of the 844,618 women, with 3.8% diagnosed with conditions and 0.02% of CC cases.

CRC screening (Table 3) from 2021 to 2023 covered over 2.9 million people. In 2021, 95.9% of the 960,010 eligible individuals were screened, with 0.48% diagnosed with conditions, including 0.02% of CRC cases. In 2022, screening coverage reached 96.6% of the 970,935 individuals, with a detection rate of 0.84% for conditions and 0.03% for CRC cases. In 2023, coverage decreased to 68.5% of the 1,007,032 individuals, with a detection rate of 0.78% for conditions and 0.03% for CRC cases. The decrease in screening coverage in 2023 requires further analysis to assess the causes and consequences.

The indicators for BC diagnosis (Table 4) by region in Kazakhstan per 100,000 female population for the period 2021-2023 show that in 2021, Akmola Region reported 52 cases (13.8 per 100,000 population). In 2022, this rate

Table 2. Results of CC Screening from 2021 to 2023, n (%).

Period	Eligible for Screening	Screened	Cases Detected	Benign Cervical Neoplasms	CC
2021	815617 (100)	757454 (92.9)	44041 (5.4)	43733 (5.4)	308 (0,04)
2022	838000 (100)	771282 (92.0)	49914 (6.0)	37449 (4.5)	382 (0,05)
2023	844618 (100)	463919 (54.9)	31913 (3.8)	8809 (1.0)	168 (0.02)

Table 3. Results of CRC Screening from 2021 to 2023, n (%).

Period	Eligible for Screening	Screened	Cases Detected	Benign Colorectal Neoplasms	CRC
2021	960010 (100)	920640 (95.9)	4654 (0.48)	4457 (0.46)	197 (0.02)
2022	970935 (100)	937859 (96.6)	8137 (0.84)	5441 (0.56)	296 (0.03)
2023	1007032 (100)	689569 (68.5)	7895 (0.78)	4127 (0.41)	259 (0.03)

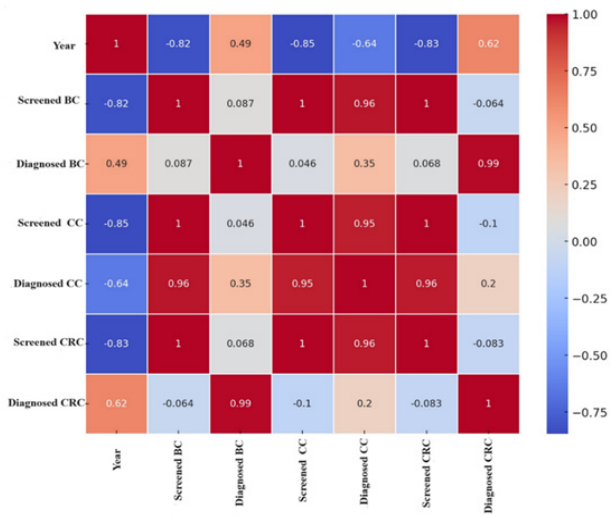

Figure 2. Main Correlational Relationships Between Year, Screening, and Diagnosis for BC, CC, and CRC.

increased to 92 cases (22.9), but in 2023, it decreased to 27 cases (6.7). In Aktobe Region, there were 21 cases (4.6) in 2021, 32 cases (6.8) in 2022, with no new cases reported in 2023. Almaty Region showed a decrease in cases from 116 (11.0) in 2021 to 64 (5.8) in 2023, despite an increase to 195 cases (17.8) in 2022. In Atyrau Region, there were 269 cases (80.7) in 2021, which significantly decreased to 16 cases (4.6) in 2023. Karaganda Region saw an increase from 206 cases (28.5) in 2021 to 211 cases (29.9) in 2022, followed by a decrease to 102 cases (14.5) in 2023. In North Kazakhstan Region, there was a decrease from 79 cases (27.8) in 2021 to 70 cases (24.4) in 2023.

