

## EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.

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### Abstract

**Objective:** The aim of this study was to assess the participation rates and performance metrics of the colorectal cancer (CRC) screening program in Saudi Arabia from 2021 to 2023.

**Design:** The research employed a retrospective cross-sectional design.

**Setting:** The investigation was based on data collected from the national CRC screening initiative targeting Saudi citizens aged 45 to 75 years, managed by the Ministry of Health.

**Participants:** The study analyzed data from all eligible participants who underwent CRC screening within the study period, sourced from secondary databases.

**Interventions:** The CRC screening program included the use of fecal immunochemical tests (FIT) and subsequent colonoscopies for those with positive results or classified as high-risk.

**Main Outcome Measures:** The primary performance indicators evaluated were the coverage rate, participation rate, FIT positivity rate, referral rate for colonoscopy, and compliance rate with colonoscopy.

**Results:** The analysis indicated significant improvements in key performance indicators over the three-year period. The coverage rate increased from 1% in 2021 to 3.4% in 2023 ( $p < 0.001$ ). The number of individuals screened escalated from 30,641 in 2021 to 100,340 in 2023 ( $p < 0.001$ ). While the FIT positivity rate remained stable at approximately 5.7%, the absolute number of positive FIT results rose significantly ( $p < 0.001$ ). The referral rate for colonoscopy consistently remained high, and compliance with colonoscopy appointments showed marked improvement ( $p < 0.001$ ). The study also highlighted gender and regional disparities, with a slight majority of participants being female (51.5%) and notable regional differences in screening outcomes.

**Conclusions:** The CRC screening program in Saudi Arabia has shown substantial progress in terms of increased participation and improved performance metrics between 2021 and 2023. The results underscore the program's success in expanding screening coverage and enhancing follow-

up compliance. However, the findings also call for targeted efforts to mitigate gender and regional disparities.

**Keywords:** Colorectal cancer, screening, Saudi Arabia, participation rate, performance indicators, public health.

## i. Introduction:

Colorectal cancer (CRC) is currently ranked as the third leading cause of cancer-related deaths worldwide. Furthermore, its occurrence is steadily increasing in developing countries. CRC typically originates from the glandular, epithelial cells of the large intestine. Based on data from GLOBOCAN 2020, CRCs represent the third most frequently diagnosed type of cancer globally, accounting for around 10% of all cancer diagnoses after Breast cancer 11.7% and lung cancer 11.4%<sup>1</sup>. It is projected that around 1.9 million new cases of colorectal cancer would have been diagnosed in 2020 alone and the 2nd cancer leading to death by 9.4% (935,000 deaths) were estimated to occur in 2020 after lung cancer by 18% (1.8 million cases)<sup>1</sup>. Among men, CRC is the most diagnosed cancer in 10 out of 191 countries worldwide. However, no country reports CRC as the most diagnosed cancer among women<sup>2,3</sup> In Saudi Arabia, (CRC) is the most frequently diagnosed cancer in males and ranks as the third most prevalent cancer among females.<sup>4</sup> In 2020, Saudi Arabia recorded 1729 newly diagnosed cases of colorectal cancer accounting for 12.3% of all newly diagnosed cases in the year 2020 among Saudi nationals.<sup>5</sup> Despite being a notable public health concern in the kingdom, the available reports on epidemiological factors related to colorectal cancer are insufficient in comparison to the data available from Western nations.<sup>6</sup> The increasing incidence of (CRC) in Saudi Arabia can be attributed to various factors, including changes in obesity rates, physical activity levels, dietary patterns, smoking habits, socioeconomic status, life expectancy, screening practices, and treatment decisions. Obesity, combined with a sedentary lifestyle, stands out as one of the key behavioral factors associated with CRC development.<sup>6–8</sup> A meta-analysis of 13 cohort studies revealed that gaining 5 kg in weight was associated with a 3% increased risk of developing CRC.<sup>9</sup>

(CRC) is among the few types of cancer that can be effectively detected at its early stages through various screening methods. Two commonly used screening tests for CRC include a fecal immunochemical test (FIT) and sigmoidoscopy or colonoscopy.<sup>10,11</sup> The FIT is a non-invasive screening method that checks for the presence of hidden blood in the stool, which can be an early sign of CRC, this test is relatively simple and can be done at home using a kit provided by a healthcare professional.<sup>12</sup> Sigmoidoscopy and colonoscopy are more invasive procedures but offer a more comprehensive examination of the colon. During a sigmoidoscopy, a flexible tube with a camera is inserted into the lower part of the colon to examine for any abnormalities. In a colonoscopy, the entire colon is examined using a similar procedure. Both tests allow for the detection of precancerous polyps or early-stage CRC, which can then be removed or treated before they progress.<sup>13</sup>

The colorectal cancer screening program in Saudi Arabia start at 2017 as a national program and aims to identify potential causes and risk factors for colorectal cancer.<sup>14</sup> This project specifically targets Saudi individuals who registered at healthcare centers and classifies them based on their probability of developing the CRC disease. Individuals at moderate risk include those aged 45 to 75 with no symptoms, family history of the disease, or polyps. On the other hand, individuals

at high risk have a history of polyps, first-degree relatives with the disease or polyps, multiple second-degree relatives with the disease or polyps, ulcerative colitis, Crohn's disease, or other relevant conditions like a personal history of requiring radiation therapy in abdomen or pelvic area. The examination periods involve early and periodic screenings for colorectal cancer, which vary depending on the severity. For individuals at moderate risk, a fecal immunochemical test (FIT) is conducted. If the result is negative, the FIT is repeated annually. If positive, a total colonoscopy is recommended. For individuals at high risk or with a positive FIT result, a total colonoscopy is performed. Negative results from the colonoscopy lead to repeated screenings every 10 years for those at moderate risk and annually for those at high risk. Positive results referred to further assesment.<sup>15</sup> The early detection service for colorectal cancer is provided in primary healthcare centers and hospitals across various regions of the Kingdom. To avail of this service, individuals can schedule an appointment through the Sehaty application at the family medicine clinic or specialized clinics for chronic diseases like diabetes, obesity, and blood pressure. Additionally, individuals within the target age group can also access the service through other relevant clinics.<sup>16</sup>

## **ii. Aim, objectives and hypothesis:**

The CRC screening program in KSA since 2017 and there is no evaluation study for it, so this study aims to evaluation of participation and performance indicators in colorectal cancer screening program in KSA and provide valuable information on screening prevalence, demographic characteristics, barriers and facilitators, early detection capability.

The main objectives of this study are as follows:

1. To determine prevalence of colorectal cancer screening test results in Saudi Arabia from 2021 to 2023.
2. To assess the demographic characteristics (age, gender) of individuals who undergo colorectal cancer screening in Saudi Arabia.
3. Identify any regional differences in program implementation and access.

There are significant demographic associations with the prevalence of positive colorectal cancer screening test results in Saudi Arabia between the regions because of screening rates and the period of screening process.

## **iii. Methods:**

The study utilized a retrospective cross-sectional design to examine the distribution and impact of the colorectal cancer screening program in Saudi Arabia between January 2021 and December 2023. The target population encompassed all accessible individuals who underwent CRC screening during this period, as documented in secondary databases. No specific sample size was calculated, as the study aimed to include all eligible participants available in secondary databases obtained from the cancer control program (CCP), the General Administration of Health Programs and Chronic Diseases, and the Ministry of Health in Saudi Arabia.

Data collection: secondary data obtained from cancer control program (CCP), General Administration of Health Programs and Chronic Diseases, and Ministry of health reported positive test result of a fecal immunochemical test (FIT) from family medicine clinic or chronic diseases clinics (such as: diabetes, obesity, blood pressure) or other clinics, and Hospitals to Colorectal cancer early detection program in Ministry of Health in KSA. All data will be anonymized, and

the following data will be extracted; demographic data: age, gender, region. Screening process data: name of the health care facility, date of sample taken, date of the results release, date of referral, date of colonoscopy conducted, the date of colonoscopy result and if it positive or negative.

Data analysis: data was extracted using Microsoft Excel (2019) and analyzed using IBM SPSS version 23. Normality of the data was assessed using a single sample K-S test. Descriptive statistics were used to summarize categorical data as numbers and percentages, parametric data as mean  $\pm$  standard deviation, and non-parametric data as median, minimum, and maximum. Independent t-tests were used to compare means of continuous parametric variables between groups, while Mann-Whitney U tests were used for non-parametric continuous variables. Chi-square and Fisher's exact tests were employed to analyze differences in proportions between categories. Univariate and multivariate logistic regression analyses were conducted to identify factors associated with positive CRC screening, with results presented as crude and adjusted odds ratios with 95% confidence intervals. Findings were presented in tables and charts, and a P-value of less than 0.05 was considered statistically significant.

To evaluate the effectiveness of the colorectal cancer (CRC) screening program, we have created key performance indicators (KPIs) that specifically target the organizational and procedural components. The organizational indicators comprised the rate of coverage by invitation and participation rate. In contrast, the process indicators comprised the rate of FIT positive, the rate of referral to colonoscopy, and the percentage of compliance (Table 1).

