Predictive value of breast cancer cognitions and attitudes toward genetic testing on women's interest in genetic testing for breast cancer risk

Abstract

In the past years advances in genetic technologies have led to an increased interest in predictive genetic testing for breast cancer risk. Studies in the US and UK reported an increasing interest among women of the general public in genetic testing for breast cancer risk, although the benefit of such a test is questionable for low risk women. The aim of the present study was to identify factors that predict interest in genetic testing of German women in the general public. Women with neither a family history of breast cancer nor breast cancer themselves received an information letter by mail, were interviewed by telephone, and completed a self-administered questionnaire (N=377). Structural equation modeling was used to determine the predictive value of attitudinal and cognitive variables on interest in genetic testing for breast cancer risk. The resulting model achieved good fit indices, and 42% of variance could be explained. Women with more expectations concerning the test, more positive attitudes concerning genetic testing in general, an increased breast cancer risk perception, and increased breast cancer worries showed more interest in testing. These findings suggest the need for information and counseling strategies for low risk women which should focus in particular on decreasing unrealistic expectations concerning genetic testing for breast cancer risk but also on decreasing perceived breast cancer risk and breast cancer worries.

Zusammenfassung

Die gentechnologischen und gendiagnostischen Fortschritte der letzten Jahre haben zu einem vermehrten Interesse an prädiktiver genetischer Brustkrebsdiagnostik geführt. Obwohl Frauen mit einem geringen Brustkrebsrisiko von einer solchen Testung nicht profitieren können, zeigen Studien ein zunehmendes Interesse von Frauen der Allgemeinbevölkerung an genetischer Brustkrebsdiagnostik. Ziel der Studie war es, Faktoren zu identifizieren, mit deren Hilfe das Interesse von Frauen mit einem geringen Brustkrebsrisiko an genetischer Brustkrebsdiagnostik vorhergesagt werden kann. Hierfür wurden 377 Frauen der Allgemeinbevölkerung, die weder eine erkrankte Erstgradangehörige hatten, noch selbst an Brustkrebs erkrankt waren, telefonisch und schriftlich befragt. Mithilfe eines Strukturgleichungsmodells wurde der Einfluss brustkrebsspezifischer Kognitionen sowie einstellungsbezogener Variablen auf das Interesse an genetischer Brustkrebsdiagnostik überprüft. Das resultierende Modell erreichte gute Fit-Indices und konnte 42% der Varianz des Interesses an genetischer Brustkrebsdiagnostik erklären. Frauen mit höheren Erwartungen an die Testung, einer positiven Einstellung gegenüber genetischen Testungen
im allgemeinen, einer höheren Einschätzung des persönlichen Brustkrebsrisikos sowie mit vermehrten brustkrebsspezifischen Ängsten und Sorgen zeigten ein größeres Interesse an genetischer Brustkrebsdiagnostik. Die Ergebnisse der Studie verdeutlichen, dass auch Frauen mit einem geringen Brustkrebsrisiko Interesse an genetischer Brustkrebsdiagnostik haben. Für die Beratung sollten Informations- und Kommunikationsstrategien entwickelt werden, die insbesondere auf unrealistische Erwartungen bezüglich genetischer Brustkrebsdiagnostik fokussieren und die darüber hinaus dazu beitragen, das wahrgenommene Brustkrebsrisiko sowie erhöhte Ängste und Sorgen zu reduzieren.

