Communication With Clinicians and Relatives About Cascade Genetic Testing in Cancer Patients With Germline Pathogenic Variants

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ABSTRACT

PURPOSE Germline testing is underutilized and varies by cancer diagnosis. We hypothesized that patient and clinician involvement in cascade testing of relatives varies by the cancer susceptibility (breast *v* gastrointestinal [GI]) of the affected gene.

METHODS All patients diagnosed with cancer in Georgia or California during 2018-2019 and reported to SEER registries, who were linked to a pathogenic variant (PV) result from testing laboratories, were surveyed 4.5 years postdiagnosis about (1) clinician involvement in result communication to relatives, (2) attitudes about result communication, (3) result communication to relatives, and (4) relatives' testing. PVs were categorized by primary association with breast (*BRCA1, BRCA2, ATM, BARD1, BRIP1, CDH1, CHEK2, PALB2, PTEN, RAD51C, RAD51D, STK11, TP53*) or GI cancers (*MLH1, MSH2, MSH6, PMS2, EPCAM, APC, BMPR1A, CDKN2A, GREM1, POLD1, POLE, SMAD4*).

RESULTS A total of 4,080 patients were surveyed; 2,183 responded (53.5%). Most had PVs associated with breast (83.4%) versus GI cancers (16.6%). Most (85.0%) reported a genetic counseling visit. Genetic counselors were most involved in encouraging family communication (71.5%, *v* oncologists 33.4%, surgeons 19.4%), advising how to talk with relatives (55.0%, versus oncologists 18.0%, surgeons 9.1%), and talking directly with relatives (33.4%, *v* oncologists 12.6%, surgeons 7.0%). Most patients considered sharing results their responsibility (86.8%); they notified 86.8% of first-degree and 44.9% of second-degree relatives. Nearly one third (29.0%) of patients reported that no relative was tested, whereas 18.3% reported that four or more relatives were tested. Outcomes did not differ by affected gene or cancer type ($P > .1$).

CONCLUSION Patients with cancer are motivated to communicate PV results to relatives. However, few clinicians are involved and relatives' testing remains low. Novel care delivery models are needed to advance cascade testing and precision risk reduction.

ACCOMPANYING CONTENT

Appendix

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INTRODUCTION

Germline genetic testing is essential for cancer care as it guides selection of treatments such as immune checkpoint inhibitors for patients with Lynch syndrome and poly(ADP-ribose) polymerase inhibitors for patients with *BRCA1* and/or *BRCA2* (*BRCA1/2*) pathogenic variants (PVs).[1-3] However, germline testing is underutilized and varies by cancer diagnosis: notably, undertesting of patients with gastrointestinal (GI) versus breast cancers has been described as a GI gap.[4-7] This GI gap is concerning because PVs in Lynch syndrome genes (*MLH1, MSH2, MSH6, PMS2, EPCAM*) are similarly prevalent as in *BRCA1/2* and PV carriers have substantial cancer risk and benefit from prevention and early detection strategies. However, public awareness has focused on *BRCA1/2* as an exemplar of hereditary cancer risk,[8-10] whereas Lynch syndrome has received less attention.

Identifying a PV in a patient with cancer should prompt result communication and cascade genetic testing of

CONTEXT

Key Objective

How do patients diagnosed with cancer communicate with their clinicians and relatives about germline genetic test results that show a pathogenic variant (PV) in a cancer susceptibility gene, and does this vary by a patient's cancer diagnosis?

Knowledge Generated

Among 2,183 patients who were diagnosed with cancer in 2018-2019, identified through population-based cancer registries and surveyed, most reported a genetic counseling visit and considered that informing family members about genetic testing results was their responsibility. However, patients reported low rates of both clinician discussion and family utilization of genetic testing, and there was no difference according to the patient's cancer diagnosis or affected gene.

