Breast Cancer Screening in Canada

MONITORING & EVALUATION OF QUALITY INDICATORS

SPECIAL TOPIC:

Spotlight on Benefits and Harms

RESULTS REPORT
JANUARY 2011 – DECEMBER 2012

CANADIAN PARTNERSHIP AGAINST CANCER
PARTENARIAT CANADIEN CONTRE LE CANCER

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Executive Summary

Burden of Disease

Breast cancer is the leading incident cancer and second leading cause of cancer death in Canadian women.[1] While breast cancer can be diagnosed at any age, more than 90% of all new cases occur in women aged 50 years or older.[1] Since the mid-1990s age-adjusted breast cancer incidence has remained stable, while age-adjusted breast cancer mortality has decreased.[1]

Screening for Breast Cancer

It has been demonstrated unequivocally that mammography screening reduces breast cancer mortality. Currently in Canada, it is recommended that average risk women aged 50 to 74 years be screened with mammography every two to three years.[2] Organized screening uses a centralized and systematic approach for the identification and invitation of the target population, provision of the screening examination, follow-up of abnormalities detected at screening, recall after a normal or benign screening episode, and monitoring and evaluation.[3] Screening that is delivered through organized programs has a greater potential to reduce cancer mortality, to be cost-effective, and to reduce the potential harms associated with screening compared with opportunistic screening.[4]

Quality Indicators

Monitoring and evaluation of organized breast cancer screening programs provides an opportunity to understand the impact of organized breast cancer screening programs on breast cancer morbidity and mortality, as well as the potential harms associated with screening. This report presents quality indicators for organized breast cancer screening programs in Canada. The quality indicator framework includes indicators within five domains: coverage, follow-up, quality of screening, detection, and disease extent at diagnosis. Data are presented for all indicators for screen years 2011–2012, and a limited number of indicators for screen years 2013–2014. Data are provided for all ten Canadian provinces and Northwest Territories. Extended time trends are presented for four quality indicators in the Special Topic section.

Results

More than 2.5 million screening mammograms were delivered to women aged 50 to 69 years through organized breast cancer screening programs in Canada in 2011–2012. A number of indicators in this report have remained relatively stable over time. While participation has increased gradually over the longer term, it has been stable at approximately 54% since 2011 and remains below the national target of ≥70%. Retention rates are also stable and remain substantially below the national target of ≥75% within 30 months of an initial screen and ≥90% within 30 months of a subsequent screen. Sensitivity has exceeded 80% since at least 2004, and both initial and subsequent invasive cancer detection rates have remained stable, with the detection rate for subsequent screens regularly meeting the national target of >3 per 1,000 subsequent screens.

Other indicators have changed over time. Abnormal call rate has increased over time and has not met the national target of <10% for initial screens and <5% for subsequent screens for several years. Time to first diagnostic assessment (national target: ≥90% within three weeks) and time to definitive diagnosis following an abnormal screen (national target: ≥90% within five weeks if no tissue biopsy is performed, ≥90% within seven weeks if a tissue biopsy is performed) have improved, but still fall well below the national targets with only 66.1% of women receiving a first diagnostic assessment within three weeks, 79.1% reaching a definitive diagnosis within five weeks when no biopsy is required, and 54.9% reaching a definitive diagnosis within seven weeks when a biopsy is required. While the rate of non-malignant biopsies increased slightly overall, the percentage of these biopsies that were open has decreased substantially since 2004. Positive predictive value has decreased steadily since 2007, though it continues to meet the national target of ≥6% for subsequent screens. The rate of post-screen invasive cancers has fluctuated, but has demonstrated a slight overall increase resulting in the national target of <6 per 10,000 person years within 12 months of the screening date and <12 per 10,000 person-years from 12 to 24 months of the screening date being unmet in the most recent reporting years.

Future Directions

While national targets within some quality indicator domains are consistently met, abnormal call rates exceed the national target values and continue to increase. This means that an increasing number of Canadian women who do not have breast cancer are being subject to the harms of diagnostic tests. Abnormal call rates can be impacted by numerous population, provider and technological characteristics. The exact reasons for the upward trend observed in abnormal call rates are not clear at this time; however, it is likely that several provider-related (e.g. radiologist experience and reading volumes) and technological (e.g. the large scale shift from screen-film to digital mammography) factors have contributed.

Continued improvement is necessary to maintain the benefits of screening while minimizing potential harms. Increasing minimum reading volume requirements for radiologists and the provision of regular audit feedback may help to remediate abnormal call rate. Accreditation of screening facilities by the Canadian Association of Radiologists' Mammography Accreditation Program can also ensure that minimum standards for personnel qualifications and experience, equipment, quality control and assurance, image quality and radiation dosing are met. Alternative imaging technologies such as digital breast tomosynthesis also continue to be evaluated and may have a future role in screening and/or diagnostic assessment.

Current national targets for quality indicators may require evaluation and refinement in light of the changes to screening technology and breast cancer screening recommendations that have ensued since they were last updated in 2013. The wide variation observed in most quality indicators by age group also indicates the need to consider the development of age-specific targets.

Programs should strive to achieve and maintain strong administrative structures for service delivery, robust frameworks for quality assurance and control, and comprehensive program evaluation. Program policies should be regularly reviewed and adapted to reflect the best available evidence for clinical practice and technology wherever possible.

Introduction

Burden of disease

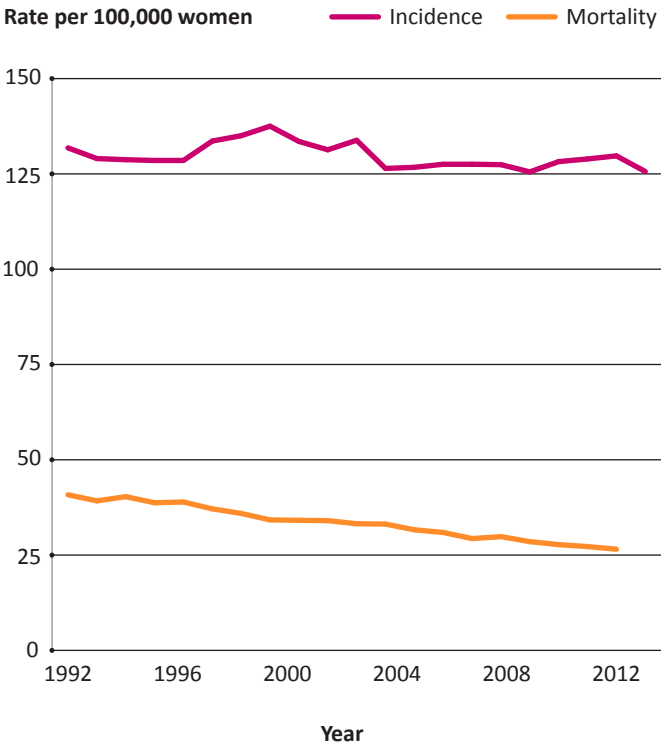
In 2016, an estimated 25,700 Canadian women will be diagnosed with breast cancer and 4,900 women will die from breast cancer.[1] This makes breast cancer the leading incident cancer and second leading cancer cause of death in Canadian women.

Of the known risk factors for breast cancer, age has the strongest influence on incidence; more than 90% of all new cases occur in women aged 50 years or older.[1] High breast density,[5,6] a first-degree family history of breast cancer,[7,8] a history of a high-risk type of benign breast disease,[9] and radiation exposure to the chest[10,11] are also strong risk factors for breast cancer. Despite a relatively smaller impact on breast cancer risk, studies have demonstrated that a substantial proportion of breast cancer cases can also be attributed to hormonal, reproductive, lifestyle, and environmental factors.[12–15]

Age-standardized breast cancer incidence rose in Canada between 1980 and the early 1990s, likely resulting from increased detection due to the uptake of mammography screening, as well as long-term changes in the prevalence of oral contraceptive use, obesity, and hormonal factors such as late age at first pregnancy.[16] Since 1992, age-standardized breast cancer incidence has remained relatively stable at approximately 130 cases per 100,000 (Figure 1). Age-standardized breast cancer mortality declined by 35%, from 40.7 deaths per 100,000 in 1992 to 26.4 deaths per 100,000 in 2011 (Figure 1). This decline was likely due to both improved breast cancer treatment and increasing rates of participation in breast cancer screening.

FIGURE 1

Age-standardized breast cancer incidence and mortality rates in women, Canada, 1992 to 2012



Notes
General: Age-standardized to the 2011 Canadian population.
Data source: Statistics Canada, Canadian Cancer Registry and Vital Statistics Death Database.

Screening for breast cancer

Prevention is an essential component of cancer control. As such, prevention activities are critically important for reducing the burden of cancer in Canada. Many of the strongest known risk factors for breast cancer are unmodifiable (e.g. age, family history) or not easily modifiable (e.g. reproductive factors). It has been estimated, however, that more than 20% of breast cancers may be attributable to modifiable risk factors which are amenable to primary prevention efforts, such as alcohol consumption, overweight and obesity, and physical activity.[13,17,18] In addition, early detection of breast cancer combined with effective treatment can significantly reduce mortality from breast cancer.

Evidence for the Effectiveness of Breast Cancer Screening

Evidence from randomized controlled trials (RCTs) has demonstrated a statistically significant, 21% reduction in breast cancer mortality attributable to regular mammography screening in women aged 50 to 69 years.[2] While the 32% mortality reduction observed for women aged 70 to 74 years was statistically non-significant, the absolute benefits of mammography screening are likely to be similar to those for women aged 50 to 69 years owing to the higher absolute risk of breast cancer in this age group.[2] While a significant mortality reduction of 15% was demonstrated for women aged 39 to 49 years, the number of false-positives and unnecessary diagnostic tests is higher for these women, which may outweigh the mortality benefit of screening.[2]

Breast Cancer Screening Recommendations

In 1994, the Canadian Task Force on the Periodic Health Examination (now the Canadian Task Force on Preventive Health Care) recommended that women aged 50 to 69 years undergo screening for breast cancer with mammography and clinical breast examination (CBE) every 1 to 2 years, and recommended against screening women aged 40 to 49 years.[19] In 2001, the Task Force released an update for women aged 40 to 49 years, finding insufficient evidence to recommend for or against screening average risk women in this age range with mammography.[20] In 2011, the Task Force updated the evidence that was reviewed by the United States Preventive Services Task Force in 2009 and released a full update to its 1994 screening guidelines.[2] Currently in Canada, it is recommended that average risk women aged 50 to 74 years be screened with mammography every two to three years. The Canadian Task Force also recommends against screening average risk women aged 40 to 49 years with mammography or average risk women of any age with breast magnetic resonance imaging (MRI), CBE, and breast self-examination. The United States Preventive Services Task Force released a subsequent update in 2016, recommending biennial screening mammography for women aged 50 to 74 years.[21] The U.S. Task Force also recommends that the decision to start screening mammography in women prior to age 50 years should be individual and concluded that current evidence is insufficient to assess the benefits and harms of screening in women 75 years of age or older, screening with digital breast tomosynthesis as a primary screening method, and adjunctive screening with ultrasound, MRI, tomosynthesis or other methods in women identified to have dense breasts.[21]

Benefits and Potential Harms of Screening

The overall goal of breast cancer screening is to reduce mortality from breast cancer. Early detection may also prevent morbidity associated with advanced stages of breast cancer.

While the benefits of breast cancer screening can be significant, it is important to understand that there are also risks. Overdiagnosis (the detection of cancers that would not have become clinically apparent during an individual's remaining lifetime) can occur because diagnostic tests cannot currently distinguish between breast cancers that will progress to be life-threatening and those that will not cause harm. Mammography is also not a perfect test; breast cancers may be missed for technical or interpretive reasons (false negative results), and false-positive results may lead to unnecessary additional imaging or biopsy. Mammography also exposes women to very low doses of ionizing radiation to the chest. While the effective dose during a single screening episode is much lower than that which could directly induce a cancer, repeated exposures over time may increase the risk of breast cancer.

Mammography Technology

Two types of mammography are currently used for breast cancer screening in Canada: screen-film mammography (SFM) and digital mammography. Digital mammography may offer additional benefits for breast screening, particularly for imaging breasts with high mammographic density. For example, digital detectors have a wider dynamic range, resulting in increased contrast resolution compared with SFM. Lower doses of radiation can also be used for imaging with a digital mammography system. Performance may depend on the type of digital imaging system used. There are also two distinct types of digital technology: direct radiography (DR) and computed radiography (CR). With DR, the detector is integrated into the mammographic unit and the digital image is processed and displayed instantaneously. With CR, the detector is cassette-based and removable, and the image is generated by an external reading device.[22]

A large study conducted within the Ontario Breast Screening Program demonstrated important differences in performance between the two types of digital mammography. While cancer detection and sensitivity were similar for SFM and digital DR, performance on these measures was significantly lower for digital CR.[23,24] A subsequent study conducted within the French national breast cancer screening program similarly demonstrated a significantly lower cancer detection rate for CR relative to SFM.[25] Conversely, a study conducted within the Québec Breast Cancer Screening Program found that cancer detection rates were comparable across technology types, but a small statistically significantly increase in abnormal call rates for CR and DR relative to SFM was noted.[26]

Screening Approaches

In Canada, screening for breast cancer can occur within a cancer screening program (organized screening) or outside of such a program (opportunistic screening). Organized screening uses a centralized and systematic approach for the identification and invitation of the target population, provision of the screening examination, follow-up of abnormalities detected at screening, recall after a normal or benign screening episode, and monitoring and evaluation.[3] Essential components of the organized approach to screening in Canada include the provision of consistent, high quality service, effective monitoring of program elements, integration of the screening program with diagnostic and treatment services, and high enrolment and participation.[3]

Screening delivered through organized programs has a greater potential to reduce cancer mortality, to be cost-effective, and to reduce the potential harms associated with screening compared with opportunistic screening.[4] A 2014 study that pooled data from seven organized breast cancer screening programs in Canada found that breast cancer mortality was 40% lower than expected for women who participated in a provincial breast cancer screening program compared with non-participating women.[27]

Organized Breast Cancer Screening in Canada

History

On the basis of RCT evidence of the efficacy of mammography screening, Canadian provinces and territories began to implement organized screening programs in the late 1980s and early 1990s. Organized breast cancer screening programs now exist in all provinces, the Northwest Territories, and Yukon. Nunavut does not have an organized screening program at this time but provides limited opportunistic screening in select circumstances. Organized programs provide asymptomatic, average risk women with no prior diagnosis of breast cancer aged 50 and 69 years with a bilateral, two-view mammogram. Some programs include clinical breast examinations (CBE) as part of screening. Program-specific policies are described in Table 1.

TABLE 1

Average risk breast cancer screening programs for women aged 40+ years, 2011 to 2012 screen years

Province/ territory	Program inception	Clinical breast examination	Program practices for women age 40+		
			Age group	Accept	Recall
Northwest Territories	2003	No	40–49	Yes	Annual
			50–69	Yes	Biennial
			70+	Yes	Biennial
Yukon	1990	No	40–49	Yes	None
			50–69	Yes	Biennial
			70+	Yes	Biennial
British Columbia	1988	No	40–49	Yes	Annual
			50–69	Yes	Biennial
			70–79	Yes	Biennial
			80+	With physician referral	None
Alberta	1990	No	40–49	With physician referral for first screen	Annual
			50–69	Yes	Biennial
			70–74	Yes	Biennial
			75+	Yes	None
Saskatchewan	1990	No	40–49	No	N/A
			50–69	Yes	Biennial
			70–74	Accept if previously enrolled in program	Biennial
			75+	Yes	None
Manitoba	1995	No	40–49	Accept to mobile unit with physician referral	Biennial
			50–69	Yes	Biennial
			70–74	Yes	Biennial
			75+	Yes	None

Province/ territory	Program inception	Clinical breast examination	Program practices for women age 40+		
			Age group	Accept	Recall
Ontario	1990	Yes	50–69	Yes	Biennial
			70–74	Yes	Biennial
			75+	With physician referral	None
Québec	1998	No	50–69	Yes	Biennial
New Brunswick	1995	No	40–49	With physician referral	None
			50–69	Yes	Biennial
			70+	With physician referral	None
Nova Scotia	1991	Yes	40–49	Yes	Annual
			50–69	Yes	Biennial
			70+	Yes	None
Prince Edward Island	1998	No	40–49	Yes	Annual
			50–69	Yes	Biennial
			70–74	Yes	Biennial
			75+	No	N/A
Newfoundland and Labrador	1996	Yes	40–49	No	N/A
			50–69	Yes	Biennial
			70+	Accept if previously enrolled in program	None

Canadian Breast Cancer Screening Network (CBCSN)

In December 1992, the Canadian federal government launched the first phase of the Canadian Breast Cancer Initiative (CBCI). The CBCI included 25 million dollars over five years and included the Canadian Breast Cancer Screening Initiative (CBCSI) among its priorities. Federal funding has continued for the CBCSI, initially through Health Canada, and then the Public Health Agency of Canada (PHAC). As of April 1, 2013, PHAC transferred the hosting of the CBCSI to the Canadian Partnership Against Cancer (CPAC). During this transfer, several key changes were made to the organizational structure of the CBCSI. The formal National Committee is now known as the Canadian Breast Cancer Screening Network (CBCSN). The former Database Management Committee (DMC) and former Database Technical Subcommittee were amalgamated into the Monitoring & Evaluation (M&E) Working Group.

Monitoring and evaluation of organized breast cancer screening programs through the systematic collection, analysis, and interpretation of data allows for continuous screening program improvement. The Canadian Breast Cancer Screening Database (CBCSD) was established in 1993 and is operated and maintained by PHAC on behalf of the CBCSN. Participating provincial and territorial screening programs contribute data to the national database while retaining full ownership and unrestricted rights over their data. The CBCSD contains screen-level data from program inception forward, including: demographic characteristics, risk factors, the screening test, screening results and subsequent referral, diagnostic tests, outcomes, and cancer information are collected. An exception is the program in Québec, which submits aggregate data for diagnostic tests and procedures (see Appendix A for additional information). Yukon does not currently submit records to the CBCSD. The CBCSD provides a method to compare organized breast screening programs in a standardized manner at a national level.

The M&E Working Group of the CBCSN is responsible for developing and maintaining a set of quality indicators (Appendix A, Report from the Evaluation Indicators Working Group), and reporting on them in a regular manner by means of the CBCSD; managing data access requests to the CBCSD, including those for research; and supporting PHAC in maintaining the CBCSD.

The Screening Process

Organized breast cancer programs in Canada typically involve four steps:

1. Identification and invitation of the target population;
2. Provision of a screening test;
3. Follow-up of any abnormalities detected at the screening test; and
4. Recall after a normal or non-malignant screening outcome.

Several methods are used to encourage women to be screened including population-based invitations, physician education to increase referrals, and mass-media campaigns. Women may participate in an organized program through self-referral or physician referral.

Screening mammograms are provided both at fixed and mobile sites. Fixed sites are located in larger urban areas while mobile sites are used to provide service to rural and remote communities and to supplement services at fixed sites.

