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Willingness to test for BRCA1/2 in high risk women: Influenced by risk perception and family experience, rather than by objective or subjective numeracy?

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Abstract

Genetic testing for breast and ovarian cancer can help target prevention programs, and possibly reduce morbidity and mortality. A positive result of *BRCA1/2* is a substantial risk factor for breast and ovarian cancer, and its detection often leads to risk reduction interventions such as increased screening, prophylactic mastectomy and oophorectomy. We examined predictors of the decision to undergo cancer related genetic testing: perceived risk, family risk of breast or ovarian cancer, and numeracy as predictors of the decision to test among women at high risk of breast cancer. Stepwise regression analysis of survey responses from 459 women registered in the Cancer Genetics Network revealed greater likelihood to test for women with more family history, higher perceived risk of mutation, or Ashkenazi descent. Neither subjective nor objective numeracy was associated with the decision to test, although we replicated an earlier finding that subjective numeracy predicted willingness to pay for testing. Findings underscore the need for genetic counselling that disentangles risk perception from objective information to promote better decision-making in the context of genetic testing. Highlighting these factors is crucial for public health campaigns, as well as to clinic-based testing and direct-to-consumer testing.

Keywords: willingness to test, genetic testing, breast cancer, BRCA1 and 2, subjective numeracy, family history. early detection.

1 Introduction

Breast cancer is the most prevalent cancer among women (Siegel, Naishadham & Jemal, 2012). For decades, public health resources and campaigns have been dedicated to early detection and education (Lee et al., 2014) to women in high-risk groups. The *BRCA1* and *BRCA2* gene mutations, for example, are a known genetic risk factor for the development of breast and ovarian cancer (Squiers et al., 2010). Their detection allows women to be better informed and proactive about future health decisions, and indeed, detection with genetic testing has become more prevalent (Kolor et al, 2012; Myriad, 2007). As Direct-to-Consumer (DTC) genetic tests proliferate, the decision of whether to undergo genetic testing is often in the individual's own hands. This was the case when we conducted our study. Indeed, the availability of DTC testing for *BRCA* in the US has ebbed and flowed in the past few years (Food and Drug Administration, 2013). With the recent US Supreme Court decision in *Association for Molecular Pathology v. Myriad Genetics, Inc.* (2013), patent rights for the *BRCA1/2* genes were revoked, opening up the genetic testing market to competition.

With the growing accessibility to genetic tests, patients might want to test, and still be apprehensive of testing: among 69 patients who participated in semi-structured interviews on testing, many expressed concerns regarding discrimination, and psychological harm due to the testing results (Gray et al., 2013). Large-scale public health studies show that testing rates in general tend to be suboptimal (e.g., Schlich-Bakker et al., 2007; Tao, Hooevr & Kent, 2012).

In order to encourage testing for the most at-risk, women are currently advised to test for the *BRCA1/2* gene mutation if a family member has tested positive for it, or if a close relative has been diagnosed with cancer (Moyer, 2014; National Cancer Institute, 2013). Guidelines also establish a standard of care for women who have family members with breast, ovarian, tubal, or peritoneal cancer that

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call for screening, genetic counselling, and, if appropriate, *BRCA* testing (U.S. Preventive Services Task Force [USPSTF], 2005; Moyer, 2014; National Comprehensive Cancer Network [NCCN], 2013). In practice, a meta-analysis of 40 studies revealed that 59% of the women identified by the investigators as high-risk would test. However, testing rates varied from 25% to 96%, depending on the study (Ropka, Wenzel, Philips, Siadaty & Philbrick, 2006). Interestingly, some work has shown that family history of breast cancer does not predict testing among women with or without breast cancer (Bruno et al., 2010). In contrast, earlier investigations have shown that attitudes, cancer worry, knowledge, religious involvement, and risk perception influence women's decision to undergo genetic testing (Chaliki et al., 1995; Ruddy et al., 2010). Thus, the decision whether to undergo genetic testing is complex (Sankar, Wolpe, Jones & Cho, 2006).

Perceived risk of breast cancer, or genetic mutations associated with it may also predict decisions related to testing for *BRCA1/2*. Prior work has found women who perceive themselves to be at greater risk of developing the disease to be more likely to test for *BRCA1/2*, and at a higher price (Chaliki et al., 1995; Ruddy et al., 2010). Further, women at increased risk for breast cancer show significantly higher levels of cancer-specific distress (but not general distress) relative to a comparison group (Rees, Fry, Cull & Sutton, 2004).