In major cities, such as Astana, the rate sharply increased in 2023 to 704 cases (99.3), whereas 62 cases (10.1) and 60 cases (8.9) were reported in 2021 and 2022, respectively. In Almaty, there was a decrease from 160 cases (15.0) in 2021 to 104 cases (9.0) in 2023. Overall in Kazakhstan, the number of breast cancer cases per 100,000 female population was 1,385 (14.3) in 2021, increased to 1,478 (14.8) in 2022, and then decreased to 1,431 (14.1) in 2023.

CC Diagnosis Rates by Region in Kazakhstan per 100,000 Female Population for 2021-2023 was presented in Table 5. In 2021, Akmola Region reported 14 cases of cervical cancer (3.7 per 100,000 population), which increased to 16 cases (4.0) in 2022 but decreased to 10 cases (2.5) in 2023. In Aktobe Region, the number of cases decreased from 5 (1.1) in 2021 to 2 (0.4) in 2023. Almaty Region recorded 25 cases (2.4) in 2021, peaked at 46 cases (4.2) in 2022, and decreased to 22 cases (2.0)

Table 4. BC Diagnosis Rates by Region in Kazakhstan per 100,000 Female Population for 2021-2023.

Region	Year		
	2021	2022	2023
Akmola	52 (13.8)	92 (22.9)	27 (6.7)
Aktobe	21 (4.6)	32 (6.8)	0
Almaty	116 (11.0)	195 (17.8)	64 (5.8)
Atyrau	269 (80.7)	53 (15.4)	16 (4.6)
West Kazakhstan	77 (22.6)	60 (17.2)	53 (15.1)
Zhambyl	35 (6.1)	23 (3.8)	27 (4.4)
Karaganda	206 (28.5)	211 (29.9)	102 (14.5)
Kostanay	71 (15.6)	81 (18.7)	63 (14.7)
Kyzylorda	37 (9.1)	42 (10.2)	36 (8.7)
Mangystau	4 (1.1)	8 (2.1)	13 (3.4)
Pavlodar	93 (23.5)	101 (25.7)	44 (11.2)
North Kazakhstan	79 (27.8)	59 (21.2)	70 (24.4)
Turkestan	62 (6.2)	57 (5.6)	24 (2.3)
East Kazakhstan	214 (30.0)	169 (24.3)	74 (10.7)
Astana City	62 (10.1)	60 (8.9)	704 (99.3)
Almaty City	160 (15.0)	169 (15.0)	104 (9.0)
Shymkent City	70 (12.6)	66 (11.0)	47 (7.6)
Republic of Kazakhstan	1385 (14.3)	1478 (14.8)	1431 (14.1)

Table 5. CC Diagnosis Rates by Region in Kazakhstan per 100,000 Female Population for 2021-2023.

Region	Year		
	2021	2022	2023
Akmola	14 (3.7)	16 (4.0)	10 (2.5)
Aktobe	5 (1.1)	3 (0.6)	2 (0.4)
Almaty	25 (2.4)	46 (4.2)	22 (2.0)
Atyrau	19 (5.7)	42 (12.2)	9 (2.6)
West Kazakhstan	13 (3.8)	11 (3.1)	3 (0.9)
Zhambyl	19 (3.3)	9 (1.5)	15 (2.4)
Karaganda	17 (2.4)	29 (4.1)	3 (0.4)
Kostanay	18 (4.0)	17 (3.9)	12 (2.8)
Kyzylorda	19 (4.7)	13 (3.2)	12 (2.9)
Mangystau	9 (2.5)	21 (5.6)	4 (1.0)
Pavlodar	24 (6.1)	30 (7.6)	14 (3.6)
North Kazakhstan	14 (4.9)	12 (4.3)	2 (0.7)
Turkestan	33 (3.3)	25 (2.4)	17 (1.6)
East Kazakhstan	30 (4.2)	45 (6.5)	16 (2.3)
Astana City	19 (3.1)	18 (2.7)	13 (1.8)
Almaty City	12 (1.1)	21 (1.9)	11 (0.9)
Shymkent City	18 (3.2)	24 (4.0)	3 (0.5)
Republic of Kazakhstan	308 (3.2)	382 (3.8)	168 (1.7)