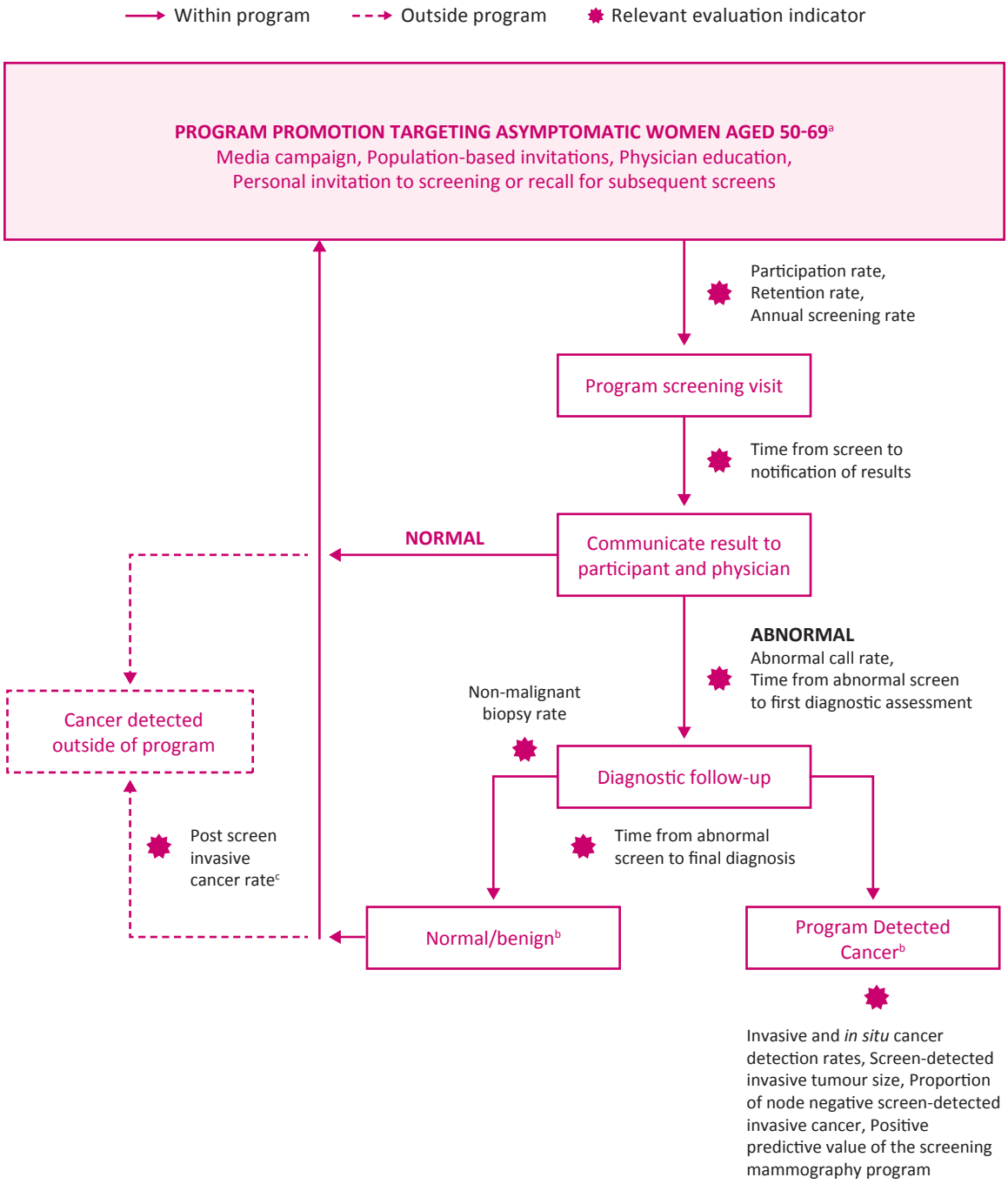
Screening results are provided to the woman and her primary health care provider. Women who have normal screening results are invited back for subsequent screening through a recall letter. Most programs recall women every two years; however, some exceptions are made and programs may recall women on an annual basis depending on their age, breast density, family history, or results of previous mammograms. After a normal screening result, women are encouraged to follow-up with their health care provider if they become symptomatic prior to their next scheduled screening visit.

When the screening mammogram is abnormal, the woman's health care provider or the screening program coordinates the required follow-up diagnostic tests. This process varies by region. The follow-up process is complete when a final diagnosis of cancer or normal/non-malignant is determined (Figure 2).

In addition to the systematic process through which a woman moves through an organized breast cancer screening program, organized screening offers additional advantages over opportunistic breast cancer screening including population-based recruitment, automatic recall and reminders for subsequent screening, coordinated follow-up for abnormal screening results, systematic quality assurance, and the ability to provide monitoring and evaluation of program quality.

FIGURE 2

Pathway of an organized breast cancer screening program in Canada



a Some women also undergo screening (opportunistic screening or diagnostic mammograms) and are diagnosed with cancer outside program.
b Breast screening programs obtain final diagnoses from sources such as physicians, pathology reports, and cancer registries.
c Cancers detected six-months after a screening event are considered to be post screen cancers at the national level.

Quality Indicator Framework

The findings presented in this report will assist in the advancement of program development and quality monitoring of organized breast cancer screening programs throughout Canada.

Monitoring and evaluation of organized screening programs is essential to ensure that Canadian women receive high quality cancer screening services. Delivery of high quality services results in the reduction of morbidity and mortality from breast cancer while minimizing potentially harmful effects of screening. The results of monitoring and evaluation using the CBCSD can be used to enhance the quality of organized breast cancer screening programs in Canada.

In order to provide fair evaluation for Canadian organized breast screening programs, standardized methods of evaluation have been developed. For detailed information about the indicators presented in this report please refer to Appendix A, and the Report from the Evaluation Indicators Working Group.

The quality indicators presented in this report are organized into the following five domains:

1. Coverage (participation rate, retention rate, annual screening rate)

2. Follow-up (abnormal call rate, diagnostic assessment, diagnostic interval);

3. Quality of screening (non-malignant biopsy rate, positive predictive value of the screening mammography program, sensitivity of the screening mammography program, post-screen invasive cancer rate);

4. Detection (in situ cancer detection rate, invasive cancer detection rate, percent ductal carcinoma in situ);

5. Disease extent at diagnosis (screen-detected invasive tumour size, proportion of node negative screen-detected invasive cancers).

Many of the quality indicators presented here only provide meaningful information when considered in relation to each other and in a broader context. In some cases, meeting ideal targets involves achieving a balance rather than continually working to increase or decrease a particular rate or indicator.

Quality Indicators

Organized breast cancer screening programs across Canada have evolved at different rates and are shaped by many provincial and territorial characteristics, including the adoption of different screening models and technologies. The results that follow should be interpreted within this context.

Coverage

Optimal benefits of organized breast cancer screening are realized through sufficient participation and retention. Many factors can influence participation and retention, such as acceptability, accessibility, promotion of screening, and program capacity. It is important to note that the participation rates reported here do not include opportunistic screening that occurs outside of organized breast cancer screening programs.

Participation Rate

Participation rate is the percentage of women who have a screening mammogram within a 30-month period, as a proportion of the target population.

***National target (50 to 69 years):** ≥70% of the target population within 30 months.*

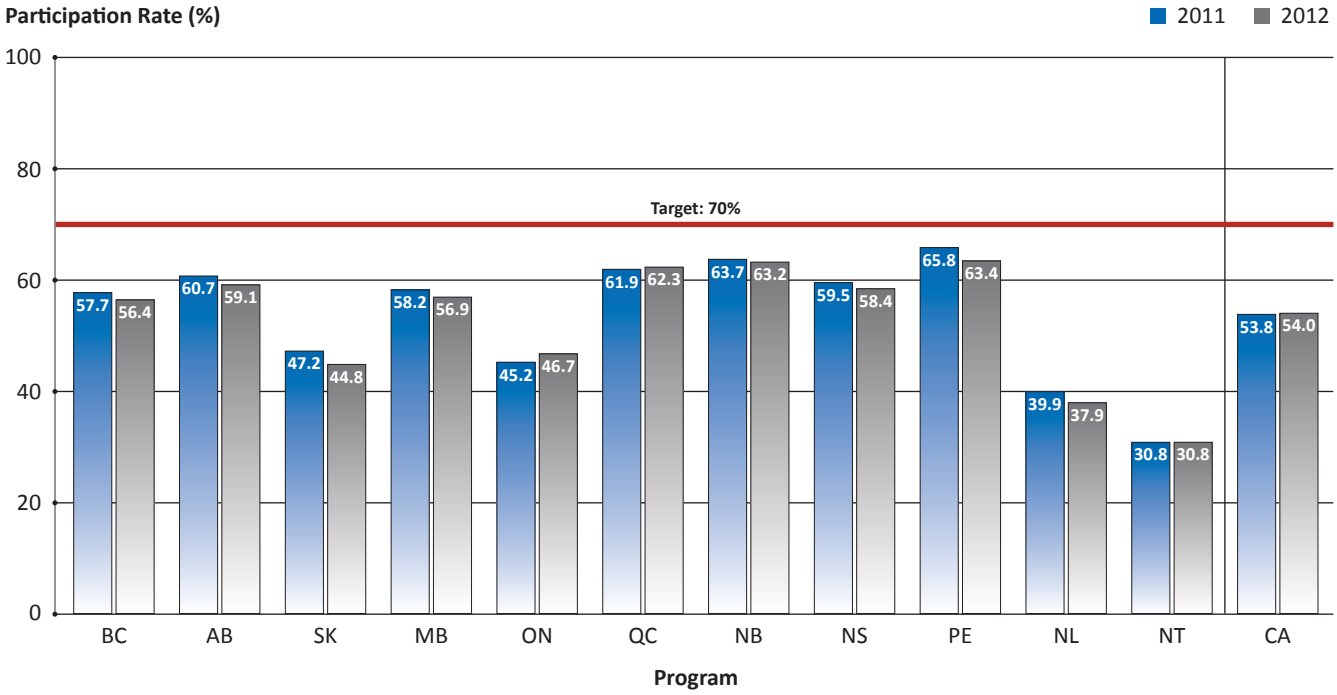
More than 2.5 million screening mammograms were delivered through organized breast cancer screening programs in Canada to women aged 50 to 69 years in screen years 2011–2012, and another 2.6 million were delivered in 2013–2014 (Table 5A, Table 5B). Overall participation rates in Canada have remained stable at approximately 54% within a 30-month period since 2011 (Figure 3A, Figure 3B, Table 6).

While participation remained substantially below the national target of ≥70% within 30 months, there continues to be wide variation observed across programs (range: 31.8% to 62.3% in the 30 months ending December 31, 2014) (Table 5B, Figure 3B). Participation also varied by age; participation rates were higher in women aged 60 to 69 years compared with women 50 to 59 years and 70 years and above (Table 7A, 7B).

It is important to recognize that mammography screening can also occur outside of organized breast cancer screening programs (opportunistic screening), thus the programmatic participation rates reported above will underestimate total screening mammography use among Canadian women. Data from the 2012 Canadian Community Health Survey indicate that 62% of Canadian women aged 50 to 69 years reported undergoing a screening mammogram in the previous two years, with provincial/territorial rates ranging from 49% to 64%.

FIGURE 3A

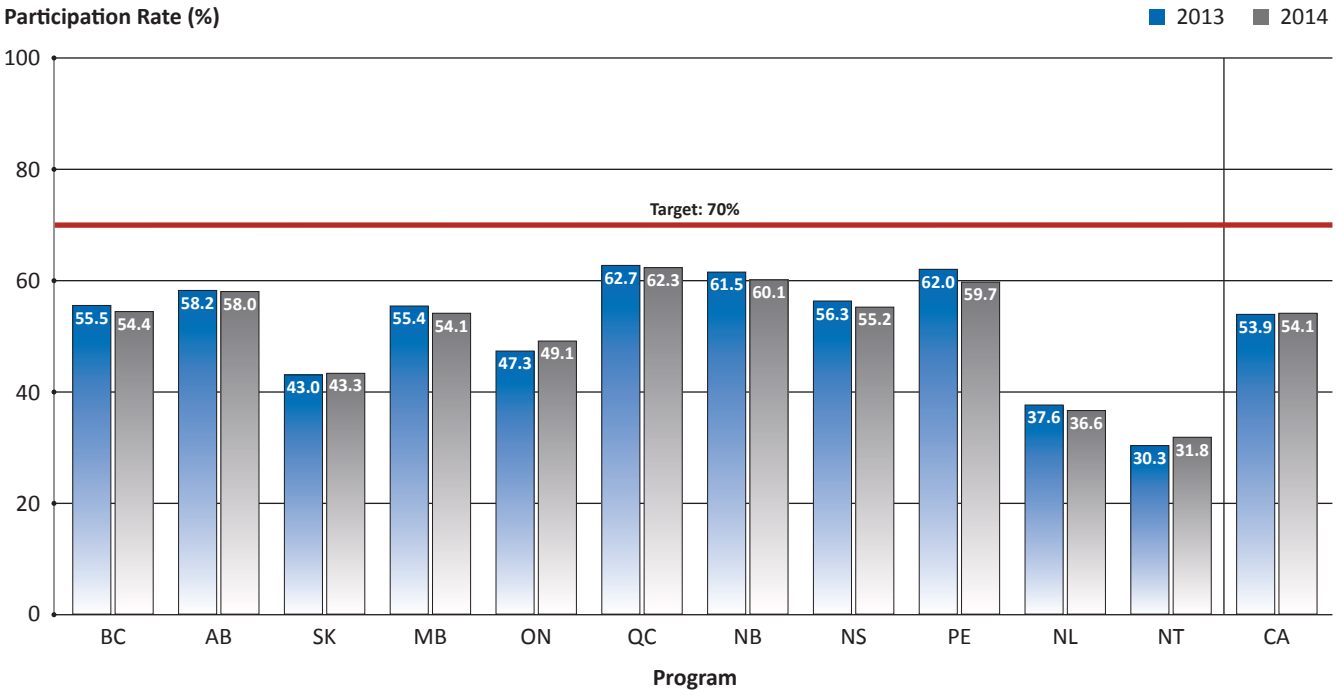
Participation in organized breast cancer screening programs, women aged 50–69 years, 2011 and 2012 screen years



Notes:
Rate for 2011 includes screens in the 30-month period July 1, 2009 – December 31, 2011; rate for 2012 includes screens in the 30-month period July 1, 2010 – December 31, 2012.
ON: Breast cancer prevalence estimates are underestimated because in-situ cancers were not registered at the time the Canadian Cancer Registry file was created.
QC: Breast cancer prevalence is estimated using the Canadian average (excluding Quebec).
Source: Statistics Canada census data estimated for December 31, 2011 and December 31, 2012 (adjusted for breast cancer prevalence calculated using Canadian Cancer Registry data) are used for denominator values in 2011 and 2012, respectively.

FIGURE 3B

Participation in organized breast cancer screening programs, women aged 50–69 years, 2013 and 2014 screen years



Notes:
Rate for 2013 includes screens in the 30-month period July 1, 2011 – December 31, 2013. Rate for 2014 includes screens in the 30-month period July 1, 2012 – December 31, 2014.
ON: Breast cancer prevalence estimates are underestimated because in-situ cancers were not registered at the time the Canadian Cancer Registry file was created.
QC: Breast cancer prevalence is estimated using the Canadian average (excluding Quebec).
Source: Statistics Canada census data estimated for December 31, 2013 and December 31, 2014 (adjusted for breast cancer prevalence calculated using Canadian Cancer Registry data) are used for denominator values in 2013 and 2014, respectively.

The percentage of all organized screening that occurs in women age 40 to 49 years decreased slightly from 11.8% in 2011–2012 to 9.0% in 2013–2014 (Figure 4A, Figure 4B). This also varied widely by program, ranging from 0% to 38.5% in screen years 2013–2014.

FIGURE 4A

Age distribution of program screens by province/territory, 2011 and 2012 screen years

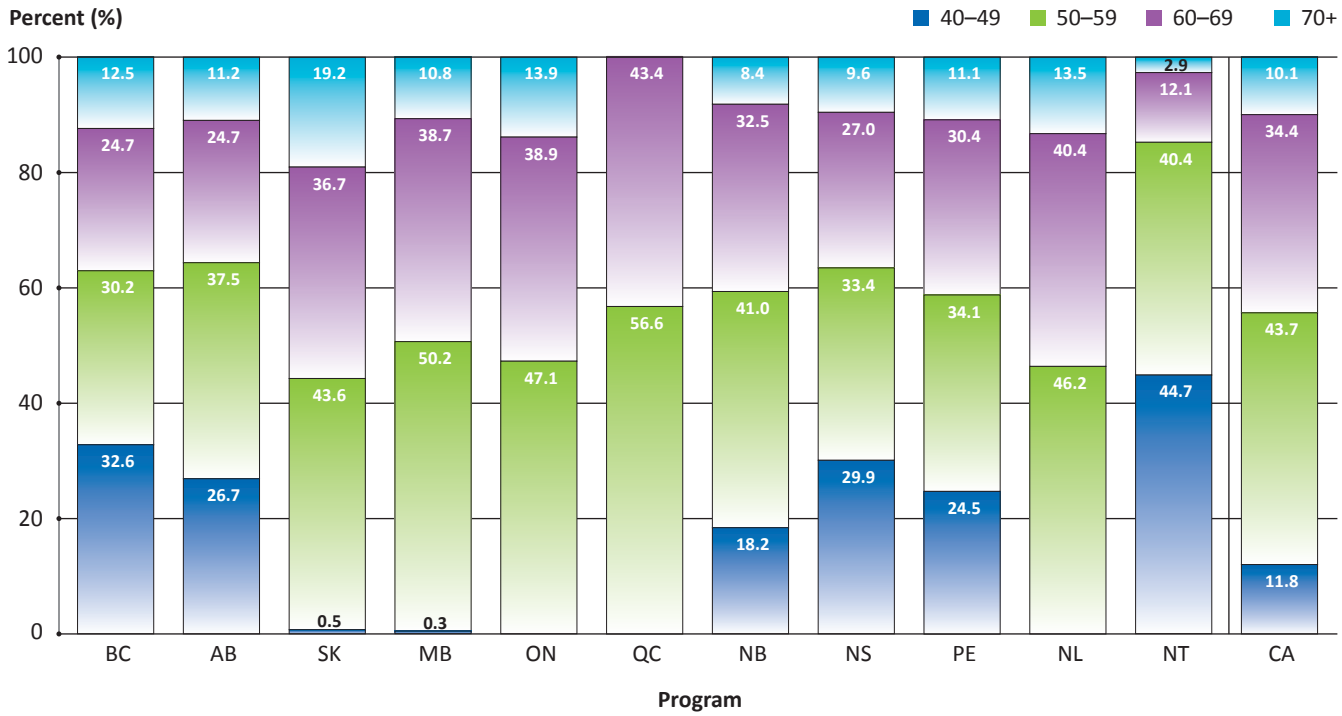
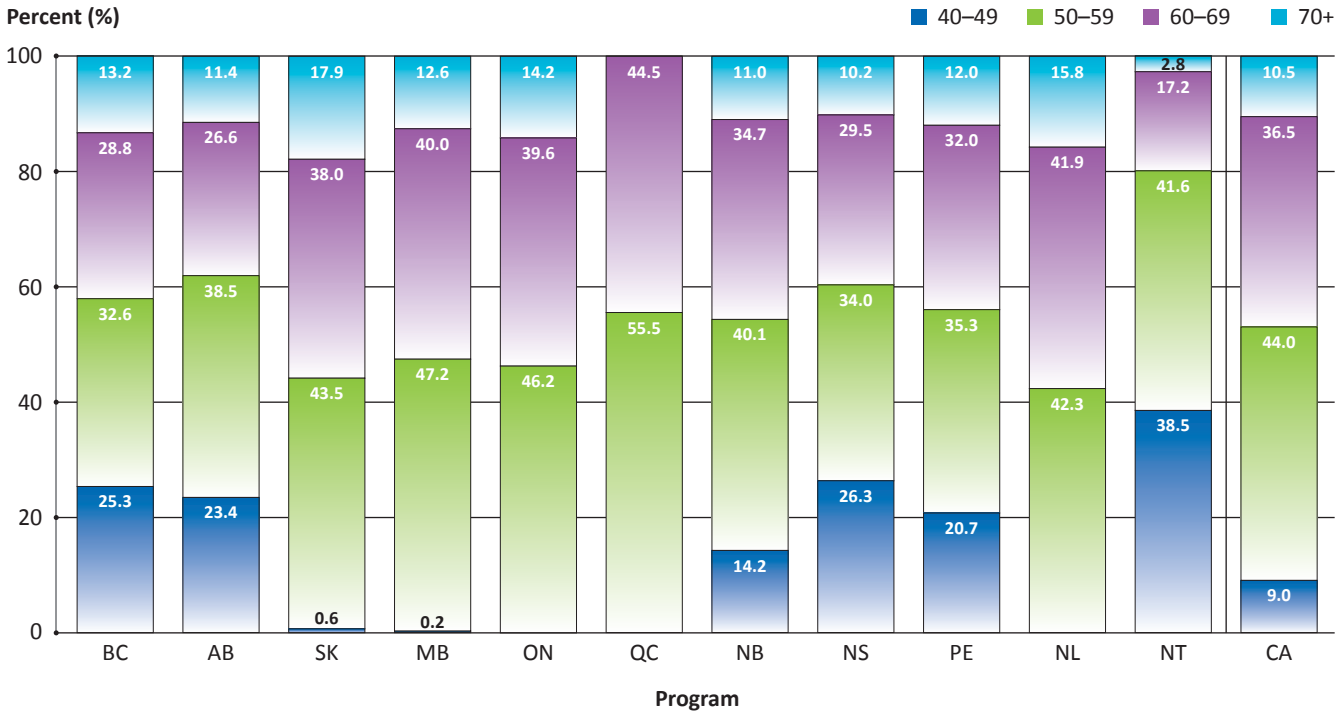


FIGURE 4B

Age distribution of program screens by province/territory, 2013 and 2014 screen years



Retention Rate

Retention rate is the estimated percentage of women aged 50 to 67 years who returned for screening within 30 months of their previous screen.

