Survey of primary care physicians' views about breast and ovarian cancer screening for true *BRCA1/2* non-carriers

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Abstract

Despite some controversy, true *BRCA1/2* non-carriers are generally considered to be at an average risk for breast and ovarian cancer. Primary care physicians are then expected to encourage their non-carrier patients to adopt cancer screening practices appropriate to women of the same age in the general population. This study aimed to describe breast and ovarian cancer screening recommendations that primary care physicians would consider advisable for young true *BRCA1/2* non-carriers. One hundred thirty-four family physicians and 123 gynecologists (response rate 45%) completed a cross-sectional mailed survey administered in the Province of Quebec, Canada. The survey included questions about basic genetic knowledge and screening recommendations for two fictitious cases (< 40 years), one carrier and one non-carrier, from a *BRCA1/2* mutation-positive family. Screening exams considered advisable did not differ significantly between family physicians and gynecologists. More than 75% of physicians considered the cancer risks of true non-carriers to be comparable with that of the general population and 14% to be a little higher. Still, 53% would prescribe a biennial and or even an annual (27%) mammography to a non-carrier woman before the recommended starting age. Physician considerations of non-carriers' expectations or requests for screening were associated with more screening prescriptions. More than half of primary care physicians would recommend more mammography screenings than expected for a young true *BRCA1/2* non-carrier. Personalized cancer risk assessment may help primary care physicians tailor screening of women from *BRCA1/2* mutation-positive families and allow these women to make more informed choices regarding cancer risk management options.

Keywords Hereditary cancer syndromes · *BRCA1* · *BRCA2* · Genetic screening · Physicians' practice patterns · Survey

Introduction

Women who do not carry the familial mutation (true non-carriers) represent a large proportion of tested women coming from *BRCA1/2* mutation-positive families (Metcalf et al. 2009). These women are usually referred to their primary care

physician (family doctor, gynecologist) for follow-up because, in the absence of other significant risk factors, their breast and ovarian cancer risks are considered to be about the same as that of other women in the general population (Dawson et al. 2008; Domchek et al. 2010; Girardi et al. 2018). Although a modest risk elevation in true-negative

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family members in *BRCA*-positive families cannot be excluded, especially in the context of strong family history (Evans et al. 2013; Robson 2011), primary care physicians are then expected to encourage their non-carrier patients to adopt cancer screening practices appropriate to women of the same age in the general population (Burke et al. 1997; American Society of Clinical Oncology 2003; Berliner and Fay 2007). In Canada, the most recent breast cancer screening guidelines, published in 2011, recommend that women of average risk undergo regular screening mammography at 2- to 3-year intervals, starting at age 50, but recommend against screening for women at an average risk under 50 (Tonelli et al. 2011). Clinicians are nevertheless encouraged to discuss with women aged 40–49 years about risks and benefits of screening and support patients in making screening decisions that are in keeping with their values and preferences (Tonelli et al. 2011; Warner et al. 2012).

Some instances of screening practices exceeding what is recommended for average-risk women have been reported among young true non-carriers (Watson et al. 2004; Claes et al. 2005; Foster et al. 2007; Dawson et al. 2008; Dorval et al. 2011; Julian-Reynier et al. 2011; Duprez et al. 2013). Such screening behaviors are hypothesized to result from many complex and intertwined factors, and attempts to explain them have up to now mainly focused on examining possible associations with non-carriers' characteristics (Dawson et al. 2008; Dorval et al. 2011; Duprez et al. 2013). However, physician-related factors may also have an impact on the screening behaviors of non-carriers and may explain some of the reported variations observed in non-carrier screening practices. Physicians are considered a significant source of influence for mammography screening (Schueler et al. 2008), and the fact that women will more likely adopt screening measures when deemed advisable by their physician is well documented (Tinley et al. 2004; Jensen et al. 2012; Haas et al. 2017). However, little is known about how primary care physicians perceive the cancer risk of their true non-carrier patients and about how they apply the relevant cancer screening guidelines.

This study aimed to evaluate to what extent primary care physicians are informed about official breast and ovarian cancer screening recommendations for non-carriers from *BRCA1/2*-positive families, and to determine which screening options they would consider advisable for such patients.

Methods

Participants

We surveyed primary care physicians (family physicians and gynecologists) practicing in the Province of Quebec, Canada, using two sampling approaches. First, a total of 209

physicians (160 family physicians and 49 gynecologists) were identified through a previous study (Guedaoura et al. 2017) of *BRCA1/2* non-carriers where participants were asked to provide their primary care physician's name and site of consultation. This recruitment strategy ensured that the study sample would include a significant number of physicians involved in the follow-up of true non-carriers. Second, an additional 400 physicians were recruited by randomly selecting 200 from each of the following public listings: the Association of Obstetricians and Gynecologists of Quebec (AOGQ), and the greater Quebec City area *Association des médecins omnipraticiens de Québec* (AMOQ).

