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Original Research

Perceived susceptibility to developing cancer and mammography screening behaviour: a cross-sectional analysis of Alberta's Tomorrow Project

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ABSTRACT

Objectives: Cross-sectional data from Alberta's Tomorrow Project (ATP) were used to assess the association between perceived susceptibility (PS) to developing cancer and mammography screening behaviour.

Study design: Cross-sectional study.

Methods: ATP participants between 35 and 70 years of age who reported being free of chronic conditions were included in the study (n = 1803). PS was measured using three variables: participants' estimate of their personal PS of developing cancer, compared to others, on a 5-point Likert scale; participants' estimate of the percentage of people in their age group who would be diagnosed with cancer; and participants' estimate of their own chance (expressed as a percentage) of being diagnosed with cancer. Multivariable logistic regression models, adjusting for age, marital status, work status, education, family history, and place of residence, were used to explore the association of interest.

Results: PS of developing cancer was modestly yet significantly associated with mammography screening behaviour for two of the three PS variables. Specifically, the adjusted odds of mammography screening were 1.20 times greater for each one-unit increase in personal PS of developing cancer (95% confidence interval [CI] = 1.07–1.36 [$P = 0.003$]) and 1.01 times greater for each one-unit increase in both participants' estimate of the percentage of people who would develop cancer (95% CI = 1.00–1.01 [$P = 0.05$]) and participants' estimate of their own chance of developing cancer (95% CI = 1.00–1.01 [$P = 0.02$]).

Conclusions: Understanding how certain factors, such as PS, are associated with screening behaviour is important to help address the underutilization of cancer screening.

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Introduction

Breast cancer is the most frequently diagnosed cancer in women across the globe, increasingly in developing countries.[1] Estimates from 2017 suggested 26,300 Canadian women and 252,710 women worldwide would receive a breast cancer diagnosis during the year. Of these women, 5000 in Canada and 40,610 worldwide were predicted to die from the disease.[2,3] Current guidelines suggest that an average woman between the ages of 50 and 74 years should be screened for breast cancer once every two years. Women with a higher risk of breast cancer, such as those with a family history of the disease, should be screened more frequently. Guidelines recommend that women aged 40–49 years should talk to their doctor about the risk of breast cancer, as well as the risks and benefits of mammograms.[4]

The preventive and systematic application of screening, such as mammography, can reduce mortality by 25%–31% in women aged 50–69 years.[5] Despite the existence of well-established screening guidelines and the widely communicated benefits of screening, screening remains underutilized in many jurisdictions.[6,7] A 2018 review of current screening guidelines suggested that personalized medicine, including assessment and discussion of individual-specific risks for breast cancer, would be a likely addition to future screening guidelines.[8]

The health belief model (HBM) supports the personalized approach. The HBM suggests personal beliefs about a disease are key determinants of health behaviours such as screening.[9,10] If a person believes they are likely to develop cancer, then they are more likely to get screened for the disease.[11]

To examine the potential of personalized medicine as a tool for promoting screening, this study assessed whether individuals' perceived susceptibility (PS) of developing cancer was associated with mammography screening in women. From a public health perspective, the existence of such an association would support personalized strategies aimed at increasing screening rates by, for example, highlighting women's personal risks for developing breast cancer during annual medical check-ups.

Methods

Study population

Alberta's Tomorrow Project (ATP) is a population-based cohort study launched in October 2000 to examine the aetiology of cancer and other chronic diseases.[12] Eligible participants recruited for the study included men and women aged 35–69 years who intended to live in the Canadian province of Alberta for at least one year, who had no personal history of cancer other than non-melanoma skin cancer, and who were able to complete self-reported written questionnaires in English.[12–14]

Participant enrolment occurred from 2000 to 2008 and incorporated a two-stage sampling design. Sampling details are provided elsewhere.[13–15] In brief, stage 1 involved random digit dialling of landlines to identify households from 17 regional health authorities across Alberta; stage 2 involved selecting one eligible adult from each household.[13] For this study, we included female participants of any age who answered at least one of three PS questions in the ATP dataset.