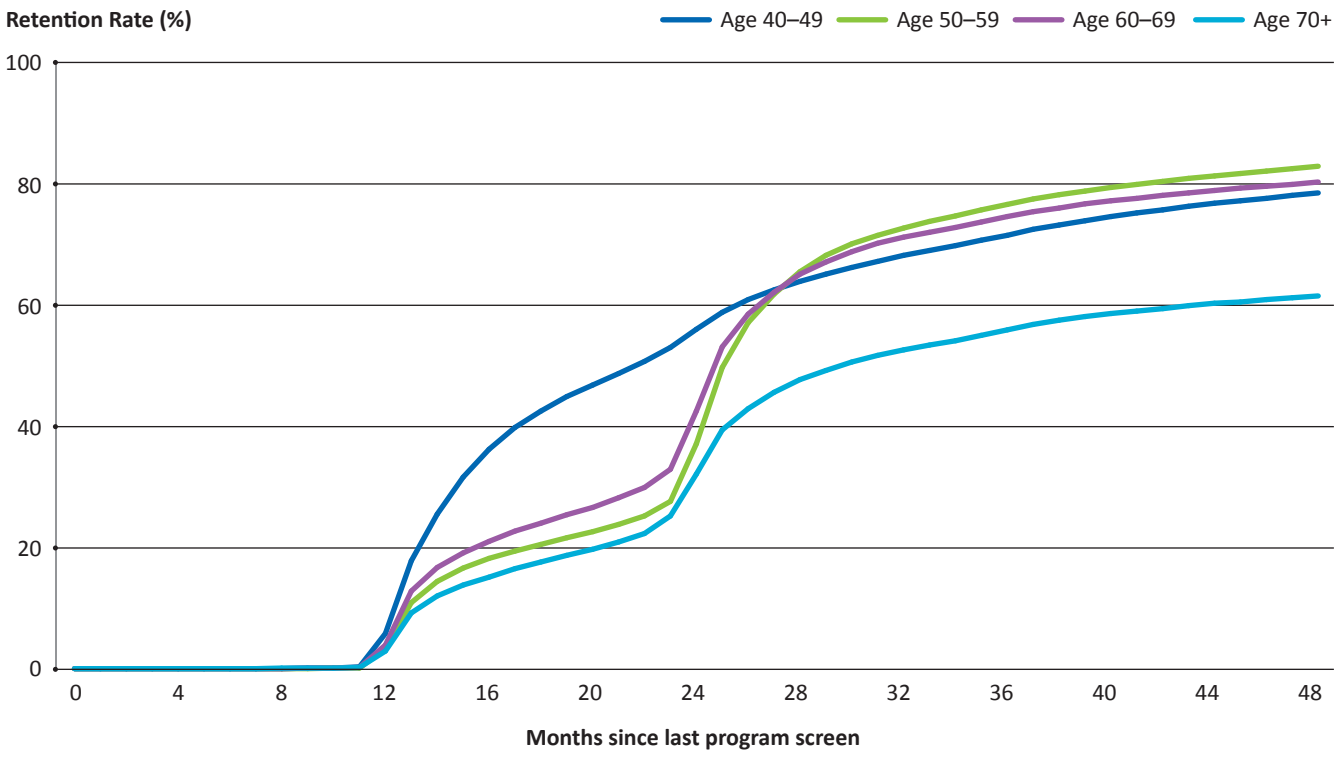
***National target (50 to 67 years):** ≥75% within 30 months of an initial screen; ≥90% within 30 months of a subsequent screen.*

The majority of women aged 50 to 67 years who received a screening mammogram in 2008–2009 returned to screening within 30 months; 68.8% of women who received their first mammogram returned, while 82.6% of women who received their second or greater mammogram returned (Table 5A). While retention rates are high overall, they still fall below the national targets and have remained relatively stable over time (Table 6). As with participation rates, retention rates also vary widely across programs. Only two reporting programs met the national target for initial screens, while retention in all programs fell below the target for subsequent screens (Table 5A).

Women aged 50 to 59 and 60 to 69 years were more likely to return within 30 months of an initial or subsequent screen than were women aged 70 years and older (Figure 5A, Figure 5B). Younger women (aged 40 to 49 years) were more likely to return to screening within 12 to 24 months compared with women aged 50 years or older. This is related to the breast cancer risk profiles and some program-specific screening recommendations for women in this age group who choose to be screened for breast cancer.

FIGURE 5A

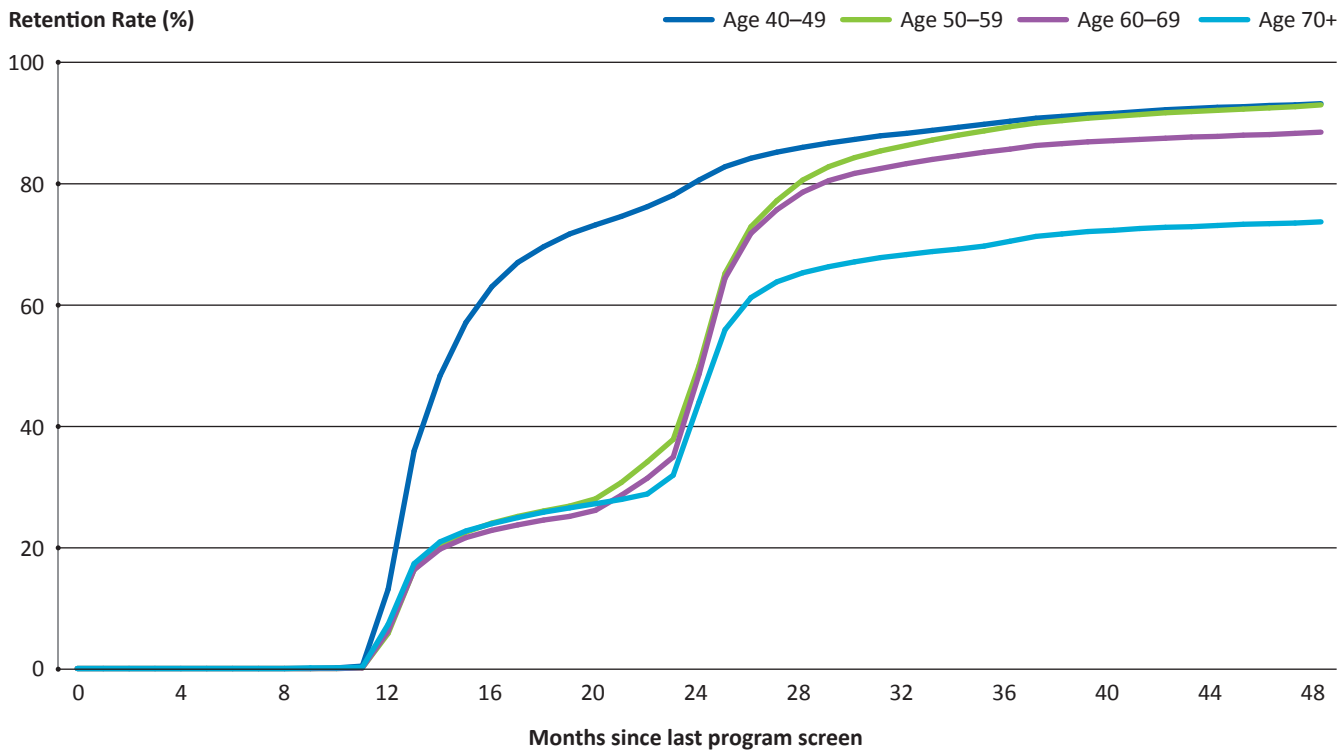
Cumulative probability of returning for a second screen, by age group, 2008 screen year



Notes:
AB: The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias national estimates for cumulative probability of returning for a second screen during the initial years of data collection by the Alberta program.

FIGURE 5B

Cumulative probability of returning for a third or greater screen by age group, 2008 screen year



Annual Screening Rate

Annual screening rate is the estimated percentage of women who returned to screen within 18 months of their previous screen.

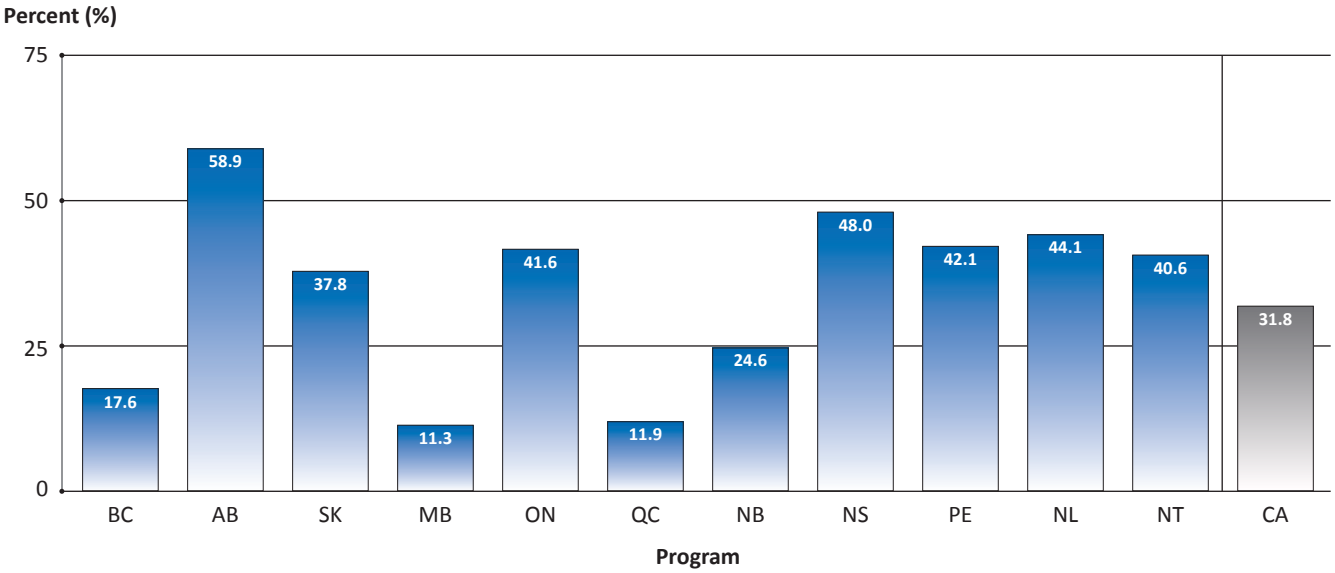
Target: *None*

Although most women are recalled to screening every two years, some women are recalled on an annual basis according to provincial cancer screening program policies. Among women who returned to screening after a subsequent screen in 2012, 31.8% returned within 18 months (Figure 6). This rate was similar to that reported for 2009–2010 screen years (32.2%), but represents a substantial increase from 2007–2008 screen years (22.8%).

There was also considerable variation between programs; annual screening rates ranged from 11.3% to 58.9% (Figure 6). This variation is probably largely due to differences in programmatic recall policies and practices.

FIGURE 6

Annual screening rate among subsequent screeners by program, women aged 50–68, 2012 screening year



Follow-Up

Abnormal Call Rate

Abnormal call rate is the percentage of screening mammograms that are identified as abnormal.

***National target (50 to 69 years):** <10% of initial screens; <5% of subsequent screens.*

Abnormal call rate is an important indicator of the quality of the mammogram image and its interpretation. It is most meaningful when considered in the context of positive predictive value (PPV), cancer detection rate, post-screen cancer rate and the breast cancer incidence rate. A high abnormal call rate could increase the false-positive rate and result in unnecessary follow-up tests. Abnormal call rates are generally higher for first-time screens, as initial screens detect prevalent cancers and because subsequent screens can be compared with previous findings. They may also be affected by the recommended screening interval, the screening technology used (digital DR, digital CR, or SFM), radiologist experience and reading volumes, the incidence of breast cancer, and population characteristics such as age and breast density.

The abnormal call rate has risen steadily in Canada; in 2013–2014 it was 16.6% for initial screens and 7.6% for subsequent screens (Table 5B), up slightly from 15.3% for initial screens and 7.2% for subsequent screens in 2011–2012 (Table 5A). Wide variation in program-specific abnormal call rates was observed (Table 5A), likely due to differences in the factors mentioned above. Refer to the Special Topic for extended time trends and additional discussion.

Abnormal call rates decrease with increasing age (Figure 7A, Figure 7B). Older women tend to have a greater number of previous screens for comparison by the radiologist, as well as less dense breasts which improves interpretive ability. For all age groups, the abnormal call rate rose substantially when the screening interval exceeded 30 months, highlighting the importance of regular attendance.

FIGURE 7A

Abnormal call rate by age group and time since last screen, 2011 and 2012 screen years

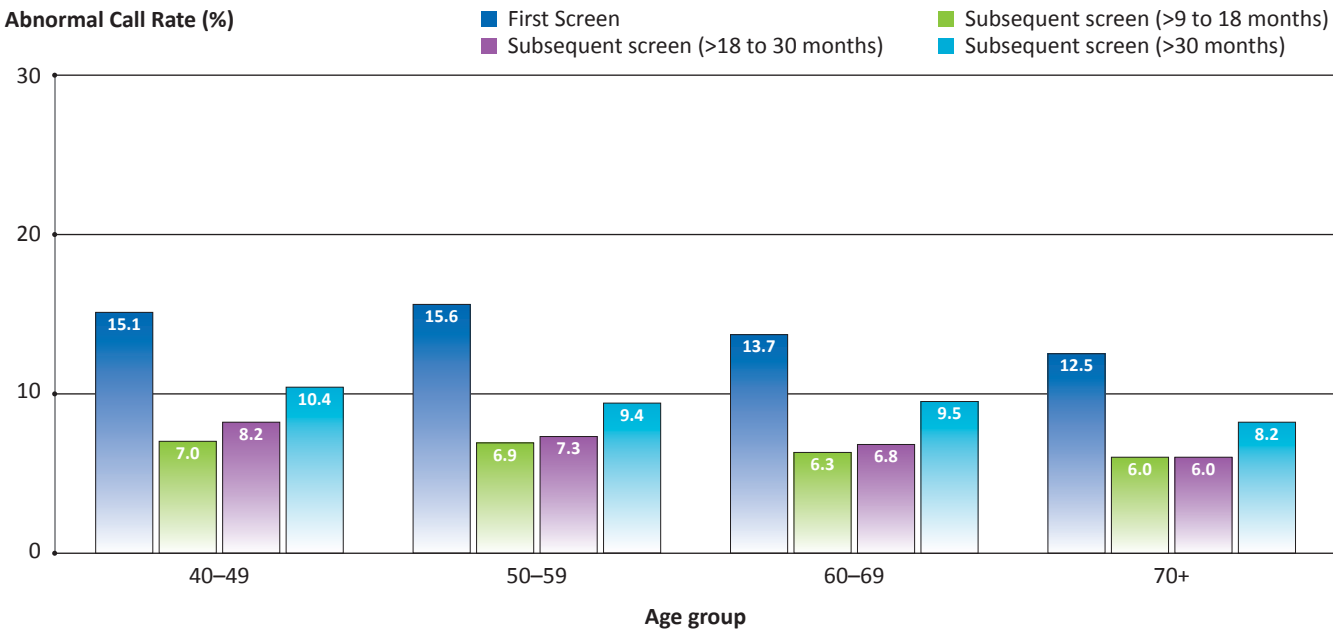
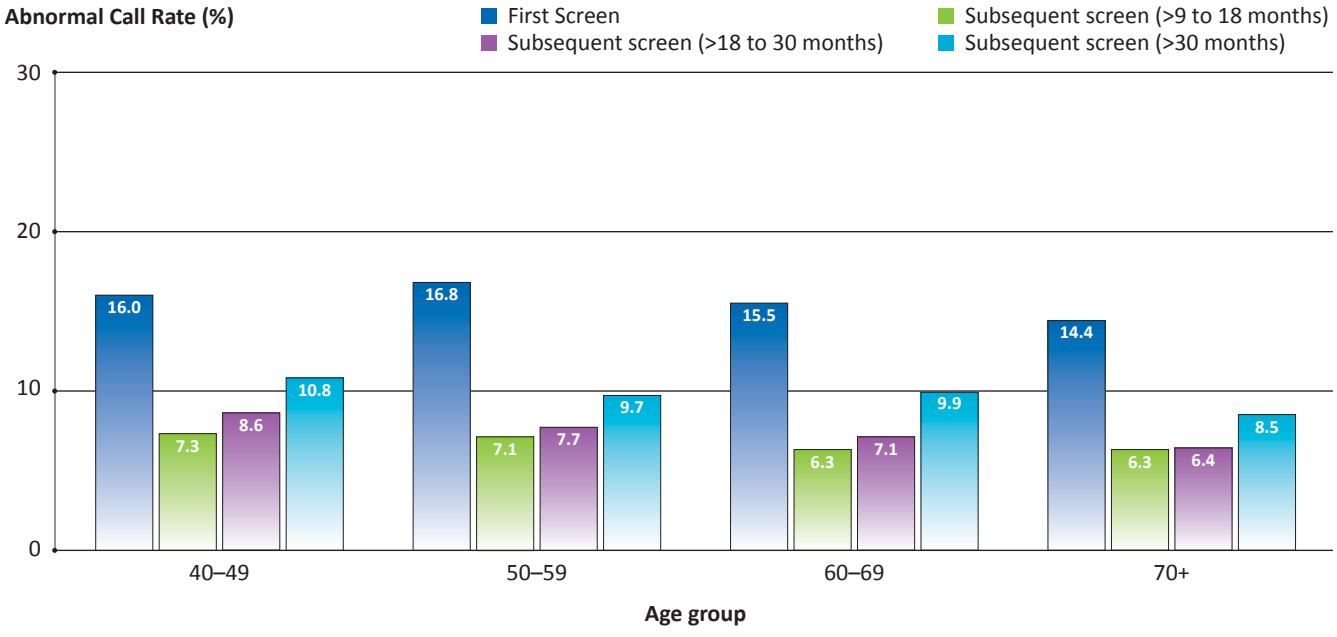


FIGURE 7B

Abnormal call rate by age group and time since last screen, 2013 and 2014 screen years



Diagnostic Assessment

Most women who receive an abnormal screening result do not go on to be diagnosed with breast cancer; however, additional assessment is required to reach a definitive diagnosis. This can include additional imaging, core or open biopsy, and/or fine needle aspiration (FNA).

In 2011–2012, 81.7% of women with an abnormal screen were assessed with additional breast imaging only, including: mammography, ultrasound and/or MRI (Figure 8).

Relatively fewer women underwent more invasive assessment procedures, similar to the patterns reported in 2009–2010. A total of 14.9% of abnormal screens required a core biopsy, 1.3% required FNA, and 1.7% required an open surgical biopsy in order to reach a definitive diagnosis (Table 2). A small percentage of women (1.8%) did not undergo any additional assessment procedures (Figure 8).

TABLE 2

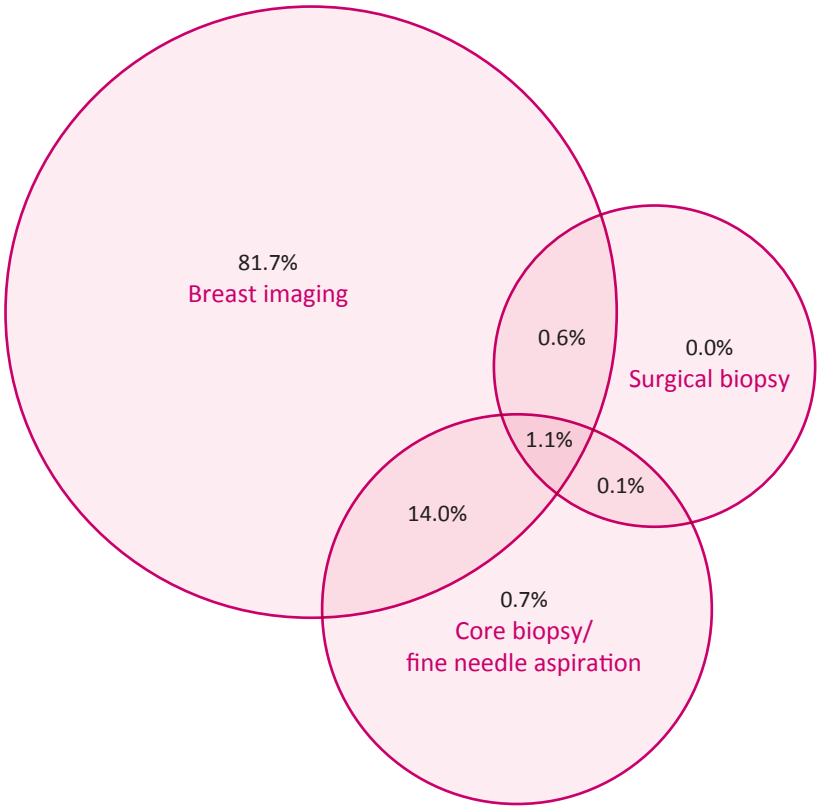
Diagnostic procedures after an abnormal screen, women aged 50–69 years, 2011 and 2012 screen years

Diagnostic Procedure	Number	Percent	Range
Diagnostic mammogram	150,580	82.2	68.9–93.8
Ultrasound	119,762	65.4	32.2–74.2
Fine-needle aspiration	2,432	1.3	0.0–2.6
Core biopsy	27,316	14.9	8.2–25.8
Open biopsy with or without fine wire localization	3,195	1.7	0.0–5.2

Notes:
AB: Excluded for data quality reasons.
QC: Aggregate data were submitted. National estimates are a weighted average of QC and the rest of Canada. Includes abnormal screens occurring from January 1, 2011 to September 30, 2012, inclusive. Ultrasound may be underestimated as tests performed in private clinics are not included.