Data collection

In May 2014, a short questionnaire, along with a pre-paid return envelope and a personalized cover letter describing the study objectives and explaining the consent procedure, was mailed to all 609 previously identified primary care physicians. Returning the completed questionnaire was considered to be consent to participate. Physicians who did not respond to the first mailing were sent a subsequent one a month later. A certified courier company was used for this second mailing to improve the response rate. All physicians having completed and returned the questionnaire received a CAD\$50 compensation and a complimentary educational booklet about hereditary breast and ovarian cancer (CHU de Québec 2013). The study was approved by the Ethics Review Board of the *CHU de Québec – Université Laval*.

Survey instrument

The questionnaire was developed in French from questionnaires used in previous studies and other survey instruments (Peshkin et al. 2003; Metcalfe et al. 2014). The main objective of the questionnaire was to investigate physicians' understanding of hereditary breast and ovarian cancer risks and management options according to different test results. To this end, the respondents were asked to indicate what screening options they would consider advisable for fictitious cases (vignettes) involving two sisters, i.e., a 35-year-old carrier and a 38-year-old non-carrier from a *BRCA1/2* mutation-positive family:

Vignette 1: "A 38-year-old woman comes to your clinic for an annual exam. She has just learned that she is a carrier of her mother's *BRCA1* genetic mutation. The patient, who has no personal history of cancer, wants to know what screening measures you would recommend for breast and ovarian cancer."

Vignette 2: "The sister of this woman, aged 35 years, also comes for a consultation. She is not a carrier of this familial mutation. What screening measures would you recommend for breast or ovarian cancer?"

The questionnaire also included general knowledge items about hereditary breast and ovarian cancer risks, questions about the respondents' perceived role and competence with respect to screening discussions with patients, statements concerning screening-related decisions, and sociodemographic questions. The questionnaire was pretested by family physicians and gynecologists leading to improved clarity and face validity, and allowing to determine completion time (15 min).

Statistical analyses

The breast and ovarian screening options indicated by the respondents for each of the two fictitious cases were described using proportions. The chi-square test was used to compare screening exams that would be prescribed by family physicians and gynecologists. The screening exams proposed by each physician for a carrier and a non-carrier were compared with McNemar's test. Multivariate logistic regression was used to assess whether participants' characteristics were associated with mammography screening prescription. Statistical significance level was $p < 0.05$ bilateral. All statistical analyses were performed using the SAS software 9.3 (SAS Institute 2012).

Results

The survey was sent to 360 family physicians and 249 gynecologists. Thirty-nine (6.4%) were excluded (retirement (10), wrong address (14), no longer practicing as family physician or gynecologist (15)). Of the remaining 571 eligible potential participants, three refused and 311 did not return the questionnaire. A total of 257 physicians (134 family physicians and 123 gynecologists) completed the survey leading to a 45% response rate. Gender proportions were similar in both physician groups. Family physicians tended to be older than gynecologists and had longer professional experience. The majority of family physicians worked in public medical settings whereas nearly half of the gynecologists worked in hospital settings (Table 1).

Almost all respondents knew that the breast cancer risk of a *BRCA1/2* mutation carrier is much higher than that of women from the general population, and most correctly estimated the cancer risk of a true non-carrier to be comparable with that of the general population (Table 2). Still, 14% perceived a non-carrier's cancer risk as slightly higher than that of a woman from the general population. Primary care physicians indicated that they placed a high value on guidelines from recognized organizations (91%) when considering whether or not to

Table 1 Selected characteristics of physicians ($n = 257$)

Characteristic	Family physicians ($n = 134$) N^a (%) ^b	Gynecol. ($n = 123$) N^a (%) ^b	Total ($n = 257$) N^a (%) ^b
Gender			
Male	58 (43)	53 (43)	111 (43)
Female	76 (57)	70 (57)	146 (57)
Age			
29–49	29 (25)	65 (63)	94 (43)
50–82	85 (75)	39 (38)	124 (57)
Mean $\pm$ SD	53 $\pm$ 9	48 $\pm$ 13	51 $\pm$ 11
Years of practice			
≤ 10	8 (6)	35 (29)	43 (17)
11–20	25 (19)	35 (29)	60 (24)
21–30	45 (34)	26 (21)	71 (28)
≥ 31	54 (41)	25 (21)	79 (31)
Mean $\pm$ SD	27 $\pm$ 9	19 $\pm$ 13	23 $\pm$ 12
University hospital			
Yes	44 (34)	70 (58)	114 (45)
No	87 (66)	50 (42)	137 (55)
Practice setting ^c			
Hospital	16 (10)	77 (46)	93 (29)
Public medical clinic	129 (84)	44 (27)	173 (54)
Private practice	8 (5)	45 (27)	53 (17)