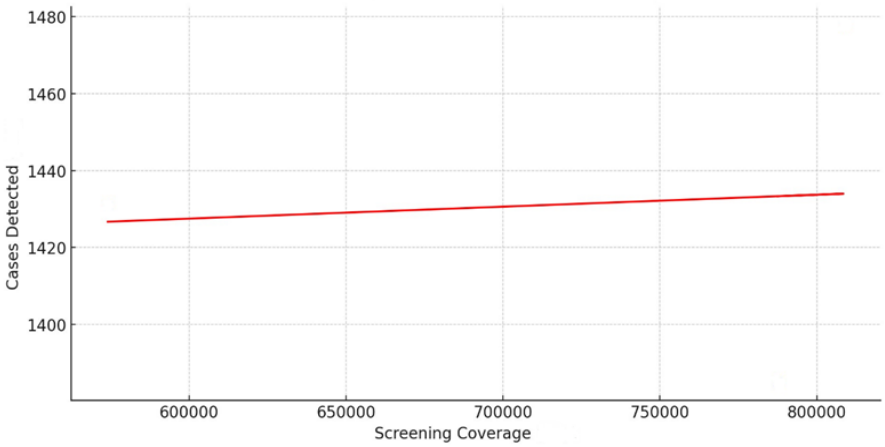

Figure 3. Regression Analysis of the Relationship between Breast Cancer Screening Coverage and the Number of Detected Cases.

Table 6. CRC Diagnosis Rates by Region in Kazakhstan per 100,000 Population for 2021-2023.

Region	Year		
	2021	2022	2023
Akmola	6 (0.8)	17 (2.1)	7 (0.8)
Aktobe	3 (0.3)	8 (0.8)	5 (0.5)
Almaty	29 (1.4)	49 (2.2)	12 (0.5)
Atyrau	6 (0.9)	19 (2.7)	8 (1.15)
West Kazakhstan	8 (1.2)	11 (1.6)	8 (1.16)
Zhambyl	12 (1.0)	7 (0.5)	6 (0.4)
Karaganda	18 (1.3)	20 (1.4)	19 (1.4)
Kostanay	12 (1.3)	17 (2.0)	19 (2.2)
Kyzylorda	7 (0.8)	5 (0.6)	2 (0.2)
Mangystau	1 (0.1)	4 (0.5)	91 (11.8)
Pavlodar	13 (1.7)	20 (2.6)	11 (1.4)
North Kazakhstan	13 (2.3)	26 (4.8)	14 (2.6)
Turkestan	1 (0.05)	5 (0.2)	8 (0.3)
East Kazakhstan	26 (1.9)	32 (2.3)	21 (1.5)
Astana City	15 (1.2)	7 (0.5)	3 (0.2)
Almaty City	22 (1.1)	32 (1.5)	18 (0.8)
Shymkent City	5 (0.4)	17 (1.4)	7 (0.5)
Republic of Kazakhstan	197 (1.04)	296 (1.5)	259 (1.3)

in 2023. Atyrau Region experienced a sharp increase in cases from 19 (5.7) in 2021 to 42 (12.2) in 2022, followed by a decrease to 9 cases (2.6) in 2023.

In Karaganda Region, 17 cases (2.4) were reported in 2021, rising to 29 cases (4.1) in 2022, and then dropping to 3 cases (0.4) in 2023. Pavlodar Region saw an increase in cases from 24 (6.1) in 2021 to 30 (7.6) in 2022, and then a decrease to 14 cases (3.6) in 2023.

Overall, in the Republic of Kazakhstan, the total number of registered cervical cancer cases was 308 (3.2) in 2021, increased to 382 (3.8) in 2022, and significantly decreased to 168 cases (1.7) in 2023.