Introduction

Advances in genetic technologies lead to more and more changes in medical practice. The increasing knowledge about genetic susceptibilities makes genetic testing for inherited diseases like Huntington disease, hereditary breast, ovarian or colon cancer, heart diseases, or Alzheimer’s diseases possible. Studies from different countries have shown that genetic testing is becoming generally accepted in the general public [1], [2], [3], [4], [5], [6] and that some of the presently available gene tests like predictive genetic testing for breast cancer risk will be more and more commercialized [7], [8]. However, these new developments require deliberating about risks and benefits related to genetic testing. We need to clarify for whom genetic testing should be accessible [7], [9]. There is consensus that in regard to breast cancer, predictive genetic testing is only reasonable for high-risk women with a family history of breast cancer. The test offers high-risk women some potential benefits like receiving certainty about one's personal breast cancer risk or getting recommendations about screening behavior and medical treatment. However, genetic testing for breast cancer risk is not meaningful for low-risk women because most of them will obtain a negative test result which cannot be interpreted without testing an affected relative first [10]. Therefore, genetic testing will not give low-risk women certainty about their breast cancer risk [11]. Although low-risk women will not benefit from the test, there is an increasing interest in genetic testing among women of the general public. Studies in the US reported high rates of interest among women at low risk for breast cancer [12], [13], [14]. A high interest in this issue within the general public or even to pursue genetic testing for breast cancer risk was also found in Germany [15], [16]. Even though there is an only moderate association between the intention to obtain genetic testing and the actual uptake of the gene test [17], [18], we should understand the motives of low-risk women to be interested in genetic testing for breast cancer risk in order to be able to provide adequate information and thereby to reduce unrealistic expectations and hopes.

Breast cancer risk perception appears to be of high relevance for the intention to pursue genetic testing for breast cancer risk. According to health behavior theories (e.g. Health Belief Model [19]; Protection Motivation Theory [20], [21]) risk perception - defined as a function of perceived vulnerability and perceived severity - is a key variable for predicting the intention to initiate and maintain health behavior. Studies on the intention to obtain genetic testing for breast cancer risk mostly focused on perceived vulnerability for breast cancer. The findings suggest that women's perceived vulnerability for breast cancer is positively related to the intention to participate in genetic testing for breast cancer risk [22], [23], [24], [25], [26], and that perceived vulnerability for breast cancer is of higher predictive value than actual breast cancer risk [27], [28]. Other variables like cancer worries and knowledge also influence the intention to participate in genetic testing for breast cancer risk. Exaggerated breast cancer worries increase the intention to obtain the gene test [26], [29], [30] and can further influence perceived vulnerability for breast cancer risk [31], [32], [33]. Thus, breast cancer worries may have a direct as well as an indirect impact on women's intentions to pursue testing. Furthermore, knowledge and attitude about breast cancer genetics was found to be of predictive value. Women with little knowledge were more interested in obtaining the test [34]. Specific expectations and fears concerning genetic testing for breast cancer risk - which could be seen as expressions of women's attitude concerning the test - were also investigated as potential predictors of the intention to participate in genetic testing. Studies have shown that an increased hope for certainty about one’s personal breast cancer risk motivates women to pursue genetic testing [35]. Moreover, the hope to get recommendations about screening behavior and medical treatment as well as the hope to get information about the risk of one's children increase the intention to obtain the test [36], [37], [38], [39]. However, there is not much research about whether fears concerning the gene test are also of relevance for women's intentions to participate in genetic testing or not.

General attitudes toward genetic testing have not been taken into account yet. There are significant associations between attitudes and the intention to act in general [40], [41], [42]. Some health behavior theories (e.g. Theory of reasoned action [43], [44]) suggest that a positive attitude toward a behavior increases the intention to initiate this behavior. Thus, it can be assumed that women's general attitude concerning genetic testing may positively influence their intentions to pursue genetic testing for breast cancer risk. Therefore, we need to investigate...
whether or not attitudes concerning genetics and genetic testing in general are also of predictive value for women's intentions to obtain genetic testing for breast cancer risk. Most studies concerning factors that influence women's intentions to participate in genetic testing for breast cancer risk focused on women with a family history of breast cancer. Thus, there is not much evidence whether the reported factors also predict the intentions of low-risk women. Furthermore, the impact of attitudinal variables - women's general attitudes concerning genetic testing in particular - have not been included yet. In addition, most of these studies reported correlative findings without taking relationships between relevant variables into account. Therefore, the aim of the present study was to identify factors that predict interest in genetic testing for breast cancer risk of low-risk women in the general public in Germany. As the intention to pursue genetic testing for breast cancer risk seems not to be reasonable as a main outcome variable for women at low risk for breast cancer, women's interest in testing as a more global construct was focused. Structural equation modeling was used to investigate the predictive value of breast cancer cognitions on the one hand and attitudes concerning genetic testing on the other hand. Perceived vulnerability, perceived severity, breast cancer worries and knowledge about breast cancer genetics were integrated in the model as cognitive variables. Specific expectations and fears concerning genetic testing for breast cancer risk as well as attitudes toward genetic testing in general were included as attitudinal variables.