^a The numbers do not always add to the total because of missing data

^b Proportions do not always add to 100% because of rounding

^c More than one answer was possible

Table 2 Participants' views about cancer screening

	Family physicians (<i>n</i> = 134) <i>N</i> ^a (%) ^b	Gynecol. (<i>n</i> = 123) <i>N</i> ^a (%) ^b	Total (<i>n</i> = 257) <i>N</i> ^a (%) ^b
Estimation of breast cancer risk for a <i>BRCA1/2</i> -carrier woman compared with that of a woman from the general population			
Much lower	1 (1)	0 (0)	1 (0.5)
Slightly higher	9 (7)	5 (4)	14 (5)
Much higher	121 (90)	117 (95)	238 (93)
Do not know	3 (2)	1 (1)	4 (1.5)
Estimation of breast cancer risk for a true non-carrier woman compared with that of a woman from the general population			
Much lower	2 (1)	1 (1)	3 (1)
Slightly lower	6 (4)	6 (5)	12 (5)
Comparable	101 (75)	99 (80)	200 (78)
Slightly higher	21 (16)	16 (13)	37 (14)
Do not know	4 (3)	1 (1)	5 (2)
Importance given to guidelines from recognized organizations			
No or little importance	0 (0)	0 (0)	0 (0)
Some importance	9 (7)	14 (11)	23 (9)
High importance	123 (93)	108 (88)	231 (91)
Importance given to patient's expectations regarding screening			
No importance	0 (0)	2 (2)	2 (2)
Little importance	16 (12)	16 (13)	32 (13)
Some importance	69 (52)	74 (61)	143 (56)
High importance	47 (36)	30 (25)	77 (30)
Would prescribe unnecessary screening exams at the patient's request			
Yes	23 (18)	9 (7)	32 (13)
Maybe	51 (39)	45 (37)	96 (38)
No	56 (43)	67 (55)	123 (49)
Feels competent to discuss screening with his/her patients			
Totally disagree	1 (1)	2 (2)	3 (1)
Disagree	26 (19)	8 (7)	34 (13)
Neither agree nor disagree	49 (37)	31 (25)	80 (31)
Agree	52 (39)	68 (56)	120 (47)
Totally agree	6 (4)	13 (11)	19 (7)

^a The numbers do not always add to the total because of missing data^b Proportions do not always add to 100% because of rounding

prescribe screening exams. Patient's expectations were also regarded as important for most physicians to the point where many would consider prescribing unnecessary screening exams if the patient asked. The majority of physicians felt competent to discuss breast and ovarian screening exams with their patients.

Table 3 presents the breast and ovarian cancer screening exams that physicians would consider advisable for a 35-year-old *BRCA1*-carrier woman and her 38-year-old true non-carrier sister (fictitious cases). Compared with family physicians, gynecologists would prescribe more frequent breast ultrasounds ($p = 0.04$) and breast MRI ($p = 0.03$) to a carrier, but less frequent pelvic/transvaginal ultrasounds ($p = 0.01$) and CA-125 tests ($p = 0.001$). As for the non-carrier, prescriptions

for any screening exams did not differ significantly between family physicians and gynecologists. Almost all screening exams were considered less advisable for the non-carrier than for the carrier case. Concerning mammography screening prescriptions to non-carriers, more than half of the physicians would advise these women to undergo such screening exam at least once every other year while one-fourth would prescribe it at least once a year.

None of the sociodemographic variables was significantly associated with mammography prescription recommendations for the true non-carrier case, whether annually or every other year (Table 4). Physicians who deemed the breast cancer risk of true non-carriers to be slightly higher than that of a woman in the general population were 3.5 times more likely to

Table 3 Breast and ovarian cancer screening considered advisable for a carrier and a true non-carrier (fictitious vignette cases)