Relevance

Patients with PVs had strong interest in genetic testing for their relatives, but gaps in clinician discussion and family testing persist. New approaches are needed to facilitate cascade genetic testing and enable precision cancer prevention.

relatives to enable risk-adapted screening and prevention. Yet, cascade testing rates are low.[11-13] Barriers include geographic dispersion and limited contact among family members, the fragmented nature of medical systems and insurance coverage, and fear of insurance discrimination or privacy loss. Patients are charged with disclosing their PV result and testing recommendations to relatives, which may be burdensome in the context of their own cancer treatment. Little is known about how patients perceive their role in family notification, whether cancer clinicians are involved, and which relatives patients notify.

We surveyed a population-based cohort of patients with any type of cancer and a germline PV. Based on the GI gap in germline testing, we hypothesized that there would be more engagement by patients, relatives, and clinicians with cascade testing for PVs in *BRCA1/2* (and other genes primarily associated with breast cancers) versus in Lynch syndrome genes (and other genes primarily associated with GI cancers), as indicated by (1) clinician involvement in result communication to relatives, (2) patient attitudes about result communication, (3) patient communication of results to relatives, and (4) relatives' testing uptake.

METHODS

Patient Sample

The Georgia-California Surveillance, Epidemiology and End Results (SEER) Genetic Linkage Initiative included all patients diagnosed with any cancer in Georgia or California from 2013 to 2019 and reported to SEER registries, who were also linked to a clinical germline testing result from any of four laboratories that performed most cancer-related germline testing in these states (Ambry Genetics, Aliso Viejo, CA; Bioreference/GeneDx, Stamford, CT; Labcorp (formerly Invitae), San Francisco, CA; Myriad Genetics, Salt Lake City, UT) from 2012 to 2021.[4] From this initiative, we identified all adults of both sexes (n = 5,697) who were (1) diagnosed with their first cancer at any anatomic site in 2018-2019 (the most recent diagnosis year for which data were available); (2) alive at the time of selection; and (3) linked to a PV or likely PV (analyzed together as PV) in any of 28 genes (for all of which gene-specific practice guidelines existed at the time of study initiation): *APC, ATM, BAP1, BARD1, BMPR1A, BRCA1, BRCA2, BRIP1, CDH1, CDK4, CDKN2A, CHEK2, EPCAM, GREM1, MITF, MLH1, MSH2, MSH6, PALB2, PMS2, POLD1, POLE, PTEN, RAD51C, RAD51D, SMAD4, STK11*, and *TP53*. Most patients were tested close to their cancer diagnosis date (mean 92.3 days, range −714, 2,490; 11.5% tested prediagnosis) and surveyed approximately 4.5 years postdiagnosis (mean 1,653.4 days, range, 1,041, 3,032).

Survey Methods

A print survey, study information, and $20 cash gift were mailed to patients with an option to complete the full survey online. A modified Dillman[14] method was implemented to optimize response rate. Bilingual materials were mailed to all patients whom SEER identified as Hispanic. Surveys were mailed in monthly waves over 15 months. The investigators obtained informed consent from each participant, and research was performed after approval by local Human Investigations Committees and the Department of Health and Human Services.

Outcome Measures

The survey questions below provided data for the following outcome measures:

Patient Report of Clinician Involvement in Communication With Relatives

Patients were asked whether "you have ever had a visit with a genetics expert to discuss cancer risk—that is, an appointment

where the whole discussion is about genetic risk for cancer? (yes or no)," and those who answered yes were categorized as having undergone genetic counseling. Patients were also asked whether a genetic counselor, medical oncologist, or cancer surgeon: "(1) Encouraged you to talk about your genetic test results with your family members; (2) Gave you advice or tips on how to talk with your family members about your genetic test results; and (3) Talked directly with your family members about whether to get genetic testing for cancer risk."

Patient Attitudes About Communication of Genetic Test Results to Relatives

Patients were asked about their attitudes about engagement with relatives on a five-point Likert scale from "not at all true" to "very true", as follows: "Thinking about talking with your biological family about genetic testing for cancer risk, how true are each of the statements below? I understand my results well enough to talk to my relatives; my results are useful to my family; it is my responsibility to share results with family; I am confident that I can talk with my family members about genetic testing; I have enough time to reach out to my family members and talk with them about genetic testing; I can handle my own emotions when talking with my family members about genetic testing."