Methods

Procedure

The present study was part of a larger study that investigated attitudes and risk perception of German women concerning breast cancer and predictive genetic testing for breast cancer risk [15]. Participants were recruited through a random sample of the registration office of Freiburg/Germany, which provided 4500 postal addresses of women aged 18 to 65. A letter initially informed women with a telephone (n=2561) about study objectives and of women who did not reject participation were interviewed in a brief telephone survey to check for eligibility criteria (age, adequate language skills) as well as to assess sociodemographic variables (age, marital status, education, and employment status) (n=657). According to their breast cancer risk status participants were divided into three groups: 1. women with neither breast cancer nor first-degree relatives with breast cancer, 2. women with at least one first-degree relative with breast cancer, 3. women with breast cancer themselves. Finally, eligible participants who agreed to take part in the study (n=652) received a questionnaire about attitudes and risk perception concerning breast cancer and predictive genetic testing as well as a consent form with a return envelope. We received 68% (n=469) of the questionnaires sent. Thus, about 18% of the initially informed women took part in the study. The study was reviewed and approved by the Ethics Committee of the Deutsche Gesellschaft für Psychologie (DGPs).

Participants

Participants were 469 women of the general public (Freiburg/Germany). The present analysis focused on low-risk women. Therefore, women with breast cancer (n=24) and women with a family history of breast cancer (n=68) were excluded from the analyses. Thus, the findings reported here are based on a total sample of 377 women. The mean age of the women was 43.4 years (SD=11.90), ranging from 21 to 65. Fifty-eight percent of the women were married, 28% were single, 12% were divorced, and a few women were widowed (2%). Forty-eight percent of the women had done an apprenticeship, 34% had completed university, 10% had none and 6% had another vocational education. About 2% of the women did not answer this question. In regard to employment status, two third of the women were full or part-time employed (66%) and about 27% of the women were trainees, pensioners or homemakers. Only a small percentage was unemployed (3%). In comparison to the German female population much more women of the study sample completed university (6% vs. 34%), but there were no differences in age and occupation.

Measures

Interest in genetic testing for breast cancer risk
We measured women's interest in genetic testing for breast cancer risk with four items concerning their intentions to 1. discuss the issue with family or friends (variable label: 1. discussion), 2. ask a medical practitioner for information about this issue (2. information), 3. make use of genetic counseling (3. counseling), and 4. pursue genetic testing (4. testing). Women were asked to judge their intention on a 4-point scale from 0=definitely not to 3=definitely yes.

Intrusions
We assessed breast cancer worries with a modified German version of the intrusion sub-scale of the Impact of Event Scale [45], [46]. Seven items asked women how their risk of breast cancer had affected them during the past seven days (5. ies1 to 11. ies7), for example "I thought about my breast cancer risk when I didn't mean to." (5. ies1). Responses were scored on a 4-point scale from 0=not at all to 3=often.

Perceived severity for breast cancer
Perceived severity for breast cancer was measured by two items. Items asked each participant how serious it would be if 1."...she was found to carry an altered breast cancer gene" (12. mutation) and if 2."...she would get breast cancer someday" (13. breast cancer). We scored items on a 5-point scale from 0=somewhat serious to 4=extremely serious.
Perceived vulnerability for breast cancer

Women were asked to estimate both their chance of having an altered breast cancer gene (14. mutation) and their chance of getting breast cancer someday (15. breast cancer). We used a 7-point scale with verbal response categories (0=no risk to 6=absolutely certain).