Surveys

Participants completed a Health and Lifestyle Questionnaire (HLQ) at baseline. This questionnaire contained diverse questions on topics such as cancer screening, personal and family health history, reproductive health, smoking, sun exposure, spirituality, social support and stress, body measurements, and demographic characteristics.[12,13]

A follow-up survey—Survey 2004 (S04)—about health and lifestyle characteristics was administered in 2004[12,13] to all individuals recruited into ATP between 2000 and 2003 (n = 3731). PS questions were only asked in Survey 2004. For the analyses in this study, we merged participants' responses to the HLQ and Survey 2004 and formed a combined baseline dataset straddling both time points.

Perceived susceptibility

Three questions from S04 measured an individual's PS to developing cancer. These questions asked about cancer in general, not specific types of cancer. The first question asked participants to estimate their personal susceptibility to developing cancer in their lifetime, compared to others, on a 5-point Likert scale ranging from 1 ('I am at a much less risk than others') to 5 ('I am at a much higher risk than others'). The second question asked participants to estimate the percentage of people in their age group, in the general population, whom they would expect to be diagnosed with cancer in their lifetime. The third question asked participants to estimate their own chance (expressed as a percentage) of being diagnosed with cancer in their lifetime.[12–16]

Mammography screening behaviour

Both HLQ and S04 contained self-report questions about mammograms. These questions were merged together to form a single screening question addressing whether participants were 'ever screened' for breast cancer. The HLQ asked, 'Have you ever had a mammogram (a breast x-ray)?' with the following response options: a) yes; b) no; or c) don't know.[12–16] S04 asked 'Since you joined the study, have you had a mammogram?', where participants could respond a) yes, and the specific year they received the mammogram; b) no; or c) don't know. If participants responded 'yes' to obtaining a mammogram in HLQ and S04, or 'yes' in one of the two surveys, then they were recorded as 'yes' to being 'ever screened' for this study. If participants responded 'no' to the HLQ and S04 mammography screening questions, or 'no' to one question and 'don't know' to the other question, then they were recorded as 'no' to being 'ever screened' in this study.[12–16]

Covariates

Potential covariates, identified through a comprehensive literature search, include sociodemographic characteristics such as age, marital status, education, work status,[11,17] family history of cancer, and place of residence (rural vs. urban).[11,18–22] Refer to Supplementary Table 1 for an explanation of why we considered these variables to be potential covariates.

Data analysis

The data were explored descriptively using histograms for continuous variables and bar charts for categorical variables. Continuous variables are summarized as medians and interquartile ranges, and categorical variables, as frequencies. We used the Mann–Whitney U test or the Chi-square test to compare differences in the covariates between mammography groups (screened: yes/no). To investigate the association between PS and mammography screening, we built separate logistic regression models for each of the three PS variables, controlling for the aforementioned covariates. All statistical tests were two-sided, and the significance level was set at $\alpha = 0.05$. We used SAS v9.4 (The SAS Institute, Cary, NC) to conduct all statistical analyses.

Using the Shieh-O'Brien approximation,[23] a sample size of 1145 would permit us to detect an adjusted odds ratio (OR) of at least 1.01 for any of the three PS variables in a multivariable logistic regression analysis, controlling for the variables listed in Table 1, given $\alpha = 0.05$, 80% power, and the proportion of participants who reported being screened for mammography (i.e., 0.70 [Table 1]).

Ethics and reporting

This study received ethics clearance from the University of Waterloo's Office of Research Ethics (file # 21726) and was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (Supplementary Table 2).[24]

Results

Study population

ATP enrolled a total of 11,983 participants who completed the HLQ survey. We excluded ten participants who did not report being free of cancer at baseline (other than non-melanoma skin cancer) and 75 participants who did not complete at least one of the three PS questions at S04. Of the remaining 11,898 participants, 3656 completed both the HLQ and S04, and the female subset of these 3656 participants (i.e., n = 1803) was retained for analysis (see Fig. 1).

Descriptive statistics and multivariable results

Table 1 shows the baseline sample characteristics of the 1803 participants included in the analysis. The median age was 45 years, and 70% (n = 1260) reported being ever screened for mammography. The majority of women were married (n = 1380), working full-time (n = 918), in possession of a postsecondary (but not university) degree (n = 828), living in an urban setting (n = 1283), and without a family history of cancer (n = 950).