Screening exam	Carrier			Non-carrier			<i>p</i> value
	<i>n</i>	%	<i>p</i> value	<i>n</i>	%	<i>p</i> value	Carrier vs non-carrier
Breast self-exam at least once every 6 months							
Family physicians	79	59	0.64	58	43	0.62	0.01
Gynecol.	76	62		57	46		0.01
Total	155	60		115	45		0.0004
Clinical breast exam at least once every year							
Family physicians	127	95	0.17	117	87	0.65	0.03
Gynecol.	111	90		105	85		0.24
Total	238	93		222	86		0.02
Mammography at least every other year							
Family physicians	117	87	0.10	73	54	0.60	< 0.0001
Gynecol.	98	80		63	51		< 0.0001
Total	215	84		136	53		< 0.0001
Mammography at least every year							
Family physicians	97	72	1.00	35	26	0.78	< 0.0001
Gynecol.	89	72		34	28		< 0.0001
Total	186	72		69	27		< 0.0001
Breast ultrasound at least every other year							
Family physicians	39	29	0.04	16	12	0.57	0.0005
Gynecol.	51	41		12	10		< 0.0001
Total	90	35		28	11		< 0.0001
MRI at least every other year							
Family physicians	43	32	0.03	2	2	0.43	< 0.0001
Gynecol.	56	45		4	3		< 0.0001
Total	99	39		6	2		< 0.0001
Pelvic/transvaginal ultrasound at least every other year							
Family physicians	73	70	0.01	9	7	0.85	< 0.0001
Gynecol.	86	54		9	7		< 0.0001
Total	159	62		18	7		< 0.0001
CA-125 at least every other year							
Family physicians	53	60	0.001	6	5	0.47	< 0.0001
Gynecol.	74	40		8	7		< 0.0001
Total	127	49		14	5		< 0.0001

recommend a mammography exam at least every other year or even annually to a non-carrier than physicians who perceived this risk as comparable or lower. Patients' expectations and requests were associated with a prescription for a mammography exam at least every other year (*high importance given to patient expectations regarding screening: $p=0.02$; may/would prescribe unnecessary screening exam if the patient requested it: $p=0.02$*). Finally, compared with physicians who feel less competent discussing screening with their patients, those who feel more competent were two times more likely to recommend having a mammography exam at least annually ($p=0.02$) or at least every other year ($p=0.05$).

Discussion

This first study to focus specifically on primary care physicians' views about breast cancer screening for true non-carriers from *BRCA1/2* families revealed that a significant proportion of them would recommend more mammography screenings than expected for young true *BRCA1/2* non-carriers. By shedding light on how primary care physicians comprehend the cancer risks of non-carriers from *BRCA1/2* mutation-positive families, and on their attitudes towards the breast cancer screening options they consider appropriate for these patients, our findings add to the recent results of Guedaoura et al. (2017) and contribute to the understanding of screening practices among young non-carriers. Such

Table 4 Characteristics associated with prescription for annual or biennial mammography screening to a non-carrier (fictitious vignette case)

Characteristics	Mammography at least every other year					Mammography at least every year				
	<i>n</i>	%	OR	95% CI	<i>p</i> value	<i>n</i>	%	OR	95% CI	<i>p</i> value
Physician category										
Gynecol.	63	51	1.34	0.65–2.79	0.43	34	28	1.46	0.64–3.34	0.37
Family physician	73	54	1	–	–	35	26	1	–	–
Gender										
Female	78	53	1.56	0.76–3.17	0.22	45	31	1.95	0.86–4.42	0.11
Male	58	52	1	–	–	24	22	1	–	–
Age										
50–82	69	56	1.68	0.67–4.21	0.27	28	23	0.94	0.35–2.50	0.90
29–49	47	50	1	–	–	30	32	1	–	–
Years of practice										
≥ 31	44	56	0.91	0.25–3.34	0.88	18	23	1.14	0.26–4.98	0.87
11–30	69	53	1.14	0.44–2.95	0.79	40	30	1.74	0.60–5.03	0.30
< 10	20	46	1	–	–	10	23	1	–	–
University hospital										
No	79	58	1.83	0.98–3.41	0.06	37	27	1.19	0.58–2.41	0.64
Yes	53	46	1	–	–	30	26	1	–	–
Estimation of breast cancer risk for a non-carrier woman compared with that of a woman from the general population										
Slightly higher	27	73	3.63	1.38–9.55	0.009	19	51	3.47	1.41–8.57	0.007
Much lower/slightly lower/comparable	107	50	1	–	–	49	23	1	–	–
Importance given to guidelines from recognized organizations										
Some importance	12	52	1.13	0.41–3.16	0.81	4	17	0.85	0.24–2.98	0.80
High importance	122	53	1	–	–	63	27	1	–	–
Importance given to patient's expectations regarding screening										
High importance	48	62	2.31	1.17–4.56	0.02	26	34	2.33	1.11–4.88	0.02
No importance/little importance/some importance	86	49	1	–	–	41	23	1	–	–
Would prescribe unnecessary screening exams at the patient's request										
Yes/maybe	80	62	2.05	1.11–3.77	0.02	38	30	1.57	0.78–3.16	0.20
No	53	43	1	–	–	28	23	1	–	–
Feels competent to discuss screening with his/her patients										
Agree/totally agree	86	62	2.21	1.15–4.21	0.02	47	34	2.10	0.99–4.43	0.05
Totally disagree/disagree/neither agree nor disagree	49	42	1	–	–	21	18	1	–	–

practices have for some time been subject to controversy because they were considered “excessive” compared with what is expected based on recommendations for women of the general population.