Likelihood to test increases as cancer becomes less of a theoretical concern, and more of a concrete fear. Women 40 years old or younger diagnosed with breast cancer are more likely to have undergone genetic testing if they have a first- or second-degree relative with breast or ovarian cancer (Ruddy et al., 2010). Indeed, family history of cancer is not only a medical risk factor but is also associated with a personal sense of vulnerability (Walter, Emery, Braithwaite & Marteau, 2004). Such vulnerability may extend to women in high-risk groups, even in the absence of a direct family member afflicted with cancer (e.g., Ashkenazi descent; Bowen, Burke, Culver, Press & Crystal, 2006). This tendency, however, is not absolute. Medical communication about breast cancer within the family is often problematic, and women may not even be fully aware of their family's level of risk (Claes, et al., 2002; Julian-Reynier et al., 2000). Alternately, some studies have examined specific groups, such as New York Latinas, and Blacks with low numeracy levels, that tend to be less likely to pursue testing, despite perceived vulnerability for *BRCA1/2* mutations: more competing life concerns minimize motivation to get tested (Langford, Resincow, Roberts & Zikmund-Fisher, 2007; Sussner, Jandorf, Thompson & Valdimarsdottir, 2012).

The decision to test may be influenced by personal factors as well as environmental factors. Numeracy, the ability to understand and manipulate numbers, has been shown to play a role in calculating various statistical estimates, including understanding medical risk information (e.g., Hanoch, Miron-Shatz & Himmelstein, 2010; Låg, Bauger, Lindberg & Friborg, 2014 ; Schwartz, Woloshin, Black & Welch, 1997). Assumedly, higher levels of numeracy should be associated with testing rates, so that women at higher risk for developing breast cancer would be more likely to test, and women at a lower risk would be less likely. Accordingly, Lipkus, Peters, Kimmick, Liotcheva and Marcom (2007) found that more numerate women tended to estimate more accurately their breast cancer risks, and were significantly more open to recommended risk management strategies. Similarly, in a sample of 6,754 adult respondents to the National Cancer Institute's 2007 Health Information National Trends Survey (HINTS), numeracy was found to directly lead to awareness of DTC genetic tests (Lanford, et al., 2007). As far as we are aware, the present study is the first to directly examine whether high numeracy informs the decision to test.

Numeracy can be measured through objective, behavioural tests and subjective, self-report questionnaires. Objective numeracy scales examine comprehension of frequency, probability and percentages (Schwartz et al., 1997; Lipkus, Samsa & Rimer, 2001). In contrast, the subjective numeracy scale (SNS, Fagerlin et al., 2007) measures perceived ability to perform various mathematical operations and preference for the use of numeric rather than textual information (Lipkus et al., 2007). SNS can differentiate among people with objectively low and high numeracy skills across different demographic groups: it is quicker to administer and provides a more agreeable experience for participants than the objective scale questions (Galesic & Garcia-Retamero, 2010). Recently it has been shown that subjective, but not objective, numeracy predicted women's decisions to pay for breast cancer testing (Miron-Shatz, Hanoch, Omer, Doniger & Ozanne, 2014).

To our knowledge, ours is the first examination of willingness to test and actual testing behaviour among women at high risk of breast cancer, involving perceived risk, family risk, and numeracy, both subjective and objective. To accomplish this, we recruited women with a family history of breast or ovarian cancer, from the registrants of the Cancer Genetic Network (CGN), some of whom had previously tested, and had already received results. Analyses were cross-sectional, but data were collected at different time points, for different participants. The data allowed us to test the following hypotheses: (i) high-risk women with more relatives with breast or ovarian cancer will be more likely to test; (ii) presence of a family member with a positive *BRCA1/2* test result will be associated with greater likelihood of testing; (iii) women with higher perceived risk of mutation and developing the disease will be more likely to test, as well as those more worried that the test might find illness; (iv) women with higher numeracy—both subjective

and objective—will be more likely to test, with a greater role for subjective numeracy given its emphasis on perception of numbers (Fagerlin et al., 2007); and, finally, (v) older women will be more likely to test.

2 Method

2.1 Participants

Participants were 449 female registrants in the Cancer Genetics Network (CGN), a US national population-based cancer registry. Inclusion criteria were: (a) unaffected by breast or ovarian cancer, and (b) family members at a higher risk for breast cancer. In this case, higher risk was defined as having at least one relative diagnosed with breast cancer at age 45 or younger, two or more diagnosed with breast cancer at age 50 or younger, or at least one diagnosed with ovarian cancer or male breast cancer. Because this was a higher-risk group, participants had a greater probability of being a carrier of the *BRCA1/2* gene. Consent was obtained and the survey completed via emails from the local CGN branch (Appendix Table A1). The CGN also maintains a core data set on each registrant and stores de-identified information on non-financial socio-demographic and medical characteristics made available to researchers with ethical approval. The CGN did not maintain data concerning differing levels of risk for breast cancer within the high-risk group.