Crude results did not show a statistically significant difference between screened and unscreened individuals on any of the three PS variables. However, age, work status, family history of cancer, and place of residence were statistically significantly different between screened and unscreened women.

Multivariable regression

Personal PS of developing cancer and participants' estimate of their own chance of developing cancer were positively and statistically significantly associated with mammography screening (Table 2). Each one-unit change on the 5-point Likert scale for personal PS of developing cancer was associated with a 20% greater odds of reporting mammography screening (95% confidence interval [CI] = 1.07–1.36, $P = 0.003$). For participants' estimate of their own chance of developing cancer, the odds of reporting mammography screening were 1.01 times greater for each one-unit increase in participants' expressed chance of being diagnosed with cancer in their lifetime (95% CI = 1.00–1.01, $P = 0.02$). Stratifying by age category, based on screening recommendations (ages 50–69 years), did not have an impact on the results. Similarly, the results were not affected after we repeated the analysis in the subgroup of the sample who reported a family history of cancer.

Discussion

PS in terms of personal risk (personal PS of developing cancer and participants' estimate of their own chance of developing cancer) was found to be positively associated with mammography screening behaviour after controlling for relevant covariates. This finding is consistent with the theoretical framework outlined by the HBM, which suggests that screening behaviour is linked to one's perception of the risk of developing cancer. This finding has also been reported by several additional studies from around the world, including Iran, Jordan and the USA, each of which assessed personal PS to mammography screening behaviour via questions that were adapted from the HBM and found a significant association between PS and mammography screening behaviour.[18,19,22]

The ORs for personal PS of developing cancer and participants' estimate of their own chance of developing cancer suggest strong effects over wide differences between women. For example, the odds of screening are two times greater for women who rate their personal PS of developing cancer as a 5 on the Likert scale, compared to women who rate their PS as a 1:

$$LogOR = \log(1.20) = 0.1823 \quad (1)$$

$$OR_{5-1} = exp^{0.1823*(5-1)} = 2.07 \quad (2)$$

Table 1 – Sample characteristics.

Characteristics	Total	Mammography - Yes	Mammography - No	P value
Personal_risk_cancer[a] (median [Q1, Q3])	n = 1803 3.0 (2.0, 3.0)	n = 1260 3.0 (2.0, 3.0)	n = 543 3.0 (2.0, 3.0)	0.4127
Percentage_people_DX_cancer[b,c] (median [Q1, Q3])	n = 1771 40.0 (25.0, 50.0)	n = 1232 40.0 (25.0, 50.0)	n = 539 35.0 (25.0, 50.0)	0.1362
Percentage_own_DX_cancer[d] (median [Q1, Q3])	n = 1783 30.0 (15.0, 50.0)	n = 1245 30.0 (15.0, 50.0)	n = 538 30.0 (10.0, 50.0)	0.3180
Age (median [Q1, Q3])	n = 1802 45.0 (40.0, 51.0)	n = 1259 47.0 (42.0, 53.0)	n = 543 40.0 (37.0,44.0)	<0.0001
Marital status (n [%])	n = 1803	n = 1260	n = 543	
Married	1380 (76.5)	967 (76.7)	413 (76.1)	0.0889
Previously, but no longer married	254 (14.1)	186 (14.8)	68 (12.5)	
Never married	169 (9.4)	107 (8.5)	62 (11.4)	
Work status (n [%])	n = 1782	n = 1246	n = 536	
Working full-time	918 (51.5)	613 (49.2)	305 (56.9)	<0.0001
Working part-time	457 (25.6)	309 (24.8)	148 (27.6)	
Retired	159 (8.9)	148 (11.9)	11 (2.1)	
Not working	248 (13.9)	176 (14.1)	72 (13.4)	
Education (n [%])	n = 1802	n = 1259	n = 543	
High school or less	553 (30.7)	393 (31.2)	160 (29.5)	0.3196
Post-secondary school, but not university	828 (45.9)	564 (44.8)	264 (48.6)	
University or more	421 (23.4)	302 (16.8)	119 (21.9)	
Family history of cancer (n [%])	n = 1803	n = 1260	n = 543	
Yes	853 (47.3)	639 (50.7)	214 (39.4)	<0.0001
No	950 (52.7)	621 (49.3)	329 (60.6)	
Area of residence (n [%])	n = 1799	n = 1257	n = 542	
Urban	1283 (71.3)	927 (73.7)	356 (65.7)	0.0005
Rural	516 (28.7)	330 (26.3)	186 (34.3)	