#### iv. Results

The analysis of Colorectal cancer screening data from 2021 to 2023 indicates significant improvements in several key performance indicators. The number of eligible individuals slightly decreased from 2,796,365 in 2021 to 2,713,033 in 2023, while the coverage rate for the targeted age group (Saudi individuals aged 45-75) increased significantly from 1% in 2021 to 3.4% in 2023 ( $p < 0.001$ ). The total number of screened individuals rose from 30,641 in 2021 to 100,340 in 2023 ( $p < 0.001$ ). The number of individuals who underwent FIT testing also experienced a substantial increase, but the percentage of positive FIT results remained consistently at 5.7% each year. However, the actual number of positive results showed a significant rise ( $p < 0.001$ ). The rates of referral for colonoscopy remained persistently high, with significant increases observed in both high-risk people and those who attended their scheduled colonoscopy sessions ( $p < 0.001$ ). These findings demonstrate significant improvements in the extent of screening coverage, participation rates, and the effectiveness of follow-up measures throughout this time frame (Table.2).

During the three-year duration, the percentage of female participants was slightly higher at 51.5% compared to male participants at 48.5%. The age distribution shows a persistent majority of individuals between the ages of 45 and 64, comprising approximately two-thirds of the sample. Riyadh had the highest proportion of participants (34.8%) among the regions, followed by Ahssa (14.4%) and Qassim (9%). The data indicates a substantial rise in the number of participants over the years, especially in 2023. The yearly distribution of individuals who underwent CRC screening from 2021 to 2023 shows a slight decline in the average age, from 58.9 years in 2021 to 56.4 years in 2023, with an overall average of 57 years ( $\pm 11.2$ ). The median age declined from 59 in 2021 to 57 in 2022 and 2023. The median age climbed from 50 in 2021 to 60 in 2022 and 2023, suggesting a greater focus on screening adults around 60. (Table 3).

(Figure.1) presents a detailed summary of the positive (FIT) cases in the colorectal cancer (CRC) screening program in Saudi Arabia. The data is categorized by age group and gender, covering 2021 to 2023. The data shows that the age categories 45-54 and 55-64 regularly had the highest positive cases, making up around 70%. More precisely, the age group between 55 and 64 made up 34.7% of the reported cases, while the age group between 45 and 54 accounted for 33.7%. 23.5% of the incidents were attributed to individuals in the age group of 65-75. The gender distribution is symmetrical, with a minor female preponderance observed in most age groups annually.

The analysis of the positive (FIT) cases in the distribution of colorectal cancer (CRC) screening, categorized by gender and region, from 2021 to 2023 reveals a consistent annual rise in positive results. In 2021, the percentage of positive cases was 8.80% in males and 9.40% in females. By 2023, these percentages increased to 27.45% in males and 29.82% in females. Gender disparities were observed in Riyadh (2023,  $p=0.031$ ), Hail (2022 and 2023,  $p<0.001$ ), Beshah (2023,  $p=0.001$ ), and Qaryat (2023,  $p=0.020$ ), with females exhibiting more significant rates of positive compared to males. Conversely, areas like Qassem, Jazan, and Makkah showed negligible gender disparities throughout the years. Riyadh recorded the highest prevalence of positive cases, accounting for 27.4% of the overall cases, experiencing a substantial surge in 2023. Ahsa and Qassim had notable increases in reported cases, especially in 2023, accounting for 15.9% and 10.7% of the total cases, respectively. The gender distribution indicates that males and females were well-represented in all regions, with a slight majority of females in specific years in areas like Ahsa and the Eastern region. This data showcases the differences in positive FIT cases across different areas. (Table 4).

Measuring the coverage percentages in different regions between 2021 and 2023 shows notable disparities. Riyadh exhibited a volatile pattern, beginning at 86% in 2021, declining to 29% in 2022, and subsequently recovering to 64% in 2023, with an average of 57%. Baha experienced a lack of coverage in 2021 and 2022 but showed improvement to reach 44% in 2023, with an average of 23%. The percentage growth in Jouf rose from 56% in 2021 to 139% in 2023, with an average of 118%. The percentage increase in Northern jumped from 22% in 2021 to 164% in 2023, with an average increase of 98%. Qassem and Ahsa consistently had high levels of coverage, with Qassem averaging 176% and Ahsa averaging 264%. Madina and Jazan had consistent, albeit comparatively lower, levels of coverage, with Madina averaging 40% and Jazan averaging 77%. Beshah and Qaryat show exceptionally high rates, with mean values of 335% and 409%, respectively. The average coverage across all regions was 100%, showing satisfactory outreach and participation. Nevertheless, certain locations were found to have specific areas that require targeted enhancements (Figure 2).

The analysis of colorectal cancer (CRC) screening from 2021 to 2023 shows notable variations in the extent of coverage, rates of positive (FIT) results, referrals, and compliance with colonoscopy among different locations. The average rate of compliance for colonoscopies is 55.5%. Baha has the highest compliance level, at 77.5%, and Najran has the lowest, at 0%. The mean referral rate for colonoscopy is 76.4%, with the greatest rate recorded in Hafir Al Batin, at 99%, and the lowest rate in Tabuk, at 31.9%. The average positivity rate for the FIT is 5.4%. Riyadh has the highest rate at 27.4%, while Baha and Jouf have the lowest rates at 0.3%. The average coverage rate by invitation is 100%, with Baha having the highest percentage at 409% and Ahsa having the lowest rate at 23%. Regionally, there are substantial differences in colonoscopy

compliance rates ( $p=0.046$ ), while referral rates, FIT Positive rates, and coverage rates do not indicate significant variation ( $p$ -values: 0.934, 1.0, and 0.0677, respectively). (Table 5).

The Pearson Chi-Square tests indicate significant regional differences in positive FIT test cases in Saudi Arabia's colorectal cancer screening program from 2021 to 2023. There are substantial variations in the distribution of positive cases across different years ( $\chi^2 (40) = 2459.544$ ,  $p = 0.000$ ) between genders ( $\chi^2 (20) = 149.724$ ,  $p = 0.000$ ). In referral practices ( $\chi^2 (20) = 890.626$ ,  $p = 0.000$ ). The Pearson Chi-Square tests reveal significant associations between age group, year, and gender among positive FIT test cases in Saudi Arabia's colorectal cancer screening program from 2021 to 2023. Specifically, the age group distribution significantly varies across different years ( $\chi^2 (8) = 47.425$ ,  $p = 0.000$ ) and between genders ( $\chi^2 (4) = 26.191$ ,  $p = 0.000$ ). (Table 6)

Significant findings were made during the analysis of risk groups based on age, gender, region, and year. Individuals younger than 45 showed a higher adjusted odds ratio (OR) of 2.5 (95% confidence interval [CI]: 1.8-3.2,  $p<0.001$ ), indicating a greater risk compared to the reference group of individuals aged 45-54 years. The 55-64 age group had an adjusted odds ratio (OR) of 1.2 (95% confidence interval [CI]: 1.0-1.5,  $p=0.05$ ), whereas the 65-75 age group exhibited an adjusted OR of 0.8 (95% CI: 0.6-1.0,  $p=0.08$ ) that did not reach statistical significance. Individuals who were 75 years old or older had a decreased risk, as indicated by an adjusted odds ratio (OR) of 0.6 (95% confidence interval [CI]: 0.4-0.8,  $p=0.01$ ). The gender analysis revealed that males had a significantly higher adjusted odds ratio (OR) of 1.30 (95% confidence interval [CI]: 1.15-1.48,  $p=0.0002$ ) in comparison to females. When comparing other localities to Riyadh, the study revealed far lower chances of the event occurring in Ahsa (adjusted odds ratio: 0.12, 95% confidence interval: 0.09-0.16,  $p<0.001$ ) and Qassim (adjusted odds ratio: 0.01, 95% confidence interval: 0.00-0.02,  $p<0.001$ ). The annual comparison revealed a rising trend in high-risk cases, with 2023 exhibiting the highest adjusted odds ratio (OR) of 10.50 (95% confidence interval [CI]: 8.87-14.12,  $p<0.001$ ) compared to the baseline year 2021. The referral rate for all cases was 74.12%, whereas the compliance rate for high-risk cases was 98.82% (Table 7).

The study uncovered significant findings when analyzing gender groups according to age, risk, region, and year. More precisely, the study discovered that males under 45 had an adjusted odds ratio (OR) of 1.32 (with a 95% confidence interval of 1.14-1.53) and a  $p$ -value of 0.00018. This indicates their risk is elevated compared to the reference group (ages 45-54). Men aged 55 to 64 had an adjusted odds ratio (OR) of 1.19 (95% confidence interval [CI]: 1.09-1.31,  $p=0.00014$ ), whereas men aged 65 to 75 had an adjusted OR of 1.36 (95% CI: 1.23-1.50,  $p<0.00001$ ). Men aged 75 and older had an adjusted odds ratio (OR) of 1.47 (95% confidence interval [CI]: 1.15-1.88,  $p=0.00193$ ). The risk study indicated that males had a substantially greater adjusted odds ratio (OR) of 1.30 (95% confidence interval [CI]: 1.15-1.48,  $p<0.001$ ) in comparison to females. When comparing different regions to Riyadh, it was discovered that males had lower probabilities of something taking place in Taif (adjusted odds ratio: 0.75, 95% confidence interval: 0.61-0.93,  $p=0.009$ ), Medina (adjusted odds ratio: 0.62, 95% confidence interval: 0.48-0.81,  $p<0.001$ ), and Hail (adjusted odds ratio: 0.54, 95% confidence interval: 0.42-0.68,  $p<0.001$ ). The annual comparison revealed no statistically significant disparities. The adjusted odds ratio (OR) for 2023 was 1.04, with a 95% confidence interval (CI) of 0.97-1.12 and a  $p$ -value of 0.28 compared to the reference year 2021. The referral rate for males was 81.05%, while for females it was 79.19%, as seen in (Table 8).