2.2 Procedure

Respondents completed an online survey. They were assured that no knowledge of genetics was required to participate and that their identifying information would remain confidential. Respondents were told that the survey would take about 30 minutes. They had an option of receiving a $30 gift card and could skip any question that made them uncomfortable. Measurement of variables was after disclosure of the genetic testing results and occurred at different points in time for different participants. The dependent variable investigated was whether the woman had tested for the *BRCA1/2* mutation. Predictor variables were number of relatives with breast or ovarian cancer, presence of family member(s) testing positive, being of Ashkenazi (Eastern European Jewish) descent, perceived risk of having a mutation, perceived risk of developing breast cancer, worry that the test might find illness, objective numeracy, subjective numeracy, and age. Though we refer to the independent variables studied as "predictor variables", the dataset was cross-sectional. Predictor variables were computed as follows:

***Number of Relatives with Breast or Ovarian Cancer*:** Number of relatives with breast or ovarian cancer (range in dataset: 1 to 13, with an open-ended question) from the CGN database.

***Of Ashkenazi (Eastern European Jewish) Descent*:** Response options for this CGN database variable were "Yes", "No", or "Unknown" – "No" and "Unknown" were combined for analysis purposes. Values of this variable were "No or Unknown" (coded 0) or "Yes" (coded 1).

***Family Member(s) with Positive Test Result*:** The concatenated responses to questions from the CGN database, asking "Has anyone in your family ever tested positive for a *BRCA1* mutation?" and likewise for *BRCA2*. Response options were "No", "Yes", "Not Sure", and "Rather Not Answer" (not selected by any participants). We recorded the responses as "Yes" (coded '3') if the response to either question was "Yes", "No" (coded 1) if the response to both questions was "No", and "Unknown" (coded 2) for all other cases.

***Perceived Risk of Having the BRCA1/2 Mutation*:** For participants who had not previously tested, responses to the survey question: "What do you think the chances are that you have the *BRCA1* or *BRCA2* gene mutation?" For participants who had previously tested, responses to the survey question: "Before you were tested for the *BRCA1* or *BRCA2* gene mutation, what do you think was the chance that you had the mutation?" Participants responded by placing an "X" on a number line running from 0 to 100%.

***Perceived Risk of Developing Breast Cancer*:** Participants who had not previously tested, responded to the following survey question: "What do you think is the chance of you developing breast cancer?" Participants who had previously tested, responded to the survey question: "Before you were tested for the *BRCA1* or *BRCA2* gene mutation, what did you think was your chance of developing breast cancer?" Again, participants responded by placing an "X" on a number line running from 0% to 100%.

***Number of Relatives with Breast or Ovarian Cancer*:** Number of relatives with breast or ovarian cancer from the CGN database.

***Worried that Test Might Lead to Discovery of Illness*:** Responses to this survey question were on a 5-point Likert scale with options of "Not Worried At All" (1), "Slightly Worried" (2), "Of Medium Worry" (3), "Worried" (4), and "Very Worried" (5). Participants who had previously tested were instructed to try to think of how worried they were before they got tested.

***Objective Numeracy*:** Respondents completed three survey questions to test facility with numbers (e.g., how many of 1,000 coin flips would come up heads) (Schwartz et al., 1997). Each question was scored as correct (1) or incorrect (0). Total number correct was analysed.

***Subjective Numeracy*:** As part of the survey, participants completed the SNS (Fagerlin et al., 2007). The overall SNS score analysed was the average rating across all eight SNS questions, with one of the questions reverse coded.

***Age*:** Participant age (in years) from the CGN database.

Table 1: Correlations for predictors included in the regression analyses.

	2	3	4	5	6	7	8	9
1. Perceived risk of mutation	.553	−.052	.046	.027	−.066	.282	.083	.185
2. Perceived risk of developing breast cancer	1	−.107	.002	−.007	−.004	.120	−.027	.050
3. Objective Numeracy		1	.364	−.172	−.040	.009	.028	.058
4. Subjective Numeracy			1	−.171	−.065	.040	−.066	.018
5. Worry that the test might find illness				1	−.034	−.086	−.063	−.072
6. Age					1	.036	−.020	−.025
7. Number of relatives with breast or ovarian cancer						1	.131	.155
8. Presence of family member(s) testing positive							1	.080
9. Of Ashkenazi descent								1

2.3 Statistical analyses

Correlations were calculated between the main variables of interest (see Table 1). Data were also analysed using stepwise regression, in which the most important predictors are selected from among the set of predictor variables. We ran both forward and backward regressions, with the entry and removal level set at 0.10 respectively (see Appendix tables A2 and A3 for order of inclusion in the final regression analysis). Consistency of results across forward and backward procedures confirms the importance of significant predictors, irrespective of the variable selection process. $P < 0.05$ was considered statistically significant.

