Andrew Coldman, PhD, Norman Phillips, MSc, Christine Wilson, MD, FRCPC, Janette Sam

Information for physicians discussing breast cancer screening with patients

Outcomes data collected by the Screening Mammography Program of BC can help women decide about participating in breast cancer screening.

ABSTRACT:

***Background*: Current breast cancer screening recommendations acknowledge the need for informed patient decision-making. This has resulted in the creation of decision aids that include quantitative information on the effects of participating in screening. In most cases, information is presented on the potential outcomes of participating in many years of screening for broad age groups of women where 100% participation is assumed.**

***Methods*: Using data from the Screening Mammography Program of BC and data from the medical literature, we set out to produce estimates of the effect of a single screening mammogram on the recognized risks and benefits of screening. The benefit selected was the reduction in the risk of dying from breast cancer. The risks selected were the risk of a false-positive mammogram, the risk of biopsy following a false-positive mammogram, and the risk of breast cancer overdiagnosis.**

***Results*: The logistic regressions of possible screening outcomes (false-positive mammogram, biopsied false-positive, cancer detected) against patient factors (age, family history, history of previous false-positive mammogram, history of previous biopsied false-positives) revealed dissimilar relationships between outcomes and factors. False-positives decreased with age, while cancers detected increased. Family history was strongly related to cancers detected, but was less strongly related to false-positive mammograms and false-positive biopsies. Breast cancer detection rates were used to calculate overdiagnoses and deaths prevented using aggregate results from published reviews. The likelihood of the risks and benefits were expressed as the number needed to screen to obtain a single screening outcome. For any combination of patient factors, a false-positive is the most likely of the outcomes and therefore has the smallest number needed to screen. An overdiagnosis and death prevented are the least likely of the outcomes and have the largest number needed to screen.**

***Conclusions*: The estimates provided here for the risks and benefits of breast cancer screening are relevant for the majority of BC women considering screening and can be used by family physicians to counsel patients. The Screening Mammography Program of BC is using these estimates to develop an online decision aid that will provide guidance on screening and evaluate a woman's chances of experiencing various screening outcomes.**

This article has been peer reviewed.

Dr Coldman is vice president of population oncology at the British Columbia Cancer Agency, and adjunct professor in the Department of Statistics at the University of British Columbia. Mr Phillips is a senior statistician in Cancer Surveillance and Outcomes, BCCA. Dr Wilson is medical director of the Screening Mammography Program of BC, BCCA, and clinical associate professor in the Department of Medicine at UBC. Ms Sam is the operations director of the Screening Mammography Program of BC.

Background

In the past 5 years breast cancer screening has come under increased scrutiny, and recommendations for screening mammography have been reviewed and revised. In the UK an independent panel was created and empowered to review evidence on breast cancer screening.[1] In North America both the Canadian Task Force on Preventive Health (CTFPH) and the US Preventive Services Task Force (USPSTF) have reviewed evidence regarding screening for breast cancer and provided recommendations.[2,3] The CTFPH used the GRADE scale[4] to present their recommendations for women of average risk (excluding those with a genetic predisposition to or personal or first-degree family history of breast cancer). The CTFPH recommends that women age 40 to 49 not be routinely screened with mammography and those age 50 to 74 be routinely screened every 2 to 3 years. All recommendations were judged to be weak. No recommendations were made for women older than 75 because of an absence of evidence from randomized controlled trials.

Recommendations provided by the CTFPH are accompanied by the suggestion that physicians use the decision aid for breast cancer screening created by the Public Health Agency of Canada[5] to inform women of the potential effects of screening and help them evaluate their risks and benefits.[2] Like other decision aids, this one includes quantitative estimates of the major risks and benefits of screening. The chief benefit of screening is a reduction in the risk of dying from breast cancer, with a less significant benefit of avoiding more intensive treatment for cancer.[6] The chief risks of screening are mammograms indicating an abnormality that turns out not to be cancer (false-positives), and biopsies before cancer is excluded. Another risk is overdiagnosis, which is the detection by screening of cancer that would not otherwise have been detected clinically, and the subsequent treatment of this cancer. It is also recognized that mammography poses a very small risk of radiation-induced breast cancer, but such cancers are included in overdiagnoses and their consequences are similar, although their onset is delayed. It is conventional practice to provide estimates of the risks and benefits of screening carried out over a prolonged period.