## v. Discussion

In this paper, the CRC screening program demonstrated a notable increase in coverage for the targeted age group (Saudi individuals aged 45-75), rising from 1% in 2021 to 3.4% in 2023. This increase, despite a slight decrease in the number of eligible individuals, indicates successful public health initiatives to raise awareness and encourage participation. The total number of screened individuals increased from 30,641 in 2021 to 100,340 in 2023 ( $p < 0.001$ ), highlighting the program's success in expanding its reach.

The yearly occurrence of positive FIT results remained consistent at 5.7% despite a notable increase in the number of individuals tested. The detection of CRC in the screened group suggests a continued incidence of the illness. However, the significant rise in favorable FIT results emphasizes. The consistently elevated referral rates for colonoscopy and notable rises in the number of high-risk persons attending their planned colonoscopy appointments ( $p < 0.001$ ) highlight the importance of an efficient follow-up system for timely detection and treatment.

The gender analysis indicated a slight majority of female participants (51.5%) compared to males (48.5%). Similar to most European CRC screening programs, there was a higher participation rate among women compared to men. The disparity in participation rates between the two groups grew over time, with the final round showing rates of 37.7% and 33.9% respectively ( $p < 0.001$ )<sup>17</sup>. The largest demographic group among the participants, including the greatest percentage, fell within the age range of 45 to 64, which corresponds to the main target population for colorectal cancer screening. The program's mean and median ages of the surveyed respondents exhibited a progressive decline from 2021 to 2023, suggesting a trend towards a younger demographic.

There might be significant variation within a nation. In the United States, the incidence of this phenomenon was nearly three times higher among those in Alaska compared to those in the Southwest. The variance in this situation is influenced by disparities in access to screening and behavior.<sup>8</sup> The Chi-Square tests reveal noteworthy regional disparities in the number of positive FIT test cases within Saudi Arabia's colorectal cancer screening program between 2021 and 2023. Significant differences exist in the distribution of positive cases among different years ( $p = 0.000$ ) and between genders ( $p = 0.000$ ). Referral practices were statistically significant ( $p = 0.000$ ). These data emphasize significant regional differences in screening outcomes over time, as well as variations by gender and referral patterns.

It is considered acceptable for follow-up colonoscopy compliance to be at 85%, but it is even more desirable for it to be above 90%.<sup>18</sup> Regional colonoscopy compliance rates are 87.9% in Riyadh and 0% in Najran. The difference shows post-FIT testing care difficulties. Asir and Jazan could improve compliance, but Riyadh and Qassem followed up well. Regional factors affect colonoscopy compliance, as shown by the p-value of 0.046. Prioritize accessibility, patient education, and referral simplification for timely follow-up care to close these gaps.

The 2018 study on cancer incidence in Saudi Arabia emphasizes notable variations in the frequency of colorectal cancer across regions. Riyadh exhibited the highest incidence rates, with 21.8% for males and 16.5% for females. Subsequently, the Eastern, Qassim, and Makkah regions

ensued. The ASR (Age-Specific Rate) for men in the Asir region is 10.7, while for women it is 7.9. Jouf had the lowest incidence of colorectal cancer (CRC), with males and females having age-standardized rates (ASRs) of 3.2 and 5.8, respectively. The significant variation in colorectal cancer (CRC) incidence in Saudi Arabia may be attributed to differences in the rates of CRC detection, which could be influenced by the availability of healthcare services.<sup>15</sup> In our study an analysis of data on colorectal cancer (CRC) screening identified significant variations in risk according to age, gender, location, and year. This highlights the need for targeted public health initiatives. The age group of 55-64 had a higher odds ratio (OR) of 1.2 ( $p=0.05$ ) compared to the age group of 45-54, but the age group of 65-75 had a lower OR of 0.8 ( $p=0.08$ ). Compared to females, males exhibited a significantly higher adjusted odds ratio (OR) of 1.30 ( $p=0.0002$ ). When comparing the data, it was found that the likelihood was much reduced in Ahsa (OR: 0.12,  $p<0.001$ ) and Qassim (OR: 0.01,  $p<0.001$ ) compared to Riyadh. In 2023, there was a substantial rise in the number of individuals who were at high risk, with an adjusted odds ratio of 10.50 ( $p<0.001$ ) compared to 2021. The overall referral rate for all patients was 74.12%, whereas the compliance rate for high-risk cases was 98.82%. When conducting a gender-specific analysis, it was shown that males under the age of 45 had an odds ratio (OR) of 1.32 ( $p=0.00018$ ), indicating a higher risk. Furthermore, older age groups also demonstrated heightened risks. Regarding certain geographical areas, males in Taif, Medina, and Hail had a diminished probability of incidents in comparison to Riyadh. The findings emphasize the importance of demographic and regional characteristics in colorectal cancer (CRC) screening programs and suggest tailored tactics to improve outcomes.

An analysis of data on colorectal cancer (CRC) screening between 2021 and 2023 demonstrates significant improvements in important performance measures. An important discovery from this study is the need for improved data collection to increase the overall effectiveness of the screening program.

## vi. Conclusion

The study conducted in Saudi Arabia from 2021 to 2023 aims to evaluate the effectiveness of colorectal cancer (CRC) screening. The study's results demonstrated significant enhancements in crucial performance indicators, in accordance with the study's goals. The screening rate for persons aged 45 to 75 experienced a significant surge, escalating from 1% to 3.4%. Simultaneously, there was an increase in the number of individuals who underwent screening, rising from 30,641 to 100,340. The incidence of positive fecal immunochemical test (FIT) results remained stable at 5.7%, but, there was a significant increase in the total number of positive cases, suggesting successful detection at an early stage. The program's efficacy in follow-up treatment is further emphasized by the elevated rates of referral and adherence to colonoscopy.

The demographic data shows that the population displayed a somewhat larger percentage of females (51.5%) than of men (48.5%). Furthermore, the study revealed that a good majority of participants fell between the ages of 45 and 64, which matches the desired population for colorectal cancer screening. The study revealed a significant discrepancy in risk between males and females, with males being at a significantly higher risk. When comparing different regions, it was found that there was a notable decrease in the likelihood in Ahsa and Qassim, although Riyadh showed a different trend. The rising occurrence of patients with a high risk, especially in 2023 when the



adjusted odds ratio reached its highest point, emphasizes the importance of continuous monitoring and targeted interventions.

The findings underscore the importance of enhancing data collection, addressing regional inequalities, and implementing targeted public health interventions. In order to improve the efficiency of the CRC screening program and reduce the prevalence of the condition in Saudi Arabia, it is essential to maintain a strong commitment to these regions. Comprehensive data collection and robust follow-up methods are crucial for preserving and enhancing the program's outcomes.

**vii. The study's strengths and weaknesses:**

The 2021–2023 colorectal cancer (CRC) screening study includes various credibility-boosting strengths. The benefits include in-depth data analysis that shows important performance indicator patterns over three years. The large sample size increases study reliability and enables for more accurate population screening and outcome generalizations. The analysis evaluates data spanning three years to showcase progress and pinpoint areas that want enhancement. The undertaking has grown and produced a substantial impact. Determining the scope of regional screening coverage and the resulting outcomes allows for targeted allocation of public health resources. Another advantage is the implementation of follow-up procedures for positive FIT findings, which leads to higher rates of referral for colonoscopy and improved compliance with early diagnosis and treatment. The comprehensive demographic analysis conducted in the study, which encompasses gender and age distribution, aids in the precise targeting of screening strategies for certain demographic groups.

Nevertheless, it is important to acknowledge and tackle the limits of the study in order to improve its efficacy and comprehensiveness. One major drawback is the dependence on secondary data sources, which can bring biases in terms of data accuracy and comprehensiveness, potentially impacting the study's findings. The study's retrospective methodology hinders the establishment of causal links between observed changes and the program's treatments, hence reducing the validity of the results on the effectiveness of the interventions. The study's focus on the participants of the screening program may overlook the difficulties encountered by those who did not participate, leading to an inadequate assessment of the program's efficacy. In addition, the research fails to consider other factors that could potentially affect the results of CRC screening, such as lifestyle choices, genetic susceptibility, and socioeconomic status.

The study's ability to track individual records is hindered by limited participant identification, hampers effective screen monitoring and understanding of long-term results. The study does not provide sufficient follow-up data on cases of colorectal cancer (CRC), such as the causes of mortality and the stages of the disease at the time of diagnosis. This data is needed to assess early detection and treatment effectiveness. The study must also assess the availability of screening resources, including colonoscopy units and skilled specialists. Future research should address these issues and capitalize on the highlighted benefits to better understand CRC screening systems. This will boost public health program efficiency and outcomes.