We examined predictors of whether participants had previously been tested for the *BRCA 1/2* mutations. The same set of predictors was entered *a priori* into all models: perceived risk of mutation, perceived risk of developing breast cancer, worry about a positive test result, number of relatives with breast or ovarian cancer, family member(s) with a positive *BRCA* testing result, age, and Ashkenazi descent. Binary logistic regression was used to model previous testing.

3 Results

Of 961 eligible participants invited to complete the online survey, 459 (mean age = 50.44 years, *sd* = 7.45; 72% college graduates; 78% married/cohabiting) consented and completed the survey (48% response rate). For total objective numeracy (possible scores: 0 to 3), the range was 0–3, with a mean of 1.97 and a standard deviation of 0.94. For SNS (possible scores: 1 to 6), the range was 2–6, with a mean of 4.74 and a standard deviation of 0.82.

3.1 Previous testing

Of the 449 participants who responded to the question on whether they had previously tested, 70% ($N = 315$) reported that they had not previously tested for the *BRCA1* or *BRCA2* genetic mutation, and 30% ($N = 134$) reported that they had previously tested.

A forward stepwise binary logistic regression predicting previous testing limited analysis to the 325 participants who both responded to the question regarding previous testing and had data for all of the predictor variables (not tested: $N = 216$; tested: $N = 109$). Analysis revealed statistically significant effects of number of relatives with breast or ovarian cancer (Wald $\chi^2 = 3.86$, $P = 0.049$, more likely to test with more affected relatives; e.g., 1–2 affected relatives: 19% tested, >2 relatives: 48% tested), and family member(s) testing positive (Wald $\chi^2 = 23.34$, $P < 0.001$, more likely to test with greater certainty of family member(s) testing positive; yes: 89% tested, no: 39% tested). Additional significant predictors were perceived risk of having a mutation (Wald $\chi^2 = 34.25$, $P < 0.001$, more likely to test with higher perceived risk; e.g., perceived risk $\leq$50%: 21% tested, perceived risk >50%: 55% tested), Ashkenazi descent (Wald $\chi^2 = 14.03$, $P < 0.001$, more likely to test if of Ashkenazi descent; Ashkenazi: 77% tested, not Ashkenazi/unknown: 28% tested), and young age (Wald $\chi^2 = 4.01$, $P = 0.045$, more likely to test if older; e.g., <40 years: 19% tested, $\geq$40 years: 35% tested). Other predictors (objective numeracy, subjective numeracy, perceived risk of developing breast cancer, and worry that the test be positive) were not included in the final model as they were not significant. Results were identical for the corresponding backward stepwise logistic regression analysis, indicating that the significant predictors obtained in the forward model are predictive of previous testing irrespective of the variable selection process. Further, results were identical even when cancer center was added as an additional predictor, indicating that, relative to the other predictors, the particular cancer center

participants came from did not have an appreciable effect on decision to test.

Since the CGN dataset does not include information on income, we used educational level as a proxy for socioeconomic status (Grzywacz, Almeida, Neupert & Ettner, 2004). Previous testing status did not differ by educational level, with 28% (35/124) of participants with less than a college degree and 30% (99/325) of college graduates reporting previous testing ($\chi^2 = 0.21$, $P = 0.64$).

3.2 Results of willingness to pay (WTP) analyses in all participants

The current data set allowed us to re-examine the results of Miron-Shatz et al. (2014) with the full sample, including those who were tested as well those who were not (the only ones used in the earlier study). Of particular interest are the correlations of WTP with subjective and objective numeracy.

WTP was significantly correlated with subjective numeracy ($r = .185$, $P < .001$) but not with objective numeracy ($r = -0.062$, $P = .199$), and these two correlations were significantly different from one another (Steiger's $Z = 4.45$, $P < .001$) despite the substantial correlation between objective numeracy and subjective numeracy ($r = .364$, $P < .001$). Although WTP is correlated with being tested (.429, by biserial correlation), we have already pointed out that being tested did not correlate with either type of numeracy, so the difference between subjective and objective numeracy in this sample cannot be explained by inclusion of subjects who were tested. (In fact, the correlation of WTP with subjective numeracy is also significantly higher than the biserial correlation of subjective numeracy with being tested [.031].)

Educational level (less than college graduate vs. college graduate or graduate school) could not explain the differential correlation between type of numeracy and WTP, as educational level was correlated with both subjective ($r = .161$, $P = .001$) and objective ($r = .253$, $P < .001$) numeracy, and not with WTP ($r = .037$, $P = .444$).

Similarly, worry that the test might find illness could not explain the differential correlation between type of numeracy and WTP, as worry was (negatively) correlated with both subjective ($r = -.171$, $P < .001$) and objective ($r = -.172$, $P < .001$) numeracy, and not with WTP ($r = -.018$, $P = .714$).

WTP was also significantly correlated with perceived risk of having a mutation ($r = .280$, $P < .001$) and, unlike in the more limited sample, WTP was significantly correlated with perceived risk of developing breast cancer ($r = .162$, $P = .001$).

