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VALIDITY OF SELF-REPORTED MAMMOGRAPHY HISTORY IN BRCA1/2 MUTATION CARRIERS

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ABSTRACT

We assessed accuracy of self-reported lifetime mammography history by BRCA1/2 mutation carriers with and without breast cancer. Within the framework of the HEBON study, 218 Dutch BRCA1/2 mutation carriers had completed a risk factor questionnaire between 2006 and 2007. Accuracy of self-reported lifetime mammography history was assessed by medical record review. For 177 (81%) carriers, validation could be completed. Accuracy of reporting of ever/never exposure was excellent for all time frames (lifetime, before age 30, and at ages 30-40). Accuracy of age at first mammogram was poor to moderate for exact agreement and improved to almost excellent for agreement within 1 year, indicating that differences were small. Though cases more often tended to underestimate their exact age at first mammogram, while unaffected carriers tended to overestimate, this difference in the direction of inaccuracy was not statistically significant (P=0.237). Accuracy of age at last mammogram was moderate and improved to excellent for agreement within 1 year. Carriers tended to underreport the time since last mammogram ("telescoping") and they overreported the number of mammograms. In conclusion, accuracy of self-reported lifetime mammography history in carriers highly varied, depending on the measure under investigation. However, the extent of the observed misclassification was small and mostly non-differential.

INTRODUCTION

It has been hypothesized that BRCA1/2 mutation carriers might experience greater risk of radiation-induced breast cancer because BRCA mutations are associated with a reduction in DNA repair efficiency[1]. In two recent studies, exposure to chest X-rays, especially at young ages, was associated with an increased breast cancer risk among carriers[2,3], but two other studies on exposure to mammography observed no association[4,5]. However, these results must be interpreted with caution as the studies relied on self-reported diagnostic radiation history and had a retrospective design (with potential recall and/or survival bias). In order to assess the potential true risk of radiation-induced breast cancer by mammographic screening, the information on exposure to mammography must be accurate. Inaccuracy of self-reported exposure may lead to non-differential and/or differential misclassification which would affect the risk estimates in different ways: non-differential misclassification (inevitable in any study using subjects' information only) mostly results in bias towards unity, while inaccuracies that are systematically different in breast cancer cases and unaffected individuals (differential misclassification) can either mask true or create spurious associations.
A recent meta-analysis on the validity of self-reported mammography among women from the general population concluded that women tend to overreport their participation in mammography screening in a recent timeframe[6]. Recall is better when the event had occurred more recently[7-9] and women tend to underreport the time since last exposure ("telescoping")[7-15]. Two studies investigated the accuracy of self-reported number of mammograms and observed that women tend to overreport the number of exposures[11,16]. Differences in accuracy of self-reported mammography between affected and unaffected women were investigated in two validation studies[16,17] which showed a certain amount of disagreement between self-reports and medical records but no differences between cases and controls.
This is the first study investigating validity of self-reported lifetime mammography history in BRCA1/2 mutation carriers. Based on their positive family history, associated cancer screens and history of DNA testing in a clinical setting, these women are probably more health conscious than the general population. Furthermore, because of their high-risk status they are screened frequently from a relatively young age onwards.

METHODS

STUDY POPULATION

This validation study on accuracy of self-reported mammography among BRCA1/2 mutation carriers was conducted within the framework of the HEBON study, of which the design was described earlier[18]. In brief, the HEBON study is an ongoing nationwide retrospective cohort study with prospective follow-up among members of BRCA1/2 families in the Netherlands. We previously reported on a test-retest reliability study[19] that included 401 carriers who had participated in the follow-up study in 2006-2007. Fifty-four percent (N=218) of this group was entered through five Clinical Genetic Centres

(CGC) (the Netherlands Cancer Institute, Amsterdam; Free University Medical Centre, Amsterdam; University Medical Centre Leiden, Leiden; Radboud University Nijmegen Medical Centre, Nijmegen; and University Medical Centre Utrecht, Utrecht) where it was feasible to collect information on mammography history from medical records.