In summary, while the CRC screening program in Saudi Arabia has achieved significant milestones, it is imperative to address these limitations of the study to increase its continuous

progress and efficacy in further studies. Extensive data collection, prospective studies, consideration of potential confounding factors, overcoming participation barriers, using unique identifiers, obtaining comprehensive follow-up information, and allocating adequate resources are crucial to ensure the long-term effectiveness of the screening program. To enhance the prompt detection and treatment of colorectal cancer, the CRC screening program in Saudi Arabia can address these deficiencies. This will lead to enhanced patient outcomes and mitigate the disease's impact.

#### **viii. Recommendations**

We have proposed numerous significant suggestions to enhance the study on colorectal cancer (CRC) screening. Shifting from depending on secondary data sources to gathering primary data will significantly improve the precision and thoroughness of the information. Enforcing stringent information verification protocols will efficiently minimize errors and uphold the integrity of the data. A prospective longitudinal study design enables the identification of causal relationships between observed trends and program interventions, resulting in more reliable evidence for the effectiveness of the procedures.

Incorporating additional variables such as lifestyle habits, genetic predispositions, and socioeconomic status in the study will provide a more comprehensive comprehension of the outcomes of colorectal cancer screening. Understanding and documenting the factors that lead to the low involvement of eligible individuals is crucial. This will aid in identifying and resolving obstacles such as restricted comprehension, cultural viewpoints, or practical hindrances. This data can then be used to create efficient tactics to enhance involvement and increase participation rates.

It is essential to collect and analyze extensive regional data in order to address specific local difficulties effectively. It is essential to have a thorough comprehension of the discrepancies in healthcare resources, infrastructure, and public health activities in various regions in order to advance equitable and uniform access to screening services. Implementing unique identifiers for each participant will enhance the ability to accurately monitor individual screening histories, follow-up compliance, and long-term outcomes.

Improving the collection of additional data on instances of colorectal cancer (CRC), specifically regarding the cause of death and the stage of disease at the time of diagnosis, is essential for assessing the efficacy of programs aimed at early detection and treatment. Conducting a comprehensive evaluation of healthcare resources and infrastructure, such as colonoscopy units and well-trained personnel, is essential for identifying and resolving any deficiencies in resources.

By including feedback mechanisms from participants, we may obtain useful insights into their experiences and viewpoints on the screening process, which can be utilized to enhance the program. By incorporating these recommendations, the study can augment its precision, comprehensiveness, and pertinence, leading to more efficacious approaches for CRC screening and enhanced public health results.

**ix. Ethical Considerations**

Our research methodology relied on secondary sources, as we did not directly interact with the subjects under study. Before obtaining any data, we ensured consent was acquired. Subsequently, following approval from the Data Management Office and the Central Institutional Review Board of the General Administration of Research and Studies (approved number 24-34 M, approval date 24/03/2024), we accessed the necessary data from the Saudi Arabian Ministry of Health. All gathered data was subjected to anonymization procedures to safeguard confidentiality, and no direct communication was established with the participants.

**x. Budget and Motivation:**

The motivation of this study aims to assess the impact of a colorectal cancer screening program in Saudi Arabia on public health. More comprehensive epidemiological data are needed to guide intervention strategies. Addressing this knowledge gap is expected to directly inform the national initiative for colorectal cancer screening. Trends can be used to evaluate current programs and identify areas for improvement, establishing a solid evidence base to support optimal resource allocation.

- No direct funding is required.

**xi. Acknowledgement**

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**Figure 1: Distribution of Positive FIT Test Cases in CRC Screening Program by Age Group and Gender in Saudi Arabia (2021-2023)**

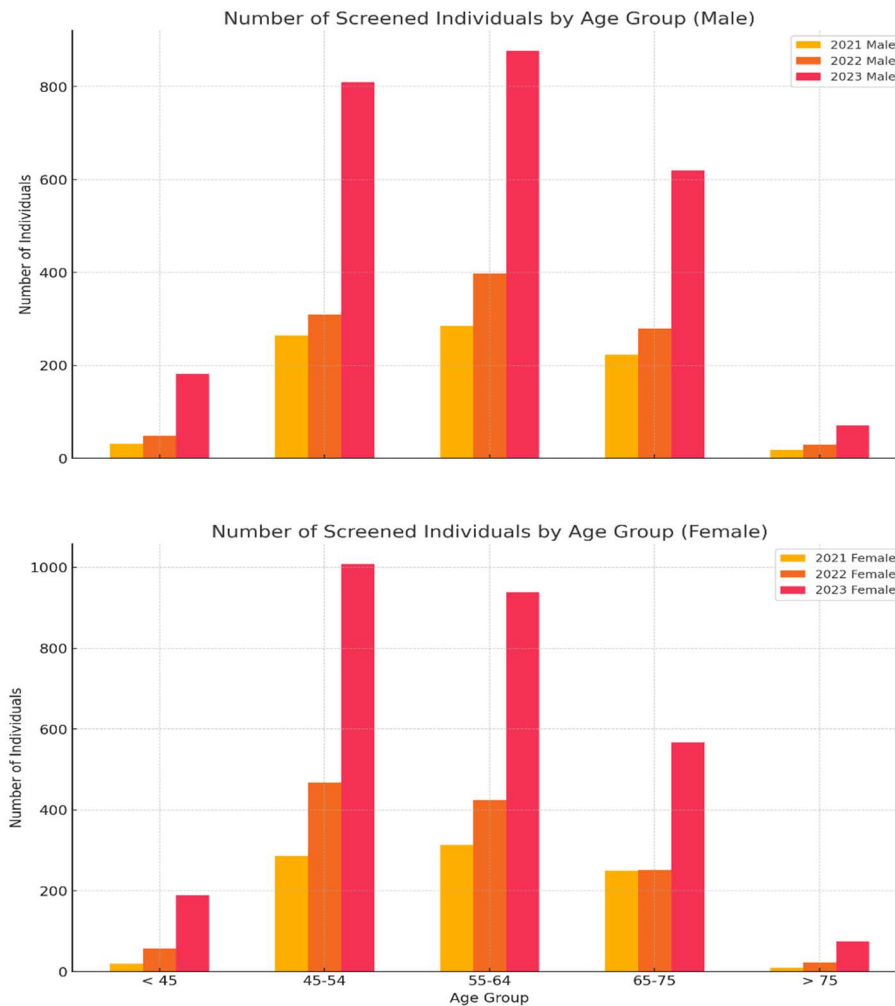


Figure 2: Annual Coverage Percentage of CRC Screening in Regions of Saudi Arabia (2021-2023)