Generally two approaches are taken when calculating the risks and benefits of screening. One approach uses a mathematical model to predict the risks and benefits for the duration of the recommendation for screening so that, for example, screening recommended for women between age 50 and 74 would include estimates of the effects of screening on a fully compliant woman for this 25-year period.[5] A second approach uses observed results from randomized clinical trials so that estimates of the effects of screening are based on the age group and duration of screening used in the trials.[2] This approach has the advantage of being supported through more direct observational data but estimates are based on the aggregate experience of women randomly assigned to screening, whether they are screened or not.[2] Furthermore, even these latter estimates require some mathematical manipulation in order to better reflect the characteristics of the population to which they will be applied, and would only be applicable to women who had not been screened previously. Both approaches provide estimates of risks and benefits for fixed patterns of screening over extended periods for women in broad age categories with no history of screening. Experience in Canadian screening programs has shown that screening patterns are variable. For example, more than 20% of women screened for the first time and found not to have cancer do not return for further screening in the next 5 years.[7]

The chief benefit of screening is a reduction in the risk of dying from breast cancer, with a less significant benefit of avoiding more intensive treatment for cancer. The chief risks of screening are mammograms indicating an abnormality that turns out not to be cancer (false-positives), and biopsies before cancer is excluded.

Methods

Using data from the Screening Mammography Program of BC (SMPBC) We set out to produce estimates of the effect of a single screening mammogram on the recognized risks and benefits. We selected one benefit, the reduction in the risk of dying from breast cancer, and three risks: the risk of a false-positive (a mammogram

indicating abnormalities with no cancer detected), the risk of biopsy following a false-positive mammogram, and the risk of an overdiagnosis. We also examined the likelihood of a woman being diagnosed with breast cancer at screening, but classified such a diagnosis as a screening outcome of interest rather than as a risk or a benefit. We then characterized these quantitative estimates using the following patient factors: age in 5-year categories, history of breast cancer in a first-degree relative, time since a previous mammogram, if any, and previous history of a false-positive mammogram or associated biopsy. These factors were selected using results from a previous analysis of factors found to affect the likelihood of a false-positive mammogram[8] and known to influence breast cancer risk.

Because SMPBC does not accept women with a history of breast cancer for screening, we collected no data for women in this group. Similarly, we collected no data for women at elevated risk of breast cancer because of genetic predisposition.

Data were extracted for women between the ages of 40 and 79 who had participated in the program between 2000 and 2009. False-positive mammograms were defined as those where further investigation was recommended, but no diagnosis of cancer was made within 6 months. A biopsied false-positive was defined as a biopsy performed within 6 months of a false-positive mammogram. The history of previous false-positive mammograms or biopsies was based upon all previous screening results in the SMPBC database. Patients reporting a history of breast cancer in a first-degree relative at the time of screening were classified as having a family history. Cancer was taken to include ductal carcinoma in situ (DCIS) and invasive breast cancer. Mammography-detected cancers were those diagnosed within 6 months of a screening mammogram indicating abnormalities. Screening episodes were classified as a first screening test or by time since a previous test. Logistic regression models were used to predict rates for false-positive mammograms, biopsied false-positives, and cancers detected. Covariate factors were age, family history, time since previous screening test or first test, and previous false-positives and biopsies.

No direct measurement is available of overdiagnosis or of the probability that a breast cancer death is averted as a result of a single screening test. A review of publications from European screening programs concluded that between 1% and 10% of breast cancer diagnoses in women participating represent overdiagnoses,[9] while a UK panel using evidence from randomized trials estimated the overdiagnosis rate to be 11%.[1] A recent study in British Columbia estimated that screening mammography resulted in overdiagnoses in 5.4% of cases when invasive breast cancer was considered, and this rose to 17.3% when ductal carcinoma in situ was included.[10]

For this study, we assumed that 10% of breast cancers represent overdiagnoses in women participating in screening, and that this estimate holds for individual screening tests. In women participating in regular breast cancer screening in British Columbia, 75% of all cancer diagnoses are mammography-detected.[11] Thus, we would predict that 13% (10% / 75%) of mammography-detected cancers are overdiagnoses. Using this approach we can estimate the number of overdiagnoses from the cancer detection rate at screening.