DATA COLLECTION

Self-reported mammography history was collected through the baseline and the follow-up questionnaires of the HEBON study. For the present study, we focused on validation of self-reported information from the follow-up questionnaire as this contained more detailed information on mammography history. The items in the follow-up questionnaire were: ever/never having had a mammogram, the age at first and last mammogram, the reason for the first mammogram (complaints/felt a lump, screening based on family history, population based screening program), exact number of mammograms before age 20, at ages 20-29, and at ages 30-39, and lifetime number in categories (1-3, 4-6, 7-9, 10 or more). Written informed consent, including permission to retrieve information on breast cancer screening from medical records, was obtained from each participant.
Medical records were considered to be any information kept by a clinician, clinic, general practitioner (GP), or an organized screening program for the purpose of patient management. Both positive and negative self-reports were validated. The medical record from the hospital of the CGC where carriers had been tested was considered as the main medical record. Information from medical records was abstracted by means of a checklist, which included dates of mammograms, the reason for the first mammography, and whether the patient had previously had mammograms in another hospital. If so, these hospitals were contacted by mail with the same checklist that was used for the main medical record. In case of non-response, one reminder letter was sent after 4 weeks. If patients were unknown at the main hospital, if other hospitals did not respond, and/or if the main record and/or the other hospitals appeared to report an incomplete mammography history when compared to the self-reported data, we contacted the GP, if known, by mail. In case the GP did not respond, one telephone reminder was conducted after 4 weeks. If either the medical record or the self-report indicated that the first mammogram was taken in the population screening program, we contacted the screening organization concerned through the comprehensive cancer centres across the Netherlands. If no main record could be traced and/or other sources did not respond and/or indicated that they had no record of mammography, validation was considered to have failed. Medical record abstraction was blinded to case status of the individual and was performed by several of the authors and two research assistants.

STATISTICAL ANALYSIS

Accuracy was assessed by proportion agreement, and Cohen's kappa coefficient (κ), which accounts for the effect of chance agreement. Accuracy was considered poor if $\kappa<0.40$, moderate if $0.40\geq\kappa\leq0.75$, and excellent if $\kappa>0.75$[20]. For ever/never variables, we also assessed sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV). For all items the direction of inaccuracy was investigated.

The accuracy of mammography exposure (ever/never), age at first and last mammogram, exposure (ever/never) before age 30 and at ages 30-39, number before age 30 and at ages 30-39, lifetime number and number in the past five years were examined in the entire study population and in cases and unaffected carriers separately. Accuracy of age at first, age at last, and number of mammograms was determined in women who ever had a mammogram according to both the self-report and the medical record.
Multivariate logistic regression was used to find predictors of accuracy of self-reported age at first mammogram lifetime. The dependent variable in this model was inaccuracy (no/yes) with accuracy as the reference category. The following possible determinants were examined: case status, age at questionnaire completion, educational level, nulliparity, menopausal status, having had prophylactic surgery (risk reducing mastectomy (RRM) and/or bilateral prophylactic (salpingo-) oophorectomy (BPSO)), the reason for the first mammogram (self-reported), lifetime number of mammograms (self-reported and based on medical record review), and length of recall (age at follow-up questionnaire completion minus ((self-reported age at 1st mammogram + age at 1st mammogram based on medical record)/2)).
In cases, lifetime mammography history was for a large part due to their breast cancer diagnosis, while only prediagnostic exposures are of interest in an epidemiological study of radiation exposure and breast cancer risk. Therefore, we also assessed accuracy of prediagnostic mammograms based on mammograms preceding the year before breast cancer diagnosis.
Differences in discrete variables and continuous variables between cases and unaffected carriers were examined with Pearson's $\chi 2$ test or Fisher's exact test and Student's t-test, respectively. Two-sided p-values ≤ 0.05 were considered statistically significant. Missing values were excluded from the analysis. All analyses were performed using STATA/SE 10.0 (StataCorp LP).