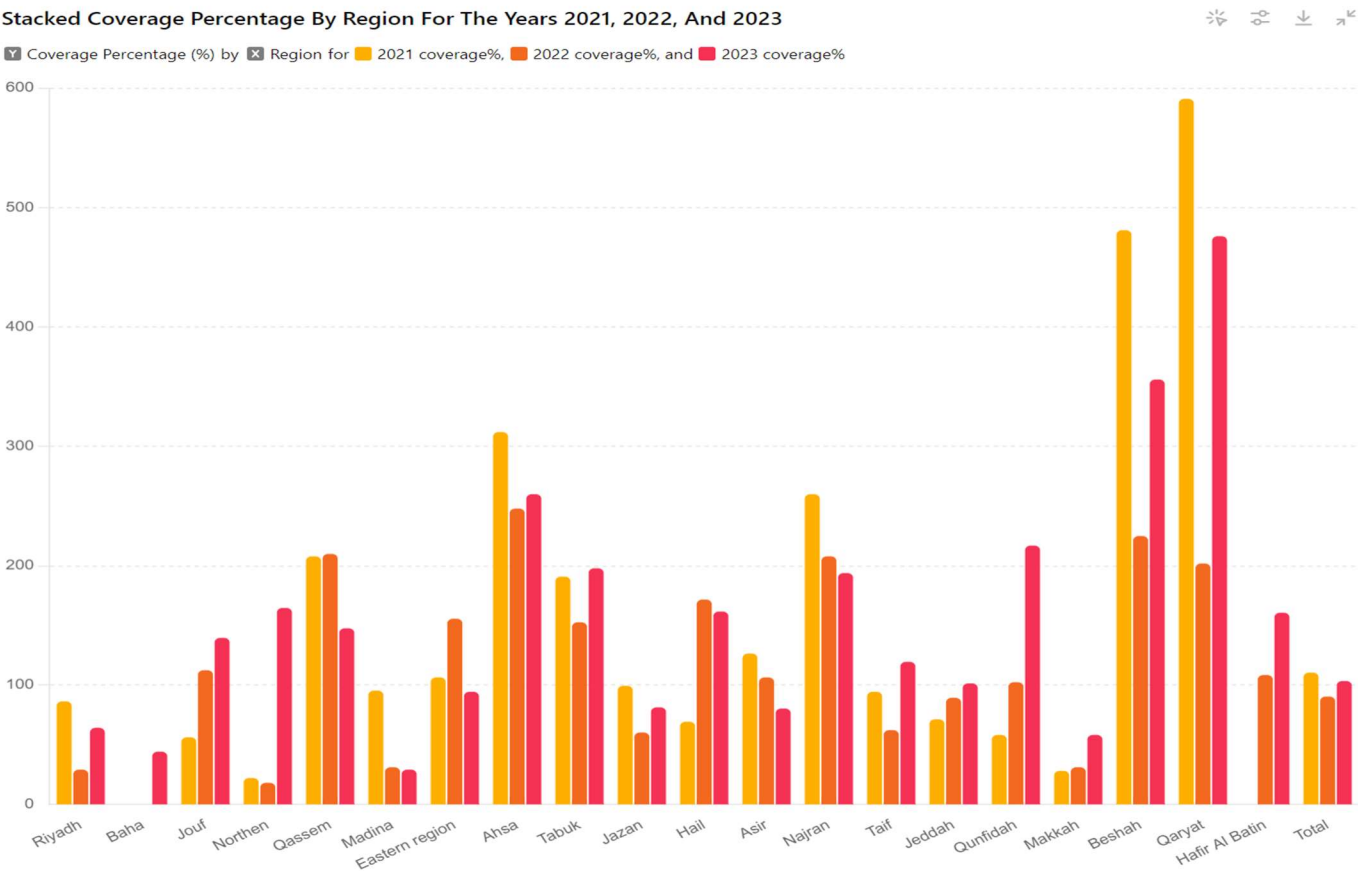


Table 1: Key Performance Indicators: To monitor the program, we developed a series of key performance indicators (KPIs), including organizational (structural) and process indicators.

| Type           | Indicator                               | Screening measure                                                                                                                                          |
|----------------|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ORGANIZATIONAL | Coverage rate by invitation (%) = A2/A1 | A1 = Eligible.                                                                                                                                             |
|                |                                         | Total number of people eligible for screening according to the program policy.                                                                             |
|                |                                         | A2 = Invited.                                                                                                                                              |
|                |                                         | Total number of people who received an invitation for screening according to the program policy.                                                           |
|                | Participation (%) = B/A2                | B = Tested                                                                                                                                                 |
|                |                                         | Total number of individuals who underwent FIT test and receive a result. This includes people with High risk and referral for colonoscopy without FIT test |

**EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.**

|         |                                   |                                                                                                                                                                                                    |
|---------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         |                                   | preformed. Note that each person is counted once regardless of the number of tests performed.                                                                                                      |
| PROCESS | FIT Positivity (%) = C/D          | C = Positive FIT                                                                                                                                                                                   |
|         |                                   | Total number of people who have a positive result with FIT.                                                                                                                                        |
|         |                                   | D = Adequately tested.                                                                                                                                                                             |
|         |                                   | The total number of individuals who underwent a FIT test and received a definitive result, either positive or negative.                                                                            |
|         | Referral to colonoscopy (%) = E/C | E = Referred to colonoscopy.                                                                                                                                                                       |
|         |                                   | Total number of people presenting with a positive FIT and referred for colonoscopy including high risk group people.                                                                               |
|         | Colonoscopy Compliance (%) = F/E  | F = Diagnostic/therapeutic colonoscopy.<br>The total number of individuals who have had a colonoscopy, including those with inadequate or incomplete procedures. Each person is counted only once. |

**Table 2: Time trends of performance indicators of the colorectal cancer screening program in Saudi Arabia, 2021-2023.**

| Performance indicators                                                          | 2021    | 2022    | 2023    | P value** | 2021-2023 |
|---------------------------------------------------------------------------------|---------|---------|---------|-----------|-----------|
| No. of individual eligible for screening*                                       | 2796365 | 2768401 | 2713033 | -         | -         |
| No. of Invited individual for screening targeted age group only                 | 27204   | 54357   | 92723   | <0.001    | 174284    |
| (Coverage rate %)                                                               | (1%)    | (2%)    | (3.4%)  | <0.001    | (6.2%)    |
| No. of Invited individual for screening                                         | 27964   | 55927   | 97873   | <0.001    | 181764    |
| No. of individual screened                                                      | 30641   | 50241   | 100340  | <0.001    | 181222    |
| No. of individual screened from the targeted age group (Saudi from 45-75 years) | 29881   | 48671   | 95190   | <0.001    | 173742    |
| No. of individual screened out the targeted age group (Saudi from 45-75 years)  | 760     | 1570    | 5150    | <0.001    | 7480      |
| Participation rate %                                                            | 106.9%  | 87.0%   | 97.3%   | <0.001    | 95.6%     |
| No. of individual screened by FIT test                                          | 29837   | 48469   | 93565   | <0.001    | 171871    |
| No. of individual with positive FIT test                                        | 1696    | 2285    | 5335    | <0.001    | 9316      |

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|                                                              |                |                 |                 |                  |                 |
|--------------------------------------------------------------|----------------|-----------------|-----------------|------------------|-----------------|
| <u>FIT Positivity (%)</u>                                    | <u>(5.7%)</u>  | <u>(4.7%)</u>   | <u>(5.7%)</u>   | <u>&lt;0.001</u> | <u>(5.4%)</u>   |
| Total positive screened individual                           | 1740           | 2487            | 6960            | <0.001           | 11187           |
| No. of individual referred for colonoscopy                   | 1445           | 1983            | 5532            | <0.001           | 8960            |
| <u>(Referral rate %)</u>                                     | <u>(83 %)</u>  | <u>(79.7 %)</u> | <u>(79.5 %)</u> | <u>&lt;0.01</u>  | <u>(80.1 %)</u> |
| No. of individual with high risk factor                      | 77             | 253             | 2376            | <0.001           | 2706            |
| <u>Individual with high risk factor %</u>                    | <u>(4.4 %)</u> | <u>(10.2 %)</u> | <u>(34.1 %)</u> | <u>&lt;0.05</u>  | <u>(24.2 %)</u> |
| No. of individuals having attended a colonoscopy examination | 522            | 915             | 3561            | <0.001           | 4998            |
| <u>(Colonoscopy Compliance %)</u>                            | <u>(30 %)</u>  | <u>(36.8 %)</u> | <u>(51.2 %)</u> | <u>&lt;0.001</u> | <u>(44.7 %)</u> |

\* The Saudi Ministry of Health recommends a colorectal cancer (CRC) screening program to cover a specific percentage of eligible individuals in Saudi Arabia. This program, which is open to all Saudi individuals between the ages of 45 and 75, aims to cover 1% of all eligible individuals in 2021, 2% in 2022, and 3.5% in 2023.

\*\* If the p-value is less than the significance level (e.g., 0.05), reject the null hypothesis ( $H_0$ =There is no difference between the two years 2021-2022 and 2022-2023).

**Table 3: Yearly Distribution of Gender, Age Groups, and Regional CRC-screened individuals Along with Mean, Median, and Mode Age from 2021 to 2023 (N= 11187)**

| Variable  | Categories | 2021       | 2022       | 2023        | P-value   | Total       |
|-----------|------------|------------|------------|-------------|-----------|-------------|
| Gender    | Male       | 837(48.1%) | 1169(47%)  | 3420(49.1%) | <0.001    | 5426(48.5%) |
|           | Female     | 903(51.9%) | 1318(53%)  | 3540(50.9%) | <0.001    | 5761(51.5%) |
| Age Group | < 45       | 52(3%)     | 157(6.3%)  | 689(9.9%)   | <0.001    | 898(8%)     |
|           | 45-54      | 564(32.4%) | 824(33.1%) | 2275(32.7%) | <0.001    | 3663(32.7%) |
|           | 55-64      | 613(35.2%) | 875(35.2%) | 2311(33.2%) | <0.001    | 3799(34%)   |
|           | 65-74      | 485(27.9%) | 571(23%)   | 1493(21.5%) | <0.001    | 2549(22.8%) |
|           | ≥75        | 26(1.5%)   | 60(2.4%)   | 192(2.8%)   | <0.001    | 278(2.5%)   |
| Region    | Riyadh     | 467(26.8%) | 443(17.8%) | 2984(42.9%) | <0.001    | 3894(34.8%) |
|           | Qassim     | 260(14.9%) | 391(15.7%) | 357(5.1%)   | 0.000714  | 1008(9%)    |
|           | Asir       | 194(11.1%) | 208(8.4%)  | 296(4.3%)   | 0.00196   | 698(6.2%)   |
|           | Ahsa       | 189(10.9%) | 304(12.2%) | 1117(16%)   | <0.001    | 1610(14.4%) |
|           | Medina     | 124(7.1%)  | 78(3.1%)   | 125(1.8%)   | 0.0273    | 327(2.9%)   |
|           | Eastern    | 121(7%)    | 385(15.5%) | 82(1.2%)    | <0.001    | 588(5.3%)   |
|           | Taif       | 102(5.9%)  | 136(5.5%)  | 249(3.6%)   | <0.001    | 487(4.4%)   |
|           | Jazan      | 63(3.6%)   | 96(3.9%)   | 234(3.4%)   | <0.001    | 393(3.5%)   |
|           | Najran     | 53(3%)     | 49(2%)     | 38(0.5%)    | 0.510     | 140(1.3%)   |
|           | Makkah     | 44(2.5%)   | 123(4.9%)  | 181(2.6%)   | <0.001    | 348(3.1%)   |
|           | Hail       | 38(2.2%)   | 120(4.8%)  | 339(4.9%)   | <0.001    | 497(4.4%)   |
|           | Jeddah     | 27(1.6%)   | 63(2.5%)   | 90(1.3%)    | 0.0000919 | 180(1.6%)   |
|           | Beshah     | 25(1.4%)   | 0(0%)      | 140(2%)     | <0.001    | 165(1.5%)   |
|           | Jouf       | 11(0.6%)   | 13(0.5%)   | 12(0.2%)    | 0.959     | 36(0.3%)    |
|           | Tabuk      | 9(0.5%)    | 56(2.3%)   | 272(3.9%)   | <0.001    | 337(3%)     |
|           | Northern   | 7(0.4%)    | 0(0%)      | 152(2.2%)   | <0.001    | 159(1.4%)   |



**EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.**

|                      |          |                   |                    |                    |        |                  |
|----------------------|----------|-------------------|--------------------|--------------------|--------|------------------|
|                      | Qaryat   | 4(0.2%)           | 0(0%)              | 85(1.2%)           | <0.001 | 89(0.8%)         |
|                      | Qunfutha | 2(0.1%)           | 22(0.9%)           | 67(1%)             | <0.001 | 91(0.8%)         |
|                      | Bahah    | 0(0%)             | 0(0%)              | 41(0.6%)           | <0.001 | 41(0.4%)         |
|                      | Hafer    | 0(0%)             | 0(0%)              | 99(1.4%)           | <0.001 | 99(0.9%)         |
| Mean Age ( $\pm$ SD) |          | 58.9 ( $\pm$ 9.4) | 57.4 ( $\pm$ 10.5) | 56.4 ( $\pm$ 11.8) | 0.073  | 57 ( $\pm$ 11.2) |
| Median Age (min-max) |          | 59 (22–90)        | 57 (13–97)         | 57 (14-98)         | 0.333  | 57 (13-98)       |
| Mode Age             |          | 50                | 60                 | 60                 | 0.333  | 60               |

**Table 4: Longitudinal Analysis of Positive FIT Cases in CRC Screening Distributions by Gender & Region (2021-2023)**

| Year           | 2021       |            |         | 2022       |            |         | 2023       |            |         | Total       |
|----------------|------------|------------|---------|------------|------------|---------|------------|------------|---------|-------------|
| Regions        | Male       | Female     | P-value | Male       | Female     | P-value | Male       | Female     | P-value |             |
| Riyadh         | 212(25.9%) | 230(26.3%) | 0.590   | 176(16.5%) | 134(11%)   | 0.107   | 929(36.3%) | 872(31.4%) | 0.031   | 2553(27.4%) |
| Ahsa           | 100(12.2%) | 89(10.2%)  | 0.643   | 139(13.1%) | 165(13.5%) | 0.330   | 501(19.6%) | 490(17.6%) | 0.261   | 1484(15.9%) |
| Qassim         | 129(15.7%) | 128(14.6%) | 1.0     | 176(16.5%) | 213(17.4%) | 0.209   | 178(7%)    | 177(6.4%)  | 0.607   | 1001(10.7%) |
| Asir           | 96(11.7%)  | 98(11.2%)  | 1.0     | 109(10.2%) | 94(7.7%)   | 0.519   | 127(5%)    | 155(5.6%)  | 0.546   | 679(7.3%)   |
| Eastern region | 59(7.2%)   | 53(6.1%)   | 0.789   | 156(14.7%) | 177(14.5%) | 0.461   | 38(1.5%)   | 30(1.1%)   | 0.449   | 513(5.5%)   |
| Taif           | 47(5.7%)   | 55(6.3%)   | 0.674   | 64(6%)     | 72(5.9%)   | 0.716   | 107(4.2%)  | 137(4.9%)  | 0.416   | 482(5.2%)   |
| Jazan          | 27(3.3%)   | 36(4.1%)   | 0.532   | 44(4.1%)   | 52(4.3%)   | 0.665   | 114(4.5%)  | 120(4.3%)  | 0.938   | 393(4.2%)   |
| Makkah         | 28(3.4%)   | 16(1.8%)   | 0.282   | 68(6.4%)   | 55(4.5%)   | 0.482   | 93(3.6%)   | 85(3.1%)   | 0.478   | 345(3.7%)   |
| Madinah        | 45(5.5%)   | 77(8.8%)   | 0.053   | 25(2.3%)   | 52(4.3%)   | 0.041   | 57(2.2%)   | 68(2.4%)   | 0.809   | 324(3.5%)   |
| Hail           | 10(1.2%)   | 25(2.9%)   | 0.112   | 25(2.3%)   | 95(7.8%)   | <0.001  | 44(1.7%)   | 114(4.1%)  | <0.001  | 313(3.4%)   |
| Tabuk          | 4(0.5%)    | 5(0.6%)    | 1.0     | 22(2.1%)   | 28(2.3%)   | 0.689   | 95(3.7%)   | 94(3.4%)   | 0.725   | 248(2.7%)   |

**EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING  
PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.**

|                |            |            |       |              |              |       |              |              |       |             |
|----------------|------------|------------|-------|--------------|--------------|-------|--------------|--------------|-------|-------------|
| Jeddah         | 15(1.8 %)  | 11(1.3 %)  | 0.781 | 25(2.3 %)    | 38(3.1 %)    | 0.325 | 53(2.1 %)    | 37(1.3 %)    | 0.185 | 179(1.9 %)  |
| Beshah         | 6(0.7 %)   | 19(2.2 %)  | 0.107 | 0(0 %)       | 0(0 %)       | -     | 40(1.6 %)    | 100(3.6 %)   | 0.001 | 165(1.8 %)  |
| Northen        | 1(0.1 %)   | 6(0.7 %)   | 0.391 | 0(0 %)       | 0(0 %)       | -     | 64(2.5 %)    | 88(3.2 %)    | 0.365 | 159(1.7 %)  |
| Najran         | 29(3.5 %)  | 24(2.7 %)  | 0.771 | 21(2 %)      | 28(2.3 %)    | 0.613 | 13(0.5 %)    | 25(0.9 %)    | 0.326 | 140(1.5 %)  |
| Hafir Al Batin | 0(0 %)     | 0(0 %)     | -     | 0(0 %)       | 0(0 %)       | -     | 34(1.3 %)    | 65(2.3 %)    | 0.072 | 99(1.1 %)   |
| Qunfidah       | 1(0.1 %)   | 1(0.1 %)   | 1.0   | 11(1 %)      | 11(0.9 %)    | 1.0   | 28(1.1 %)    | 38(1.4 %)    | 0.645 | 90(1 %)     |
| Qaryat         | 3(0.4 %)   | 0(0 %)     | 0.637 | 0(0 %)       | 0(0 %)       | -     | 25(1 %)      | 60(2.2 %)    | 0.020 | 88(0.9 %)   |
| Baha           | 0(0 %)     | 0(0 %)     | -     | 0(0 %)       | 0(0 %)       | -     | 15(0.6 %)    | 17(0.6 %)    | 1.0   | 32(0.3 %)   |
| Jouf           | 8(1 %)     | 3(0.3 %)   | 0.511 | 3(0.3 %)     | 7(0.6 %)     | 0.648 | 2(0.1 %)     | 6(0.2 %)     | 0.665 | 29(0.3 %)   |
| Total          | 820(8.80%) | 876(9.40%) | 0.354 | 1064(11.42%) | 1221(13.11%) | 0.022 | 2557(27.45%) | 2778(29.82%) | 0.034 | 9316 (100%) |

**Table 5: Regional Analysis of Coverage Rates, FIT Positivity, Referral, and Colonoscopy Compliance of CRC-screened individuals by region (2021-2023)**

| Regions        | Coverage rate by invitation (%) | FIT Positivity (%) | Referral to colonoscopy (%) | Colonoscopy Compliance (%) |
|----------------|---------------------------------|--------------------|-----------------------------|----------------------------|
| Riyadh         | 57%                             | 27.4 %             | 77.8 %                      | 87.9%                      |
| Ahsa           | 23%                             | 15.9 %             | 71.6 %                      | 37.9%                      |
| Qassem         | 118%                            | 10.7 %             | 84.2 %                      | 62.8%                      |
| Asir           | 98%                             | 7.3 %              | 88.8 %                      | 7.1%                       |
| Eastern region | 176%                            | 5.5 %              | 61.2 %                      | 40.6%                      |
| Taif           | 40%                             | 5.2 %              | 56.4 %                      | 56.3%                      |
| Jazan          | 114%                            | 4.2 %              | 76.8 %                      | 4.0%                       |
| Makkah         | 264%                            | 3.7 %              | 72.5 %                      | 39.9%                      |
| Madina         | 183%                            | 3.5 %              | 73.1 %                      | 13.3%                      |
| Hail           | 77%                             | 3.4 %              | 97.4 %                      | 57.7%                      |
| Tabuk          | 150%                            | 2.7 %              | 31.9 %                      | 70.4%                      |
| Jeddah         | 95%                             | 1.9 %              | 97.8 %                      | 16.5%                      |
| Beshah         | 208%                            | 1.8 %              | 97.6 %                      | 5.0%                       |
| Northen        | 97%                             | 1.7 %              | 48.4 %                      | 45.5%                      |
| Najran         | 93%                             | 1.5 %              | 97.9 %                      | 0%                         |
| Hafir Al Batin | 157%                            | 1.1 %              | 99 %                        | 24.5%                      |
| Qunfidah       | 45%                             | 1 %                | 91.1 %                      | 6.0%                       |
| Qaryat         | 335%                            | 0.9 %              | 79.5 %                      | 38.0%                      |
| Baha           | 409%                            | 0.3 %              | 96.9 %                      | 77.5%                      |
| Jouf           | 120%                            | 0.3 %              | 93.1 %                      | 52.9%                      |
| p-value        | 0.0677                          | 1.0                | 0.934                       | 0.046                      |
| Total          | 100%                            | 5.4 %              | 76.4 %                      | 55.5%                      |