n, sample size; Q1, first quartile; Q3, third quartile; DX, diagnosis.

[a] Perceived susceptibility question 1: 'Compared to other people your age, what do you think are your chances of being diagnosed with cancer during your lifetime?'; mean = 2.6, standard deviation = 1.0; kurtosis = 0.19; range = 4.0; skewness = 0.20.

[b] Perceived susceptibility question 2: 'On a scale of 0 %–100%, what percentage of people your age in the general population do you think will be diagnosed with cancer in their lifetime?'; mean = 38.6, standard deviation = 18.8; kurtosis = 0.25; range = 100.0; skewness = 0.40.

[c] Lifetime chance of developing breast cancer in women = 12.5% (*Source:* Canadian Cancer Statistics Advisory Committee. Canadian Cancer Statistics 2018. Toronto, ON: Canadian Cancer Society; 2018. Available at: cancer.ca/Canadian-Cancer-Statistics-2018-EN [p. 44]).

[d] Perceived susceptibility question 3: 'On a scale of 0%–100%, what would you estimate to be your chance of being diagnosed with cancer in your lifetime?'; mean = 33.6, standard deviation = 23.0; kurtosis = 0.47; range = 100.0; skewness = 0.52.

The odds of screening for women who estimate their own chance of developing cancer to be 50% are 1.49 times higher than the odds for women who estimate their chance to be 10%:

$$LogOR = \log(1.01) = 0.01 \quad (3)$$

$$OR_{50-10} = exp^{0.001*(50-10)} = 1.10 \quad (4)$$

Policy implications

Findings from this research can contribute to public health programming aimed at promoting screening behaviour through personalized medicine initiatives. Specifically, highlighting personal PS to developing cancer through doctor-patient visits may raise individuals' awareness about developing breast cancer, thereby increasing their likelihood of being screened for breast cancer. Improving health literacy could also enhance a woman's perception of risk and improve her likelihood of being screened for breast cancer.[25] To avoid unnecessary alarmism among women with a low risk of developing breast cancer, programmes to emphasize PS might best be targeted to higher risk individuals, such as women with a family history of breast cancer. Programmes emphasizing PS might also not be optimal for women who have experienced multiple negative screens over time, regardless of their risk status.

Health promotion efforts focused on PS and screening may be directed at mammography in jurisdictions where screening rates are low. For example, data from wave I of the European Health Interview Survey, which collected comprehensive health data from all countries in the European Union, revealed mammography screening rates to be lower than 40% for women aged between 50 and 69 years in Belgium (39%), Turkey (28%), and Romania (14%).[26] Comparatively, Canadian rates were higher at 73% in 2008 for women aged 50–69 years,[27] while American rates were 81% in 2008 for women aged 50–74 years.[28] Although mammography screening rates in North America are relatively high, a considerable proportion of women are still not seeking this service, thereby indicating a need for further health promotion efforts. Of course, other factors besides PS (e.g., lack of transportation, mistrust of healthcare providers) can help explain the underutilization of screening in certain jurisdictions. PS should be considered as one item in a larger armamentarium directed toward increasing the use of mammography screening in these jurisdictions.