RESULTS

For 177 (81%) carriers, validation could be completed. For 18/177 (10%) carriers, the validation was completed for just age at last mammogram because some hospitals maintained or accessed computerized records only; some sites indicated that there was no record available of mammography completed before the computerized recording started. To achieve the 81% success rate, we contacted 107 other hospitals (95% response), 84 GPs (86% response), and 5 comprehensive cancer centres (100% response) in addition to reviewing the main medical record. There were no differences in characteristics between the eligible (N=218) and the validated (N=177) group (data not shown). The proportion of successful validations was not different between cases and unaffected carriers (77% and 85%, respectively, P=0.11).
The age (mean ± standard deviation) at follow-up questionnaire completion was 48.9 ± 12.1 years. Cases were older at questionnaire completion than unaffected carriers (52.6 ± 10.5 and 45.9 ± 12.6 years, respectively; P<0.001). The majority of women carried a mutation in the BRCA1 gene and was postmenopausal at time of questionnaire

TABLE 1. Characteristics of BRCA1/2 mutation carriers with validated self-reported mammography history

	Total (N=177)		Cases (N=79)		Unaffected (N=98)	
Characteristic	**mean ± sd**		**mean ± sd**		**mean ± sd**	
Age at questionnaire completion[a,b]	48.9 ± 12.1		52.6 ± 10.5		45.9 ± 12.6	
Age at diagnosis[a]	-		41.1 ± 9.7		-	
	N	**%**	**N**	**%**	**N**	**%**
BRCA1	141	80%	66	84%	75	77%
BRCA2	36	20%	13	16%	23	23%
Nulliparous	41	23%	17	22%	24	25%
Postmenopausal	141	80%	71	90%	70	71%
Ever RRM	99	56%	48[c]	61%	51	52%
Ever BPSO	122	69%	60[d]	76%	62	63%
Educational level[e]						
Low	71	41%	37	47%	34	35%
Medium	64	37%	22	28%	42	43%
High	40	23%	19	24%	21	22%

RRM, risk reducing mastectomy; BPSO, bilateral prophylactic (salpingo-) oophorectomy

a In years

b At follow-up questionnaire

c 7/60 before breast cancer diagnosis; 1/7 was for benign disease and 1/7 was for endometrial carcinoma

d All after breast cancer diagnosis

e Low, primary school; medium, secondary school; high, college or university; n=2 missing

completion (Table 1). There were no significant differences in characteristics between cases and unaffected carriers (data not shown).

Almost all carriers (99%) reported ever having had a mammogram which was in agreement with the medical record information (Table 2). Two negative self-reports (1%, both unaffected carriers screened by MRI only) were confirmed as well, resulting in an accuracy of ever/never having had a mammogram of 100%. The accuracy of ever/never having had a mammogram before age 30 and at ages 30-40 was good to excellent: agreement, κ, sensitivity, specificity, PPV, and NPV were at least 90%, 0.80, 88%, 81%, 78%, and 89%, respectively. The PPV of ever/never having had a mammogram before age 40 was lower in cases than in unaffected carriers (P=0.03 and P=0.65 for ages 30-40 and before age 30, respectively).

Among women who reported ever having had a mammogram, the mean age at first mammogram was 36.0 ± 10.0 years based on self-report and 36.8 ± 9.9 years based on medical record information. The mean time between age at first mammogram and questionnaire completion was 15.1 ± 6.4 and 11.4 ± 7.2 years for cases and unaffected carriers, respectively (P<0.001). The accuracy of exact age at first mammogram was poor to moderate (agreement 39%, κ 0.37) (Table 2). Accuracy was higher for cases than for unaffected carriers, but this was not significantly different (P=0.142). Cases more often tended to report a younger age at first mammogram, while unaffected carriers more often reported an older age at first mammogram as compared with the medical record; however, a separate $\chi 2$ test on the direction of inaccuracy showed that this difference was not statistically significant (P=0.146). For accuracy within 1 year, agreement

improved to 70% and κ to 0.69 and there no longer was a difference between cases and unaffected carriers (P=0.511).

The accuracy of self-reported age at last mammogram was moderate (agreement 52%; κ 0.51) (Table 2). For accuracy within 1 year, agreement and κ values improved to excellent (agreement 83, κ 0.82). Accuracy of age at last mammogram was better for unaffected carriers than for cases but this was not significantly different (P=0.775 and P=0.192 for exact agreement and agreement within 1 year, respectively). For both cases and unaffected carriers, the direction of inaccuracy tended to involve a self-reported age at last mammogram that was older than the age retrieved from the medical record (32% with an older versus 16% with a younger self-reported age). For both directions of inaccuracy, the median difference between the self-reported age and age retrieved from the medical record was 1 year (data not shown). The mean time between age at last mammogram and questionnaire completion was 5.2 ± 4.4 and 3.3 ± 3.7 years for cases and unaffected carriers, respectively (P=0.003).