FIGURE 8

Combinations of diagnostic procedures after an abnormal screen, women aged 50 to 69 years, 2011 and 2012 screen years



1.8% of women had none of the above procedures

Notes:
AB: Excluded for data quality reasons.
QC: Aggregate data were submitted. National estimates are a weighted average of QC and the rest of Canada. Includes abnormal screens occurring from January 1, 2011 to September 30, 2012, inclusive. Ultrasound may be underestimated as tests performed in private clinics are not included.

Diagnostic Interval

Timely, well-coordinated, and minimized diagnostic assessment is critical; long diagnostic intervals can have negative psychological impacts and potentially worsen prognosis where cancer is present.[28–30]

Diagnostic interval is the duration of time from the abnormal screening mammogram to a final diagnosis. For the purposes of this report, three distinct intervals are presented which describe the different phases of follow-up after a screening mammogram. Diagnostic interval can be improved by patient navigation, 'fast track' or other referral systems.

Time from screen to notification of screen result

National target (50 to 69 years): *≥90% within two weeks*

In screen years 2011–2012, 96% of notifications were sent within two weeks for the seven Canadian programs that reported data for this indicator (Table 5A). This overall rate was well above the national target of ≥90%, and the target was met individually by nearly all reporting programs. This indicator has remained relatively stable since 2004 (Table 6).

Time from abnormal screen to first diagnostic assessment

National target (50 to 69 years): *≥90% within three weeks*

In screen years 2011–2012, 66.1% of women with an abnormal screening mammogram result received their first diagnostic assessment within three weeks (Table 5A). While this marked an increase from 59.8% in 2009–2010, this indicator remained below the national target for all reporting programs. The time from abnormal screen to first diagnostic assessment is affected by a number of factors, including: mammographic suspicion, the type of diagnostic test(s) performed, as well as provincial and programmatic capacity.

Time from abnormal screen to definitive diagnosis

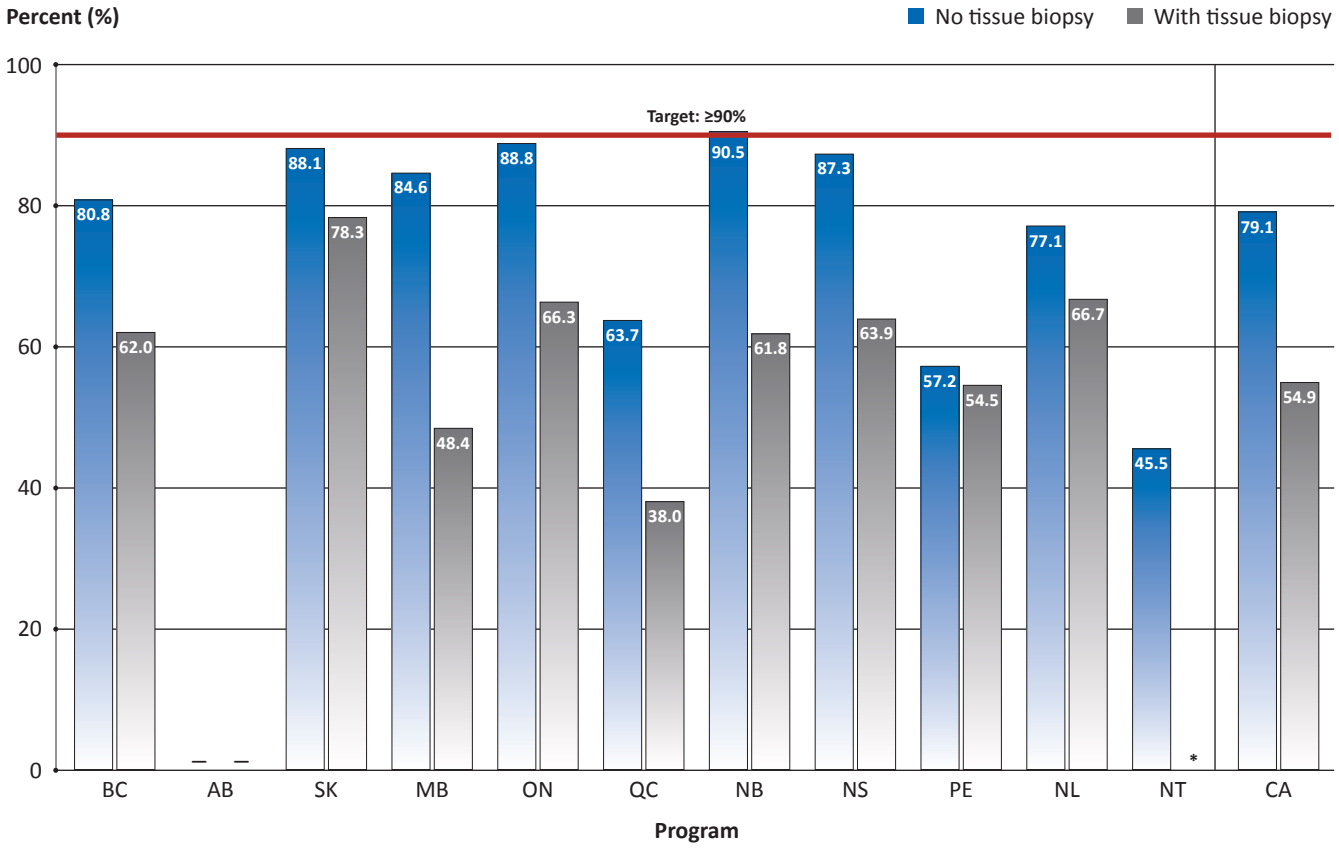
National target (50 to 69 years): *≥90% within five weeks if no tissue biopsy is performed; ≥ 90% within seven weeks if tissue biopsy (core or open) is performed*

In screen years 2011–2012, only 79.1% of Canadian women who did not require a biopsy received a final diagnosis within five weeks, though several programs reported values that were near to or which exceeded the national target (Figure 9, Table 5A). For women who required a biopsy, only 54.9% received a final diagnosis within seven weeks, with all programs reporting values which fell well below the national target.

While these values are suboptimal, the percentage of women reaching resolution within the targeted timeframes has increased since 2009–2010 and 2007–2008 screen years. The increase has been more pronounced in women who require tissue biopsy. Time to final diagnosis is affected by many of the same factors as noted for time to first diagnostic assessment, as well as the clinical complexity of the case.

FIGURE 9

Time from abnormal screen to definitive diagnosis§, women aged 50 to 69 years, 2011 and 2012 screen years



Notes

§: Time is expressed as the percent achieving the benchmark (No tissue biopsy: 5 weeks; Tissue Biopsy: 7 weeks).

*: suppressed owing to small numbers.

"—" Data not available.

National target: 5 weeks where no tissue biopsy is performed, 7 weeks where tissue biopsy is performed.

QC: Aggregate data were submitted. National estimates are a weighted average of QC and the rest of Canada. Includes abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive. Ultrasound tests performed in private clinics are not included.

Quality of Screening

Non-Malignant Biopsy Rate

Non-malignant open and core biopsy rate is the number of non-malignant open and core biopsies per 1,000 screens

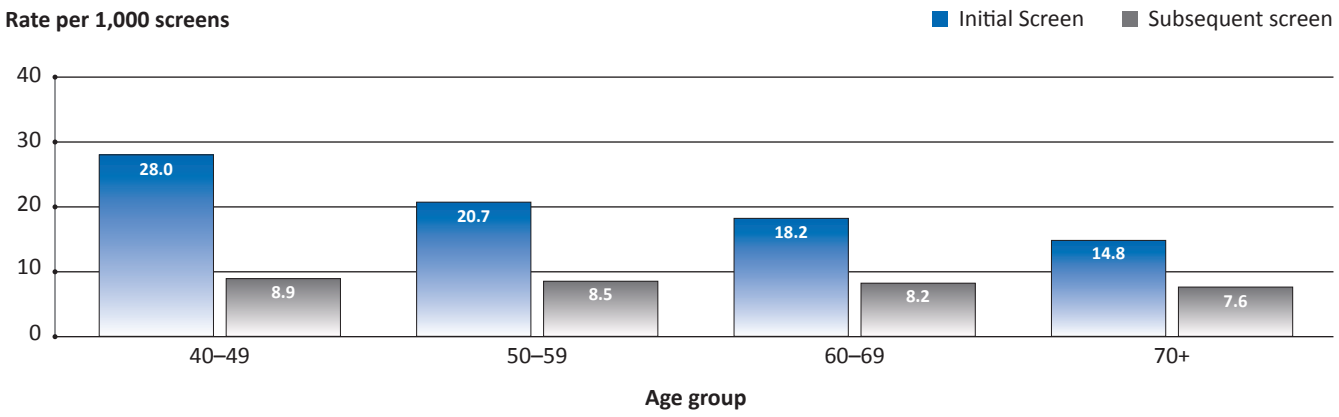
National target: *No target established*

The non-malignant biopsy rate provides an indication of the quality of the pre-operative assessment. Variation in the use of open biopsy is reflected in the percentage of non-malignant biopsies which were open. Programs should strive to limit the number of unnecessary tests and procedures performed, including those that are invasive – this may involve collaborations with stakeholders engaged in the planning and delivery of diagnostic services.

In screen years 2011–2012, the rate of open and core biopsies with a non-malignant result was 20.3 per 1,000 initial screens and 8.4 per 1,000 subsequent screens (Table 5A). These rates are slightly higher than those reported in screen years 2007–2008 and 2009–2010. Currently, there is no national target for this indicator. While targets for non-malignant open biopsy rate have been set by screening programs in other jurisdictions, including the United Kingdom (<3.6 per 1,000 initial screens, <2 per 1,000 subsequent screens),[31] Australia (≤0.35% of initial screens, ≤0.16% of subsequent screens),[32] and New Zealand (≤3.5 per 1,000 initial screens, ≤1.6 per 1,000 subsequent screens)[33], as Canadian rates include both core and open biopsies they cannot be directly compared. Rates varied considerably across programs, particularly for initial screens (Table 5A). This is likely reflective of jurisdictional differences in assessment practices. For initial screens, the rate decreased substantially in each successive age group (Figure 10, Table 7A). For subsequent screens the rates displayed a similar trend, though much less variation was observed across age groups.

FIGURE 10

Non-malignant open and core biopsy rate by age group, 2011 and 2012 screen years



Notes
AB: Excluded; data were unavailable.
QC: Aggregate data were submitted. National estimates are a weighted average of QC and the rest of Canada. Includes abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive.

Non-Malignant Biopsy Rate

Percentage non-malignant open surgical biopsies is the percentage of non-malignant biopsies which were open surgical biopsies

National target: *No target established*

While there is no national target for this indicator, programs should strive to maximize non-operative diagnoses and avoid open biopsy of benign screen-detected abnormalities wherever possible. In screen years 2011–2012, 9.7% of non-malignant biopsies occurring after an initial screen were open, with program-specific values ranging from 5.1% to 22.6% (Table 5A). Of all non-malignant biopsies following a subsequent screen, 11.5% were open, ranging from 4.6% to 20.4% across programs.

The rate of non-malignant open biopsies has decreased steadily over the past decade (Table 6), and the highest rates are observed in women aged 40 to 49 years for both initial and subsequent screens (Table 7A).

Positive Predictive Value (PPV) of the Screening Mammography Program

Positive predictive value (PPV) of the screening mammography program is the percentage of abnormal cases diagnosed with breast cancer (invasive or in situ) after diagnostic work-up.

National target (50 to 69 years): *≥5% for initial screens; ≥6% for subsequent screens*

PPV is an indicator of the predictive validity of screening. A high PPV will minimize unnecessary follow-up procedures. Factors that influence cancer detection and abnormal call rates must also be taken into consideration when evaluating a program's PPV. PPV is generally higher for subsequent screens because a normal baseline for comparison has been established, which likely results in a lower number of false-positive abnormal calls.

In screen years 2011–2012, PPV met the national target for subsequent screens (6.5%), and was close to the target for initial screens (4.1%) (Table 5A). PPV increased in each successive age group, from 2.0% to 13.7% (initial screens) and 2.6% to 12.8% (subsequent screens) in women aged 40 to 49 years and 70 years or older, respectively (Table 7A). PPV increases with age for several reasons: breast cancer incidence increases with age, older women are more likely to have been screened previously, and older women typically have less dense breasts which improves interpretive ability.

PPV has declined slightly in recent years (see Special Topic) and demonstrates wide variation by program (Table 5A), likely as a result of differences in population characteristics, level of radiologist experience and reading volumes, and the screening technology used.

Sensitivity of the Screening Mammography Program

Sensitivity of the screening mammography program is the percentage of breast cancer cases (invasive and in situ) that were correctly identified as cancer during the screening episode.

National target: *No target established*

Sensitivity is an indicator of how well the screening mammography program detects cancers. This rate is affected by underlying incidence rates, age, the rate of disease progression, radiologist experience, the recommended screening interval and diagnostic interval. The accuracy of this indicator is also dependent upon the completeness of cancer registration.

Sensitivity has remained relatively stable over time (Table 6), and was 84.3% in screen years 2010–2011 (Table 5A). Sensitivity exceeded 80% in nearly all reporting programs. Sensitivity also increases with increasing age (Table 7A), for similar reasons as noted for abnormal call rate and PPV.

Post-Screen Invasive Cancer Rate

Post-screen invasive cancer rate is the number of invasive breast cancers found after a normal or benign mammography screening episode within 0 to <12 months and 12 to 24 months of the screen date, per 10,000 person-years of follow-up.

National target (50 to 69 years): *<6 per 10,000 person-years within 0 to <12 months of the screen date; <12 per 10,000 person-years within 12 to 24 months of the screen date.*

Post-screen invasive breast cancers are cancers that are found during the interval after a normal screening mammogram and before the next screen is due. This can include both new cancers which have developed during the screening interval (true interval cancers) and cancers that were missed during the screening episode. The post-screen invasive cancer rate is an indicator of the sensitivity of the mammography screening program. This rate is affected by underlying incidence rates, age, sojourn time, opportunistic screening, the recommended screening interval and diagnostic interval. A high post-screen invasive cancer rate may negatively affect the mortality reduction expected for a successful, organized breast cancer screening program. The accuracy of this indicator is dependent upon the completeness of cancer registration.

In 2009–2010, post-screen invasive cancer rates were close to the national target, at 7.4 per 10,000 person-years within 12 months and 12.7 per 10,000 person-years between 12 and 24 months of the program screen (Table 5A). Many reporting programs met the national target for the 12 to 24 month post-screen period. Post-screen cancer rates are higher for women aged 60 to 69 years and aged 70 years or older (Table 7A).

Detection

Cancer detection rates are an indicator of how effective a screening mammography program is at finding cancers. They are most meaningful when considered in relation to the abnormal call rate, post-screen cancer detection rate, and the underlying rate of breast cancer in the eligible population. Cancer detection rates are affected by age, the screening technology used, the recommended screening interval and diagnostic interval.

In Situ Cancer Detection Rate

In situ cancer detection rate is the number of ductal carcinoma in situ (DCIS) cancers detected per 1,000 screens.

National target: *No target established*

DCIS is a heterogeneous disease that involves only the lining of the breast duct and it can be detected through mammography screening. The DCIS detection rate may be interpreted as an indicator of screening quality, but it would be inappropriate to set specific targets as the natural history of DCIS is not well understood and not all cases will progress to invasive cancer.

In screen years 2011–2012, the *in situ* cancer detection rate was 1.2 per 1,000 initial screens and 0.8 per 1,000 subsequent screens (Table 5A). Rates were relatively consistent across programs, and increased with age (Figure 11, Table 7A).

Invasive Cancer Detection Rate

Invasive cancer detection rate is the number of invasive cancers detected per 1,000 screens.

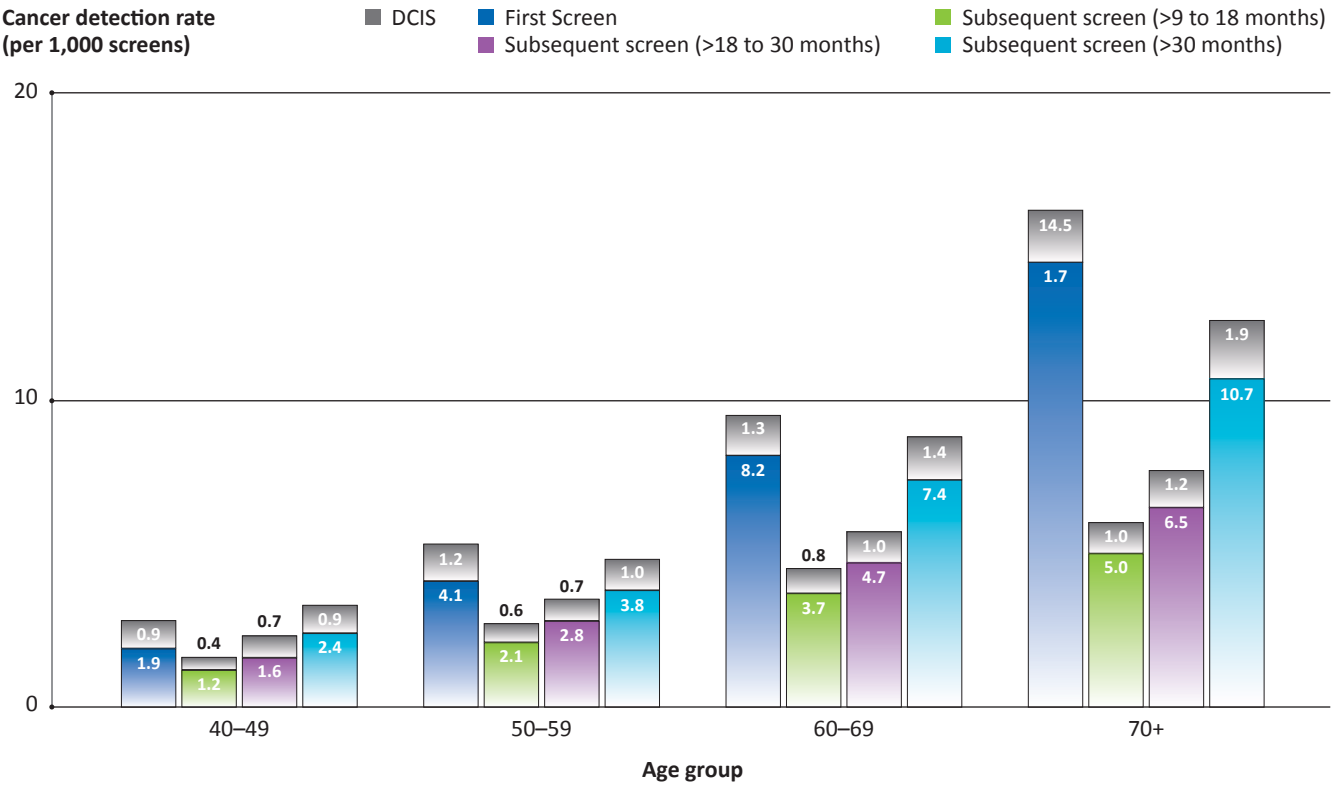
National target (50 to 69 years): *>5 per 1,000 initial screens; >3 per 1,000 subsequent screens.*

In screen years 2011–2012, the invasive cancer detection rate in women aged 50 to 69 years was 4.9 per 1,000 initial screens and 3.7 per 1,000 subsequent screens (Table 5A). These rates have remained relatively stable over time (Table 6), and many individual programs reported values which met or exceeded the national targets (Table 5A).