CRC Diagnosis Rates by Region in Kazakhstan per 100,000 Population for 2021-2023 displayed in Table 6. In Akmola Region, the number of colorectal cancer cases increased from 6 (0.8 per 100,000 population) in 2021 to 17 (2.1) in 2022, and then decreased to 7 cases (0.8) in 2023. Aktobe Region also showed growth, from 3 cases (0.3) in 2021 to 8 cases (0.8) in 2022, with a slight decrease to 5 cases (0.5) in 2023. In Almaty Region, the number of cases rose from 29 (1.4) in 2021 to 49 (2.2) in 2022, but fell to 12 cases (0.5) in 2023. Atyrau Region exhibited a similar trend, with cases increasing from 6 (0.9) in 2021 to 19 (2.7) in 2022, followed by a decrease to 8 cases (1.15)

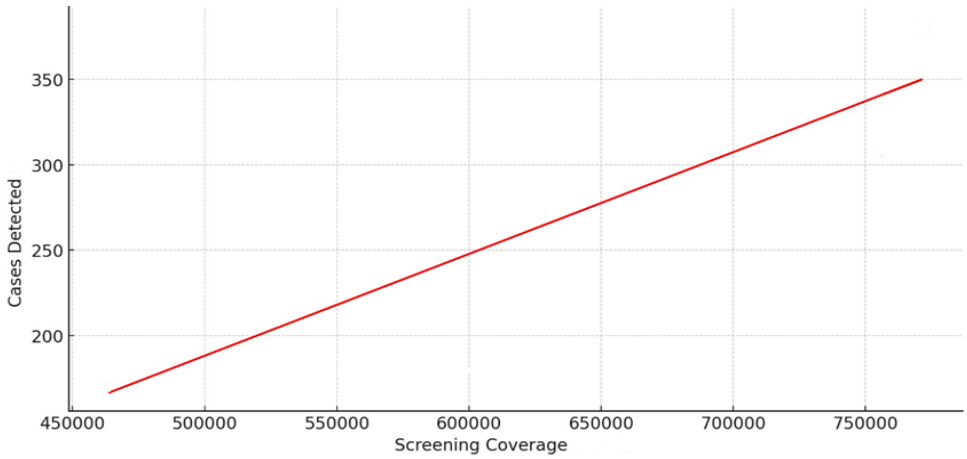

Figure 4. Regression Analysis of the Relationship between the Coverage of Screening for Cervical Cancer and the Number of Detected Cases.

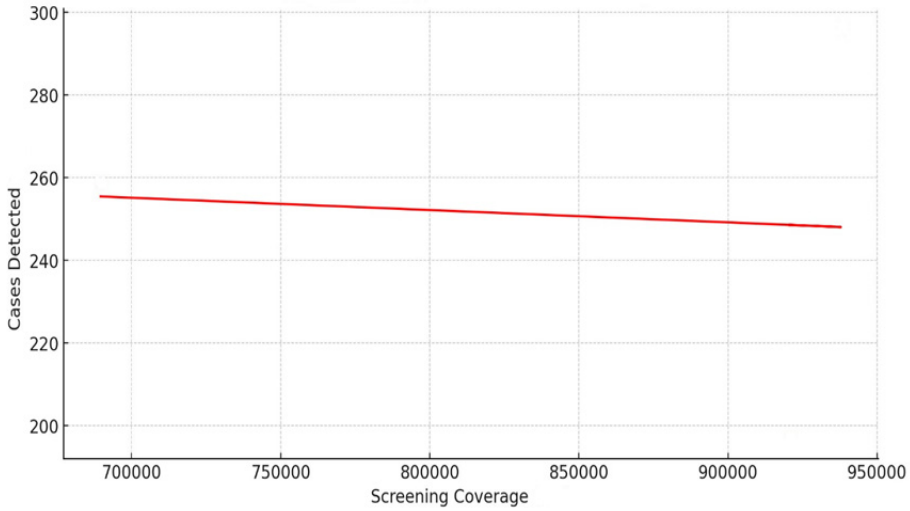

Figure 5. Regression Analysis of the Relationship between CRC Screening Coverage and the Number of Detected Cases.