For lifetime number of exposures, accuracy was moderate (agreement 55%, κ 0.40). The accuracy was poor for number of exposures before age 30 (agreement 34%, κ 0.24) and at ages 30-40 (agreement 24%, κ 0.13) and good for number of exposures in the past 5 years (agreement 68%, κ 0.55) (Table 2). Cases performed better than unaffected carriers on number in the past 5 years and number before age 30, but this was not significantly different (P=0.145 and P=0.313, respectively). For all items on number of exposures, the direction of inaccuracy indicated that carriers tended to overreport the number of mammograms; however, the direction of inaccuracy was not different between cases and unaffected carriers. The median numbers of exposures over- and underreported were 2 and 1, 2 and 1, and 3 and 2, for number of exposures before age 30, at ages 30-40, and in the last 5 years, respectively. The size of disagreement on total number of mammograms lifetime, of which 36% (54/148) was overreported, is shown in Table 3.

We examined determinants of inaccuracy of self-reported age at first mammogram lifetime (Table 4). In univariate analysis, there were two marginally significant predictors of inaccuracy on age at first mammogram: a higher age at questionnaire completion increased inaccuracy (Odds Ratio (OR)=1.01, 95%CI=0.99-1.04), and complaints versus screening as the reason for the first mammogram decreased inaccuracy (OR=0.50, 95%CI=0.25-1.00). Case-status decreased the chance of inaccuracy but this was not statistically significant (OR=0.64, 95%CI=0.34-1.22). In the multivariate model, we found no significant predictors of inaccuracy of self-reported age at first mammogram. Additional multivariate analysis (data not shown) on predictors of the direction of inaccuracy showed that greater length of recall increased the chance of underestimating the age at first mammogram (OR=1.16, 95%CI=1.01-1.33). Case-status and ever having had RMM were non-significant predictors (OR=2.21, 95%CI=0.70-6.97 and OR=2.29, 95%CI=0.76-6.93, respectively) (data not shown).

TABLE 2. Accuracy of self-reported mammography history in the follow-up questionnaire

	Total (N=177)		Cases (N=79)		Unaffected (N=96)		
	N	%	N	%	N	%	P*
Ever/never							
Lifetime							
(self-report/medical record)							
never / never	2	1%	0	0%	2	2%	
never / ever	0	0%	0	0%	0	0%	
ever / never	0	0%	0	0%	0	0%	
ever / ever	175	99%	79	100%	96	98%	
Agreement	*100%*		*100%*		*100%*		-
κ	-		-		-		
Sensitivity	*100%*		*100%*		*100%*		
Specificity	*100%*		*100%*		*100%*		
PPV	*100%*		*100%*		*100%*		-
NPV	*100%*		*100%*		*100%*		
Before age 30							
(self-report/medical record)							
never / never	116	73%	61	86%	55	63%	
never / ever	4	3%	1	1%	3	3%	
ever / never	7	4%	2	3%	5	6%	
ever / ever	33	21%	7	10%	26	29%	
Agreement	*93%*		*96%*		*91%*		*0.237*
κ	*0.81*		*0.80*		*0.80*		
Sensitivity	*89%*		*88%*		*90%*		
Specificity	*94%*		*97%*		*92%*		
PPV	*83%*		*78%*		*84%*		*0.650*
NPV	*97%*		*98%*		*95%*		
Between age 30 and 40[a]							
(self-report/medical record)							
never / never	59	39%	26	37%	33	41%	
never / ever	5	3%	1	3%	4	5%	
ever / never	6	4%	6	9%	0	0%	
ever / ever	80	53%	37	53%	43	54%	
Agreement	*93%*		*90%*		*95%*		*0.241*
κ	*0.85*		*0.80*		*0.90*		
Sensitivity	*94%*		*97%*		*91%*		
Specificity	*91%*		*81%*		*100%*		
PPV	*93%*		*86%*		*100%*		*0.026*
NPV	*92%*		*96%*		*89%*		
Age at first							
Exact agreement							
equal	62	39%	32	45%	30	34%	
self-reported age older	48	30%	16	23%	32	37%	
self-reported age younger	48	30%	23	32%	25	29%	
Agreement	*39%*		*45%*		*34%*		*0.142*
κ	*0.37*		*0.43*		*0.32*		
Agreement within 1 year							
equal	111	70%	53	75%	58	67%	
self-reported age older	20	13%	7	10%	13	15%	
self-reported age younger	27	17%	11	15%	16	18%	
Agreement	*70%*		*75%*		*67%*		*0.511*
κ	*0.69*		*0.73*		*0.65*		