As anticipated, invasive cancer detection rates were highest among initial screens (due to the detection of prevalent cancers), increased with age (as breast cancer incidence increases with age), and increased when subsequent screening was not timely (Figure 11, Table 7A). Refer to the Special Topic section for extended time trends and additional discussion.

FIGURE 11

Cancer detection (invasive and in situ) rate per 1,000 screens by age group and time from last screen, 2011 and 2012 screen years



Notes
Area in grey indicates the rate of DCIS cancer detected, while the areas not in grey indicate the rate of invasive cancers detected, while the non-shaded area indicates the rate of DCIS cancer detected.
QC: Includes all screens occurring between January 1, 2011 and September 30, 2012, inclusive.

Percent Ductal Carcinoma in Situ

Percent ductal carcinoma in situ is the percentage of all cancers detected that are DCIS

National target: *No target established*

In screen years 2011–2012, 19.6% of cancers detected at initial screen and 18.6% of cancers detected at subsequent screen were DCIS (Table 5A). The percentage decreased with increasing age (Table 4, Table 7A).

Disease Extent at Diagnosis

Invasive breast cancers detected at earlier stages generally have a greater availability of treatment options, less recurrence and improved survival. Staging of invasive cancers is based on three prognostic factors: tumour size, the presence and extent of lymph node involvement, and the presence of distant metastasis. Below-target values on these prognostic indicators may reduce the expected mortality reduction possible through screening with mammography.

Screen-Detected Invasive Tumour Size

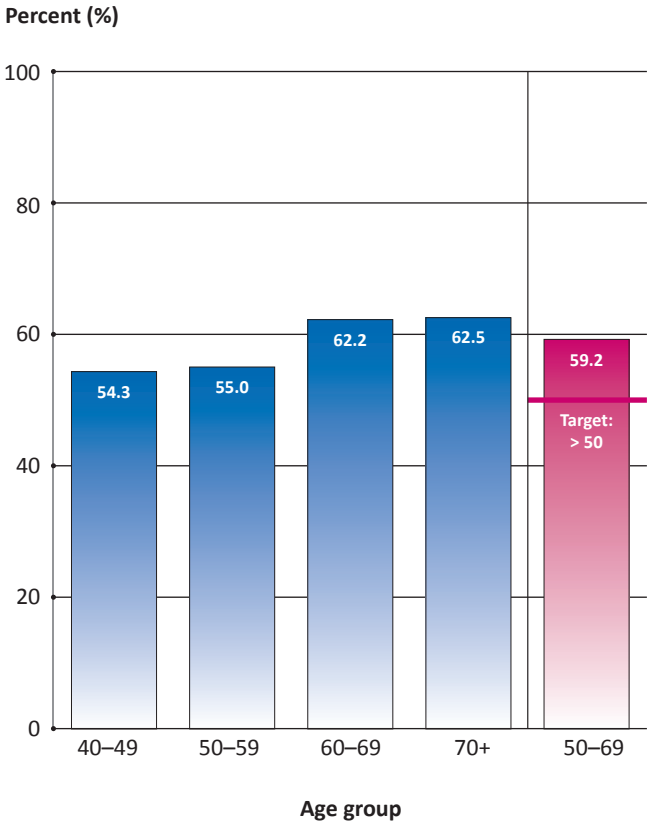
Screen-detected invasive tumour size is the percentage of screen-detected invasive cancers with a tumour size ≤15 mm in greatest diameter as determined by the best available evidence: 1) pathological, 2) radiological, and 3) clinical.

***National target (50 to 69 years):** >50% screen-detected invasive tumours ≤15 mm.*

In screen years 2011–2012, 59.2% of screen-detected invasive cancers in women aged 50 to 69 years had a tumor size equal to or less than 15mm (Figure 12, Table 5A), with all programs reporting values that exceeded the national target. A larger percentage of older women had tumours smaller than 15mm compared with younger women (Figure 12, Table 7A). This may be in part because younger women are more likely to have a prevalent cancer detected by screening compared with older women who tend to have a higher number of previous screens.

FIGURE 12

Percentage of screen-detected cancers with a tumour size ≤15mm by age group, 2011 and 2012 screen years



Notes
AB, QC: Excluded; data were unavailable.
ON: Data were unavailable for 2011.

Proportion of Node Negative Screen-Detected Invasive Cancers

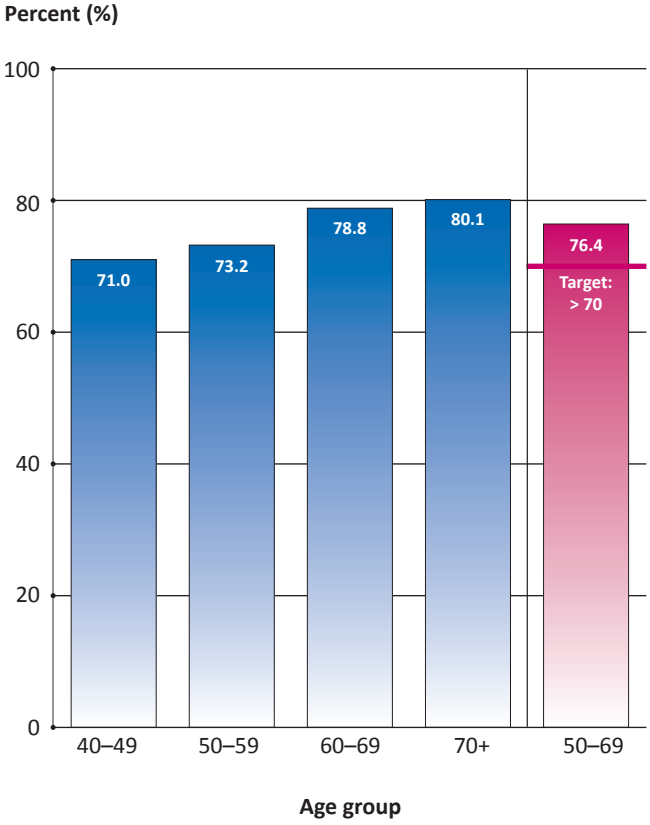
Proportion of node negative screen-detected invasive cancers is the percentage of screen-detected invasive cancers in which the cancer has not invaded the axillary lymph nodes as determined by pathological evidence.

***National target (50 to 69 years):** >70% of screen-detected invasive cancers*

In screen years 2011–2012, 76.4% of screen-detected invasive cancers in women aged 50 to 69 years were assessed as node-negative (Figure 13, Table 5A). All reporting programs reported values that well exceeded the national target. Similar to the trend observed for tumour size, the percentage of invasive cancers that were node negative increased with age (Figure 13, Table 7A).

FIGURE 13

Percentage of screen-detected invasive cancers that are node negative by age group, 2011 and 2012 screen years



Notes
AB, QC: Excluded; data were unavailable.

Special Topic: Spotlight on Benefits and Harms

Introduction

The goal of breast cancer screening is to detect breast cancers early in their natural history in order to prevent death. Screening mammography has been demonstrated to be effective in reducing breast cancer mortality; however, it is not a perfect test, and can lead to harm in some cases. It is imperative that screening providers take action to maximize the benefits of screening while minimizing potential harms. Organized screening programs are designed to do this; women are screened and followed-up according to comprehensive clinical practice guidelines, strategies to increase and maintain participation, retention and follow-up rates are used, and comprehensive programs for quality assurance, quality control and quality assessment exist.[4] As a result, organized screening has been demonstrated to offer increased clinical- and cost-effectiveness compared with opportunistic screening.[4,34,35]

Monitoring and evaluation of breast cancer screening programs provides an opportunity to understand the impact of organized breast screening. In Canada, this is done by examining the effectiveness of provincial and territorial programs according to the quality indicators presented in this report. These indicators are best examined in relation to each other and other external factors such as breast cancer incidence. A single unmet target may not warrant concern, depending on the value of others. For example, an abnormal call rate that exceeds the national target may not be of concern if cancer detection rates are similarly elevated. Organized screening programs should strive to achieve the greatest number of cancers detected while limiting unnecessary diagnostic tests and cancers missed at screening or assessment.

Time trends for four key indicators (Table 3) are presented here to further examine some of the potential benefits and harms of screening. Data are presented for subsequent screens only because the benefits of breast screening are incurred as a result of timely, repeated screening.

TABLE 3

Quality indicator definitions and national targets in women aged 50–69 years

Measure	Definition	National target
Abnormal call rate	Percentage of mammograms that are identified as abnormal at program screen	<5% (for subsequent screens)
Invasive cancer detection rate	Number of invasive cancers detected per 1,000 screens	>3 per 1,000 (for subsequent screens)
Positive predictive value (PPV)	Percentage of abnormal cases with completed follow-up found to have breast cancer (invasive or in situ) after diagnostic work-up	≥6% (for subsequent screens)
Post-screen invasive cancer rate	Number of invasive cancers found per 10,000 person-years of follow-up after a normal or benign mammography screening episode	<12 per 10,000 person-years (12–24 months)

- **Abnormal call rate** refers to the percentage of screens called positive by the radiologist, including true and false positives. It is an important indicator of the quality of the image and its interpretation. A high abnormal call rate resulting from a high rate of false positives results in a lower PPV and can subject women to harms from unnecessary diagnostic tests. A low abnormal call rate resulting from a high rate of false negatives would lead to a lower cancer detection rate and could increase the rate of post-screen invasive cancers, despite having a high PPV.
- **Invasive cancer detection rate** refers to the number of cancers detected per 1,000 screens. As it is highly linked to the underlying incidence, it increases with age. A low cancer detection rate could result in a higher than optimal rate of post-screen invasive cancers, which could reduce the mortality reduction expected for a successful screening program.
- **The positive predictive value (PPV)** of the screening mammography program refers to the percentage of participants with a positive screening result who are diagnosed with breast cancer after diagnostic assessment. It is an indicator of the predictive validity of screening. A high abnormal call rate unaccompanied by a high cancer detection rate will result in a lower PPV and unnecessary diagnostic tests.
- **Post-screen invasive cancer rate** refers to the number of cancers found after a normal or benign screening result and before the next screen is due. It is an indicator of the sensitivity of the screening program. A high rate of post-screen cancers may diminish the mortality reduction expected for a screening program if these cancers are detected at a later stage.

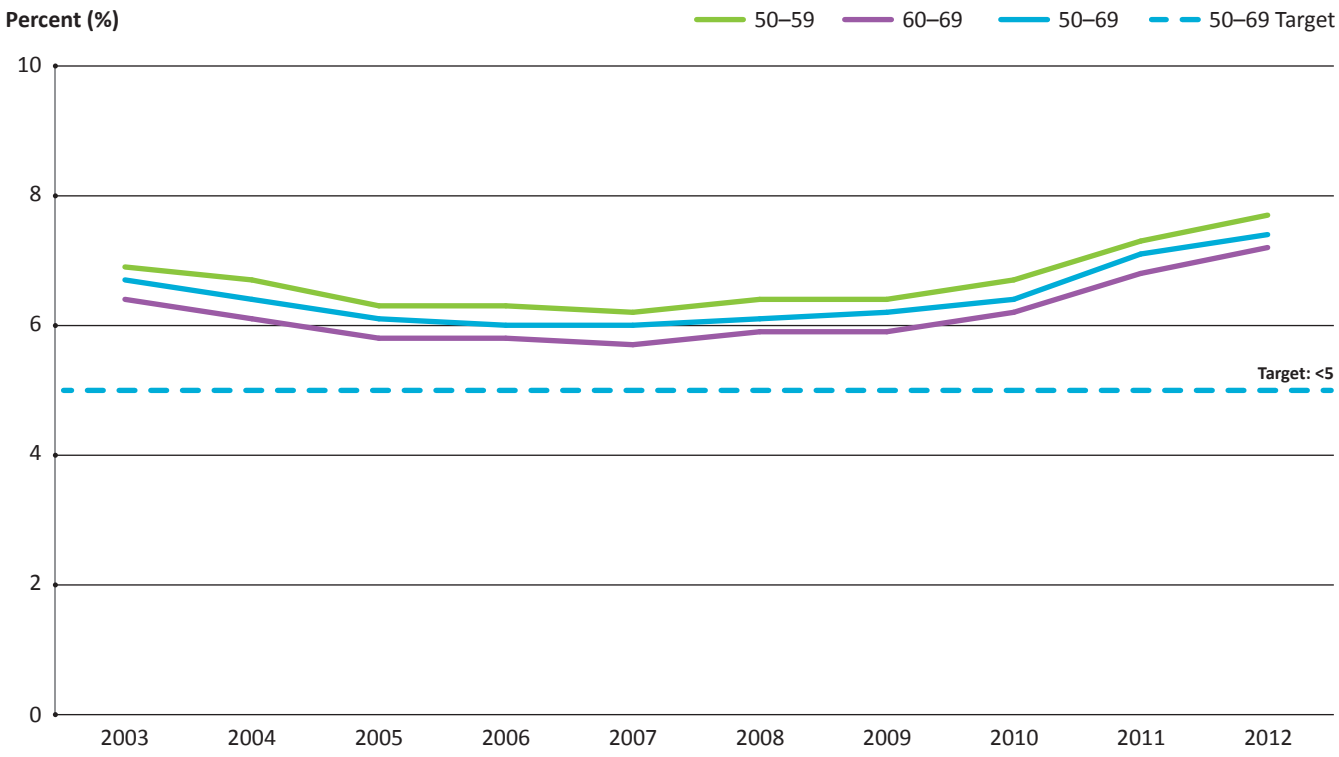
Time trends

The national target for abnormal call rate (<5%) was not met in screen years 2003 through 2012. The rate was stable from 2005 to 2008 at approximately 6%, after which it began to increase (Figure 14). As of 2012, the abnormal call rate was 7.4%. As expected, the rate was slightly lower in women aged 60 to 69 years than women aged 50 to 59 years. Older women tend to have more extensive screening histories and less dense breasts, which improves interpretation.

While the same overall trend has been observed over time across programs, program-specific rates have varied considerably. In screen years 2011–2012 for example, abnormal call rates ranged from 4.0% to 11.9% (Figure 15). This variation is likely related to a number of factors, including differences in screening intervals and technology; radiologist experience, reading volumes and quality assurance processes; population characteristics such as age; and the underlying incidence of breast cancer.

FIGURE 14

Abnormal call rate among subsequent screeners by age group, 2003 to 2012 screen years

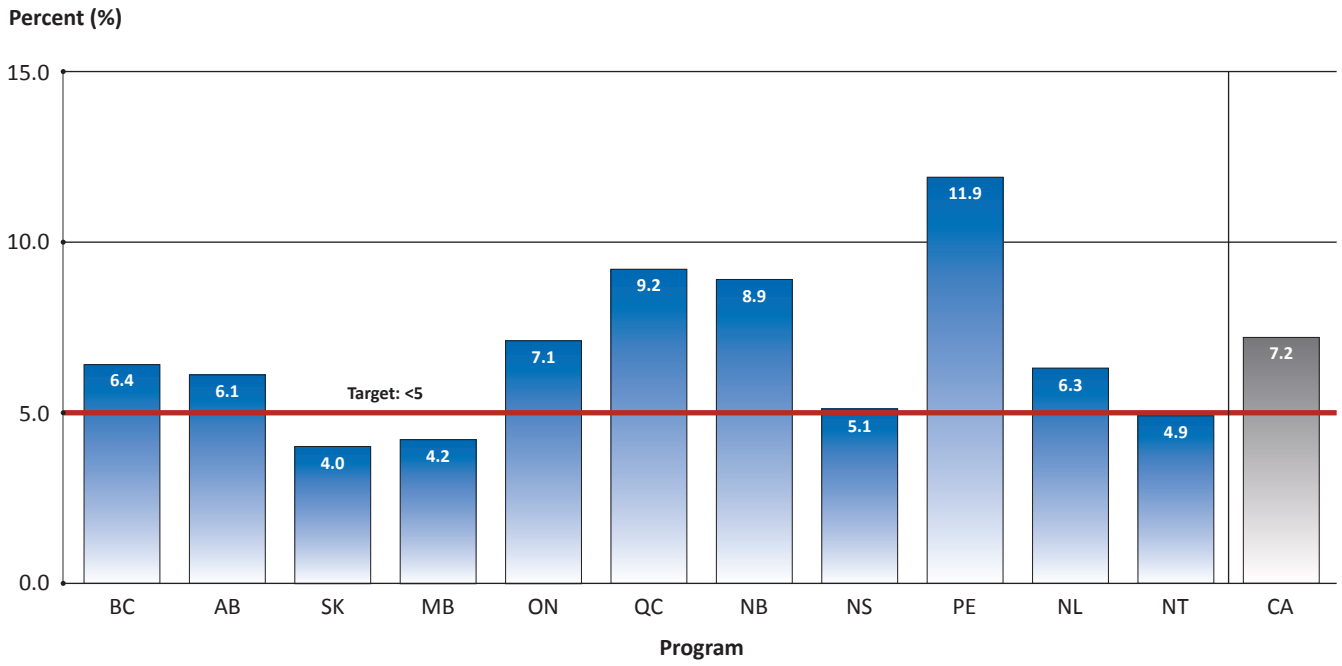


Notes

AB: Excluded from data prior to 2007 as the Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007.

FIGURE 15

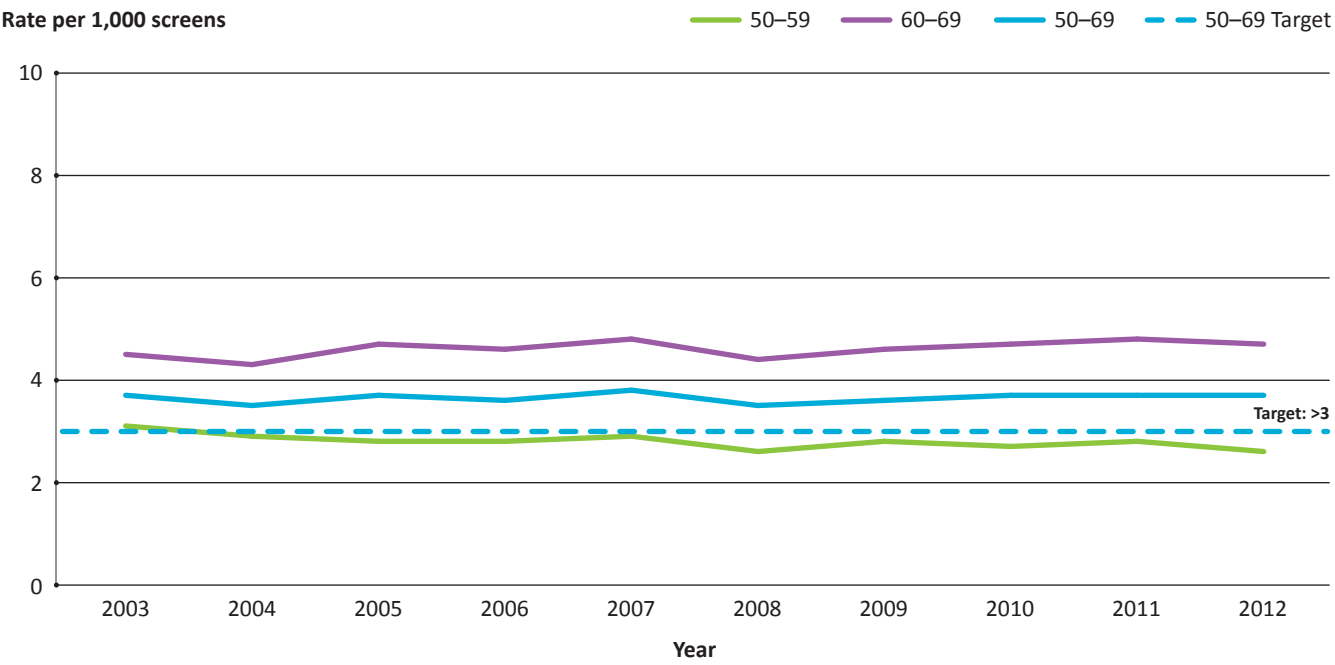
Abnormal call rate among subsequent screeners by program, women aged 50 to 69 years, 2011 and 2012 screen years



The rate of invasive cancer detection remained relatively stable at approximately 3.7 per 1,000 screens from screen years 2003 to 2012, with some minor fluctuation observed (Figure 16). The national target of >3 per 1,000 subsequent screens has been consistently achieved. The rate is higher in women aged 60 to 69 years versus women aged 50 to 59 years, likely due to a higher rate of breast cancer incidence and lower breast density. Program-specific rates ranged from 2.9 per 1,000 to 4.6 per 1,000, with nearly all programs reporting values that met or exceeded the national target (Figure 17).