Knowledge about breast cancer genetics

We assessed knowledge about breast cancer genetics by asking four true or false questions according to Lerman et al. (1997) [29]: 1. "A father can pass down an altered BRCA1 gene to his children." (16. father), 2. "A woman who does not have an altered BRCA1 gene can still get breast cancer." (17. without mutation), 3. "A woman who has an altered BRCA1 gene has a higher breast cancer risk." (18. higher risk), 4. "All women who have an altered BRCA1 gene get breast cancer." (19. all women).

Expectations concerning predictive genetic testing for breast cancer risk

To measure women's expectations concerning genetic testing for breast cancer risk we generated a list of seven possible reasons in favor of the test (presented as statements): 1. to learn something about the risk of the child (20. risk of children), 2. to get recommendations concerning screening behavior (21. screening), 3. to use the result for future planning (22. future), 4. to get recommendations about treatment options (23. treatment), 5. to get certainty about personal breast cancer risk (24. certainty), 6. to use the result for family planning (25. family planning), and 7. to reduce breast cancer worries (26. reduce worry). We asked women to judge on a 4-point scale (0=not relevant to 3=extremely relevant) how much the presented topics would be relevant for them if they had to decide whether to undergo testing or not.

Fears concerning predictive genetic testing for breast cancer risk

Women's fears concerning genetic testing for breast cancer risk were assessed with six statements which presented the following reasons against genetic testing: 1. the result could be a burden for the family (27. burdens), 2. cancer cannot be prevented (28. prevention), 3. the result could have negative consequences for health insurance (29. insurance), 4. the result could be inaccurate (30. inaccurate result), 5. a positive test result could increase breast cancer worries (31. increased worry), and 6. waiting for the result could be a strain (32. waiting for result). The items were scored on a 4-point scale (0=not relevant, 3=extremely relevant).

Attitudes concerning genetics and genetic testing

To assess women's general attitudes toward genetics and genetic testing participants were asked to judge the following four items (according to Human Genetics Commission [4]) on a 5-point scale from 1=strongly disagree to 4=strongly agree: 1. "Couples who are at risk of having a child with a serious genetic disorder should be discouraged from having children of their own." (33. no children), 2. "People should be encouraged to be tested in young adulthood for disorders that develop in middle age or later in life." (34. testing adults), 3. "Parents have a right to ask for their child to be tested for genetic disorders that develop in adulthood." (35. testing children), and 4. "New genetic developments will mean children who are healthier and free from inherited disabilities." (36. healthy children).