Age at last[b]							
Exact agreement							
equal	89	52%	38	49%	51	55%	
self-reported age older	54	32%	26	34%	28	30%	
self-reported age younger	27	16%	13	17%	14	15%	
Agreement	*52%*		*49%*		*55%*		*0.775*
κ	*0.51*		*0.48*		*0.53*		
Agreement within 1 year							
equal	141	83%	60	78%	81	87%	
self-reported age older	19	11%	10	13%	9	10%	
self-reported age younger	10	6%	7	9%	3	3%	
Agreement	*83%*		*78%*		*87%*		*0.192*
κ	*0.82*		*0.77*		*0.87*		
Number of exposures							
Lifetime							
Categorical (1-3, 4-6, 7-9, 10 or more)							
equal	81	55%	37	57%	44	53%	
self-reported no. higher	54	36%	22	34%	32	39%	
self-reported no. lower	13	9%	6	9%	7	8%	
Agreement	*55%*		*57%*		*53%*		*0.840*
κ	*0.40*		*0.39*		*0.38*		
Before age 30							
equal	11	34%	4	57%	7	28%	
self-reported no. higher	19	59%	3	43%	16	64%	
self-reported no. lower	2	6%	0	0%	2	8%	
Agreement	*34%*		*57%*		*28%*		*0.313*
κ	*0.24*		*0.52*		*0.15*		
Between age 30 and 40[a]							
equal	18	24%	8	23%	10	25%	
self-reported no. higher	44	59%	23	66%	21	53%	
self-reported no. lower	13	17%	4	11%	9	22%	
Agreement	*24%*		*23%*		*25%*		*0.385*
κ	*0.13*		*0.11*		*0.13*		
In the past 5 years[b]							
equal	103	68%	53	76%	50	61%	
self-reported no. higher	33	22%	12	17%	21	26%	
self-reported no. lower	16	11%	5	7%	11	13%	
Agreement	*68%*		*76%*		*61%*		*0.145*
κ	*0.55*		*0.65*		*0.47*		

* P-value of Pearson's $\chi 2$ or Fisher's exact test difference in agreement and PPV between cases and unaffected carriers; for agreement and PPV ever/never exposure comparison: 2x2 table; for agreement comparison of age at first and last exposure, and number of exposures: 2x3 table

a Carriers who were younger than 30 years at questionnaire completion excluded

b Prior to questionnaire completion

TABLE 3. Differences in number of exposures lifetime between medical record data and self-reported data in the follow-up questionnaire

		Self-report				
		1-3	4-6	7-9	10 or more	*Total*
Medical record	1-3	24	12	3	4	*43*
	4-6	6	20	8	8	*42*
	7-9	0	4	8	19	*31*
	10 or more	1	0	2	29	*32*
	Total	*31*	*36*	*21*	*60*	*148*

TABLE 4. Analysis of potential determinants of inaccuracy of self-reported age at first mammogram in the follow-up questionnaire