As expected, all proposed screening exams in the vignettes were considered significantly less advisable for the non-carrier than for the carrier case. As for mammography screening, many physicians would prescribe biennial (53%) or even annual (27%) screening to a 38-year-old true non-carrier. Even if physicians perceiving the breast cancer risk of true non-carriers as being slightly higher than the population-level risk were much more likely to prescribe mammography screening, most correctly estimated the breast and ovarian cancer risk of non-carriers as comparable with or slightly lower than the population-level risk. The frequency of mammography

screening prescriptions to a non-carrier revealed in this study is rather unexpected, considering that the fictitious non-carrier was under 40, which is much younger than the recommended screening starting age for women at general population risk in Canada. It is also noteworthy that family physicians were significantly more likely than gynecologists to recommend unproven ovarian cancer screening to a carrier but less likely to recommend proven MRI screening.

A number of factors are considered important by the physicians when they have to make decisions about screening. Among these is the existence of official guidelines. However, this factor was not associated with either an annual or biennial mammography prescription despite the fact that all physicians reported giving some or high importance to official

guidelines. This finding may seem contradictory but should be taken into account, given the fact that no screening guidelines apply specifically to non-carriers coming from *BRCA1/2* mutation-positive families. Since the introduction of genetic testing for *BRCA1/2*, primary care physicians have been told to base their breast cancer screening recommendations for non-carrier women on guidelines intended for the general population. However, physicians are confronted with multiple existing guidelines (Han et al. 2011; Anderson et al. 2013) that vary not only between, but also within countries (Kadaoui et al. 2012; Onega et al. 2014), including Canada (Metcalf et al. 2013; Seely et al. 2017). Variations in screening guidelines mainly concern younger women which may add to the uncertainty (Kadaoui et al. 2012) of what should be considered advisable for non-carriers under the age of 50. Thus, even if guidelines are deemed important, their inconsistency may be a source of confusion to physicians (Tudiver et al. 2001). For instance, uncertainty may result in physicians' preference for individualized screening recommendations, as observed by Han et al. (2011). Some physicians may also adopt a defensive clinical position, an attitude documented in situations where guidelines lack uniformity (Han et al. 2011).

Patients' expectations regarding screening were given high importance among primary care physicians in our study so much so that a number of them would prescribe unnecessary screening exams at the patient's request. Unlike guidelines, patients' expectations and requests regarding screening were associated with mammography prescription, as was the feeling of self-competency in discussing screening options which was reported by the majority of the physicians. These associations should be examined bearing in mind the interaction between non-carriers and their primary care physicians. First, the relationship with their physician represents a highly valued reference source for non-carriers who generally do not receive any specialized follow-up after receiving their genetic test result (Dawson et al. 2008). Second, it is plausible that the recognized influence of patients' expectations on physicians screening decisions (Haggerty et al. 2005) could be even more marked when screening expectations or requests are expressed by non-carriers. Coming from high-risk families, these women may have been exposed, for a long time, to information about cancer screening and management measures applicable to other carrier family members. Such exposure may have exacerbated their worries or even had a misleading effect. As a result, some non-carriers may have difficulty conceiving that their breast cancer risk is comparable with that of general population and continue to perceive it as higher (Bakos et al. 2008; Pelletier et al. 2016). Consequently, they may be reluctant to embrace a less frequent screening schedule and are likely to need reassurance (Dawson et al. 2008), namely by asking for screening exams. Moreover, physicians tend to be more sympathetic to patients' expectations when screening guidelines are unclear (Haggerty et al. 2005).

We conclude that a number of physician-related factors influence mammography recommendations given to non-carrier women. The high frequency of hypothetical mammography prescriptions observed in our study is probably the result of a combination of factors such as physicians' sensitivity to patients' expectations, aspects that are particular to non-carrier women, and the uncertainty generated from inconsistencies in guidelines concerning mammography screening, particularly for young women. Given the high response rate for a survey among physicians, our findings might be representative of current opinions of primary care physicians regarding screening for true *BRCA1/2*-non-carrier women.