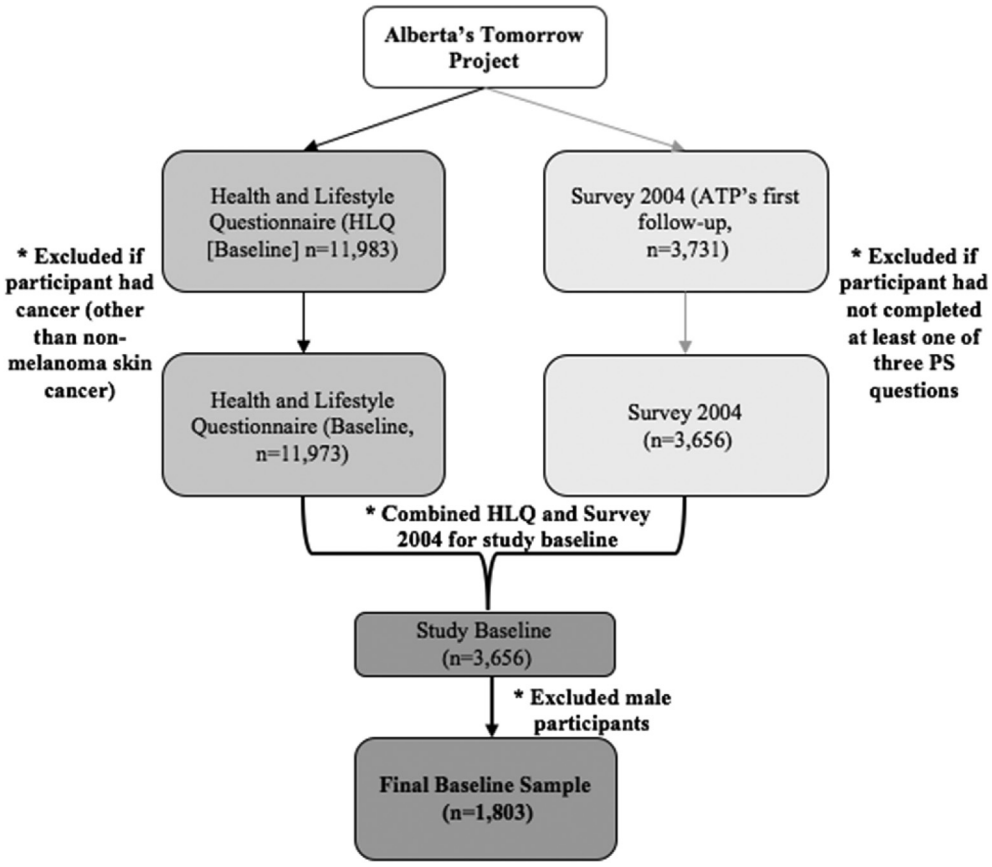

Fig. 1 – Derivation of baseline study sample. ATP, Alberta's Tomorrow Project; HLQ, Health and Lifestyle Questionnaire; PS, perceived susceptibility.

Strengths and limitations

To our knowledge, most previously published studies incorporated highly selected samples, limiting internal and external validity. For example, Hassan et al.[21] recruited individuals primarily through posters and flyers distributed at a private tertiary hospital, which restricts enrolment to individuals who are at the hospital and who see the advertisements. By using the ATP dataset, we were able to investigate the association between PS and breast cancer screening using a population-based sample, which minimizes selection biases related to narrowly defined sample frames and enhances generalizability to similar populations with the same demographic composition as Alberta (e.g., other Canadian provinces or countries such as the USA).[12]

Of course, as with many epidemiological studies, the participants in our sample tended to display characteristics associated with a healthier subset of the population (e.g., predominantly married, those with postsecondary education, and those who reported past mammography screening). Since these individuals are also the likely types of people to visit family doctors, the policy implications of our findings suggest the utility of communicating cancer risk information in family practice settings. For other types of persons not represented by our sample, different means of communicating cancer risk information may be necessary.

We could only assess the cross-sectional impact of PS on mammography screening behaviour in the ATP dataset. Two reasons precluded longitudinal assessment. First, PS was asked in one survey (S04), meaning we could not examine whether changes in PS over time would affect screening behaviour. Second, an overwhelmingly large proportion of the sample reported receipt of mammography screening at follow-up time points (i.e., 87%–98%, depending on the time point). In such situations, quasi-complete or complete separation of the data will produce questionable model fit.