	Inaccurate age at 1st mammogram[a] N=158	
Potential determinants of inaccuracy	**Univariate OR (95% CI)**	**Adjusted OR[b] (95% CI)**
Case status (case vs. unaffected)	0.64 (0.34, 1.22)	0.78 (0.33, 1.85)
Age at follow-up questionnaire (per year)	1.01 (0.99, 1.04)	1.01 (0.96, 1.06)
Educational level		
Medium vs. low	0.81 (0.39, 1.67)	0.99 (0.43, 2.25)
High vs. low	1.50 (0.63, 3.57)	2.15 (0.80, 5.80)
Nulliparous (yes vs. no)	0.57 (0.27, 1.18)	0.49 (0.19, 1.26)
RRM (ever vs. never)	1.34 (0.71, 2.55)	1.78 (0.81, 3.90)
Menopausal status		
Natural menopause vs. premenopausal	2.21 (0.59, 8.32)	2.06 (0.28, 15.2)
BPSO vs. premenopausal	1.09 (0.49, 2.40)	0.96 (0.30, 3.06)
Reason 1st mammogram[c]		
Complaints vs. screening	0.50 (0.25, 1.00)	*
Other reason vs. screening	1.45 (0.47, 4.44)	
Lifetime no. of mammograms (≥7 vs. 1-6)[c]	0.88 (0.45, 1.69)	NA
Lifetime no. of mammograms (≥7 vs. 1-6)[d]	0.78 (0.41, 1.50)	1.01 (0.44, 2.32)
Length of recall[e] (per year)	1.00 (0.95, 1.06)	1.00 (0.92, 1.09)

OR, odds ratio; CI, confidence interval; NA, not applicable

a Exact accuracy

b Obtained from multivariate logistic regression model, adjusted for all applicable variables listed in table except lifetime no. of mammograms

c Self-reported

d Medical record

e Length of recall = age at follow-up questionnaire completion minus ((self-reported age at 1st mammogram + age at 1st mammogram based on medical record)/2)

* Dropped because of collinearity

The accuracy of ever/never having had a prediagnostic mammogram was excellent (agreement 89%, κ 0.76; Table 5). Accuracy of self-reported age at first prediagnostic mammogram was poor for exact age (agreement 31%, κ 0.29) and moderate for age within 1 year (agreement 65%, κ 0.64). Again, cases more often underestimated their exact age at first mammogram, while unaffected women tended to overestimate (P=0.016); for accuracy within 1 year this difference was not statistically significant (P=0.713). In the 76 carriers who reported an inaccurate age at first prediagnostic mammogram, the difference between the self-reported age and the age retrieved from the medical record was only 1 year for 38 (50%) carriers (>2 years: 34%, >5 years: 18%); these proportion were not different between cases and unaffected carriers (P=0.337). Investigation of other items was not possible because the number of prediagnostic mammograms in specific age-periods was too small.

TABLE 5. Accuracy of self-reported prediagnostic mammography history in the follow-up questionnaire

	Total (N=177)		**Cases (N=79)**		**Unaffected (N=98)**		
	N	**%**	**N**	**%**	**N**	**%**	**P***
Ever/never[a]							
(self-report/medical record)							
never / never	42	25%	40	56%	2	2%	
never / ever	3	2%	3	4%	0	0%	
ever / never	5	3%	5	7%	0	0%	
ever / ever	119	70%	23	32%	96	98%	
Agreement	*95%*		*89%*		*100%*		*0.001*
κ	*0.88*		*0.76*		-		
Sensitivity	*98%*		*88%*		*100%*		
Specificity	*89%*		*89%*		*100%*		
PPV	*96%*		*82%*		*100%*		*<0.001*
NPV	*93%*		*93%*		*100%*		
Age at first							
Exact agreement							
equal	34	31%	4	17%	30	34%	
self-reported age older	37	34%	5	22%	32	37%	
self-reported age younger	39	35%	14	61%	25	29%	
Agreement	*31%*		*17%*		*34%*		*0.016*
κ	*0.29*		*0.15*		*0.32*		
Agreement ± 1 year							
equal	72	65%	14	61%	58	67%	
self-reported age older	16	15%	3	13%	13	15%	
self-reported age younger	22	20%	6	26%	16	18%	
Agreement	*65%*		*61%*		*67%*		*0.713*
κ	*0.64*		*0.59*		*0.65*		

* P-value of Pearson's $\chi 2$ test difference in agreement between cases and unaffected carriers; for ever/never exposure comparison: 2x2 table; for comparison of age at first exposure: 2x3 table

a For both the self-report and the medical record data: if the age at first mammogram was equal to or one year less than the age at diagnosis, the subject was assigned to the 'never' category