Statistical analyses

We used Structural Equation Modeling (SEM) to identify factors that predict interest in genetic testing for breast cancer risk of women in the general public. SEM offers the advantages to assess complex interrelated, dependent relationships at the same time as well as to take measurement errors into account. The model was generated, modified and validated in a five-step approach. In a first step the study sample of N=377 women was randomly divided in half, resulting in sample 1 (n=181) and sample 2 (n=196). In order to verify whether the randomized split was successful we performed chi-square tests as well as independent t-tests of demographic variables and all variables intended to be in the model. In a second step an initial model was developed based on theory and experiential variables that were found significant in previous research (Figure 1). The following variables were defined as latent variables: interest in genetic testing for breast cancer risk (main outcome variable), intrusions, perceived severity for breast cancer, perceived vulnerability for breast cancer, knowledge about breast cancer genetics, expectations, fears and attitudes concerning genetic testing. We hypothesized that each latent variable has a direct impact on women's interest in testing. We further assumed that women's general attitude toward genetics and genetic testing influences expectations and fears concerning genetic testing for breast cancer risk directly. Moreover, we expected that women's perceived severity for breast cancer has a direct impact on perceived vulnerability for breast cancer and on intrusion and is further correlated with women's knowledge about breast cancer. In addition, we presumed that women's perceived vulnerability for breast cancer is influenced by perceived severity, intrusion and knowledge. All latent variables were measured by at least two manifest variables. Before SEM analyses of the covariance matrix were conducted, we checked whether the postulation of normal distribution of the manifest variables was fulfilled. P-P-plot analyses and K-S-tests of normal distribution indicated that none of the manifest variables fulfilled the postulation of normal distribution. Therefore, exponential transformations were conducted in order to obtain or approximate a normal distribution. After that, the goodness of fit of the hypothesized model was tested by using sample 1. In the third step we modified the model according to modification indices. After every modification we tested the goodness of fit indices to determine whether the modifications improved model fit, again using sample 1. In the fourth step this restricted model was validated by using sample 2. Finally, the modified and validated structural equation model was applied to the total sample (N=377) and the overall goodness of fit was assessed.
All SEM analyses were performed with AMOS 5.0 [47]. For all analyses maximum likelihood estimates were used and the Full Information Maximum Likelihood algorithm was used to account for missing data. Overall goodness of fit was assessed with $\chi^2$/degree of freedom ratio (CMIN/DF), the normed fit index (NFI), the comparative fit index (CFI), the goodness of fit (GFI), the adjusted goodness of fit index (AGFI), the root mean square error of approximation (RMSEA), and the PCLOSE-value. For CMIN/DF a ratio of less than 1.5 is considered to be very good, a ratio of less than two is good [48]. A RMSEA-value of about .05 or less indicates a close fit of the model in relation to the degrees of freedom [49], [50] and the PCLOSE-value is a "p value" for testing the null hypothesis that the population RMSEA is no greater than .05. For all other fit indices (NFI, CFI, GFI, AGFI) values close to 1.00 are indicators of good fit [48], [51], [52].

Results

Descriptive statistics

Descriptive statistics of the total sample concerning the variables in the model are shown in Table 1. Concerning interest in testing as the main outcome variable it is noticeable that women were more interested in information and discussion about genetic testing for breast cancer risk than in the uptake of counseling or testing. There were no significant differences in demographic variables between sample 1 and sample 2. However, we found significant differences in expectations and fears concerning genetic testing for breast cancer risk: women in sample 2 rated the expectation to get information about their children's risk more relevant than women in sample 1 ($t(375)=2.03; p=.043$). Furthermore, women in sample 1 rated the fears that a positive test result could increase breast cancer worries and that waiting for the result could be a strain significantly more relevant for decision making than women in sample 2 ($t(369)=2.28; p=.023$ respectively $t(366)=2.14; p=.033$). In order to judge whether these differences are relevant for interpreting the final results we calculated effect sizes. For all of the three variables we found small effects ranging from $d=.21$ to $d=.23$. Thus, we can assume that the differences between sample 1 and sample 2 concerning the mentioned variables are not relevant for the following results.
Table 1: Descriptive statistics and factor loadings of the modified and final model