**Table 6: Pearson Chi-Square Tests Age group vs. (Year, Gender) and Pearson Chi-Square Tests of Regions vs. (Year, Gender, Referral) of Positive FIT test cases in CRC screening program in KSA from 2021-2023.**

| Pearson Chi-Square Tests Age group vs. Year |            |        |        |
|---------------------------------------------|------------|--------|--------|
|                                             |            | Year   | Gender |
|                                             | Chi-square | 47.425 | 26.191 |

|                                                                             |            |          |         |          |
|-----------------------------------------------------------------------------|------------|----------|---------|----------|
| Age Group                                                                   | df         | 8        | 4       |          |
|                                                                             | Sig.       | 0.000*   | 0.000*  |          |
| Pearson Chi-Square Tests of Regions vs. (Year, Gender, Referral)            |            |          |         |          |
|                                                                             |            | Year     | Gender  | Referral |
| Region                                                                      | Chi-square | 2459.544 | 149.724 | 890.626  |
|                                                                             | df         | 40       | 20      | 20       |
|                                                                             | Sig.       | 0.000*   | 0.000*  | 0.000*   |
| Results are based on nonempty rows and columns in each innermost sub table. |            |          |         |          |
| *. The Chi-square statistic is significant at the .05 level.                |            |          |         |          |

**Table 7: Comparative Analysis of Risk Factors for High-Risk Cases by Age, Gender, Region, and Year:**

| <b>Category</b>  | <b>Subcategory</b> | <b>Average risk cases</b> | <b>High risk cases</b> | <b>Crude 95% C.I for OR (Lower-Upper)</b> | <b>Crude OR P-value</b> | <b>Adjusted 95% C.I for OR (Lower-Upper)</b> | <b>Adjusted OR P-value</b> |
|------------------|--------------------|---------------------------|------------------------|-------------------------------------------|-------------------------|----------------------------------------------|----------------------------|
| <b>Age group</b> | <b>45&gt;</b>      | 276 (3.25%)               | 622 (22.99%)           | 9.18 (7.80 - 10.84)                       | <0.001                  | 2.5 (1.8 - 3.2)                              | <0.001                     |
|                  | <b>45-54*</b>      | 2941 (34.68%)             | 722 (26.68%)           | Reference                                 | -                       | Reference                                    | -                          |
|                  | <b>55-64</b>       | 3010 (35.49%)             | 789 (29.16%)           | 1.07 (0.95 - 1.22)                        | 0.23                    | 1.2 (1.0 - 1.5)                              | 0.05                       |
|                  | <b>65-75</b>       | 2057 (24.25%)             | 493 (18.22%)           | 0.98 (0.86 - 1.11)                        | 0.75                    | 0.8 (0.6 - 1.0)                              | 0.08                       |
|                  | <b>75&lt;</b>      | 197 (2.32%)               | 80 (2.96%)             | 1.65 (1.22 - 2.23)                        | 0.0003                  | 0.6 (0.4 - 0.8)                              | 0.01                       |
| <b>Gender</b>    | <b>Female</b>      | 4457 (52.55%)             | 1304 (48.19%)          | Reference                                 | -                       | Reference                                    | -                          |
|                  | <b>Male</b>        | 4024 (47.45%)             | 1402 (51.81%)          | 1.19 (1.09 - 1.30)                        | 0.00007                 | 1.30 (1.15 - 1.48)                           | 0.0002                     |
| <b>Regions</b>   | <b>Riyadh</b>      | 1867 (22.01%)             | 2027 (74.91%)          | Reference                                 | -                       | Reference                                    | -                          |
|                  | <b>Ahsa</b>        | 1467 (17.30%)             | 143 (5.28%)            | 0.0897 (0.0747 - 0.1096)                  | <0.001                  | 0.12 (0.09 - 0.16)                           | <0.001                     |

EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.

|  |                 |                 |                |                             |        |                    |        |
|--|-----------------|-----------------|----------------|-----------------------------|--------|--------------------|--------|
|  |                 |                 |                |                             |        |                    |        |
|  | <b>Qassim</b>   | 999<br>(11.78%) | 9<br>(0.33%)   | 0.0083<br>(0.0043 - 0.0120) | <0.001 | 0.01 (0.00 - 0.02) | <0.001 |
|  | <b>Asir</b>     | 643<br>(7.58%)  | 55<br>(2.03%)  | 0.0292<br>(0.0221 - 0.0385) | <0.001 | 0.03 (0.02 - 0.05) | <0.001 |
|  | <b>Eastern</b>  | 501<br>(5.91%)  | 87<br>(3.22%)  | 0.0272<br>(0.0221 - 0.0335) | <0.001 | 0.04 (0.03 - 0.06) | <0.001 |
|  | <b>Taif</b>     | 471<br>(5.55%)  | 16<br>(0.59%)  | 0.0092<br>(0.0057 - 0.0150) | <0.001 | 0.01 (0.01 - 0.03) | <0.001 |
|  | <b>Jazan</b>    | 393<br>(4.63%)  | 0<br>(0.00%)   | 0 (0 - 0.0032)              | <0.001 | 0.00 (0.00 - 0.01) | <0.001 |
|  | <b>Makkah</b>   | 287<br>(3.38%)  | 61<br>(2.25%)  | 0.0324<br>(0.0251 - 0.0418) | <0.001 | 0.05 (0.04 - 0.08) | <0.001 |
|  | <b>Medina</b>   | 322<br>(3.80%)  | 5<br>(0.18%)   | 0.0065<br>(0.0026 - 0.0159) | <0.001 | 0.01 (0.00 - 0.03) | <0.001 |
|  | <b>Hail</b>     | 305<br>(3.60%)  | 192<br>(7.10%) | 0.1846<br>(0.1568 - 0.2175) | <0.001 | 0.22 (0.17 - 0.29) | <0.001 |
|  | <b>Tabouk</b>   | 248<br>(2.92%)  | 89<br>(3.29%)  | 0.1681<br>(0.1360 - 0.2079) | <0.001 | 0.18 (0.14 - 0.23) | <0.001 |
|  | <b>Jeddah</b>   | 179<br>(2.11%)  | 1<br>(0.04%)   | 0.0006<br>(0.0001 - 0.0043) | <0.001 | 0.00 (0.00 - 0.00) | <0.001 |
|  | <b>Beshah</b>   | 165<br>(1.95%)  | 0<br>(0.00%)   | 0 (0 - 0.0032)              | <0.001 | 0.00 (0.00 - 0.01) | <0.001 |
|  | <b>Northern</b> | 158<br>(1.86%)  | 1<br>(0.04%)   | 0.0006<br>(0.0001 - 0.0043) | <0.001 | 0.00 (0.00 - 0.00) | <0.001 |
|  | <b>Najran</b>   | 140<br>(1.65%)  | 0<br>(0.00%)   | 0 (0 - 0.0032)              | <0.001 | 0.00 (0.00 - 0.01) | <0.001 |
|  | <b>Hafer</b>    | 98<br>(1.16%)   | 1<br>(0.04%)   | 0.0006<br>(0.0001 - 0.0043) | <0.001 | 0.00 (0.00 - 0.01) | <0.001 |
|  | <b>Qunfutha</b> | 90<br>(1.06%)   | 1<br>(0.04%)   | 0.0006<br>(0.0001 - 0.0043) | <0.001 | 0.00 (0.00 - 0.01) | <0.001 |

EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.