FIGURE 16

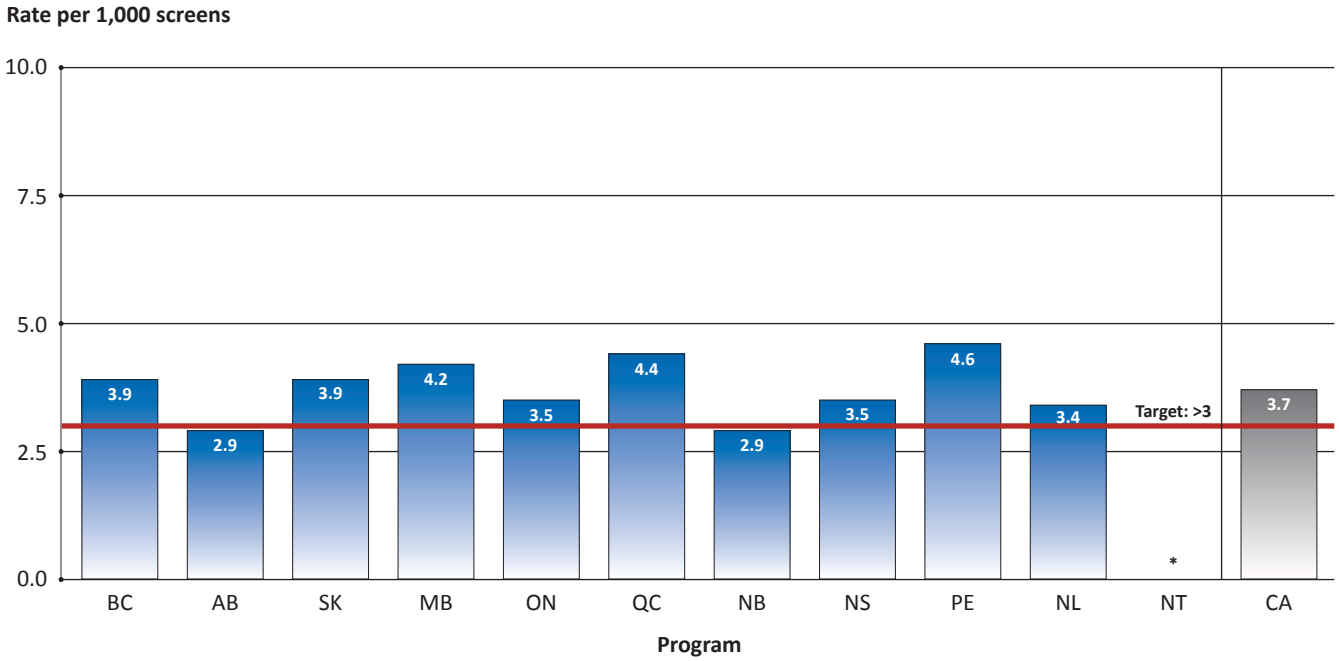
Invasive cancer detection rate among subsequent screeners by age group, 2003 to 2012 screen years



Notes:
AB: Excluded from data prior to 2007 as the Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007.
QC: Complete diagnostic/cancer information was available to September 30, 2012.

FIGURE 17

Invasive cancer detection rate among subsequent screeners by program, women aged 50 to 69 years, 2011 and 2012 screen years



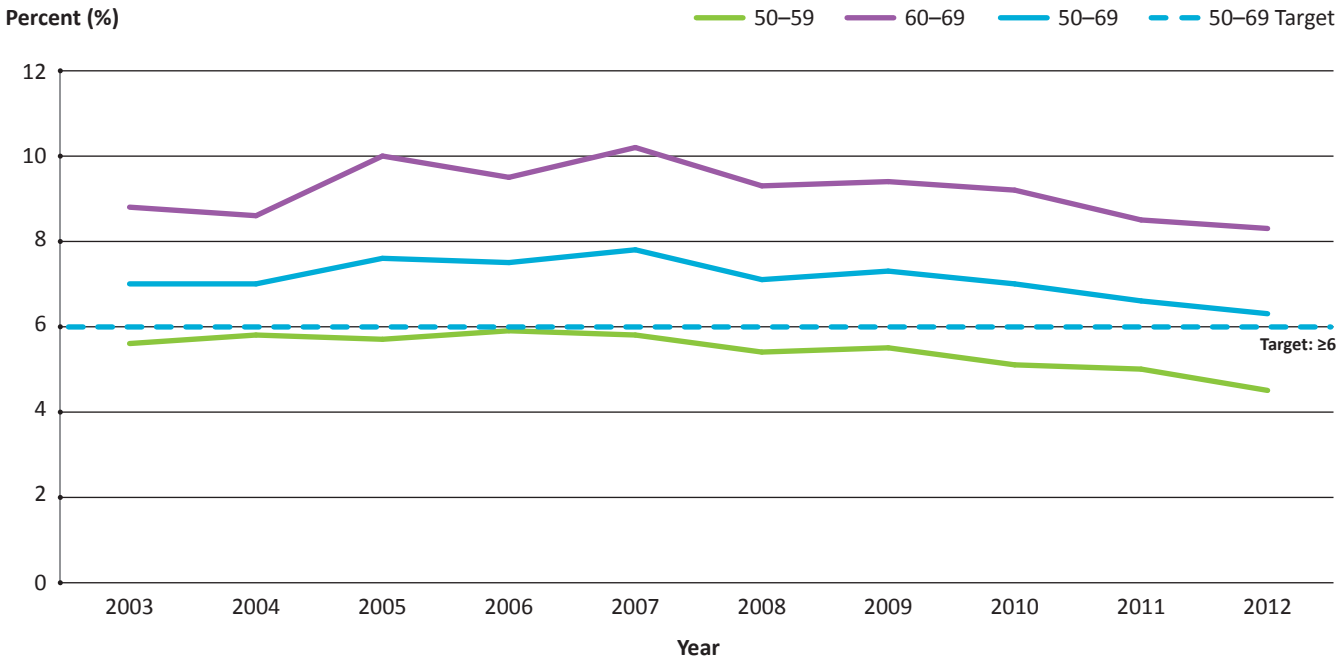
Notes

*: suppressed owing to small numbers.

QC: Complete diagnostic/cancer information was available to September 30, 2012.

FIGURE 18

Positive predictive value among subsequent screeners by age group, 2003 to 2012 screen years

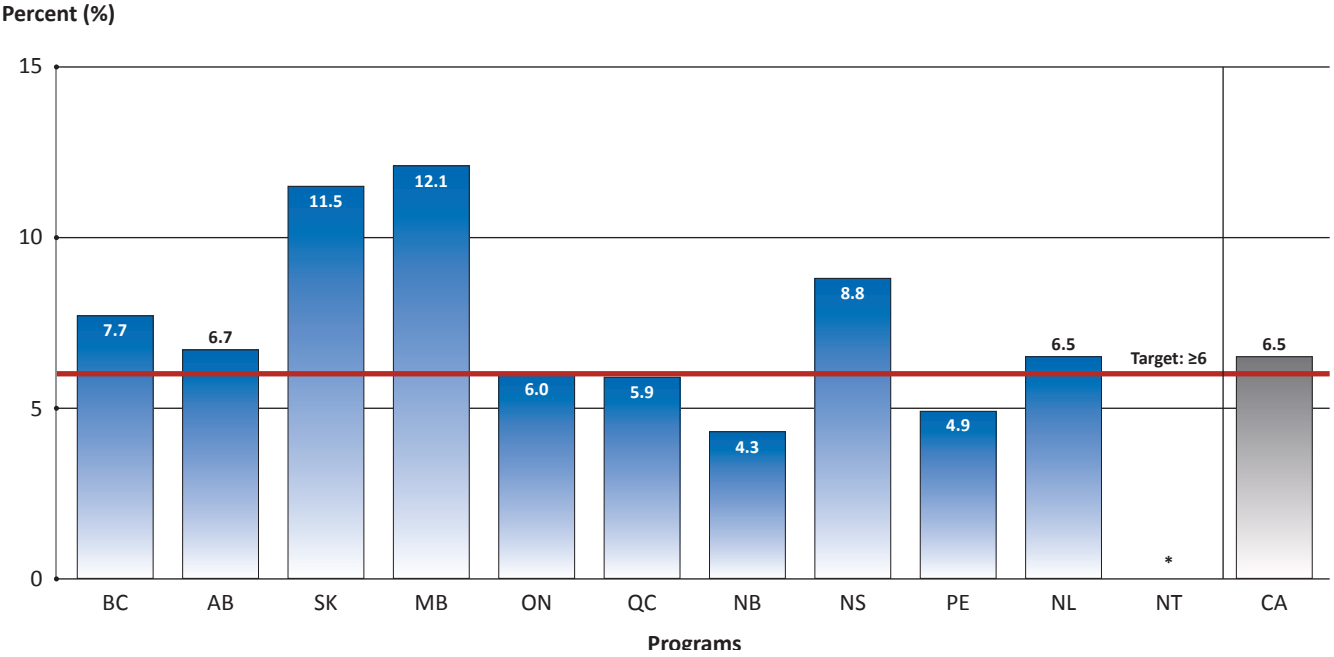


Notes
AB: Excluded from data prior to 2007 as the Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007.
QC: Complete diagnostic/cancer information was available to September 30, 2012.

PPV fluctuated during screen years 2003 to 2012, though the national target was consistently met. PPV increased from 7.0% in 2003 to a peak of 7.8% in 2007 (Figure 18), after which it declined steadily. PPV is now just above the national target (≥6%) at 6.3%. Like invasive cancer detection rate, PPV was substantially higher in women aged 60 to 69 years versus women aged 50 to 59 years. Program-specific PPV also varied considerably, ranging from 4.3% to 12.1% in 2011–2012 (Figure 19).

FIGURE 19

Positive predictive value among subsequent screeners by program, women aged 50 to 69 years, 2011 and 2012 screen years

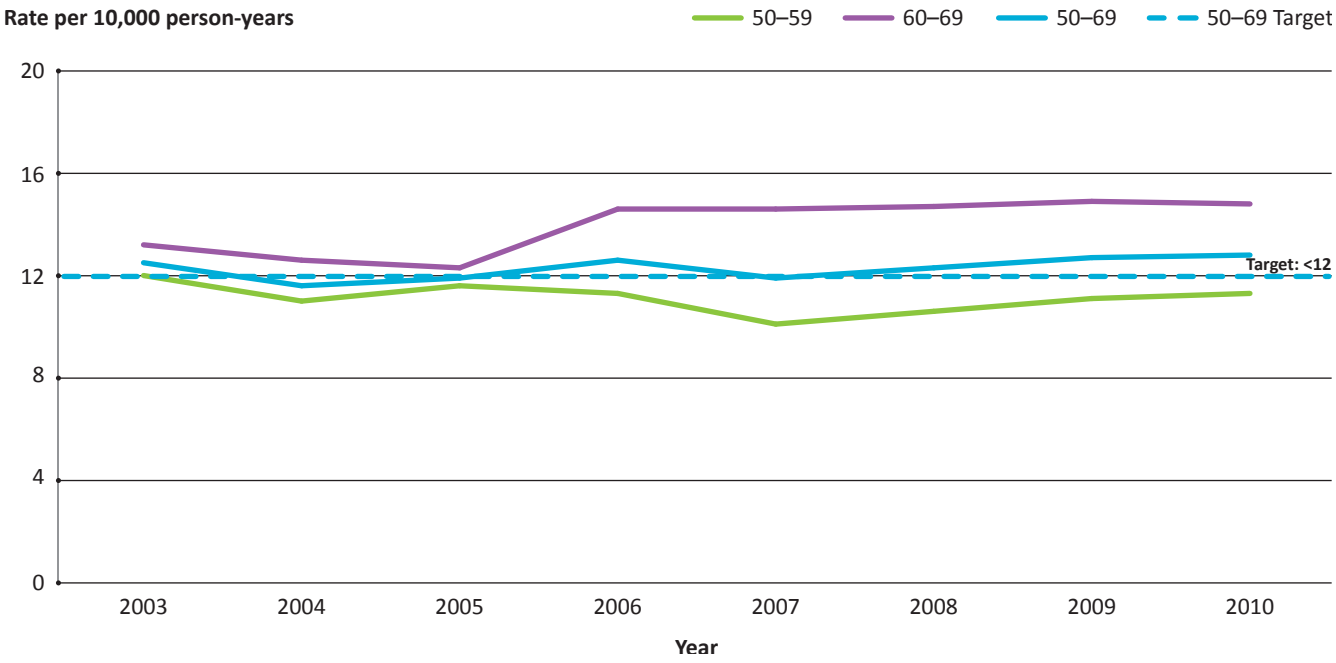


Notes

*: suppressed owing to small numbers.

FIGURE 20

Post-screen invasive cancer rate (12 to 24 months) among subsequent screeners by age group, 2003 to 2010 screen years



Notes
AB: Excluded from data prior to 2007 as the Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007.
PE: Excluded; data were unavailable.

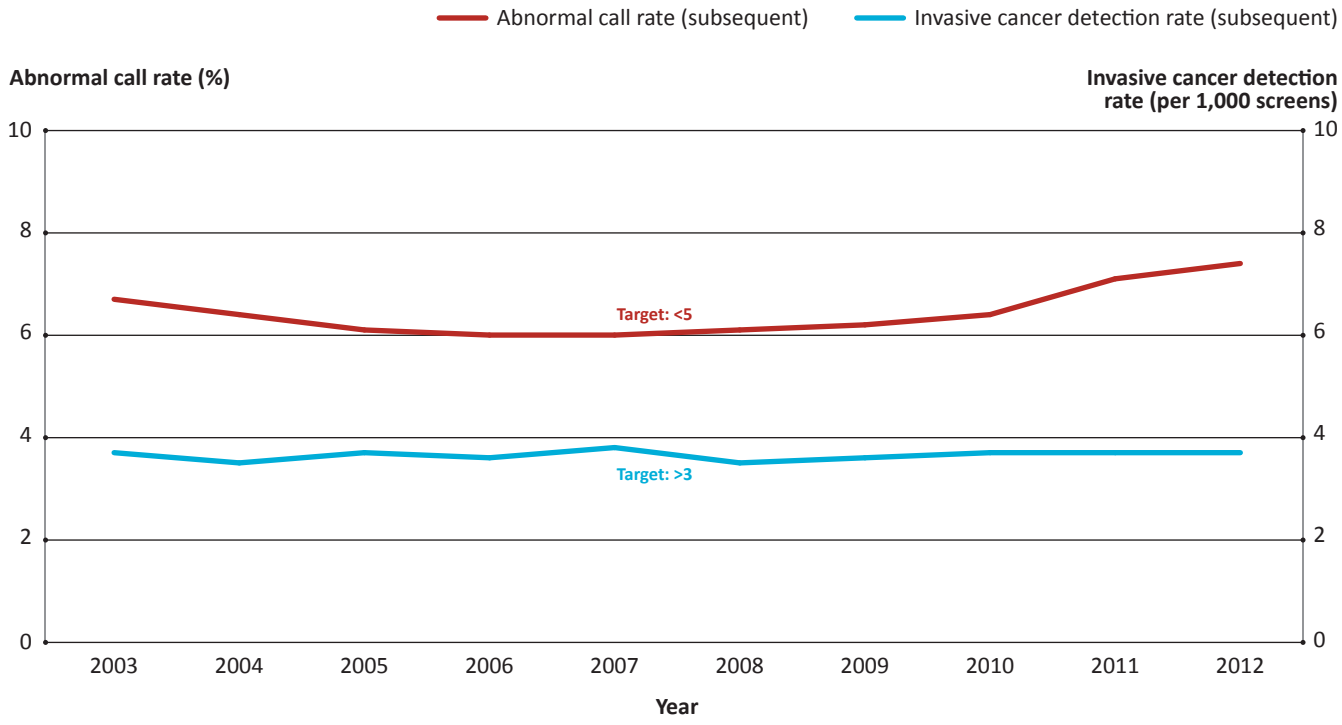
The post-screen invasive cancer rate fluctuated during screen years 2003 to 2012, exhibiting a slight overall increase from 12.5 per 10,000 person-years in 2003 to 12.8 per 10,000 person-years in 2010 (Figure 20). The national target (≤12 per 10,000 person-years) was only met in screen years 2004, 2005 and 2007. Rates of post-screen cancers were higher in women aged 60 to 69 years versus women aged 50 to 59 years, likely due to the relationship between age and breast cancer incidence.

Discussion

National targets set for cancer detection and PPV have been met consistently by organized breast screening programs in Canada, demonstrating good ability to detect cancers when they are present. While it appears that the benefits of breast cancer screening are likely being achieved, higher than optimal abnormal call rates may mean that more women who do not have cancer are subject to the harms of diagnostic tests, some of which are invasive. While the abnormal call rate rose by 1.4% from 2007 to 2012, this increase was unaccompanied by an increase in the cancer detection rate (Figure 21). PPV also fell by 1.5% from 2007 to 2012 (Figure 18), indicating that the observed increase in abnormal call rate was driven largely by an increasing rate of false-positive screening results. Additionally, the rate of post-screen invasive cancers is higher than optimal, which is particularly concerning given the high abnormal call rate.

FIGURE 21

Abnormal call rate and invasive cancer detection among subsequent screeners, women aged 50 to 69 years, 2003–2012 screen years



Notes
AB: Excluded from data prior to 2007 as the Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007.
QC: Complete diagnostic/cancer information was available to September 30, 2012.

While the vast majority of women with an abnormal mammogram result do not have breast cancer, assessment is required to reach a definitive diagnosis. Potential harms may include post-procedural pain or rare outcomes such as infection from invasive procedures, and/or negative psychological outcomes that can persist beyond resolution.[36] As previously discussed, most women (81.7%) who have a positive screen result require only additional imaging to reach a diagnosis (Figure 8), but some women (16.5%) alternatively or additionally required biopsy. Reassuringly, only 11.5% of biopsies with a non-malignant result were open surgical biopsies (Table 5A).

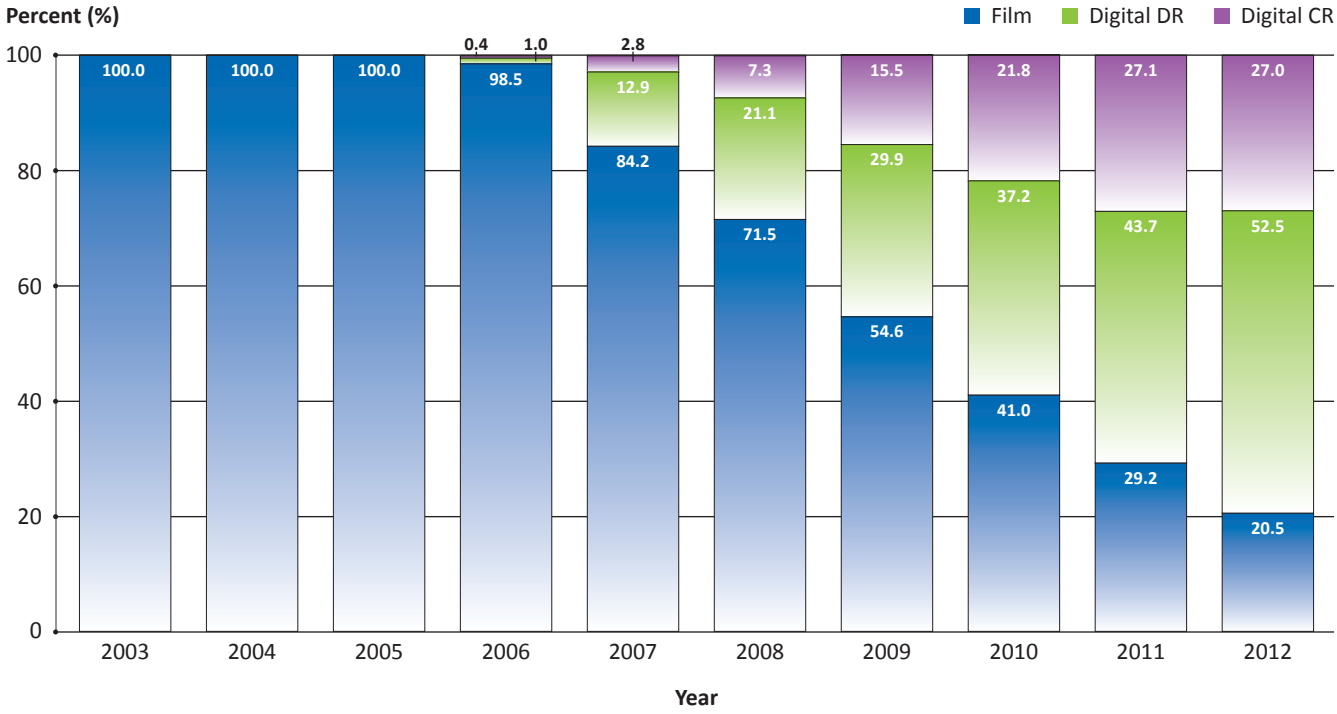
The cause of the upward trend observed in abnormal call rates over time is not clear. Abnormal call rates can be impacted by numerous population-, provider- and technology-related characteristics. While individual characteristics, such as breast density and hormone replacement therapy (HRT) use can affect mammography performance, the prevalence of overweight and obesity has increased over time (suggesting a corresponding decrease in breast density) and HRT use has declined. Breast cancer incidence was also stable during this period. Together, these trends suggest that provider and technology-related changes may be a more plausible explanation for this increase.