| Variables                                  | Descriptive statistics | Factor loadings |
|--------------------------------------------|------------------------|-----------------|
| Latent variable                            | Manifest variable      | n    | M    | SD   | modified | final    |
| Interest in genetic testing for breast cancer risk | discussion (1)         | 374  | .91  | .86  | .47     | .37     |
|                                            | information (2)        | 374  | 1.21 | .99  | .73     | .68     |
|                                            | counseling (3)         | 374  | .20  | .55  | .44     | .49     |
|                                            | testing (4)            | 374  | .29  | .64  | .53     | .58     |
| Intrusions                                 | ies1 (5)               | 372  | .53  | .77  | .63     | .62     |
|                                            | ies2 (6)               | 372  | .31  | .64  | .56     | .57     |
|                                            | ies3 (7)               | 371  | .06  | .27  | .40     | .45     |
|                                            | ies4 (8)               | 370  | .02  | .16  | -       | -       |
|                                            | ies5 (9)               | 372  | .20  | .51  | .69     | .57     |
|                                            | ies6 (10)              | 372  | .38  | .69  | .78     | .74     |
|                                            | ies7 (11)              | 372  | .17  | .47  | .72     | .74     |
| Perceived severity                         | mutation (12)          | 374  | 1.44 | .79  | .80     | .81     |
|                                            | breast cancer (13)     | 374  | 1.89 | .68  | .86     | .83     |
| Perceived vulnerability                    | mutation (14)          | 366  | 1.91 | .94  | .63     | .80     |
|                                            | breast cancer (15)     | 368  | 2.14 | .90  | .79     | .81     |
| Expectations                               | risk of children (20)  | 377  | 1.10 | 1.31 | .40     | .44     |
|                                            | screening (21)         | 377  | 2.05 | 1.25 | .64     | .64     |
|                                            | future (22)            | 377  | .57  | 1.08 | .57     | .60     |
|                                            | treatment (23)         | 376  | 1.55 | 1.26 | .78     | .75     |
|                                            | certainty (24)         | 375  | 1.76 | 1.16 | .83     | .78     |
|                                            | family planning (25)   | 376  | .62  | 1.14 | .42     | .47     |
|                                            | reduce worry (26)      | 375  | .81  | 1.26 | .61     | .53     |
| Fears                                      | burdens (27)           | 376  | 1.02 | 1.33 | .41     | .35     |
|                                            | prevention (28)        | 371  | 1.29 | 1.32 | .37     | .33     |
|                                            | insurance (29)         | 376  | .59  | 1.17 | -       | -       |
|                                            | inaccurate result (30) | 373  | .80  | 1.21 | .43     | .38     |
|                                            | increased worry (31)   | 371  | 1.17 | 1.44 | .72     | .73     |
|                                            | waiting for result (32) | 368  | 1.20 | 1.31 | .62     | .57     |
| Attitudes concerning genetic testing       | no children (33)       | 375  | .27  | 1.29 | -       | -       |
|                                            | testing adults (34)    | 375  | .14  | 1.34 | .74     | .72     |
|                                            | testing children (35)  | 375  | .24  | 1.15 | .75     | .83     |
|                                            | healthy children (36)  | 375  | .25  | 1.27 | .50     | .57     |
| Latent Variable                            | Manifest Variables     | n    | %    |      |          |          |
| Knowledge (correct answers)                | father (16)            | 97   | 25.9 | .35  | .38     |
|                                            | without mutation (17)  | 237  | 63.7 | .65  | .66     |
|                                            | higher risk (18)       | 313  | 83.5 | .68  | .63     |
|                                            | all women (19)         | 258  | 68.4 | .69  | .67     |

Note: For variable labels see "measures".
Structural equation modeling

The initial test of the hypothesized structural equation model resulted in a moderate model fit (CMIN=925.651; DF=580; CMIN/DF=1.596; NFI=.599; CFI=.790; GFI=.599; AGFI=.311; RMSEA=.058; PCLOSE=.039). According to modification indices we excluded the manifest variables "8. ies4", "29. insurance" and "33. no children". Furthermore, we added correlations between perceived severity and expectations (due to methodological constraints the correlation with the error term e41 was used), between perceived severity and fears (respectively the error term e40), and between perceived severity and attitudes concerning genetic testing. Additionally, local dependencies between the error terms e1 and e2, between e15 and e18, between e20 and e21, between e22 and e23, and between e26 and e29 were set. These alterations resulted in a better model fit (Figure 2). The goodness of fit indices were acceptable (CMIN/DF=1.298; NFI=.708; CFI=.909; GFI=.708; AGFI=.654; RMSEA=.041; PCLOSE=.958) and a solution was admissible. Therefore, the model was accepted. For factor loadings of the latent variables see Table 1.