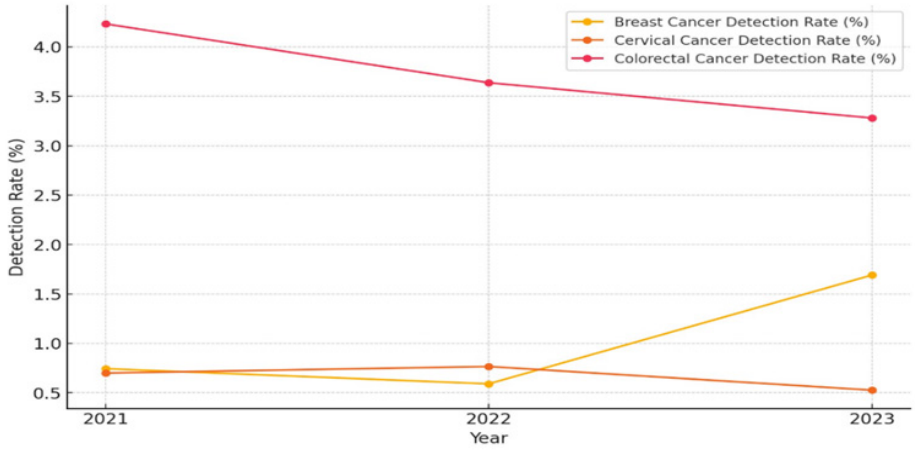

Figure 6. Detection Rates for BC, CC, and CRC from 2021 to 2023

in 2023. A significant change was observed in Mangistau Region, where the number of colorectal cancer cases grew from 1 (0.1) in 2021 to 4 (0.5) in 2022, and then surged to 91 cases (11.8) in 2023.

Overall, in the Republic of Kazakhstan, the total number of registered colorectal cancer cases was 197 (1.04) in 2021, increased to 296 (1.5) in 2022, and then decreased to 259 cases (1.3) in 2023.

Main Correlational Relationships Between Year, Screening, and Diagnosis for BC, CC, and CRC indicated in Figure 2. The analysis revealed a strong negative correlation between the year and the number of women screened for BC (-0.82), CC (-0.85), and CRC (-0.83). However, a positive correlation was observed between the year and diagnosed cases of CRC (0.62), indicating a clear increase in diagnosed CRC cases over time. For BC (0.49) and CC (-0.64), weaker correlations were found.

The results of the regression analysis of the relationship between BC screening coverage and the number of detected cases are presented in Figure 3. For the linear regression model of breast cancer, screening coverage was not a significant factor influencing the number of detected cases (p-value 0.876).

The results of the regression analysis of the relationship between cervical cancer screening coverage and the number of detected cases are presented in Figure 4. For the linear regression model, cervical cancer screening coverage showed a significant effect on the number of detected cases (coefficient -0.0038), but the results are not statistically significant (p- 0.188).

The results of the regression analysis of the relationship between CRC screening coverage and the number of detected cases are presented in Figure 5. For the linear regression model of CRC, screening coverage also did not turn out to be a significant factor influencing the number of detected cases (p-value 0.947).

The detection rate (Figure 6) of breast cancer in 2021 was 0.74%, then there was a decrease to 0.59% in 2022. However, in 2023, there was a significant increase to 1.69%. For cervical cancer, the detection rate was 0.70% in 2021, slightly increased to 0.77% in 2022, but decreased again to 0.53% in 2023. In contrast, the detection rate for colorectal cancer shows a consistent decline. It was 4.23% in 2021, decreased to 3.64% in 2022, and continued to

decrease to 3.28% in 2023.

Discussion

In this study, we present an analysis of the effectiveness of screening programs for BC, CC, and CRC in Kazakhstan for the period 2021-2023. Screening attendance is a crucial metric in a country where screening is conducted at the population level. This metric is important not only for assessing the utilization of screening but also for monitoring its progress [21].

According to the our results of the analysis, benign tumors predominantly account for most of the detected cases. This is especially noticeable in cases of breast and cervical cancer, where the percentage of benign cases is significantly higher compared to malignant ones.

The selected study period of 2021-2023 was the post-pandemic period of COVID-19. Many studies show that, despite the peak of COVID-19 occurring in 2020, a continued decrease in screening activity, including for BC, CC, and PC, was observed in 2021 compared to the pre-pandemic period, reflecting societal adaptation to restrictions [22]. In addition, since 2021, a recovery in screening activity was observed, reaching levels comparable to the period before 2020 [22].