A radiologist's training, experience, and annual reading volumes as well as quality assurance processes have been shown to impact interpretive quality, therefore temporal changes in these characteristics for radiologists practicing within screening programs could impact abnormal call rates. It is also possible that the malpractice environment in North America could influence the conservative interpretation of mammograms by radiologists. In one survey of radiology residents in Canada and the U.S., 72% reported greater concern about litigation for mammography than for other types of imaging.[41] Delayed diagnosis of breast cancer is one of the most common reasons that physicians are subject to litigation in the United States; however, medical malpractice lawsuits related to mammography have been demonstrated to be relatively uncommon in other regions jurisdictions that offer organized screening, such as the United Kingdom[42] and the Netherlands.[42] There is little Canadian literature available on this topic, therefore it is unclear if the perceived threat of malpractice has a substantial impact on interpreting radiologists in Canada.

A major shift in mammogram technology during this period could account for some of the observed increase in abnormal call rates. Until 2007, nearly 100% of mammograms delivered through organized programs in Canada were SFM (Figure 22). Since then, a growing proportion of mammograms have been digital. As of 2012, nearly 80% of all screens delivered by programs were digital (27% CR, 52.5% DR). Digital mammography's superior contrast resolution may permit better visualization of breast tissue, leading to an increase in the identification of suspicious radiographic lesions. Studies comparing digital to SFM have demonstrated significantly higher abnormal call rates for digital mammography.[44–46] Studies by Chiarelli et al.,[23] Séradour et al.,[25] and Théberge et al.[26] have examined CR and DR separately, finding that abnormal call rates for DR were significantly higher versus SFM. Chiarelli et al. and Seradour et al. found that abnormal call rates were lowest for CR, likely due to its decreased contrast resolution, while Théberge et al. demonstrated a small but significant overall increase in abnormal call rates for CR relative to SFM. Théberge et al. also demonstrated that abnormal call rates for CR varied according to the plate reader manufacturer, so differences in the manufacturers of digital mammography systems used across breast cancer screening programs may partially account for the conflicting results of these studies.

FIGURE 22

Mammography image type by screen year, women aged 50–69 years, 2003 to 2012



Future Directions

Breast cancer screening programs have achieved optimal rates of cancer detection and PPV from 2003 to 2012. Along with the high rates of sensitivity presented earlier in this report, these findings suggest that Canadian programs are able to achieve the mortality benefit that would be expected for a successful, organized breast screening program. Canadian breast cancer screening programs demonstrate a strong ability to detect cancers when they are present; however, continued improvement is necessary to minimize the potential harms of diagnostic assessment, by improving diagnostic intervals and reducing the use of unnecessary diagnostic procedures to rule out diagnoses of breast cancer.

Some studies have demonstrated that higher annual radiologist reading volumes are associated with higher rates of specificity and PPV[47–49] and lower false-positive rates.[49–51] As a result, screening programs in the United Kingdom, Europe and Australia have minimum annual volume requirements for interpreting radiologists that range from 2,000 to 5,000. In Canada, radiologists practicing in mammography facilities accredited by the Canadian Association of Radiologists' Mammography Accreditation Program (CAR-MAP) must read a minimum of 480 mammograms per year, though 1,000 is recommended.[52] Increasing the minimum annual volumes required for radiologists reading mammograms within organized breast screening programs in Canada could contribute to a reduction in abnormal call rates and the harms associated with false-positive work-ups. The provision of regular audit feedback reports to radiologists and facilities may also be useful for monitoring and remediating interpretive quality.[53–54]

Alternative imaging technologies continue to be evaluated and may have a role in screening and/or diagnostic assessment. Digital breast tomosynthesis (DBT) produces a 3-D image of the breast, which can provide greater detail and overcome the issues associated with overlapping breast tissue on a 2-D image. Several recent studies have demonstrated that combined mammography and DBT reduced abnormal call rates and increased cancer detection when compared with mammography alone.[55–57] The evidence for DBT's clinical effectiveness is still limited, however, and the use of DBT as an adjunct to mammography would increase the effective radiation dose.[58]

National targets for the quality indicators presented in this and previous reports were developed based primarily on evidence from studies of SFM. Given the strong evidence of differences in technical performance across types of mammography technology and the growing use of digital mammography, the applicability of current targets to digital mammography should be evaluated. The development of age-stratified targets may also need to be considered in light of the important differences observed by age group for most of the quality indicators presented. The changes to Canadian breast cancer screening guidelines within the past five years will also have implications for the refinement and reporting of quality indicators and targets by the CBCSN Evaluation Indicators Working Group. While women aged 50 to 69 years were the primary focus of this and previous reports, the Canadian Task Force recommended in 2011 that women aged 70 to 74 years be screened with mammography every two to three years and women in this age group are already accepted by the majority of Canadian programs (Table 1, Figure 4A, Figure 4B).

Programs should strive to achieve and maintain strong administrative structures for service delivery, robust frameworks for quality assurance and control, and comprehensive program evaluation. Accreditation of screening facilities by CAR-MAP and/or a provincial body can ensure that minimum standards for personnel qualifications and experience, equipment, quality control and assurance procedures, image quality and radiation dosing are met. Program policies should be regularly reviewed and adapted to reflect the best available evidence for clinical practice and technology wherever possible. Program evaluation and research on the predictors of screening quality should continue in order to inform strategies for enhancement. Continued monitoring and reporting at both the provincial and national level allows decision-makers, programs, clinicians and screen-eligible Canadian women to understand the benefits, harms and overall quality of screening offered within Canada.

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Appendix A: Quality Indicator Definitions

More information on the quality indicators can be found in the Report from the Evaluation Indicators Working Group: guidelines for monitoring breast cancer screening program performance

Indicator definition & target	Calculation	Notes
Coverage		
Participation Rate **Definition:** percentage of women who have a screening mammogram within a 30-month period, as a proportion of the target population. ***National target (50 to 69 years):*** *≥70% of the target population within 30 months.*	**Numerator:** number of women within the age group as of December 31st of the last year, screened at least once within a 30-month period. **Denominator:** target population (estimate of population as of December 31st of the last year from census/ forecast, minus prevalent cases).	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program. **ON:** Breast cancer prevalence estimates are underestimated because in-situ cancers were not registered at the time the Canadian Cancer Registry file was created. **QC:** Breast cancer prevalence is estimated from Canadian average (excluding Quebec).
Retention Rate **Definition:** estimated percentage of women aged 50 to 67 years who returned for screening within 30 months of their previous screen. ***National target (50 to 67 years):*** *≥75% within 30 months of an initial screen; ≥90% within 30 months of a subsequent screen.*	**Numerator:** women returning to screening within 30 months of their previous screen. **Denominator:** women eligible for subsequent screening adjusted for losses due to death or breast cancer diagnosis. The cumulative probability of returning to screening is calculated using the Kaplan-Meier survival analysis method, which accounts for changes in women's screening eligibility during the relevant time period.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program.

Indicator definition & target	Calculation	Notes
Coverage, continued		
Annual Screening Rate **Definition:** estimated percentage of women aged 50 to 68 years who returned for screening within 18 months of their previous screen. ***National target:*** *No target established*	**Numerator:** women returning to screening within 18 months of their previous screen. **Denominator:** women who return to screening. The cumulative probability of returning to screening is calculated using the Kaplan-Meier survival analysis method, which accounts for changes in women's screening eligibility during the relevant time period.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program.
Follow-up		
Abnormal Call Rate **Definition:** percentage of screening mammograms that are identified as abnormal. ***National target (50 to 69 years):*** *<10% of initial screens; <5% of subsequent screens.*	**Numerator:** number of screening mammograms identified as abnormal **Denominator:** total number of screening mammograms	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program.
Diagnostic Interval **Definition:** **a)** time from screen to notification of screen result; **b)** time from abnormal screen to first diagnostic assessment; **c)** time from abnormal screen to definitive diagnosis. ***National target (50 to 69 years):*** ***a)*** *≥90% within two weeks;* ***b)*** *≥90% within three weeks;* ***c)*** *≥90% within five weeks if no tissue biopsy is performed; ≥90% within seven weeks if tissue biopsy (core or open) is performed.*	**a) Numerator:** number of notifications sent within two weeks of screening date. Denominator: total number of screens. **b) Numerator:** number of first diagnostic assessments occurring within three weeks of screening date. **Denominator:** total number of abnormal screens. **c) If no tissue biopsy** **Numerator:** number of definitive diagnoses occurring within five weeks of screening date. **Denominator:** total number of abnormal screens where tissue biopsy is not performed. **Tissue biopsy** **Numerator:** number of definitive diagnoses occurring within seven weeks of screening date. **Denominator:** total number of abnormal screens where a tissue biopsy is performed.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program. **NB (a):** Data were unavailable. **QC (a):** Data were unavailable. **QC (b, c):** Aggregate data were submitted. National estimates are a weighted average of Quebec and the rest of Canada. Complete diagnostic/cancer information was available for abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive. Ultrasound tests performed in private clinics are not included. **SK (a):** Data were unavailable.

Indicator definition & target	Calculation	Notes
Quality of Screening		
Non-Malignant Biopsy Rate **Definition:** **a)** number of non-malignant open and core biopsies per 1,000 screens **b)** percentage of non-malignant biopsies which were open surgical biopsies. ***National target:*** *No targets established*	**a) Numerator:** number of non-malignant open and core biopsies. **Denominator:** total number of screens. **b) Numerator:** number of non-malignant open biopsies. **Denominator:** number of non-malignant open and core biopsies.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program. **QC:** Aggregate data were submitted. National estimates are a weighted average of Quebec and the rest of Canada. Complete diagnostic/cancer information was available for abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive.
Positive Predictive Value (PPV) of the Screening Mammography Program **Definition:** percentage of abnormal cases diagnosed with breast cancer (invasive or in situ) after diagnostic work-up. ***National target (50 to 69 years):*** *≥5% for initial screens; ≥6% for subsequent screens.*	**Numerator:** number of screen-detected cancers. **Denominator:** total number of abnormal screens.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program. **QC:** Complete diagnostic/cancer information was available for abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive.
Sensitivity of the Screening Mammography Progam **Definition:** percentage of breast cancer cases (invasive and *in situ*) that were correctly identified as having cancer during the screening episode. ***National target:*** *No target established*	**Numerator:** number of screen-detected cancers (subsequent screens only). **Denominator:** total number of screen-detected cancers + total number of post-screen cancers detected within 0 to <12 months of screen (subsequent screens only).	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias AB's and national estimates during the initial years of data collection by the Alberta program. **PE:** Data were unavailable as post-screen cancer data were not submitted.

Indicator definition & target	Calculation	Notes
Quality of Screening, continued		
Post-Screen Invasive Cancer Rate **Definition:** number of invasive breast cancers found after a normal or benign mammography screening episode within 0 to <12 months and 12–24 months of the screen date, per 10,000 person-years of follow-up. ***National target (50 to 69 years):*** ***a)*** *<6 per 10,000 person-years within 0 to <12 months of the screen date;* ***b)*** *<12 per 10,000 person-years within 12–24 months of the screen date.*	**a) Numerator:** number of invasive cancers detected in the 0 to <12 month interval after a normal or benign mammography screening episode. **Denominator:** total person-years at risk. **b) Numerator:** number of invasive cancers detected in the 12–24 month interval after a normal or benign mammography screening episode. **Denominator:** total person-years at risk.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program **PE:** Data were unavailable as post-screen cancer data were not submitted.
Detection		
In Situ* Cancer Detection Rate** **Definition:** number of ductal carcinoma *in situ* (DCIS) cancers detected per 1,000 screens. ***National target (50 to 69 years): *No target established*	**Numerator:** number of *in situ* cancers detected. **Denominator:** total number of screens.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program **QC:** Complete diagnostic/cancer information was available for abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive.
Invasive Cancer Detection Rate **Definition:** number of invasive cancers detected per 1,000 screens. ***National target (50 to 69 years):*** *>5 per 1,000 initial screens; >3 per 1,000 subsequent screens.*	**Numerator:** number of invasive cancers detected. **Denominator:** total number of screens.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program **QC:** Complete diagnostic/cancer information was available for abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive.

Indicator definition & target	Calculation	Notes
Detection, continued		
Percent Ductal Carcinoma *in Situ* **Definition:** percentage of all cancers detected that are DCIS ***Target:*** *No target established*	**Numerator:** number of *in situ* cancers detected. **Denominator:** total number of *in situ* and invasive cancers detected.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program **QC:** Complete diagnostic/cancer information was available for abnormal screens occurring between January 1, 2011 and September 30, 2012, inclusive.
Disease Extent at Diagnosis		
Screen-Detected Invasive Tumour Size **Definition:** percentage of screen-detected invasive cancers with a tumour size ≤15 mm in greatest diameter as determined by the best available evidence: 1) pathological, 2) radiological, and 3) clinical. ***National target (50 to 69 years):*** *>50% screen-detected invasive tumours ≤15 mm.*	**Numerator:** number of screen-detected invasive tumours ≤15 mm. **Denominator:** total number of screen-detected invasive cancers where tumour size was assessed.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program **NT:** Data were unavailable. **QC:** Data were unavailable
Proportion of Node Negative Screen-Detected Invasive Cancers **Definition:** percentage of screen-detected invasive cancers in which the cancer has not invaded the axillary lymph nodes as determined by pathological evidence. ***National target (50 to 69 years):*** *>70% of screen-detected invasive cancers.*	**Numerator:** number of cases of screen-detected invasive cancers with negative lymph nodes. **Denominator:** total number of screen-detected invasive cancers where lymph nodes were assessed.	**AB:** The Alberta Breast Cancer Screening Program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias Alberta's and national estimates during the initial years of data collection by the Alberta program **NT:** Data were unavailable. **QC:** Data were unavailable.

Appendix B: Supplementary Quality Indicator Results

TABLE 4

Characteristics of screen-detected cancers by age group, 2011 and 2012 screen years

		Age group (years)							
		40 to 49		50 to 59		60 to 69		70+	
		N	%	N	%	N	%	N	%
Number of cancers	Invasive	564	70.6	4,110	78.8	5,306	83.2	2,296	84.8
	DCIS	235	29.4	1,105	21.2	1,073	16.8	410	15.2
	unknown behaviour	*	N/A	27	N/A	17	N/A	6	N/A
TNM staging	0 (in situ)	233	30.9	778	22.2	779	17.6	406	16.3
	I	319	42.3	1,604	45.8	2,418	54.7	1,422	57.0
	II	163	21.6	917	26.2	1,008	22.8	561	22.5
	III/IV	39	5.2	203	5.8	215	4.9	106	4.2
	unknown stage	48	N/A	1,740	N/A	1,976	N/A	217	N/A
Tumour size	>0 to <2 mm	7	1.8	36	2.1	35	1.4	19	1.4
	2 to 5 mm	27	7.0	102	5.9	173	7.0	93	6.7
	6 to 10 mm	66	17.2	355	20.5	654	26.4	374	26.9
	11 to 15 mm	108	28.2	460	26.5	682	27.5	381	27.4
	16 to 20 mm	62	16.2	280	16.1	390	15.7	228	16.4
	>=21 mm	113	29.5	501	28.9	547	22.0	293	21.1
	Size unknown	181	N/A	2,376	N/A	2,825	N/A	908	N/A
	Median tumour size (mm)	15		15		13		13	
Positive nodes	0	273	70.5	1,243	73.3	1,912	79.2	1,082	80.2
	1 to 3	88	22.7	361	21.3	404	16.7	218	16.2
	4+	26	6.7	91	5.4	97	4.0	49	3.6
	Nodal status unknown	177	N/A	2,415	N/A	2,893	N/A	947	N/A

Notes:
* Suppressed owing to small numbers.
N/A: Data not available.
Tumour size and nodal status are presented for invasive cancers. Nodal status is based on pathological evidence.
AB: Tumour size and nodal status are unknown.
SK: Stage is unknown.
ON: Information on tumour size and positive nodes is unavailable for 2011.
QC: Stage, tumour size, and nodal status are unknown.

TABLE 5A

Quality indicators by program, women aged 50 to 69, 2011 and 2012 screen years

Indicator	Target	Program		
		NT	BC	AB
number of screens	None	1,235	321,630	277,442
number of first screens	None	115	17,872	32,808
number of screen-detected cancers	None	*	1,654	1,098
participation rate within a 30-month period (%)	≥70	30.8	56.4	59.1
retention rate (% screened within 30 months of an initial screen)	≥75	56.7	57.2	62.5
retention rate (% screened within 30 months of a subsequent screen)	≥90	72.5	80.5	79.5
annual screening rate (% screened within 18 months of an initial screen)	None	38.7	11.3	46.3
annual screening rate (% screened within 18 months of a subsequent screen)	None	40.6	17.6	58.9
abnormal call rate (%), initial screen	<10	11.3	17.5	13.9
abnormal call rate (%), subsequent screen	<5	4.9	6.4	6.1
invasive cancer detection rate (per 1,000 screens),initial screen	>5	*	7.9	5.0
invasive cancer detection rate (per 1,000 screens),subsequent screen	>3	*	3.9	2.9
in situ cancer detection, initial screen (per 1,000 screens)	None	*	1.6	1.3
in situ cancer detection, initial screen, % in situ	None	*	16.7	21.1
in situ cancer detection, subsequent screen (per 1,000 screens)	None	*	1.0	0.7
in situ cancer detection, subsequent screen, % in situ	None	*	19.7	20.1
diagnostic interval (%), notified within 2 weeks of screen	≥90	89.9	97.1	N/A
diagnostic interval (%), first diagnostic assessment within 3 weeks	≥90	20.0	76.6	N/A
diagnostic interval (%), final diagnosis (with no tissue biopsy) within 5 weeks	≥90	45.5	80.8	N/A
diagnostic interval (%), final diagnosis (with tissue biopsy) within 7 weeks	≥90	*	62.0	N/A
positive predictive value (%), initial screen	≥5	*	5.4	5.0
positive predictive value (%), subsequent screen	≥6	*	7.7	6.7
non-malignant biopsy rate, initial screen (per 1,000 screens)	None	*	38.5	N/A
non-malignant biopsy rate, initial screen, % open	None	*	16.3	N/A
non-malignant biopsy rate, subsequent screen (per 1,000 screens)	None	*	9.7	N/A
non-malignant biopsy rate, subsequent screen, % open	None	*	18.5	N/A
screen-detected invasive cancer tumour size (%), <=15 mm	>50	N/A	62.4	N/A
percentage of node negative screen-detected invasive cancer (%)	>70	N/A	78.0	N/A
post-screen invasive cancer rate (per 10,000 person-years), 0 to <12 months	<6	*	7.6	6.5
post-screen invasive cancer rate (per 10,000 person-years), 12 to 24 months	<12	*	13.0	14.5
sensitivity of the screening mammography program, subsequent screen	None	*	83.5	82.4

Notes:
*: Suppressed owing to small numbers and/or to avoid residual disclosure.
N/A: Data not available.
Participation rate is presented for a 30 month period ending December 31, 2012.
Retention rate is based on the 30 month period following the 2008–2009 screen years.
Annual screening rate is based on the 18 month period following the 2012 screen year.
Post-screen invasive cancer rate is based on the period following the 2009–2010 screen years.
Sensitivity is based on the 2010–2011 screen years.