DISCUSSION

To our knowledge, this is the first study investigating accuracy of self-reported lifetime mammography history in BRCA1/2 mutation carriers. We observed that the accuracy varied between poor and excellent, depending on the measure under investigation. Reporting of ever/never exposure was excellent for all time frames (lifetime, before age 30, and at ages 30-40). Accuracy of age at first mammogram was poor to moderate for exact agreement and improved to almost excellent when considering agreement within 1 year. Although we observed no significant differential misclassification, cases tended to be more accurate than unaffected carriers, but if inaccurate, cases underreported (i.e. report a younger age) their age at first mammogram more than unaffected carriers. This difference was partly due to the longer recall period of the cases. As a result, the PPV of ever/never having had a mammogram was somewhat lower for cases than for unaffected carriers. Accuracy of age at last mammogram was moderate and improved to excellent for agreement within 1 year. We observed that carriers tend to underreport the time since last mammogram ("telescoping"). Accuracy of number of exposures was moderate for total number of mammograms, poor for number before age 30 and at ages 30-40, and moderate to excellent for number in the past 5 years. Carriers tended to overreport the number of mammograms independent of the specific age period recalled.

In general, our results are in line with previous validation studies in women from the general population. A recent review and meta-analysis on the validity of self-reported mammography reported a pooled sensitivity and specificity of ever having had a mammogram of 95% and 62%, respectively[6]. Differences in accuracy of self-reported (prediagnostic) mammography between affected and unaffected women were so far only investigated in two validation studies[16,17] which showed a certain amount of disagreement between self-reports and medical records but no differences between cases and controls. Accuracy of ever/never having had a mammogram was 100% as almost all carriers had ever had a mammogram and the two negative self-reports were validated as well. The accuracy of ever/never having had a mammogram before age 30 and at ages 30-40 was excellent: agreement, κ, sensitivity, specificity, PPV, and NPV were at least 90%, 0.80, 88%, 81%, 78%, and 89%, respectively.

Previous studies focused on validation of recent uptake of mammography and were conducted to evaluate screening programs[6]. The main aim of the present study was to assess accuracy of self-reported lifetime mammography history and potential differential misclassification in retrospective etiologic studies among BRCA1/2 mutation carriers who are screened frequently from a relatively young age onwards. Because especially exposure at young ages has been associated with increased breast cancer risk among carriers, a main interest was the accuracy of self-reported mammography before age 30 and prediagnostic mammograms. Cases tended to underreport (i.e. report a younger age) their age at first mammogram more often than unaffected carriers. For prediagnostic age at first mammogram we observed the same pattern, which could result in an overestimation of the association between early exposure of mammography and breast cancer risk, although age at first prediagnostic mammogram is not necessarily the same as early mammography. Additionally, the accuracy of ever/never having had a mammogram before age 30 was excellent and not different between cases and unaffected carriers. Furthermore, the direction of inaccuracy based on the baseline questionnaire (data not shown) was similar in unaffected carriers and cases (i.e. more often a younger self-reported age) indicating that the direction of inaccuracy among unaffected carriers is less consistent than among cases and the presence of differential misclassification is depends on measurement time and instrument. For all other items, the accuracy of self-reported mammograms in the baseline questionnaire was similar (data not shown) to what we observed for the follow-up questionnaire. Prediction modelling of determinants of direction of inaccuracy of age at first mammography showed that the difference between cases and unaffected carriers was partly due to the longer recall period of the cases (data not shown). Interestingly, this prediction model also showed that having had prophylactic surgery increased the chance of underreporting of the age at first mammogram. This finding supports the hypothesis of a recent psychological study[21] that a time interval punctuated by a greater number of relevant subsequent events (event markers) makes the target event feel more distant. In other words, life events related to mammography, like a breast cancer diagnosis or among unaffected carriers RRM and/or BPSO, may cause greater underreporting of the first mammography. In accordance with the lower accuracy with longer recall time, we found a lower accuracy for ever/never having had a prediagnostic mammogram than for ever/never having had a mammogram lifetime. Unfortunately, the numbers were too small to investigate accuracy of, for example, prediagnostic mammogram exposure before age 30 (N=2 cases). The two previous case-control studies that investigated accuracy of prediagnostic mammograms only included exposures within 5 years[17] and 10 years[16] prior to diagnosis an did not take exposure at young age into account. Therefore, we could not compare our results on accuracy of age at first mammogram with data from others.