Neither age ($r = -.048$, $P = .321$) nor presence of family member(s) testing positive ($r = .085$, $P = .077$) predicted WTP. However, unlike in the published sample of women who had not tested, WTP was correlated with number of relatives with breast or ovarian cancer ($r = .147$, $P = .005$) and Ashkenazi descent ($r = .155$, $P = .001$).

4 Discussion

This study examined factors affecting the decision to test for the *BRCA 1/2* gene mutations in women reporting a family history of breast and ovarian cancer. The findings indicate that women with more family members with breast or ovarian cancer, or with a family member who tested positive for the *BRCA1/2* mutation are more likely to have undergone *BRCA1/2* genetic testing. In addition, women who perceived a higher risk of carrying the mutation, those of Ashkenazi descent and older women were more likely to undergo testing.

Numeracy—both subjective and objective—did not influence whether women tested for *BRCA1/2*. While these results seem not to dovetail with earlier work, it should be noted that the majority of earlier studies focus on the link between numeracy and comprehension of risk information. Furthermore, our results are not isolated. For example, Vassy and colleagues (Vassy, O'Brian, Waxler, Park, Delahanty, Florez, et al., 2012), examined participants' motivation to change behaviour following genetic testing for diabetes. In their study, participants were classified as either low-risk or high-risk. The Vassy et al. (2012) study showed that among high risk individuals, numeracy levels were not associated with motivation to alter behaviour, while in the low-risk group, individuals with low-numeracy skills expressed greater motivation to change behaviour. Although there are indications that numeracy is related to greater awareness of DTC genetic testing (Agurs-Collins, Ferrer, Ottenbacher, Waters, O'Connell & Hamilton, 2015), this relationship is typically found among the general population, whereas few studies examine this association in high-risk individuals, as in our study.

Our results thus suggest that awareness of the statistical relevance of undergoing genetic testing, and actually testing, are unrelated to the ability to use or interpret the results. Rather, it is possible that the decision to undergo testing is based not on comprehension of multiple factors, but rather on a single cue or a one-reason-based heuristic (Gigerenzer & Gaissmaier, 2011): having a family history. That is, among the women who decide to test, their decision is largely driven by whether or not they have a family history. This idea, however, will require further testing. Cancer worry was not a predictor of the decision to test as measured by the participant's actual behaviour in the past—specifically, whether or not she tested for *BRCA 1* and *2* gene mutations. This probably was due to the majority of our participants (64%) reporting no cancer worry, consistent with the distribution of cancer worry in both general

and high-risk populations, but precluding empirical and theoretical conclusions (Hay, Buckley & Ostroff, 2004).

Our finding that the decision to test is predicted by presence of a family member with a positive test result and Ashkenazi descent must be qualified by the greater likelihood of a physician recommending testing in such individuals (Squiers et al., 2010). Thus, in practice, testing is likely influenced by desire to comply with physician recommendation, though this factor was not examined in the current study.

We found that the decision to test is predicted by perceived risk of having the mutation (but not perceived risk of developing breast cancer). This is consistent with research suggesting that risk assessment is not solely through cognitive lenses, or "risk as analysis", but is also based upon instinctive and intuitive reactions, or "risk as feeling" (Lowenstein, Weber, Hsee & Welch, 2001). That even subjective numeracy did not predict the decision to test suggests that the role of emotion, as expressed by perceived risk and personal experience, may exceed the role of the cognitive benefits of knowledge from testing. The process might be such that women feel an "emotional need" to find out whether they are carriers, which overrides their assessment of whether they would be able to make use of the information. Indeed, research in a variety of contexts has shown that personal experience has led people to perceive hazards as more frequent, themselves as potential future victims, and to think about risk more often and with greater clarity (Lindell & Perry, 2012; Weinstein, 1989). Health advertising studies have similarly found that advertisements for DTC tests are especially effective for women with a higher perceived threat for developing breast cancer (Rollins, Ramakrishnan & Perri, 2014). Granted, this possibility should be tested more directly in this vulnerable population.

Previous work (Miron-Shatz et al., 2014) examined willingness to pay (WTP) for breast cancer testing in this population, using only a sub-sample of women who were not previously tested, and for whom we had data on willingness to pay (n = 299). They were asked "How much money would you be willing to spend on getting testing for the *BRCA1* and *BRCA2* gene mutations?" and were instructed to assume that testing was not covered by their medical insurance. We excluded women who had tested because their response would likely have been influenced by actual cost of testing. The main findings were that subjective numeracy (but not objective numeracy, number of relatives with breast or ovarian cancer, presence of family member(s) testing positive, age, Ashkenazi descent, worry that the test might find illness, perceived risk of developing breast cancer, or educational level) correlated positively with WTP, as did perceived risk of having a mutation. The contrast between subjective and objective numeracy as predictors of WTP was replicated here (section 3.2) with a larger sample that included those who were tested (n=429).