|                      |               |                  |                   |                             |        |                         |        |
|----------------------|---------------|------------------|-------------------|-----------------------------|--------|-------------------------|--------|
|                      | <b>Qrayat</b> | 87<br>(1.03%)    | 2<br>(0.07%)      | 0.0035<br>(0.0009 - 0.0137) | <0.001 | 0.01(0.00 - 0.04)       | <0.001 |
|                      | <b>Bahah</b>  | 32<br>(0.38%)    | 9<br>(0.33%)      | 0.0122<br>(0.0060 - 0.0250) | <0.001 | 0.02 (0.01 - 0.05)      | <0.001 |
|                      | <b>Jouf</b>   | 29<br>(0.34%)    | 7<br>(0.26%)      | 0.0101<br>(0.0047 - 0.0220) | <0.001 | 0.02 (0.01 - 0.05)      | <0.001 |
| <b>Year</b>          | <b>2021</b>   | 1663<br>(19.61%) | 77<br>(2.85%)     | Reference                   | -      | Reference               | -      |
|                      | <b>2022</b>   | 2234<br>(26.34%) | 253<br>(9.35%)    | 2.44 (1.88 - 3.17)          | <0.001 | 2.30                    | <0.001 |
|                      | <b>2023</b>   | 4584<br>(54.05%) | 2376<br>(87.80% ) | 11.19<br>(8.87 - 14.12)     | <0.001 | 10.50                   | <0.001 |
| <b>Total</b>         | -             | 8481<br>(75.81%) | 2706<br>(24.19% ) | 1.30 (1.26, 1.34)           | <0.001 | 1.30 (1.26, 1.34)       | <0.001 |
| <b>Referral rate</b> | -             | 74.12%           | 98.82%            | 29.24<br>(29.20, 29.29)     | <0.001 | 29.24<br>(29.20, 29.29) | <0.001 |

**Table 8: Comparative Analysis of Male and Female Cases Across Age Groups, Risk Levels, Regions, and Years:**

| Category         | Subcategory   | Male cases       | Female cases      | Crude 95% C.I for OR (Lower-Upper) | Crude OR P-value | Adjusted 95% C.I for OR (Lower-Upper) | Adjusted OR P-value |
|------------------|---------------|------------------|-------------------|------------------------------------|------------------|---------------------------------------|---------------------|
| <b>Age group</b> | <b>45&gt;</b> | 462<br>(8.51%)   | 436<br>(7.57%)    | 1.32 (1.14 - 1.53)                 | 0.0002           | 1.32 (1.14 - 1.53)                    | 0.00018             |
|                  | <b>45-54</b>  | 1629<br>(30.02%) | 2034<br>(35.31% ) | Reference                          | -                | Reference                             | -                   |
|                  | <b>55-64</b>  | 1857<br>(34.22%) | 1942<br>(33.71% ) | 1.19 (1.07 - 1.33)                 | 0.0001           | 1.19 (1.09 - 1.31)                    | 0.00014             |
|                  | <b>65-75</b>  | 1328<br>(24.47%) | 1222<br>(12.12% ) | 1.36 (1.24 - 1.61)                 | <0.001           | 1.36 (1.23 - 1.50)                    | <0.00001            |
|                  | <b>75&lt;</b> | 150<br>(2.76%)   | 127<br>(2.20%)    | 1.47 (1.16 - 1.87)                 | 0.002            | 1.47 (1.15- 1.88)                     | 0.00193             |

EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.

|                |                     |                  |                  |                       |         |                       |         |
|----------------|---------------------|------------------|------------------|-----------------------|---------|-----------------------|---------|
| <b>Risk</b>    | <b>High risk</b>    | 1402<br>(25.84%) | 1304<br>(22.63%) | 1.19 (1.09<br>- 1.30) | 0.00007 | 1.30 (1.15<br>- 1.48) | <0.001  |
|                | <b>Average risk</b> | 4024<br>(74.16%) | 4457<br>(77.37%) | Reference             | -       | Reference             | -       |
| <b>Regions</b> | <b>Riyadh</b>       | 2011<br>(37.06%) | 1883<br>(32.69%) | Reference             | -       | Reference             | -       |
|                | <b>Ahsa</b>         | 809<br>(14.91%)  | 801<br>(13.90%)  | 0.95 (0.83,<br>1.08)  | 0.45    | 0.92 (0.80,<br>1.06)  | 0.27    |
|                | <b>Qassim</b>       | 489<br>(9.01%)   | 519<br>(9.01%)   | 0.9 (0.77,<br>1.05)   | 0.17    | 0.88 (0.75,<br>1.03)  | 0.12    |
|                | <b>Asir</b>         | 340<br>(6.27%)   | 358<br>(6.21%)   | 0.9 (0.76,<br>1.07)   | 0.24    | 0.89 (0.74,<br>1.07)  | 0.21    |
|                | <b>Eastern</b>      | 292<br>(5.38%)   | 296<br>(5.14%)   | 0.95 (0.79,<br>1.14)  | 0.56    | 0.93 (0.77,<br>1.12)  | 0.44    |
|                | <b>Taif</b>         | 220<br>(4.05%)   | 267<br>(4.63%)   | 0.77 (0.63,<br>0.95)  | 0.01    | 0.75 (0.61,<br>0.93)  | 0.009   |
|                | <b>Jazan</b>        | 185<br>(3.41%)   | 208<br>(3.61%)   | 0.83 (0.67,<br>1.03)  | 0.09    | 0.81 (0.65,<br>1.02)  | 0.08    |
|                | <b>Makkah</b>       | 191<br>(3.52%)   | 157<br>(2.73%)   | 1.2 (0.95,<br>1.51)   | 0.12    | 1.18 (0.92,<br>1.50)  | 0.19    |
|                | <b>Medina</b>       | 129<br>(2.38%)   | 198<br>(3.44%)   | 0.64 (0.50,<br>0.82)  | < 0.001 | 0.62 (0.48,<br>0.81)  | < 0.001 |
|                | <b>Hail</b>         | 186<br>(3.43%)   | 311<br>(5.40%)   | 0.56 (0.45,<br>0.69)  | < 0.001 | 0.54 (0.42,<br>0.68)  | < 0.001 |
|                | <b>Tabouk</b>       | 170<br>(3.13%)   | 167<br>(2.90%)   | 0.96 (0.75,<br>1.23)  | 0.75    | 0.94 (0.72,<br>1.21)  | 0.61    |
|                | <b>Jeddah</b>       | 93<br>(1.71%)    | 87<br>(1.51%)    | 1.11 (0.80,<br>1.55)  | 0.54    | 1.09 (0.78,<br>1.52)  | 0.62    |
|                | <b>Beshah</b>       | 46<br>(0.85%)    | 119<br>(2.07%)   | 0.37 (0.25,<br>0.55)  | < 0.001 | 0.36 (0.24,<br>0.53)  | < 0.001 |
|                | <b>Northern</b>     | 65<br>(1.20%)    | 94<br>(1.63%)    | 0.67 (0.48,<br>0.93)  | 0.02    | 0.65 (0.46,<br>0.91)  | 0.01    |
|                | <b>Najran</b>       | 63<br>(1.16%)    | 77<br>(1.34%)    | 0.77 (0.54,<br>1.10)  | 0.16    | 0.75 (0.52,<br>1.08)  | 0.13    |
|                | <b>Hafer</b>        | 34<br>(0.63%)    | 65<br>(1.13%)    | 0.49 (0.31,<br>0.78)  | 0.003   | 0.48 (0.30,<br>0.76)  | 0.002   |
|                | <b>Qunfutha</b>     | 41<br>(0.76%)    | 50<br>(0.87%)    | 0.77 (0.51,<br>1.17)  | 0.22    | 0.75 (0.49,<br>1.15)  | 0.19    |
|                | <b>Qrayat</b>       | 29<br>(0.53%)    | 60<br>(1.04%)    | 0.45 (0.28,<br>0.71)  | 0.001   | 0.44 (0.27,<br>0.69)  | 0.001   |
|                | <b>Bahah</b>        | 17<br>(0.31%)    | 24<br>(0.42%)    | 0.67 (0.35,<br>1.29)  | 0.23    | 0.65 (0.33,<br>1.27)  | 0.22    |

EVALUATION OF PARTICIPATION AND PERFORMANCE INDICATORS IN COLORECTAL CANCER SCREENING PROGRAM IN SAUDI ARABIA FROM 2021 TO 2023.

|                          |             |                  |                      |                       |         |                      |         |
|--------------------------|-------------|------------------|----------------------|-----------------------|---------|----------------------|---------|
|                          | <b>Jouf</b> | 16<br>(0.29%)    | 20<br>(0.35%)        | 0.75 (0.38,<br>1.50)  | 0.42    | 0.73 (0.37,<br>1.45) | 0.39    |
| <b>Year</b>              | <b>2021</b> | 837<br>(15.43%)  | 903<br>(15.67%<br>)  | Reference             | -       | Reference            | -       |
|                          | <b>2022</b> | 1169<br>(21.54%) | 1318<br>(22.88%<br>) | 0.96 (0.85<br>- 1.08) | 0.52    | 0.96 (0.86,<br>1.08) | 0.49    |
|                          | <b>2023</b> | 3420<br>(63.03%) | 3540<br>(61.45%<br>) | 1.04 (0.93<br>- 1.17) | 0.47    | 1.04 (0.97,<br>1.12) | 0.28    |
| <b>Total</b>             | -           | 5426<br>(48.50%) | 5761<br>(51.50%<br>) | 0.94 (0.90,<br>0.98)  | < 0.001 | 0.94 (0.90,<br>0.98) | < 0.001 |
| <b>Referral<br/>rate</b> | -           | 81.05%           | 79.19%               | 1.12 (1.08,<br>1.17)  | < 0.001 | 1.12 (1.08,<br>1.17) | < 0.001 |