Today, the cancer risk of non-carrier women can no longer be regarded as equivalent to population risk in all cases. The ongoing identification of new, rare, and common breast cancer susceptibility variants (Michailidou et al. 2017) and the development of new genetic screening technologies (Moran et al. 2017) have paved the way for updated testing capacities. These upgraded capabilities should allow better estimates of individual cancer risks, namely for young women, who are currently absent from age-based guideline recommendations (Gagnon and Levesque 2016). Current research efforts are aimed towards developing more personalized risk evaluation tools and strategies (Onega et al. 2014; Shieh et al. 2017) including stratification models that rely on risk estimates that combine genetic and non-genetic risk factors (Gagnon and Levesque 2016). One such tool is the extended Breast and Ovarian Analysis of Disease Incidence and Carrier Estimation Algorithm (BOADICEA) model. This well-validated model allows for the prediction of breast cancer for unaffected women on the basis of rare genetic susceptibility variants, such as *BRCA1* and *BRCA2*, common genetic variants, family history, and other known risk factors, including mammographic density, reproductive factors, exogenous hormonal factors, and lifestyle factors (Lee et al. 2019). Personalized risk evaluation will benefit true non-carriers not only by possibly alleviating their worries but also by recognizing these worries as legitimate, thus contributing to reducing their feelings of being dismissed from follow-up or abandoned by the health care system (Claes et al. 2004; Pelletier et al. 2016; Michailidou et al. 2017). Personalized approaches to screening can also benefit primary care physicians. By reducing uncertainties about risk, physicians can discuss and offer screening options that are based on tailored risk evaluations (Collins et al. 2014). However, clinicians will have to acquire new knowledge and competencies, which remains a complicated process (Jbilou et al. 2014). Support will have to be provided to physicians in this regard (Onega et al. 2014).

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Compliance with ethical standards All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

Conflict of interest The authors declare that they have no conflict of interest.