Unlike that work, the present paper focused on *all* participants who responded to the question on whether they had previously tested (N =449, though the number of participants who had data for all study variables and were included in the main analysis was 325). Rather than asking a hypothetical question, the main dependent variable was a behavioural one—whether or not the participants had tested for the *BRCA* gene mutation. The main predictors here were family history (number of relatives with breast or ovarian cancer and relatives who tested positive), perceived risk of having the mutation, Ashkenazi descent, and age. This is in keeping with literature suggesting that family history of breast cancer and perceived risk will increase the likelihood of testing (Ropka, et al., 2006). Although there has been ample research into the lower testing rates of other ethnoreligious groups (e.g., Levy, et al., 2011), the higher rate of Ashkenazi testing seems to be a novel finding.

The numeracy variables, as well as perceived risk of developing breast cancer, and worry that the test be positive, were not significant predictors of testing. We suggest interpreting the different results obtained in the two studies as reflecting whether the decision is made solely (or even mainly) by the woman, as in the decision of how much to pay for testing, or also by her physician, by adhering to guidelines and recommending testing to women with a relevant family history. This would explain why numeracy variables do not predict the decision to test and would suggest that, unlike WTP, decision to test does not depend on the woman's sense of how easily she will be able to interpret the testing results. This is particularly important in view of the abundance of research on WTP, but the relative paucity of research on actual testing behaviour. The findings suggest that while WTP is mainly driven by emotional reasons, actual testing is based primarily on family history, including being of Ashkenazi descent. It might be that public health efforts to promote testing should focus on creating clear recommendations and action paths via healthcare professionals, rather than appealing to women's concerns regarding breast cancer. However, these conclusions must be qualified in that we do not know which of our participants were indeed referred for testing by their physicians.

The present results have important practical implications for both conventional clinic-based testing and any potential DTC genetic testing. Since perceived risk of having the mutation is a central factor in women's decision to test, DTC marketing campaigns may increase anxiety and perceived risk by exploiting consumers' emotional concerns (Gollust, Hull & Wilfond, 2002). Further, upon receipt of DTC testing results, consumers of *BRCA* test results may experience anxiety and distress (Dohany, Gustafson, Ducaine & Zakalik, 2012), especially if they receive inadequate counselling during the process (Brierley et al., 2010). Given our find-

ings, if the counsellor is aware that family history and emotional relevance may impact the patient's decision, he/she will be able to offer better, more cogent advice.

This study has a number of limitations. Among participants who had not yet tested, many of their opinions on the testing process were necessarily hypothetical. For those who had already undergone *BRCA1/2* genetic testing, it was retrospective. Further, it was the women's decision to test, and we did not influence it. These groups relate differently to their breast cancer risk, and those who have not yet tested may not follow through on their indicated willingness to test (Rollins, et al., 2014). Indeed a potential criticism is that perceived risk may be affected by actual risk for women who previously tested. However, any such influence on our results is likely minimal, as the questions were worded to instruct women who were previously tested to respond as they would have prior to testing and the majority of participants were not tested.

Another limitation is that our sample was composed of a relatively small group of high-risk, mainly white women, who may not be representative of other low-risk and non-white populations. Indeed it may be that high-risk individuals have an intuitively better appreciation of risk and implications of testing. Follow-up studies in larger, more heterogeneous samples are needed to confirm our findings. Of the women we approached, only 48% responded. This response rate may be attributed to reluctance to delve into their disease or to more practical reasons, such as the relative length of the survey.

Further, it is possible that the response rate has made our sample less representative in terms of the educational level of the responders. The risk-level limitation, however, is mitigated by the fact that *BRCA1/2* genetic testing is sought mainly by women who are at high risk for developing cancer or have already been diagnosed with cancer (Ropka et al., 2006; but see King, Levy-Lahad & Lahad, 2014 who advocate population-based screening). As such, they are unlikely to appreciably affect the implications of our findings. In this regard, rather than a limitation, the sample risk level may be viewed as a strength, in that our findings are highly relevant to the women most likely to undergo *BRCA 1/2* genetic testing.

The current study explored factors that contribute to women's willingness to test for the *BRCA1/2* gene or decision to have done so in the past. Findings indicated that decision to test is influenced most by personal experiences, especially having relatives who are carriers of the *BRCA1/2* gene mutation, or have suffered breast cancer themselves. Similarly, being of the high-risk Ashkenazi group was also a major risk factor. Importantly, perceived chance of mutation, an emotional factor, was more predictive of willingness to test, and decision to test, than more objective numeracy skills.

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Appendix

Table A1: Demographic and clinical characteristics (N = 459).