However, according to our data, in 2023, there is a notable decrease in the percentage of individuals screened for BC, CC, and CRC compared to previous years. This may indicate a reduction in the activity of screening programs or other factors affecting the accessibility of medical services, which warrants further investigation. For example, predictive models have shown that COVID-19 related disruptions of cervical cancer prevention activities would increase cervical cancer cases by 2027 [23]. It is also reported that this increase will be primarily due to disruption of excisional treatment and follow-up appointments, rather than delays in first-level screening, which will probably have a negligible effect on cancer diagnosis [24].

In the world, approximately 85% of CC cases are recorded in developing countries, highlighting global healthcare disparities [25]. In our study, there is a noticeable decrease in the number of detected cases of CC (1.7) in 2023 compared to previous years (3.2 in 2021 and 3.8 in 2022). In contrast, the detection rates for BC (14.0) and CRC (around 1) per 100,000 population in 2023 remained almost stable compared to previous years. Globally, cancer incidence rates fluctuate; for example, in Southeast Asia, the rate was only 9.6 per 100,000 people, while it reached 77.9 in Singapore [26]. Data from the national cancer registry show, for example, that BC has a detection rate of 129.5 per 100,000 women [27], while in Canada and Europe this rate was 83 [28] and 92 [29], respectively.

According to data from the Centers for Disease Control and Prevention (CDC), the incidence rate of CC in the United States is approximately 7.5 per 100,000 women [30], in European Union countries, the detection rate of CC varies, but the average rate is around 10.6 per 100,000 women [31], in Japan [32] and South Korea [33] the average detection rate is around 5 per 100,000 women. Regarding CRC detection rates, according to the National Cancer Institute (NIH), the incidence rate in the United States is approximately 38 per 100,000 people. In Canada, the CRC detection rate is about 63 per 100,000 people [28], in contrast, in India, the detection rate is 7 per 100,000 people [34]. These data indicate that the incidence rates for BC (14 per 100,000 women), CC (2-4 per 100,000 women), and CRC (1-1.5 per 100,000 people) in Kazakhstan are significantly lower than in most developed countries. This may reflect differences in disease diagnosis and detection, screening coverage, and medical care. Such low rates in Kazakhstan could also suggest potential gaps in the organization of cancer screening programs, highlighting the need for more in-depth analysis and improvements.

Geographic accessibility plays a crucial role in determining the effectiveness of cancer screening and treatment, and this issue extends beyond cancer to encompass a broad range of medical services [35]. Regional differences in BC, CC, and CRC detection rates in Kazakhstan for the period from 2021 to 2023 demonstrate significant variations. For example, in 2021, the Atyrau region had relatively high breast cancer detection rates (80.7 per 100,000 population), whereas in 2023, the rate in Nur-Sultan (formerly Astana) rose to 99.3 per 100,000 population. CC detection rates were relatively stable at 5-6 cases per 100,000 population in the Atyrau and Pavlodar regions, but by 2023, the number of cases had decreased to 2-3 per 100,000 population. CRC rates showed the most pronounced fluctuations in regions like Mangystau, where the incidence increased significantly to 11.8 per 100,000 population in 2023. These variations may be attributed to differences in regional resources for screening, as well as disparities in healthcare infrastructure and access to specialized services. [36]. These regional differences highlight the need for targeted efforts to improve the coverage and effectiveness of screening programs across different parts of the country. In addition, such heterogeneous indicators of identified cases of oncopathology of the reproductive system may also be associated with possible errors and shortcomings in statistical data collection, in the incorrect organization of the sample, which requires improvement of these issues. One possible solution could be adopting the experience of other countries in addressing issues related to accurate screening data recording to improve its effectiveness. For instance, the CanScreen5 project aims to serve as a tool for enhancing the quality of cancer screening programs [37]. Its primary focus is on building the capacity of healthcare providers and program managers to encourage and assist countries in regularly gathering and utilizing cancer screening data in a standardized way through an efficient information system. The project is expected to contribute to the generation and collection of high-quality data, facilitating improved program monitoring, evaluation, and ongoing quality enhancement.