Another European review of screening programs concluded that approximately two breast cancer deaths were averted for every case of overdiagnosis,[12] whereas a UK panel concluded that one death would be averted for every three cases of overdiagnosis[1] in women participating in screening for an extended period. In the analysis presented here we assume a 1:1 ratio between overdiagnoses and breast cancer deaths prevented, and also that these aggregate results can be applied to single screening tests. Thus, the number of deaths prevented can be estimated from the number of overdiagnoses, which in turn can be estimated from the rate of cancers detected.

The reviews described earlier[1,9,12] estimate overdiagnoses and lives saved for screening in a particular age range (typically 50 to 69). With increasing age, mortality from causes other than breast cancer increases, and these causes will have opposing effects on overdiagnosis and mortality reductions. This is easily visualized using an extreme case. A screening mammography–detected breast cancer will almost certainly be an overdiagnosis in a patient dying of other causes within 6 months of screening, since the lead time associated with screening is typically years. Conversely, the same patient almost certainly will not have her death from breast cancer prevented by screening, since the chance that an asymptomatic patient would develop symptoms and die from breast cancer within 6 months is very small.

As all-cause mortality rates increase with advancing patient age, we can expect the ratio of breast cancer overdiagnoses to deaths prevented to increase. To make adjustment for competing causes of mortality, we have assumed simple models of how overdiagnosis and breast cancer death prevention occur. For overdiagnosis, we assumed the likelihood of an overdiagnsis decreases uniformly from 100% of mammography-detected

cancers at the time of screen detection to 13% at 5 years and thereafter. For deaths prevented, we assumed that these begin 5 years after screen detection and then increase to 13% of mammography-detected cancers at 10 years and thereafter. Both these simplifying assumptions are informed by analysis of screening lead times[13] and time before mortality gains are seen in randomized trials of screening.[14]

Results

Table 1 summarizes data collected by the Screening Mammography Program of BC between 2000 and 2009 for 726 932 women and over 2.5 million

Table 1. Number of screening mammograms by age, timing, and outcome, Screening Mammography Program of BC, 2000–2009.

Age	First screening mammogram	Previously screened			False-positive mammograms	Biopsied false-positives	Cancers detected
		Within 18 months	Within 19–29 months	30 or more months earlier			
40–49	238 043	495 019	91 131	47 044	72 472	6 810	1 755
50–59	83 922	191 119	406 936	121 732	53 082	5 522	3 057
60–69	33 329	88 207	342 382	68 647	28 503	3 006	3 087
70–79	12 615	41 583	212 530	33 555	14 158	1 531	2 200

Table 2. Average number of mammograms per cancer detected at screening, by family history of breast cancer in a first-degree relative, time since previous screening, history of false-positive screening results, and current age.

Family history of breast cancer in a first-degree relative	Months since previous screening test	History of false-positives	Current age							
			40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79
No	<18 Months	None or Yes, but no biopsy	960	680	480	370	290	250	220	200
		Yes, with biopsy	590	420	300	230	180	150	140	120
	18–29 months	None or Yes, but no biopsy	730	510	370	280	220	190	170	150
		Yes, with biopsy	450	320	230	170	140	120	100	92
	30+ months	None or Yes, but no biopsy	460	320	230	170	140	120	100	94
		Yes, with biopsy	280	200	140	110	86	73	65	58
	No previous screening		430	250	180	150	110	83	73	67
Yes	<18 months	None or Yes, but no biopsy	640	450	320	240	200	160	150	130
		Yes, with biopsy	390	280	200	150	120	100	90	81
	18–29 months	None or Yes, but no biopsy	480	340	240	180	150	120	110	99
		Yes, with biopsy	300	210	150	110	92	77	69	62
	30+ months	None or Yes, but no biopsy	300	210	150	120	93	79	70	62
		Yes, with biopsy	190	130	94	71	58	49	43	39
	No previous screening		300	170	120	100	76	58	51	47

screening tests. Of the women screened, 106 492 reported a first-degree relative with breast cancer. Women age 40 to 49 were reminded to return for rescreening after 12 months, whereas those over 50 were reminded to return after 24 months, and this pattern of return is evident in the data.

The logistic regressions of screening outcomes (false-positive mammogram, biopsied false-positive, cancer detected) against patient factors (age, family history, previous false-positive, previous biopsied false-positive) revealed dissimilar relationships between outcomes and factors.

Age was related to all the screening outcomes. False-positives and biopsies decreased with age, while cancers detected increased. Time since previous screening test was also related to all outcomes, with increasing rates being seen as time increased, with first screening tests having the highest rates. Family history was strongly related to cancers detected but less strongly related to false-positive mammograms and false-positive biopsies. Having an earlier false-positive increased the likelihood of further false positives and biopsies. Having an earlier false-positive biopsy increased the likelihood of further biopsies and cancer detection.