References

- American Society of Clinical Oncology (2003) American Society of Clinical Oncology policy statement update: genetic testing for cancer susceptibility. *J Clin Oncol* 21(12):2397–2406
- Anderson BL, Pearlman M, Griffin J, Schulkin J (2013) Conflicting and changing breast cancer screening recommendations: survey study of a national sample of ob-gyns after the release of the 2009 USPSTF guidelines. *J Healthc Qual* 35(4):25–35
- Bakos AD, Hutson SP, Loud JT, Peters JA, Giusti RM, Greene MH (2008) BRCA mutation-negative women from hereditary breast and ovarian cancer families: a qualitative study of the BRCA-negative experience. *Health Expect* 11(3):220–231
- Berliner JL, Fay AM (2007) Risk assessment and genetic counseling for hereditary breast and ovarian cancer: recommendations of the National Society of Genetic Counselors. *J Genet Couns* 16(3):241–260
- Burke W, Daly M, Garber J, Botkin J, Kahn MJ, Lynch P, McTiernan A, Offit K, Perlman J, Petersen G, Thomson E, Varricchio C (1997) Recommendations for follow-up care of individuals with an inherited predisposition to cancer. II. *BRCA1* and *BRCA2*. Cancer Genetics Studies Consortium. *JAMA* 277(12):997–1003
- CHU de Québec (2013). Consulter en génétique: Cancer du sein ou de l’ovaire
- Claes E, Denayer L, Evers-Kiebooms G, Boogaerts A, Legius E (2004) Predictive testing for hereditary non-polyposis colorectal cancer: motivation, illness representations and short-term psychological impact. *Patient Educ Couns* 55(2):265–274
- Claes E, Evers-Kiebooms G, Decruyenaere M, Denayer L, Boogaerts A, Philippe K, Legius E (2005) Surveillance behavior and prophylactic surgery after predictive testing for hereditary breast/ovarian cancer. *Behav Med* 31(3):93–105
- Collins IM, Steel E, Mann GB, Emery JD, Bickerstaffe A, Trainer A, Butow P, Pirota M, Antoniou AC, Cuzick J, Hopper J, Phillips KA, Keogh LA (2014) Assessing and managing breast cancer risk: clinicians’ current practice and future needs. *Breast* 23(5):644–650
- Dawson SJ, Price MA, Jenkins MA, McKinley JM, Butow PN, McLachlan SA, Lindeman GJ, Weideman P, Friedlander ML, Hopper JL, Phillips KA (2008) Cancer risk management practices of noncarriers within *BRCA1/2* mutation positive families in the Kathleen Cuninghame Foundation Consortium for Research into Familial Breast Cancer. *J Clin Oncol* 26(2):225–232
- Domchek SM, Gaudet MM, Stopfer JE, Fleischaut MH, Powers J, Kauff N, Offit K, Nathanson KL, Robson M (2010) Breast cancer risks in individuals testing negative for a known family mutation in *BRCA1* or *BRCA2*. *Breast Cancer Res Treat* 119(2):409–414
- Dorval M, Noguez C, Berthet P, Chiquette J, Gauthier-Villars M, Lasset C et al (2011) Breast and ovarian cancer screening of non-carriers from *BRCA1/2* mutation-positive families: 2-year follow-up of cohorts from France and Quebec. *Eur J Hum Genet* 19(5):494–499
- Duprez C, Christophe V, Milhabet I, Krzemiński A, Adenis C, Berthet P, Peyrat JP, Vennin P (2013) Comparison of the screening practices of unaffected noncarriers under 40 and between 40 and 49 in *BRCA1/2* families. *J Genet Couns* 22(4):469–481
- Evans DG, Ingham SL, Buchan I, Woodward ER, Byers H, Howell A et al (2013) Increased rate of phenocopies in all age groups in *BRCA1/BRCA2* mutation kindred, but increased prospective breast cancer risk is confined to *BRCA2* mutation carriers. *Cancer Epidemiol Biomark Prev* 22(12):2269–2276
- Foster C, Watson M, Eeles R, Eccles D, Ashley S, Davidson R, Mackay J, Morrison PJ, Hopwood P, Evans DG, Psychosocial Study Collaborators (2007) Predictive genetic testing for *BRCA1/2* in a UK clinical cohort: three-year follow-up. *Br J Cancer* 96(5):718–724
- Gagnon J, Levesque E (2016) Recommendations on breast cancer screening and prevention in the context of implementing risk stratification: impending changes to current policies. *Curr Oncol* 23(6):e615–e625
- Girardi F, Barnes DR, Barrowdale D, Frost D, Brady AF, Miller C, Henderson A, Donaldson A, Murray A, Brewer C, Pottinger C, Evans DG, Eccles D, EMBRACE, Lalloo F, Gregory H, Cook J, Eason J, Adlard J, Barwell J, Ong KR, Walker L, Izatt L, Side LE, Kennedy MJ, Tischkowitz M, Rogers MT, Porteous ME, Morrison PJ, Eeles R, Davidson R, Snape K, Easton DF, Antoniou AC (2018) Risks of breast or ovarian cancer in *BRCA1* or *BRCA2* predictive test negatives: findings from the EMBRACE study. *Genet Med* 20(12):1575–1582
- Guedaoura S, Pelletier S, Foulkes WD, Hamet P, Simard J, Wong N et al (2017) No evidence of excessive cancer screening in female noncarriers from *BRCA1/2* mutation-positive families. *Curr Oncol* 24(6):352–359
- Haas JS, Barlow WE, Schapira MM, MacLean CD, Klabunde CN, Sprague BL, Beaber EF, Chen JS, Bitton A, Onega T, Harris K, Tosteson ANA, PROSPR (Population-based Research Optimizing Screening through Personalized Regimens) consortium (2017) Primary care providers’ beliefs and recommendations and use of screening mammography by their patients. *J Gen Intern Med* 32(4):449–457
- Haggerty J, Tudiver F, Brown JB, Herbert C, Ciampi A, Guibert R (2005) Patients’ anxiety and expectations: how they influence family physicians’ decisions to order cancer screening tests. *Can Fam Physician* 51:1658–1659
- Han PK, Klabunde CN, Breen N, Yuan G, Grauman A, Davis WW, Taplin SH (2011) Multiple clinical practice guidelines for breast and cervical cancer screening: perceptions of US primary care physicians. *Med Care* 49(2):139–148
- Jbilou J, Halilem N, Blouin-Bougie J, Amara N, Landry R, Simard J (2014) Medical genetic counseling for breast cancer in primary care: a synthesis of major determinants of physicians’ practices in primary care settings. *Public Health Genomics* 17(4):190–208
- Jensen LF, Mukai TO, Andersen B, Vedsted P (2012) The association between general practitioners’ attitudes towards breast cancer screening and women’s screening participation. *BMC Cancer* 12:254
- Julian-Reynier C, Mancini J, Mouret-Fourme E, Gauthier-Villars M, Bonadona V, Berthet P, Fricker JP, Caron O, Luporsi E, Noguès C (2011) Cancer risk management strategies and perceptions of unaffected women 5 years after predictive genetic testing for *BRCA1/2* mutations. *Eur J Hum Genet* 19(5):500–506
- Kadaoui N, Guay M, Baron G, St-Cerny J, Lemaire J (2012) Breast cancer screening practices for women aged 35 to 49 and 70 and older. *Can Fam Physician* 58(1):e47–e53
- Lee A, Mavaddat N, Cunningham AP, Carver T, Hartley S, Babb de Villiers C et al (2019) BOADICEA: a comprehensive breast cancer risk prediction model incorporating genetic and nongenetic risk factors. *Genet Med* 21(8):1708–1718
- Metcalfe KA, Finch A, Poll A, Horsman D, Kim-Sing C, Scott J, Royer R, Sun P, Narod SA (2009) Breast cancer risks in women with a family history of breast or ovarian cancer who have tested negative for a *BRCA1* or *BRCA2* mutation. *Br J Cancer* 100(2):421–425