Cancer center, %	Colorado	34%	n=157
	Duke	8%	36
	Emory	6%	25
	Johns Hopkins	13%	60
	MD Anderson	6%	25
	Univ. of North Carolina	6%	26
	Univ. of Utah	28%	129
Age, mean years (sd)		50.44 (7.45)	458
Highest degree or year of school completed, %	≤8 years	34%	157
	High School/GED	5%	24
	Some College/Technical	22%	101
	College+	72%	329
Marital status, %	Single	8%	37
	Married or Living Together	78%	356
	Separated	2%	7
	Divorced	11%	50
	Widowed	2%	8
Race, %	American Indian/Alaskan Native	1%	4
	Asian	1%	3
	Black or African American	1%	4
	White	96%	438
	More than one race	1%	5
	Other	<1%	1
Tested for BRCA1 or BRCA2 mutation, %	No	70%	315
	Yes	30%	134
	Tested Positive	33%	41
	Tested Negative	67%	85
Amount willing to pay (WTP) for BRCA 1/2 testing, mean $ (sd)	Not Tested	$143.66 (191.57)	299
	Tested	$925.93 (1342.57)	129
	Tested Positive	$1466.67 (1739.68)	39
	Tested Negative	$644.45 (979.81)	82
Objective numeracy[23] (range: 0-3), mean (sd)	Not Tested	2.01 (0.93)	311
	Tested	1.94 (0.94)	133
Subjective numeracy[26] (overall SNS score), mean (sd)	Not Tested	4.72 (0.83)	315
	Tested	4.76 (0.79)	134
Of Ashkenazi (Eastern European Jewish) descent, % of subgroup	Not Tested	4%	12 of 315
	Tested	23%	31 of 134

Table A1, continued: Demographic and clinical characteristics (N = 459).

Any family member(s) tested positive for BRCA1 or BRCA2 mutation, %	No	27%	123
	Yes	8%	38
	Unknown	65%	298
Number of relatives with breast or ovarian cancer, %	1	27%	n=104
	2	24%	93
	3	20%	79
	4	12%	46
	5	6%	24
	6	5%	20
	7	3%	12
	>7	3%	13
Perceived risk of mutation, mean % (sd)	Not Tested	32.43% (24.33)	286
	Tested	59.22% (21.30)	122
Perceived risk of developing breast cancer, mean % (sd)	Not Tested	44.53% (28.52)	288
	Tested	60.55% (28.11)	128
Worried that test might find illness, % of subgroup	Not Tested		
	Not Worried at All	59%	186 of 314
	Slightly Worried	18%	57 of 314
	Of Medium Worry	12%	39 of 314
	Worried	6%	19 of 314
	Very Worried	4%	13 of 314
	Tested		
	Not Worried at All	71%	93 of 132
	Slightly Worried	16%	21 of 132
	Of Medium Worry	7%	9 of 132
	Worried	7%	9 of 132
	Very Worried	0%	0 of 132

All available data shown; amount of missing data varied across the variables. Percentages are out of the total number of participants with data.

Table A2: Variables entered at each step in the forward stepwise binary logistic regression predicting previous testing.

Step		B	S.E.	Wald	df	Sig.	Exp(B)
1[a]	Perceived risk of mutation	.041	.006	52.352	1	.000	1.042
	Constant	−2.636	.319	68.112	1	.000	.072
2[b]	Presence of family member(s) testing positive			33.366	2	.000	
	Presence of family member(s) testing positive (“No”)	−2.275	.602	14.255	1	.000	.103
	Presence of family member(s) testing positive (“Unknown/Missing”)	−3.193	.585	29.756	1	.000	.041
	Perceived risk of mutation	.040	.006	43.243	1	.000	1.041
	Constant	−.035	.621	.003	1	.955	.965
3[c]	Presence of family member(s) testing positive			28.802	2	.000	
	Presence of family member(s) testing positive (“No”)	−2.156	.624	11.953	1	.001	.116
	Presence of family member(s) testing positive (“Unknown/Missing”)	−3.059	.607	25.417	1	.000	.047
	Perceived risk of mutation	.039	.006	38.807	1	.000	1.040
	Of Ashkenazi descent	−1.818	.469	15.017	1	.000	.162
	Constant	1.484	.759	3.819	1	.051	4.410
4[d]	Number of relatives with breast or ovarian cancer	.170	.075	5.142	1	.023	1.186
	Presence of family member(s) testing positive			22.263	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.912	.626	9.334	1	.002	.148
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.733	.615	19.733	1	.000	.065
	Perceived risk of mutation	.037	.006	33.676	1	.000	1.037
	Of Ashkenazi descent	−1.762	.468	14.192	1	.000	.172
	Constant	.708	.820	.745	1	.388	2.030
5[e]	Number of relatives with breast or ovarian cancer	.150	.076	3.861	1	.049	1.161
	Presence of family member(s) testing positive			23.337	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.920	.623	9.513	1	.002	.147
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.790	.614	20.679	1	.000	.061
	Age	.043	.022	4.009	1	.045	1.044
	Perceived risk of mutation	.038	.006	34.254	1	.000	1.039
	Of Ashkenazi descent	−1.825	.487	14.033	1	.000	.161
	Constant	−1.367	1.326	1.063	1	.302	.255

a. Variable(s) entered on step 1: Perceived risk of mutation.