Table 2 provides calculated values for the likelihood of a cancer diagnosis at screening. The values are provided in a number-needed-to-screen format—that is, the average number of screening tests per cancer detected. The calculated values range from a high of 960 tests per cancer detected for women 40 to 44 with no family history of breast cancer or history of breast biopsy, who have been screened in the last 18 months, to a low of 39 tests per cancer detected for women 75 to 79 with a family history of breast cancer and a history of breast biopsies, who have not been screened for more than 30 months.

Two additional tables provide numbers needed to screen for the risks (false-positives, biopsied false-positives, and overdiagnoses) and the benefit (breast cancer death prevented) for women *without* (**Table 3**) and *with* (**Table 4**) a history of breast cancer in a first-degree relative. For each combination of patient factors—family history, time since previous mammogram, history of previous false-positive mammograms, history of previous biopsy, and age—the tables contain four numbers needed to screen. Numbers under 100 have been rounded to the nearest integer, while numbers exceeding 100 have been rounded to the first two figures. The table entries represent the average number of screening tests required in women with the same patient factors to observe a single outcome: a false-positive, a false-positive with biopsy, a breast cancer overdiagnosis, and a breast cancer death prevented. (Confidence intervals are not presented because they would greatly complicate the presentation of results without adding to their usefulness.)

For example, for 44-year-old women with no first-degree relatives with breast cancer who have not been screened before, we would expect, on average, 1 false positive per 8 screening tests, 1 false-positive with biopsy per 68 tests, and 1 breast cancer death prevented and 1 case of overdiagnosis per 3300 tests. As another example, for 72-year-old women with first-degree relatives with breast cancer who had their previous screening more than 30 months ago, and who had previously been biopsied as a result of a screening mammogram, we would expect an average of 1 false-positive per 11 screening tests, 1 false-positive with biopsy per 37 tests, 1 cancer overdiagnosis per 260 tests, and 1 breast cancer death prevented per 390 tests. For any combination of patient factors, a false-positive is the most likely of the four outcomes and therefore has the smallest number needed to screen. An overdiagnosis and death prevented are the least likely of the outcomes and have the largest number needed to screen.

Conclusions

The number-needed to screen estimates of risks and benefits contained in Tables 3 and 4 can be used to inform BC women contemplating breast cancer screening. Rates of false-positive mammograms, associated biopsies, and cancers detected are based upon a large sample of women who have participated in screening in British Columbia. Although false-positive rates are known to vary across the province,[8] the average rates presented provide useful guides. The rates of false-positive mammograms and associated biopsies do not vary greatly by age or family history of breast cancer. Instead, the time since previous screening and the history of a previous false-positive are the main determinants. Thus, patients with a family history of breast cancer can be assured they are not at greatly elevated risk of experiencing false-positives when participating in screening. In contrast, those outcomes related to the risk of breast cancer (cancer detected, overdiagnosis, and breast cancer death prevented) show a strong relationship to age and a family history of breast cancer.

Use of the risk-benefit information included here requires knowledge of the personal history of the patient contemplating screening. If the patient is uncertain about personal or family history, we suggest utilizing the "no breast cancer in first degree relative" and "no false-positive" categories when discussing screening risks.

Table 3. Women *without* a family history of breast cancer in a first-degree relative: Number of screens per screening outcome.