As expected, accuracy of age at last mammogram was better than for age at first mammogram, which is in agreement with better recall of more recent mammograms[7-9]. Studies assessing the validity of date of last mammogram and/or time since last mammogram found that accuracy was between 30% and 70% for exact agreement and increased to between 50% and 97% for agreement within 1 year[7-9,11-15,22,23]. For age at last mammogram, we observed an accuracy of 52% and 83% for exact agreement and agreement within 1 year, respectively. Consistent with the finding of the meta-analysis[6] that women tend to overreport their participation in mammography screening in a recent, we observed evidence of telescoping, i.e. carriers tended to underreport the time since last exposure; two-thirds (54/81) of the carriers that misreported their age at last mammogram, had an older self-reported age than the age retrieved from the medical record. In our study, telescoping seemed to have led the direction of inaccuracy of age at last mammogram in cases and age at first and age at last mammogram in unaffected carriers towards overreporting, while the underreporting of age at first mammogram in cases may be the result of a larger number of event markers. Although the accuracy of age at last mammogram seemed better in our unaffected carriers than in cases, this difference was not statistically significant (87% versus 78%, respectively, P=0.192).

Similar to the result of prediction model of accuracy of age at first mammogram this finding may be related to a difference between unaffected carriers and cases in length of recall which is 3.3 and 5.2 years, respectively (P=0.003).
Two studies showed that accuracy of self-reported number of mammograms was relatively poor[11,16]. In the present study, poor accuracy was observed for number before age 30 and at ages 30-40 only. As expected, accuracy of number of exposures in the most recent period (i.e. number in the past 5 years) was best. However, this measure included 0 mammograms as well. Exclusion of the null category resulted in proportions agreement for cases and unaffected carriers of 68% and 51%, respectively (P=0.140). Even though number of mammograms lifetime was a categorical variable and therefore small differences in number of mammograms could not be detected, the accuracy was moderate. Like previous studies[11,16], we observed that carriers tended to overreport the number of mammograms, not only in recent, but in all time frames. Part of the overreporting of number of mammograms in the past 5 years may be attributed to the telescoping phenomenon. Another explanation for the overreporting in general might be that, if the procedure is believed to occur annually, the respondent will report receiving 5 screens in 5 years, while in fact the interval between examinations was estimated incorrectly[24].
As expected, we observed that accuracy of self-reported mammograms in carriers was sometimes better than in the general population, but not exceptionally high. An explanation may be the relatively high frequency of mammographic screening among carriers; Pogoda et al. observed that greater total exposure was associated with greater disagreement[16].
There are several limitations to this study. Although medical record data are considered to be a golden standard in self-report validation studies, we came across several barriers while conducting the present study. Firstly, a number of medical records were missing or did not report on mammograms (17%, 38/218). Records could have been misfiled, lost or destroyed as we were sometimes looking for mammograms taken in the distant past. Medical record notes on previous mammograms taken in other hospitals may have been reported to the physician by the carrier herself. Records may be incomplete because some hospitals maintained or accessed computerized records only. Considering that overall we could validate 81% of the eligible group and there were no differences between the eligible and validated group, we believe that this has not markedly influenced our results. Secondly, among the validations considered successful, we cannot be certain that records were indeed complete. For these reasons, accuracy may sometimes have been underestimated, especially for items like age at first mammogram if this had occurred a long time ago. Unfortunately, numbers were too small to investigate accuracy of, for example, prediagnostic mammogram exposure before age 30, which is a relevant measure in view of results from studies on breast cancer risk following diagnostic radiation.
In conclusion, we observed that the accuracy of self-reported lifetime mammography history in carriers varied between poor and excellent, depending on the measure under investigation. Accuracy was sometimes better than observed in studies in the general

population. Our study shows that accuracy is acceptable for use in an epidemiological study because accuracy of reporting age at first mammogram within 1 year approached excellence, accuracy of ever/never exposure before age 30 was excellent, accuracy of number of exposures was moderate, and, in general, there was no differential misclassification between cases and unaffected carriers. The observed non-differential misclassification and the overreporting of number of exposures will likely result in relative risks biased toward the null, underestimating the association between mammography and breast cancer risk.

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APPENDIX

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