- Metcalfe P, Liney GP, Holloway L, Walker A, Barton M, Delaney GP, Vinod S, Tome W (2013) The potential for an enhanced role for MRI in radiation-therapy treatment planning. *Technol Cancer Res Treat* 12(5):429–446
- Metcalfe KA, Kim-Sing C, Ghadirian P, Sun P, Narod SA (2014) Health care provider recommendations for reducing cancer risks among women with a BRCA1 or BRCA2 mutation. *Clin Genet* 85(1):21–30
- Michailidou K, Lindstrom S, Dennis J, Beesley J, Hui S, Kar S et al (2017) Association analysis identifies 65 new breast cancer risk loci. *Nature* 551(7678):92–94
- Moran O, Nikitina D, Royer R, Poll A, Metcalfe K, Narod SA, Akbari MR, Kotsopoulos J (2017) Revisiting breast cancer patients who previously tested negative for BRCA mutations using a 12-gene panel. *Breast Cancer Res Treat* 161(1):135–142
- Onega T, Beaber EF, Sprague BL, Barlow WE, Haas JS, Tosteson AN, D Schnall M, Armstrong K, Schapira MM, Geller B, Weaver DL, Conant EF (2014) Breast cancer screening in an era of personalized regimens: a conceptual model and National Cancer Institute initiative for risk-based and preference-based approaches at a population level. *Cancer* 120(19):2955–2964
- Pelletier S, Wong N, El Haffaf Z, Foulkes WD, Chiquette J, Hamet P et al (2016) Clinical follow-up and breast and ovarian cancer screening of true BRCA1/2 noncarriers: a qualitative investigation. *Genet Med* 18(6):627–634
- Peshkin BN, Isaacs C, Finch C, Kent S, Schwartz MD (2003) Tamoxifen as chemoprevention in BRCA1 and BRCA2 mutation carriers with breast cancer: a pilot survey of physicians. *J Clin Oncol* 21(23):4322–4328
- Robson M (2011) Do women remain at risk even if they do not inherit a familial *BRCA1/2* mutation? *J Clin Oncol* 29(34):4477–4478
- SAS Institute Inc (2012). Statistical Analytic System (SAS) v. 9.3, SAS Institute Inc., Cary, NC,
- Schueler KM, Chu PW, Smith-Bindman R (2008) Factors associated with mammography utilization: a systematic quantitative review of the literature. *J Womens Health (Larchmt)* 17(9):1477–1498
- Seely JM, Lee J, Whitman GJ, Gordon PB (2017) Canadian radiologists do not support screening mammography guidelines of the Canadian Task Force on Preventive Health Care. *Can Assoc Radiol J* 68(3):257–266
- Shieh Y, Eklund M, Madlensky L, Sawyer SD, Thompson CK, Stover Fiscalini A et al (2017) Breast cancer screening in the precision medicine era: risk-based screening in a population-based trial. *J Natl Cancer Inst* 109(5)
- Tinley ST, Houfek J, Watson P, Wenzel L, Clark MB, Coughlin S et al (2004) Screening adherence in BRCA1/2 families is associated with primary physicians' behavior. *Am J Med Genet A* 125A(1):5–11
- Tonelli M, Gorber SC, Joffres M, Dickinson J, Singh H, Birtwhistle R et al (2011) Recommendations on screening for breast cancer in average-risk women aged 40–74 years. *CMAJ* 183(17):1991–2001
- Tudiver F, Brown JB, Medved W, Herbert C, Ritvo P, Guibert R et al (2001) Making decisions about cancer screening when the guidelines are unclear or conflicting. *J Fam Pract* 50(8):682–687
- Warner E, Heisey R, Carroll JC (2012) Applying the 2011 Canadian guidelines for breast cancer screening in practice. *CMAJ* 184(16):1803–1807
- Watson M, Foster C, Eeles R, Eccles D, Ashley S, Davidson R et al (2004) Psychosocial impact of breast/ovarian (*BRCA1/2*) cancer-predictive genetic testing in a UK multi-centre clinical cohort. *Br J Cancer* 91(10):1787–1794

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