Months since previous screening test	History of false-positives	Screening outcome*	Current age							
			40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79
<18	None	False Pos	18	19	23	26	27	29	30	31
		FP+Biopsy	280	270	290	310	320	310	320	370
		OverDx	7400	5200	3700	2800	2100	1600	1300	1000
		DthPrev	7400	5200	3700	2800	2400	2100	2000	1900
	Yes, no biopsy	False Pos	12	12	14	16	17	18	19	20
		FP+Biopsy	170	160	170	190	200	190	200	220
		OverDx	7400	5200	3700	2800	2100	1600	1300	1000
		DthPrev	7400	5200	3700	2800	2400	2100	2000	1900
	Yes, with biopsy	False Pos	12	12	14	16	17	18	19	20
		FP+Biopsy	80	79	83	91	94	91	94	110
		OverDx	4600	3200	2300	1700	1300	1000	830	650
		DthPrev	4600	3200	2300	1700	1500	1300	1200	1200
18–29	None	False Pos	16	17	20	23	24	25	26	27
		FP+Biopsy	220	210	220	240	250	240	250	280
		OverDx	5600	3900	2800	2100	1600	1300	1000	800
		DthPrev	5600	3900	2800	2100	1800	1600	1500	1500
	Yes, no biopsy	False Pos	10	11	13	14	15	16	16	17
		FP+Biopsy	130	130	140	150	150	150	150	170
		OverDx	5600	3900	2800	2100	1600	1300	1000	800
		DthPrev	5600	3900	2800	2100	1800	1600	1500	1500
	Yes, with biopsy	False Pos	10	11	13	14	15	16	16	17
		FP+Biopsy	63	61	65	71	73	71	73	83
		OverDx	3500	2400	1700	1300	970	770	630	490
		DthPrev	3500	2400	1700	1300	1100	980	920	920
≥30	None	False Pos	12	12	14	16	17	18	19	20
		FP+Biopsy	130	130	140	150	150	150	150	170
		OverDx	3500	2500	1800	1300	980	780	640	500
		DthPrev	3500	2500	1800	1300	1100	990	930	930
	Yes, no biopsy	False Pos	8	8	9	11	11	12	12	12
		FP+Biopsy	79	77	82	89	92	89	92	100
		OverDx	3500	2500	1800	1300	980	780	640	500
		DthPrev	3500	2500	1800	1300	1100	990	930	930
	Yes, with biopsy	False Pos	8	8	9	11	11	12	12	12
		FP+Biopsy	38	38	40	43	45	43	45	50
		OverDx	2200	1500	1100	830	610	490	400	310
		DthPrev	2200	1500	1100	830	700	610	580	580
No previous screens		False Pos	8	6	7	7	7	8	9	9
		FP+Biopsy	68	55	53	58	66	72	75	75
		OverDx	3300	1900	1400	1100	770	550	440	360
		DthPrev	3300	1900	1400	1100	890	700	650	660

*False Pos = false-positive, FP+Biopsy = false-positive requiring biopsy, OverDx = breast cancer overdiagnosis, DthPrev = breast cancer death prevented

Table 4. Women *with* a family history of breast cancer in a first-degree relative: Number of screens per screening outcome.

Months since previous screening test	History of false-positives	Screening outcome*	Current age							
			40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79
<18	None	False Pos	17	18	21	24	25	27	28	29
		FP+Biopsy	230	220	240	260	270	260	270	300
		OverDx	4900	3400	2500	1900	1400	1100	890	700
		DthPrev	4900	3400	2500	1900	1600	1400	1300	1300
	Yes, no biopsy	False Pos	11	11	13	15	16	17	17	18
		FP+Biopsy	140	140	140	160	160	160	160	180
		OverDx	4900	3400	2500	1900	1400	1100	890	700
		DthPrev	4900	3400	2500	1900	1600	1400	1300	1300
	Yes, with biopsy	False Pos	11	11	13	15	16	17	17	18
		FP+Biopsy	67	65	69	76	78	75	78	88
		OverDx	3000	2100	1500	1200	840	680	550	430
		DthPrev	3000	2100	1500	1200	980	850	800	800
18–29	None	False Pos	15	16	19	21	22	23	24	25
		FP+Biopsy	180	180	190	200	210	200	210	240
		OverDx	3700	2600	1900	1400	1000	830	680	530
		DthPrev	3700	2600	1900	1400	1200	1000	990	980
	Yes, no biopsy	False Pos	10	10	12	13	14	15	15	16
		FP+Biopsy	110	110	110	120	130	120	130	140
		OverDx	3700	2600	1900	1400	1000	830	680	530
		DthPrev	3700	2600	1900	1400	1200	1000	990	980
	Yes, with biopsy	False Pos	10	10	12	13	14	15	15	16
		FP+Biopsy	52	51	54	59	61	59	61	69
		OverDx	2300	1600	1200	880	640	510	420	330
		DthPrev	2300	1600	1200	880	740	650	610	610
≥30	None	False Pos	11	11	13	15	16	17	17	18
		FP+Biopsy	110	110	110	120	130	120	130	140
		OverDx	2300	1600	1200	890	650	520	420	330
		DthPrev	2300	1600	1200	890	750	660	620	620
	Yes, no biopsy	False Pos	7	7	9	10	10	11	11	12
		FP+Biopsy	66	64	68	75	77	74	77	87
		OverDx	2300	1600	1200	890	650	520	420	330
		DthPrev	2300	1600	1200	890	750	660	620	620
	Yes, with biopsy	False Pos	7	7	9	10	10	11	11	12
		FP+Biopsy	32	31	33	36	37	36	37	42
		OverDx	1400	1000	730	550	400	320	260	210
		DthPrev	1400	1000	730	550	470	410	390	380
No previous screening		False Pos	8	7	7	7	8	8	9	9
		FP+Biopsy	63	51	49	54	61	67	69	69
		OverDx	2300	1300	940	780	530	390	310	250
		DthPrev	2300	1300	940	780	620	490	450	460