b. Variable(s) entered on step 2: Presence of family member(s) testing positive.

c. Variable(s) entered on step 3: Of Ashkenazi descent.

d. Variable(s) entered on step 4: Number of relatives with breast or ovarian cancer.

e. Variable(s) entered on step 5: age.

Table A3: Variables entered at each step in the backward stepwise binary logistic regression predicting previous testing.

Step		B	S.E.	Wald	df	Sig.	Exp(B)
1[a]	Number of relatives with breast or ovarian cancer	.152	.077	3.845	1	.050	1.164
	Objective Numeracy	−.190	.180	1.122	1	.289	.827
	Subjective Numeracy	−.047	.207	.052	1	.820	.954
	Presence of family member(s) testing positive			22.245	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.834	.627	8.555	1	.003	.160
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.714	.614	19.513	1	.000	.066
	Age	.042	.022	3.732	1	.053	1.043
	Perceived risk of mutation	.036	.008	20.457	1	.000	1.037
	Perceived risk of developing breast cancer	.004	.007	.283	1	.595	1.004
	Worry that the test might find illness	−.218	.156	1.943	1	.163	.804
	Of Ashkenazi descent	−1.817	.497	13.395	1	.000	.162
	Constant	−.580	1.655	.123	1	.726	.560
2[a]	Number of relatives with breast or ovarian cancer	.151	.077	3.844	1	.050	1.164
	Objective Numeracy	−.204	.168	1.473	1	.225	.815
	Presence of family member(s) testing positive			22.223	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.850	.624	8.791	1	.003	.157
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.720	.614	19.605	1	.000	.066
	Age	.042	.022	3.777	1	.052	1.043
	Perceived risk of mutation	.036	.008	20.447	1	.000	1.037
	Perceived risk of developing breast cancer	.004	.007	.302	1	.583	1.004
	Worry that the test might find illness	−.214	.155	1.903	1	.168	.808
	Of Ashkenazi descent	−1.819	.497	13.416	1	.000	.162
	Constant	−.785	1.391	.318	1	.573	.456
3[a]	Number of relatives with breast or ovarian cancer	.147	.077	3.664	1	.056	1.158
	Objective Numeracy	−.215	.167	1.663	1	.197	.806
	Presence of family member(s) testing positive			22.401	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.840	.626	8.647	1	.003	.159
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.728	.617	19.544	1	.000	.065
	Age	.043	.022	3.979	1	.046	1.044
	Perceived risk of mutation	.038	.007	34.660	1	.000	1.039
	Worry that the test might find illness	−.221	.154	2.059	1	.151	.802
	Of Ashkenazi descent	−1.795	.494	13.230	1	.000	.166
	Constant	−.718	1.390	.267	1	.606	.488
4[a]	Number of relatives with breast or ovarian cancer	.150	.076	3.835	1	.050	1.161
	Presence of family member(s) testing positive			22.330	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.860	.622	8.943	1	.003	.156
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.723	.613	19.731	1	.000	.066
	age	.043	.022	3.991	1	.046	1.044
	Perceived risk of mutation	.038	.007	34.639	1	.000	1.039
	Worry that the test might find illness	−.189	.151	1.579	1	.209	.828
	Of Ashkenazi descent	−1.789	.489	13.365	1	.000	.167
	Constant	−1.183	1.341	.778	1	.378	.306
5[a]	Number of relatives with breast or ovarian cancer	.150	.076	3.861	1	.049	1.161
	Presence of family member(s) testing positive			23.337	2	.000	
	Presence of family member(s) testing positive (“No”)	−1.920	.623	9.513	1	.002	.147
	Presence of family member(s) testing positive (“Unknown/Missing”)	−2.790	.614	20.679	1	.000	.061
	age	.043	.022	4.009	1	.045	1.044
	Perceived risk of mutation	.038	.006	34.254	1	.000	1.039
	Of Ashkenazi descent	−1.825	.487	14.033	1	.000	.161
	Constant	−1.367	1.326	1.063	1	.302	.255

a. Variable(s) entered on step 1: Number of relatives with breast or ovarian cancer, Objective Numeracy, Subjective Numeracy, Presence of family member(s) testing positive, age, Perceived risk of mutation, Perceived risk of developing breast cancer, Worry that the test might find illness, Of Ashkenazi descent.