In the next step, the modified model was validated using sample 2. Again, we found a plausible model with acceptable goodness of fit indices (CMIN=638.354; DF=473; CMIN/DF=1.350; NFI=.716; CFI=.902; GFI=.666; AGFI=.613; RMSEA=.042; PCLOSE=.938). The modified and validated model was used to test the total sample. This again resulted in a plausible model with an acceptable model fit (CMIN=755.634; DF=473; CMIN/DF=1.598; NFI=.799; CFI=.799; GFI=.763; RMSEA=.044; PCLOSE=.999). Figure 3 presents the final model. As shown in Table 1 all factor loadings were satisfactory except for the manifest variables "1. discussion", "16. father", "27. burdens", "28. prevention", and "30. inaccurate result". Forty-two percent of the variance of interest in genetic testing for breast cancer risk was explained. Most predictive value had expectations concerning genetic testing for breast cancer risk (β=.41) which were again strongly influenced by attitudes concerning genetic testing (β=.47). The two psychological variables perceived vulnerability (β=.21) and intrusions (β=.17) as well as the two attitudinal variables attitudes concerning genetic testing (β=.21) and fears concerning genetic testing for breast cancer risk (β=.13) were of lower but also of substantial predictive value. Similar to women's expectations concern-
Discussion

The present study aimed at finding factors that predict interest in genetic testing for breast cancer risk of low-risk women of the general public in Germany. We were able to get information about factors that influence interest in genetic testing for breast cancer risk of low-risk women and to show relationships between relevant variables. A total of 42% of the variance of interest in genetic testing for breast cancer risk was explained by attitudes concerning genetic testing on the one hand and breast cancer cognitions on the other hand.

In regard to women's attitudes concerning genetic testing for breast cancer risk in particular as well as toward genetic testing in general our data support the assumption of models of health behavior that attitudes are key variables for predicting health behavior [43], [44], [53]. We found that women's expectations concerning genetic testing for breast cancer risk - which we considered as an expression of their attitude concerning the test - are strongly predicting women's interest in testing. Women who anticipate more positive consequences of the gene test are more interested in genetic testing for breast cancer risk. In contrast, fears concerning the test, which are negatively influencing women's interest, seem to be of lower predictive value.

Regarding women's attitudes concerning genetic testing in general we found that these attitudes are of direct as well as of indirect predictive value for interest in genetic testing for breast cancer risk. Women with positive attitudes toward genetic testing in general are more interested in genetic testing for breast cancer risk. An indirect influence of women's general attitudes might be represented by its strong influence on specific expectations.
Concerning genetic testing for breast cancer risk. We can assume that the strong impact of women's specific expectations on interest in testing may partially be due to women's general attitudes concerning these techniques. In contrast, the influence of women's general attitudes on fears concerning the test is much lower. Thus, the specific attitude concerning genetic testing for breast cancer risk and - in consequence - women's interest in the test seem to be more influenced by positive attitudes toward genetic testing in general than by a negative view of these techniques. In addition, the correlations between perceived severity for breast cancer and the attitudinal variables suggest that attitudes concerning such techniques are not independent from the perceived personal threat by such a disease.

Besides women's attitudes concerning genetic testing, also breast cancer cognitions predict interest in genetic testing for breast cancer risk. We found that women who feel more vulnerable for breast cancer and who have more intrusions about breast cancer are more interested in testing. This is consistent with findings from a study which applied the Protection Motivation Theory to investigate predictors of women's motivation to obtain the test [26]. Further on, according to previous findings about the relationship between cancer worries and breast cancer risk perception [31], [32], [33], we found a strong association between intrusions and perceived vulnerability for breast cancer. Breast cancer intrusions seem to trigger women's perceived vulnerability for breast cancer and might therefore not only be of direct but also of indirect predictive value for interest in genetic testing. However, we have to take into account that the strong association between intrusions and perceived vulnerability for breast cancer might be influenced by women's perceived severity for breast cancer because of its strong impact on intrusions.