*False Pos = false-positive, FP+Biopsy = false-positive requiring biopsy, OverDx = breast cancer overdiagnosis, DthPrev = breast cancer death prevented

The estimates of the per-mammogram rate of overdiagnosis and averted deaths from breast cancer are based on observations of relationships at an aggregate level in studies conducted in other jurisdictions, which have been extrapolated to per-mammogram outcomes in British Columbia. Although there is no unanimity in these findings, even among studies at an aggregate level, the range does not seem great.[1,12] The estimates provided in Tables 3 and 4 should be sufficiently accurate to give patients a sense of the general order of magnitude for each screening outcome, including the per-mammogram likelihood of an overdiagnosis or death averted, which is small in absolute terms.

Previous research has shown that inferences about false-positives based on BC data are in broad agreement with findings elsewhere in North America.[8] The significance of a false-positive screening result to a woman remains a subject of dispute. Some authors believe these false alarms cause significant harms, and certainly research has shown that women do suffer anxiety, which, in a small proportion of cases, can persist beyond the clinical resolution of the screening result.[15] Others feel that the harm done by false alarms is small, given that most cases are resolved with a second mammogram, and follow-up testing should be viewed as part of the screening process and not cause undue alarm. Given different possible patient responses, weighing benefits and risks is best approached on an individual basis rather than considered according to general conclusions.

Unfortunately, results on a per-mammogram basis of deaths from breast cancer prevented and overdiagnosis on a per-screen basis are not available from studies. In a review of results from randomized trials, Moss[16] found evidence of overdiagnosis when screening was not generally implemented in both arms following conclusion of the trial, but found no evidence when it was. The magnitude of the mortality reduction associated with screening has been a subject of conflicting evidence and opinion. Evidence from well-conducted observational studies has generally suggested stronger effects than were found in randomized trials,[17,18] although whether this results from bias, improved screening effectiveness, or a different measure of exposure to screening is a subject of controversy. Some authors assert that recent studies of breast cancer screening demonstrate reduced effectiveness, but surveys of published studies come to the opposite conclusion.[19] The assumption we have used, that overdiagnoses and deaths prevented are equal in women under 60, is more conservative (favoring screening) than found by a recent UK panel,[1] but less conservative than found in a review of European screening programs.[12]

The best way to present information about risks and benefits to patients is not well known. A "Citizens' Jury," which consisted of a focus group with expert guidance conducted over 3 days, recently provided some recommendations in the UK.[20] While many of the recommendations seem suitable for delivering high-level general information to patients, they do not apply to the kind of specific information presented here.

The Screening Mammography Program is currently using this information to develop an online decision-making tool for women, which will be available at www.screeningbc.ca. A woman will enter her age, previous screening and benign biopsy history, family history, and personal cancer history. The online tool will then provide screening guidance based on the woman's age, and evaluate her chances of experiencing various screening outcomes[1] if she decides to be screened and[2] if she continues participating in screening for 10 years. Women will be encouraged to print their reports and take them to their primary care providers for discussion.

In women participating in regular breast cancer screening in British Columbia, 75% of all cancer diagnoses are mammography-detected.

In discussing breast cancer screening with patients the physician should mention possible consequences of long-term participation using the information available from several sources.[15,21,22] The physician should also help the patient understand the possible consequences of a single screening test. The recent discussions and emphasis on the harms that may be associated with breast

cancer screening (unnecessary biopsies and surgery, exposure to radiation) have resulted in heightened concern expressed by women and their physicians—concern that appears to be reflected in declining attendance at SMPBC clinics by women 40 to 59.