Also, enhancing access to diagnostic services, improving the training of healthcare personnel, increasing public awareness, and ensuring equal access to high-quality medical care are crucial [38]. Moreover, it is important to consider the cultural and social characteristics

of regions when developing and implementing cancer prevention and treatment programs [39]. Numerous studies have shown that income level, culture, and lack of knowledge about screening influence the level of participation in screening [40]. In addition, a previously conducted cross-sectional study in our country identified the main barriers to screening as: fear of receiving unfavorable results during screening, fear of future illness, and lack of knowledge [11].

In our study, the correlation analysis showed that a high number of detected cases of one type of cancer generally corresponds to a high number of detected cases of other types of cancer. This may indicate that the effectiveness of screening and timely detection of diseases is directly dependent on the proper functioning of the screening service. In the United Kingdom, a national population-based screening program for BC, CC, and CRC has led to a reduction in cancer incidence. Specifically, the mortality rate from BC in women decreased from 28.92 to 15.90 per 100,000 people, from CC decreased from 4.78 to 1.64 per 100,000 cases between 1990 and 2013; the mortality rate from CRC decreased from 14.36 to 12.67 per 100,000 in men and from 8.97 to 8.26 per 100,000 in women between 2006 and 2013 [41].

Regular monitoring and analysis of screening coverage are critically important for identifying problem areas and developing effective strategies to increase public adherence to preventive screenings [42]. For example, in the United States, it was found that the level of adherence to screening programs was relatively high: the adherence rates for BC, CC, and CRC screenings were 71.5%, 83%, and 62%, respectively [43]. In this regard, the experience of developed countries, such as China, also demonstrates the importance of regular, systematic official evaluations of results and any new data that could suggest the need for changes, intensification, or cessation of screening programs [35].

To increase screening coverage, it is essential to enhance cooperation between government institutions, medical organizations, and public initiatives. This includes improving informational campaigns, ensuring the accessibility of medical services, and supporting vulnerable groups within the population [43].

In conclusion, data from 2021-2023 highlight the need for continuous monitoring, analysis, and adaptation of screening program strategies, considering regional specifics and new challenges such as the pandemic. Ensuring high screening coverage for BC, CC, and CRC is a key factor for early detection and effective treatment of these diseases. Our data suggest possible shortcomings in the planning of screening programs and uneven public participation depending on regional differences.

To measure the benefits and harms of screening, regular program monitoring and evaluation of key outcomes, including economic efficiency analysis, are crucial for determining the optimal screening strategy.

Study limitations

This study has limitation. The analysis only covers three years (2021-2023), which may limit the ability to identify long-term trends and assess the sustainability of programs.

Author Contribution Statement

Conceptualisation: Alfiya Shamsutdinova and Gulnara Kulkayeva, data curation: Alfiya Shamsutdinova and Zhadyra Karashutova; formal analysis: Baimakhan Tanabayev; investigation: Alfiya Shamsutdinova, Anel Ibrayeva, Shynar Tanabayeva and Ildar Fakhradiyev methodology: Baimakhan Tanabayev, Ildar Fakhradiyev and Gulnara Kulkayeva; project administration: Alfiya Shamsutdinova; resources: Alfiya Shamsutdinova; supervision: Alfiya Shamsutdinova; validation: Baimakhan Tanabayev; visualisation: Zhadyra Karashutova; writing – original draft, and writing– review & editing: Alfiya Shamsutdinova, Shynar Tanabayeva, Zhadyra Karashutova, and Ildar Fakhradiyev.

Acknowledgements

The authors express their gratitude for the administrative and technical support provided by the S.D. Asfendiyarov Kazakh National Medical University.

Ethical Declaration

The study was approved by the Local Ethics Committee of S.D. Asfendiyarov Kazakh National Medical University (excerpt from the LEC meeting minutes No. 4 dated May 3, 2017). The research complies with international and national standards for conducting medical studies, and the confidentiality of participants' data has been fully maintained.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest

The authors declare no conflict of interest.

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