Contrary to our expectations, we found no influence of perceived severity on interest in genetic testing for breast cancer risk. However, our data suggest that perceived severity might be a variable which affects interest in genetic testing for breast cancer risk by its relation to other relevant factors. The strong relationship between perceived severity and intrusion indicates that perceived severity rather influences interest in genetic testing via breast cancer intrusions than in a direct way. Furthermore, the association between perceived severity and women's expectations, fears and general attitudes concerning genetic testing might be a sign for an indirect impact of perceived severity on interest in testing.

Although perceived severity and perceived vulnerability for breast cancer are discussed as strongly related variables [19], [20], [21],[54], we found no relation between perceived severity and perceived vulnerability for breast cancer. But, breast cancer intrusions might have a moderating effect because perceived severity seems to trigger intrusions which in turn increase women's perceived vulnerability for breast cancer. Thus, perceived severity and perceived vulnerability might be indirectly related to each other.

Knowledge demonstrated no relationship to interest in genetic testing for breast cancer risk. According to previous findings we expected that women who know more about breast cancer genetics are less interested in genetic testing for breast cancer risk [34], [55]. To be aware that the personal genetic background does not refer to an increased breast cancer risk might help women to realize that genetic testing for breast cancer risk will not give them the certainty they may hope for. However, our findings suggest that increasing women's knowledge might not decrease women's interest in testing. This may on the one hand be due to the assessment of knowledge because we only included questions which were related to breast cancer genetics but not to the gene test in particular. On the other hand, interest in genetic testing included not only the intention to make use of genetic counseling and to pursue genetic testing but also to discuss the issue in the family or to search for more information. Both latter intentions don't have to be a sign for having unrealistic expectations and inadequate intentions concerning genetic testing for breast cancer risk. Despite having a realistic perception of the personal risk status due to knowledge about breast cancer and breast cancer genetics, women may intend to deal with the issue by searching for information or discussing it with related persons. Furthermore, participating in our study might have motivated women to engage themselves in the issue.

The study has some limitations that should be noted. First, the outcome of this study was interest in genetic testing for breast cancer risk. It was measured by the intention to discuss the issue with family and friends, by the intention to search for more information, by the intention to make use of genetic counseling as well as to pursue the gene tests. These four intentions represent different levels of interest. Thus, it has to be taken into account that interest in genetic testing as it was defined in our study is a global construct. Furthermore, other data indicate that interest in and actual uptake of genetic testing might be different [56]. Secondly, the data and the resulting structural equation model are from a cross-sectional sample. Therefore, path models do not demonstrate causation. Third, there may be a selection bias in the sample which limits generalizability. The women of our sample were higher educated than German women of the general public which may indicate that women's interest in genetic testing for breast cancer risk might also be influences by the educational level. Higher educated women might deal with these new technologies in a more sophisticated way than lower educated women. Thus, we should take into account that the influences of the investigated factors on interest in genetic testing for breast cancer risk might be different in a less educated sample.

Conclusions

Low-risk women with more expectations concerning the test, a positive attitude concerning genetic testing in
general, a higher perceived vulnerability for breast cancer, and more breast cancer intrusions are more interested in genetic testing for breast cancer risk. Except for the general attitude concerning genetic testing, these findings are similar to the results of studies on women with a family history of breast cancer or breast cancer themselves. Thus, also women at low to moderate breast cancer risk should receive information about breast cancer genetics and the gene test that focus on decreasing exaggerated breast cancer risk perceptions and breast cancer intrusions. In addition, counseling of low-risk women should focus on underlying attitudes and expectations concerning genetic testing in order to reduce unrealistic beliefs and hopes as well as to influence inadequate health behavior. Women might interpret the test rather as a possibility of health prevention than as a diagnostic instrument. They might therefore need more detailed information about the gene test, its chances and limits. This might help them to verify and revise their expectations. Thereby women's interest in genetic testing for breast cancer risk might decrease.

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