Program								
SK	MB	ON	QC	NB	NS	PE	NL	CA
58,002	83,858	907,837	658,617	68,991	87,076	13,664	31,454	2,509,806
8,592	13,476	200,307	115,460	5,189	4,525	800	4,204	403,348
269	430	4,089	3,196	265	409	*	146	11,638
44.8	56.9	46.7	62.3	63.2	58.4	63.4	37.9	54.0
64.6	66.7	75.5	67.0	59.7	60.4	68.3	78.9	68.8
83.0	84.0	86.1	81.5	75.8	80.8	86.1	87.4	82.6
26.0	11.8	36.1	9.3	14.5	35.0	31.6	39.9	27.6
37.8	11.3	41.6	11.9	24.6	48.0	42.1	44.1	31.8
11.4	9.1	13.5	19.3	17.7	14.2	20.8	14.0	15.3
4.0	4.2	7.1	9.2	8.9	5.1	11.9	6.3	7.2
4.0	3.9	4.4	5.2	4.9	8.6	*	7.1	4.9
3.9	4.2	3.5	4.4	2.9	3.5	4.6	3.4	3.7
0.9	1.8	1.1	1.2	1.2	1.1	*	1.2	1.2
19.0	31.2	19.7	19.4	19.4	11.4	*	14.3	19.6
0.7	0.9	0.7	1.0	0.8	0.9	1.2	0.7	0.8
14.5	17.0	17.5	18.7	21.4	20.5	20.3	17.1	18.6
N/A	99.3	96.3	N/A	N/A	92.6	50.5	98.2	96.0
64.2	70.7	77.0	48.7	76.0	63.8	23.9	71.4	66.1
88.1	84.6	88.8	63.7	90.5	87.3	57.2	77.1	79.1
78.3	48.4	66.3	38.0	61.8	63.9	54.5	66.7	54.9
4.3	6.3	4.2	3.3	3.6	7.0	3.0	6.0	4.1
11.5	12.1	6.0	5.9	4.3	8.8	4.9	6.5	6.5
13.4	21.5	14.2	29.0	17.5	35.0	45.1	15.2	20.3
22.6	14.8	8.6	8.3	18.9	5.1	*	7.8	9.7
4.0	6.5	6.0	11.7	7.4	9.8	17.7	5.6	8.4
20.4	14.5	10.7	8.6	20.0	4.6	*	13.1	11.5
60.8	60.8	55.1	N/A	58.6	63.8	71.7	55.7	59.2
81.4	76.7	75.1	N/A	79.4	74.8	82.3	79.5	76.4
6.2	6.1	8.0	7.8	6.3	4.1	N/A	10.0	7.4
13.4	12.6	10.6	14.8	9.8	10.9	N/A	6.2	12.7
86.1	88.4	82.6	85.9	85.9	90.3	N/A	78.0	84.3

National estimates are a weighted average of QC and the rest of Canada for the following indicators: first diagnostic assessment within 3 weeks; final diagnosis (with no tissue biopsy) within 5 weeks; final diagnosis (with tissue biopsy) within 7 weeks; non-malignant biopsy rate, initial screen (per 1,000 screens); non-malignant biopsy rate, initial screen, % open; non-malignant biopsy rate, subsequent screen (per 1,000 screens); non-malignant biopsy rate, subsequent screen, % open.
ON: Participation rate is underestimated because in situ cancers were not registered at the time the Canadian Cancer Registry file was created, leading to an underestimation of breast cancer prevalence estimates. Screen-detected invasive tumour size is unavailable for 2011.
QC: Aggregate data were submitted for a number of indicators and complete diagnostic/cancer information was available for abnormal screens from January 1, 2011 to September 30, 2012, inclusive. Breast imaging may be underestimated as ultrasound tests performed in private clinics are not included. Affected indicators are listed in Appendix A. Breast cancer prevalence is estimated from the Canadian average (excluding Quebec).

TABLE 5B

Quality indicators by program, women aged 50 to 69, 2013 and 2014 screen years

Indicator	Target	Program		
		NT	BC	AB
number of screens	None	1,301	335,865	283,715
number of first screens	None	147	17,703	28,291
participation rate within a 30-month period (%)	≥70	31.8	54.4	58.0
retention rate (% screened within 30 months of an initial screen)	≥75	56.7	57.2	62.5
retention rate (% screened within 30 months of a subsequent screen)	≥90	72.5	80.5	79.5
annual screening rate (% screened within 18 months of an initial screen)	None	38.7	11.3	46.3
annual screening rate (% screened within 18 months of a subsequent screen)	None	40.6	17.6	58.9
abnormal call rate (%), initial screen	<10	9.5	18.8	16.2
abnormal call rate (%), subsequent screen	<5	4.8	6.8	6.8

Notes:
Participation rate is presented for a 30 month period ending December 31, 2014.
Retention rate is based on the 30 month period following 2008–2009 screen years.
Annual screening rate is based on the 18 month period following the 2012 screen year.
ON: For participation rate, breast cancer prevalence estimates are underestimated because in-situ cancers were not registered at the time the Canadian Cancer Registry file was created.

Program								
SK	MB	ON	QC	NB	NS	PE	NL	CA
62,294	80,938	985,713	680,762	66,571	83,238	13,668	32,950	2,627,015
8,941	12,269	207,594	114,405	4,490	4,438	765	4073	403,116
43.3	54.1	49.1	62.3	60.1	55.2	59.7	36.6	54.1
64.6	66.7	75.5	67.0	59.7	60.4	68.3	78.9	68.8
83.0	84.0	86.1	81.5	75.8	80.8	86.1	87.4	82.6
26.0	11.8	36.1	9.3	14.5	35.0	31.6	39.9	27.6
37.8	11.3	41.6	11.9	24.6	48.0	42.1	44.1	31.8
10.7	10.1	14.6	21.1	16.7	15.6	30.5	14.2	16.6
4.2	4.4	7.3	9.8	7.6	5.3	15.6	6.2	7.6

TABLE 6

Quality indicators by year, women aged 50–69

Indicator	Target	Screen year		
		2004	2005	2006
number of screens	None	682,619	748,717	806,675
number of first screens	None	158,265	170,456	185,206
number of screen-detected cancers	None	3,262	3,580	3,867
participation rate within a 30-month period (%)	≥70	40.8	42.8	45.2
retention rate (% screened within 30 months of an initial screen)	≥75	69.9	70.4	70.8
retention rate (% screened within 30 months of a subsequent screen)	≥90	83.2	83	83.3
annual screening rate (% screened within 18 months of an initial screen)	None	16.2	17.7	18.6
annual screening rate (% screened within 18 months of a subsequent screen)	None	21.1	20.8	21.8
abnormal call rate (%), initial screen	<10	12.4	12.3	12.3
abnormal call rate (%), subsequent screen	<5	6.4	6.1	6
invasive cancer detection rate (per 1,000 screens),initial screen	>5	4.5	4.3	4.7
invasive cancer detection rate (per 1,000 screens),subsequent screen	>3	3.5	3.7	3.6
in situ cancer detection, initial screen (per 1,000 screens)	None	1.3	1.2	1.1
in situ cancer detection, initial screen, % in situ	None	22.3	21.4	18.9
in situ cancer detection, subsequent screen (per 1,000 screens)	None	1	0.9	0.9
in situ cancer detection, subsequent screen, % in situ	None	22	20.1	19.2
diagnostic interval (%), notified within 2 weeks of screen	≥90	96.9	95.8	96.5
diagnostic interval (%), first diagnostic assessment within 3 weeks	≥90	59.1	57.7	57.5
diagnostic interval (%), final diagnosis (with no tissue biopsy) within 5 weeks	≥90	77.5	77.4	76.9
diagnostic interval (%), final diagnosis (with tissue biopsy) within 7 weeks	≥90	49.2	47.7	47.4
positive predictive value (%), initial screen	≥5	4.7	4.5	4.8
positive predictive value (%), subsequent screen	≥6	7	7.6	7.5
non-malignant biopsy rate, initial screen (per 1,000 screens)	None	17.7	17.2	18.2
non-malignant biopsy rate, initial screen, % open	None	24.9	21.3	17.3
non-malignant biopsy rate, subsequent screen (per 1,000 screens)	None	8	7.2	7.6
non-malignant biopsy rate, subsequent screen, % open	None	29.8	27.2	21.8
screen-detected invasive cancer tumour size (%), <=15 mm	>50	64.2	64	62.3
percentage of node negative screen-detected invasive cancer (%)	>70	74.1	74.3	73
post-screen invasive cancer rate (per 10,000 person-years), 0 to <12 months	<6	7.6	7.9	7.2
post-screen invasive cancer rate (per 10,000 person-years), 12 to 24 months	<12	11.6	11.9	12.6
sensitivity of the screening mammography program, subsequent screen	None	83.3	83.2	84.3

Notes:
N/A: Data not available.
Participation rate was calculated for the 30 months ending December 31 of the screen year.
AB: Excluded from the following indicators as data were unavailable: diagnostic interval (%), notified within 2 weeks of screen; diagnostic interval (%), first diagnostic assessment within 3 weeks; diagnostic interval (%), final diagnosis (with no tissue biopsy) within 5 weeks; diagnostic interval (%), final diagnosis (with tissue biopsy) within 7 weeks; non-malignant biopsy rate, initial screen; non-malignant biopsy rate initial screen % open; non-malignant biopsy rate subsequent screen; non-malignant biopsy rate, subsequent screen % open; screen-detected invasive cancer tumour size; percentage of node negative screen-detected invasive cancer. The Alberta breast cancer screening program (ABCSP) was launched in 2007 and resulted in all initially registered women being classified as "first screens" when they may have been screened in the past. This may bias national estimates for "first screens" during the initial years of data collection by the Alberta program for the following indicators: number of first screens; retention rate; annual screening rate; abnormal call rate; invasive cancer detection rate; in situ cancer detection; positive predictive value.
NB: Excluded from diagnostic interval (%), notified within 2 weeks of screen as data were unavailable.

Screen year							
2007	2008	2009	2010	2011	2012	2013	2014
1,008,480	1,080,711	1,157,434	1,214,477	1,246,561	1,263,245	1,291,037	1,335,978
310,307	270,262	231,530	212,142	203,182	200,166	194,499	208,617
4,480	5,013	5,363	5,688	6,032	5,606	N/A	N/A
47.5	49.6	52.1	53.2	53.8	54	53.9	54.1
72.2	70.1	67.3	N/A	N/A	N/A	N/A	N/A
83.3	84.8	84.6	N/A	N/A	N/A	N/A	N/A
29.2	24.3	21.3	21.2	22.4	27.6	N/A	N/A
22.9	27.1	28.2	28.4	28.2	31.8	N/A	N/A
10.3	11.5	12.7	13.7	14.8	15.8	16.7	16.6
6	6.1	6.2	6.4	7.1	7.4	7.6	7.6
3.3	4.5	4.4	4.7	4.9	4.8	N/A	N/A
3.8	3.5	3.6	3.7	3.7	3.7	N/A	N/A
0.8	1.1	1.1	1.1	1.1	1.3	N/A	N/A
19.4	18.9	20.3	19.5	18.5	20.9	N/A	N/A
0.9	0.9	0.8	0.8	0.9	0.8	N/A	N/A
19	20.2	18.4	17.7	18.5	18.6	N/A	N/A
96.5	94.8	94.9	95.7	95.7	96.3	N/A	N/A
59.2	55.9	57.2	62.3	62.9	69.5	N/A	N/A
77	75.4	76	79.1	77.5	80.7	N/A	N/A
48.4	48.6	51	53.3	52.7	57.2	N/A	N/A
5.1	5	4.4	4.3	4.2	4	N/A	N/A
7.8	7.1	7.3	7	6.6	6.3	N/A	N/A
18.3	18.2	17.9	19	20.4	20.1	N/A	N/A
15.8	14.3	11.3	10.2	10.1	9.2	N/A	N/A
7.5	7.2	7.1	7.2	8.3	8.5	N/A	N/A
19.1	16.3	13.9	12.9	12.6	10.5	N/A	N/A
61.9	63.7	63.4	62.5	61.8	58	N/A	N/A
73.6	76.1	74	74.3	76.3	76.5	N/A	N/A
6.6	7.2	7.2	7.7	N/A	N/A	N/A	N/A
11.9	12.3	12.7	12.8	N/A	N/A	N/A	N/A
85.5	84	84.6	83.6	85	N/A	N/A	N/A

NT: Excluded from the following indicators from 2008 onwards as data were unavailable: percentage of node negative screen-detected invasive cancer, and screen-detected invasive cancer tumour size.
ON: Participation rate is underestimated because in situ cancers were not registered at the time the Canadian Cancer Registry file was created, leading to an underestimation of breast cancer prevalence estimates. For screen-detected invasive tumour size, partial data is available for 2008 and no data is available for 2009, 2010 and 2011.
PE: Post-screen invasive cancer rate and sensitivity of the screening mammography program are not available as post-screen cancer data were not submitted.
QC: Aggregate data were submitted for a number of indicators and complete diagnostic/cancer information was available for abnormal screens to September 30, 2012. Breast imaging may be underestimated as ultrasound tests performed in private clinics are not included. Affected indicators are listed in Appendix A. Breast cancer prevalence is estimated from the Canadian average (excluding Quebec). Excluded from screen-detected invasive cancer tumour size and percentage of node negative screen-detected invasive cancers for 2011–2012 as data were unavailable. Excluded from diagnostic interval (%), notified within 2 weeks of screen as data were unavailable. Because post-screen cancers are not available for QC screens occurring prior to 2008, QC is excluded from the following indicators prior to 2008: post-screen invasive cancer rate (per 10,000 person-years), 0 to <12 months; post-screen invasive cancer rate (per 10,000 person-years), 12 to 24 months; sensitivity of the screening mammography program, subsequent screen.
SK: Data were unavailable for diagnostic interval (%), notified within 2 weeks of screen.

TABLE 7A

Quality indicators by age group, 2011 and 2012 screen years

Indicator	Age Group (years)			
	40 to 49	50 to 59	60 to 69	70+
number of screens	377,643	1,404,693	1,105,113	323,344
number of first screens	93,836	328,918	74,430	19,126
number of screen-detected cancers	802	5,242	6,396	2,712
participation rate within a 30-month period (%)	10.5	50.1	59.3	21.1
retention rate (% screened within 30 months of an initial screen)	64.0	69.0	67.0	47.7
retention rate (% screened within 30 months of a subsequent screen)	80.5	81.9	79.6	63.1
annual screening rate (% screened within 18 months of an initial screen)	66.7	26.9	30.9	39.1
annual screening rate (% screened within 18 months of a subsequent screen)	76.0	32.3	31.6	40.5
abnormal call rate (%), initial screen	15.1	15.6	13.7	12.5
abnormal call rate (%), subsequent screen	7.5	7.5	7.0	6.3
invasive cancer detection rate (per 1,000 screens),initial screen	1.9	4.1	8.2	14.5
invasive cancer detection rate (per 1,000 screens),subsequent screen	1.4	2.7	4.7	6.7
in situ cancer detection, initial screen (per 1,000 screens)	0.9	1.2	1.3	1.7
in situ cancer detection, initial screen, % in situ	33.0	22.0	14.1	10.4
in situ cancer detection, subsequent screen (per 1,000 screens)	0.5	0.7	1.0	1.2
in situ cancer detection, subsequent screen, % in situ	27.6	20.8	17.2	15.8
diagnostic interval (%), notified within 2 weeks of screen	95.6	95.9	96.2	96.4
diagnostic interval (%), first diagnostic assessment within 3 weeks	72.2	65.1	67.8	77.1
diagnostic interval (%), final diagnosis (with no tissue biopsy) within 5 weeks	81.7	78.8	79.6	86.2
diagnostic interval (%), final diagnosis (with tissue biopsy) within 7 weeks	56.8	53.1	57.3	67.9
positive predictive value (%), initial screen	2.0	3.5	7.2	13.7
positive predictive value (%), subsequent screen	2.6	4.8	8.4	12.8

Indicator	Age Group (years)			
	40 to 49	50 to 59	60 to 69	70+
non-malignant biopsy rate, initial screen (per 1,000 screens)	28.0	20.7	18.2	14.8
non-malignant biopsy rate, initial screen, % open	12.8	9.7	9.6	10.4
non-malignant biopsy rate, subsequent screen (per 1,000 screens)	8.9	8.5	8.2	7.6
non-malignant biopsy rate, subsequent screen, % open	16.1	12.2	10.9	13.0
screen-detected invasive cancer tumour size (%), <=15 mm	54.3	55.0	62.2	62.5
percentage of node negative screen-detected invasive cancer (%)	71.0	73.2	78.8	80.1
post-screen invasive cancer rate (per 10,000 person-years), 0 to <12 months	6.4	6.7	8.4	11.1
post-screen invasive cancer rate (per 10,000 person-years), 12 to 24 months	11.5	11.2	14.9	15.3
sensitivity of the screening mammography program, subsequent screen	71.3	82.6	85.5	86.4

Notes:
General: Participation rate is presented for the 30 months ending December 31, 2012.
Retention rate is based on the 30 month period following 2008–2009 screen years.
Annual screening rate is based on the 18 month period following the 2012 screen year.
Post-screen invasive cancer rate is based on the period following the 2009–2010 screen years.
Sensitivity is based on the 2010–2011 screen years.
AB: Excluded from the following indicators as data were unavailable: diagnostic interval (%), notified within 2 weeks of screen first diagnostic assessment within 3 weeks; diagnostic interval (%), final diagnosis (with no tissue biopsy) within 5 weeks; diagnostic interval (%), final diagnosis (with tissue biopsy) within 7 weeks; non-malignant biopsy rate, initial screen; non-malignant biopsy rate, initial screen % open; non-malignant biopsy rate subsequent screen; non-malignant biopsy rate, subsequent screen % open; screen-detected invasive cancer tumour size; percentage of node negative screen-detected invasive cancer.
NB: Excluded from diagnostic interval (%), notified within 2 weeks of screen as data were unavailable.
NT: Excluded from the following indicators as data were unavailable: percentage of node negative screen-detected invasive cancers and screen-detected invasive cancer tumour size.
ON: Participation rate is underestimated because in situ cancers were not registered at the time the Canadian Cancer Registry file was created, leading to an underestimation of breast cancer prevalence estimates. Information on screen-detected invasive tumour size is unavailable for 2011.
PE: Excluded from the following indicators as data was unavailable: post-screen invasive cancer rate (per 10,000 person-years), 0 to <12 months; post-screen invasive cancer rate (per 10,000 person-years), 12 to 24 months; sensitivity of the screening mammography program, subsequent screen.
QC: Aggregate data were submitted for a number of indicators and complete diagnostic/cancer information was available for abnormal screens from January 1, 2011 to September 30, 2012, inclusive. Breast imaging may be underestimated as ultrasound tests performed in private clinics are not included. Affected indicators are listed in Appendix A. Breast cancer prevalence is estimated from the Canadian average (excluding Quebec). Excluded from the following indicators as data were unavailable: diagnostic interval (%), notified within 2 weeks of screen; screen-detected invasive cancer tumour size; percentage of node negative screen-detected invasive cancers.
SK: Excluded from diagnostic interval (%), notified within 2 weeks of screen as data were unavailable.

TABLE 7B

Quality indicators by age group, 2013 and 2014 screen years

Indicator	Age Group (years)			
	40 to 49	50 to 59	60 to 69	70+
number of screens	293,197	1,436,539	1,190,476	342,763
number of first screens	76,031	332,891	70,225	15,026
participation rate within a 30-month period (%)	9.2	49.8	59.8	21.5
retention rate (% screened within 30 months of an initial screen)	64.0	69.0	67.0	47.7
retention rate (% screened within 30 months of a subsequent screen)	80.5	81.9	79.6	63.1
annual screening rate (% screened within 18 months of an initial screen)	66.7	26.9	30.9	39.1
annual screening rate (% screened within 18 months of a subsequent screen)	76.0	32.3	31.6	40.5
abnormal call rate (%), initial screen	16.0	16.8	15.5	14.4
abnormal call rate (%), subsequent screen	8.1	7.9	7.3	6.7

Notes:
Participation rate is presented for the 30 months ending December 31, 2014.
Retention rate is based on the 30 month period following 2008–2009 screen years.
Annual screening rate is based on the 18 month period following the 2012 screen year.
ON: Partial data available for screen-detected invasive tumor size (2008–2011).

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