We were also limited to measuring PS with the three questions in ATP. Our literature search found several different means of measuring PS (Supplementary Table 3), with no agreed-upon consensus about the optimal measure. Despite the plethora of measures, our results were consistent across the PS questions in ATP and consistent with previously published analyses. The use of multiple questions in ATP permitted us to compare our results across different means of operationalizing the PS construct, and the similarities in findings suggest our conclusions are robust to differences among measures. Of course, the PS questions in ATP asked about cancer in general, precluding us from assessing PS for breast cancer specifically.

Table 2 – Multivariable logistic regression results.

Characteristics	Personal_risk_cancer[a,b,c]			Percentage_people_DX_cancer[d,e,f]			Percentage_own_DX_cancer[g,h,i]		
	Adjusted odds ratio estimate	95% Confidence interval		Adjusted odds ratio estimate	95% Confidence interval		Adjusted odds ratio estimate	95% Confidence interval	
Perceived susceptibility (continuous)	**1.20**	**1.07**	**1.36**	1.01	1.00	1.01	**1.01**	**1.00**	**1.01**
Age	**1.20**	**1.17**	**1.22**	**1.19**	**1.16**	**1.22**	**1.19**	**1.17**	**1.22**
Marital status									
Married	1.09	0.75	1.60	1.12	0.76	1.64	1.08	0.74	1.59
Previously, but no longer married	0.82	0.51	1.32	0.83	0.51	1.33	0.81	0.50	1.30
Never married	1.00			1.00			1.00		
Work status									
Working full-time	1.02	0.71	1.48	1.02	0.71	1.47	1.01	0.70	1.45
Working part-time	1.02	0.69	1.51	0.99	0.67	1.46	1.00	0.68	1.47
Retired	0.50	0.23	1.10	0.52	0.24	1.13	0.51	0.23	1.11
Not working	1.00			1.00			1.00		
Education									
University or more	**1.41**	1.02	1.95	**1.43**	1.03	1.99	1.44	1.04	2.00
Post-secondary school, but not university	1.20	0.91	1.57	1.19	0.91	1.57	1.20	0.91	1.58
High school or less	1.00			1.00			1.00		
Family history of cancer									
Yes	1.12	0.88	1.42	1.21	0.96	1.53	1.16	0.91	1.48
No	1.00			1.00			1.00		
Area of residence									
Urban	**1.79**	**1.39**	**2.32**	**1.78**	**1.38**	**2.31**	**1.74**	**1.34**	**2.25**
Rural	1.00			1.00			1.00		

DX, diagnosis.
Bolded values in the table body are significant at the 5% level of significance.
[a] C-statistic = 0.792.
[b] Yes (n = 1243), no (n = 535), 25 missing values.
[c] Perceived susceptibility question 1: 'Compared to other people your age, what do you think are your chances of being diagnosed with cancer during your lifetime?'
[d] C-statistic = 0.790.
[e] Yes (n = 1215), no (n = 531), 57 missing values.
[f] Perceived susceptibility question 2: 'On a scale of 0 %–100%, what percentage of people your age in the general population do you think will be diagnosed with cancer in their lifetime?'
[g] C-statistic = 0.790.
[h] Yes (n = 1228), no (n = 530), 45 missing values.
[i] Perceived susceptibility question 3: 'On a scale of 0%–100%, what would you estimate to be your chance of being diagnosed with cancer in your lifetime?'

Conclusions

In conclusion, personal PS of developing cancer was found to be statistically significantly associated with mammography screening behaviour when analysed cross-sectionally. From a health promotion perspective, our findings suggest that highlighting personal PS of developing cancer can improve breast cancer screening rates, which are still relatively low in many jurisdictions. Based on these findings, future studies could explore whether cognitive factors such as psychological characteristics (e.g., personality) and perceived barriers to health system access may influence screening behaviour.

Author statements

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Ethical approval

This study received ethics clearance from the University of Waterloo's Office of Research Ethics (file #21726).

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

M.G. and M.O. conceptualized and designed the study. M.G., A.C., J.G., and M.O. acquired, analysed, or interpreted the data. M.G. drafted the manuscript, and A.C., J.G., and M.O. revised the manuscript for important intellectual content.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2019.08.004.