Mammography is evolving and screening is now usually performed on digital rather than analog units,[23] which are the source of most data used in the research described here. While we can expect that screening performance will change, and the quantities we have estimated here will also change, this change should be modest.

In the meantime, family physicians can use the estimates provided here, as well as the patient information sheet on page 429, to counsel patients concerned about possible harms caused by breast cancer screening and to put any risks in perspective and contrast them with the likelihood of death prevented.

Competing interests

None declared.

References

1. Independent UK Panel on Breast Cancer Screening. The benefits and harms of breast cancer screening: An independent review. Lancet 2012;380(9855):1778-1786.
2. The Canadian Task Force on Preventive Health Care. Recommendations on screening for breat cancer in average-risk women aged 40-74 years. CMAJ 2011; 183:1991-2001.
3. US Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. Erratum in: Ann Intern Med. 2010;152:199-200; Ann Intern Med 2010;152:688. Ann Intern Med 2009; 151:716-726, W-326.
4. Canadian Task Force on Preventive Health Care. GRADE. 2011. Accessed 19 February 2013. http://canadiantaskforce.ca/methods/grade/.
5. Public Health Agency of Canada. Information on mammography for women aged 40 or older: A decision aid for breast screening in Canada. 2010. Accessed 19 February 2013. www.phac-aspc.gc.ca/cd-mc/mammography-mammographie-eng.php.
6. Vainio H, Bianchini F (eds). IARC Handbooks of Cancer Prevention—Breast Cancer Screening. Lyon: IARC Press; 2002.
7. Organized Breast Screening Programs in Canada: Report on program performance in 2005 and 2006. Ottawa: Public Health Agency of Canada; 2011.
8. Coldman A, Phillips N. False positive screening mammograms and biopsies among women participating in a Canadian breast screening program. Can J Public Health 2012;103:e420-424.
9. Puliti D, Duffy S, Miccinesi G, et al. Overdiagnosis in mammographic screening for breast cancer in Europe: A literature review. J Med Screen 2012;19(Suppl1):42-56.
10. Coldman A, Phillips N. Incidence of breast cancer and estimates of overdiagnosis after the initiation of a population-based mammography screening program. CMAJ 2013;185:E492-498.
11. BC Cancer Agency. Screening Mammography Program 2010 Annual Report. Vancouver: Provincial Health Services Authority; 2010.
12. EUROSCREEN Working Group. Summary of the evidence of breast cancer service screening outcome in Europe and first estimate of the benefit and harm balance sheet. J Med Screen 2012;19(suppl):5-13.
13. Walter S, Day N. Estimation of the duration of a pre-clinical disease state using screening data. Am J Epidemiol 1983; 118:865-886.
14. Nystrom L, Anderson I, Bjurstam N, et al. Long-term effects of mammography screening: Updated overview of the Swedish randomised trials. Lancet 2002;359(9334):909-919.
15. Brewer NT, Salz T, Lillie SE. Systematic review: The long-term effects of false-positive mammograms. Ann Intern Med 2007;146:502-510.
16. Moss S. Overdiagnosis and overtreatment of breast cancer: Overdiagnosis in randomised controlled trials of breast cancer screening. Breast Cancer Res 2005;7:230-234.
17. Coldman A, Phillips N, Warren L, et al. Breast cancer mortality after screening mammography in British Columbia women. Int J Cancer 2007;120:1076-1080.
18. Broeders M, Moss S, Nystrom L, et al. The impact of mammographic screening on breast cancer mortality in Europe: A review of observational studies. J Med Screen 2012;19:14-25.
19. Coldman A, Phillips N. Population studies of the effectiveness of mammographic screening. Prev Med 2011;53:115-117.
20. Kohr Z. Citizens' Jury on information for women about breast screening. Report to Informed Choice about Cancer Screening. London: Office for Public Management; 2012.
21. Canadian Task Force on Preventative Health Care. Screening for breast cancer: Summary of recommendations for clinicians and policy-makers. 2011. Accessed 23 September 2013. http://canadiantaskforce.ca/guidelines/2011-breast-cancer.
22. Elmore JG, Barton MB, Moceri VM, et al. Ten-year risk of false positive screening mammograms and clinical breast examinations. N Engl J Med 1998;338:1089-1096.
23. Pisano ED, Hendrick RE, Yaffe MJ, et al. Diagnostic accuracy of digital versus film mammography: Exploratory analysis of selected population subgroups in DMIST. Radiology 2008;246:376-383. BCMJ