Patient Report of Communication With Relatives About Genetic Test Results

Patients were asked to define their family size in terms of the number of living adult first-degree and second-degree relatives (parents, siblings, half siblings, nephews/nieces) and, for each degree, were asked, "How many have you talked with about your cancer genetic test result?" This enabled calculation of the proportion of first- and second-degree relatives with whom patients discussed results.

Patient Report of Family Genetic Testing

Patients were asked how many relatives subsequently underwent testing for the identified PV, as follows "After you received your cancer genetic test results, how many of your biological family members got genetic testing?". Response categories were ordinal (0, 1, 2-3, 4 or more). This question was added to the latter one third of the survey waves (620 of 1,944, 31.9%) to investigate the interplay between patients' notification of relatives about results and report of testing in the family.

Demographic, Clinical, and Genetic Measures

Demographic and clinical variables included age at cancer diagnosis, sex, race, ethnicity, and cancer anatomic site from SEER registries; and education level from the survey.

Genes with PVs were identified by results from participating laboratories. As in prior work,[4] we categorized genes as primarily associated with breast cancer (*BRCA1, BRCA2, ATM, BARD1, BRIP1, CDH1, CHEK2, PALB2, PTEN, RAD51C, RAD51D, STK11, TP53*) or GI cancer (Lynch syndrome genes *MLH1, MSH2, MSH6, PMS2, EPCAM,* and other genes: *APC, BMPR1A, CDKN2A, GREM1, POLD1, POLE, SMAD4*). Uncertainty persists about an association of *BRIP1* with breast cancer risk; accordingly, we performed a sensitivity analysis excluding patients with *BRIP1* PVs (n = 36) and observed no statistically significant or clinically meaningful difference in any results.

Previously,[4] we included genes associated with other hereditary cancer syndromes. However, given the small number of survey respondents with PVs in this category (n = 31), we excluded them from analysis.

Statistical Analysis

We examined patient-reported outcomes by PV gene group and other patient factors (age at cancer diagnosis, sex, race and ethnicity, family size, education, cancer anatomic site) using bivariate statistics. We created response weights to account for nonresponse bias and adjusted bivariate results using these weights. In secondary analyses, we examined multivariable models including all covariates shown in Appendix Table A1 to account for possible confounding. We also included the response weights in the secondary analyses. We found no meaningful or statistically significant differences between these secondary analyses and the primary results.

RESULTS

Patient Characteristics

A total of 4,080 eligible patients were surveyed, and 2,183 responded (response rate 53.5%). The response rate was significantly lower in Hispanic patients (41.2%) versus others (47.0%, 57.3%, and 59.0% for Asian, Black, and non-Hispanic White patients, respectively; $P < .001$) and in patients age 19-45 years (48.9%) versus older (54.6%, 57.6% and 54.1% for ages 46-55, 56-65, and >65, respectively, $P < .001$), but no statistically significant differences in response rate were observed by PV gene group, cancer type, or sex. All analyses were run using response weights to account for these differences. There were 239 analytic exclusions, leaving an analytic sample of 1,944 (Appendix Fig A1).

Table 1 shows patient characteristics. Consistent with our prior study of testing utilization by cancer type,[4] the most common diagnosis among tested patients was breast cancer and the most commonly identified PVs were in genes associated with breast cancer (1,621, 83.4%), followed by GI cancer–associated PVs (323, 16.6%). A total of 93 patients had PVs in multiple genes; however, no patient had PVs from both gene groups (breast and GI, per study categories). The sample was diverse in terms of cancer anatomic sites, including female breast (1,237, 63.6%), colorectal (116, 6.0%), ovary (107, 5.5%), endometrial (86, 4.4%), prostate (73, 3.8%), melanoma (60, 3.1%), other gynecologic (44, 2.3%), thyroid (26, 1.3%), lung (21, 1.1%), and pancreas (20, 1.0%). In the analytic sample, 11.4% was male, 64.3% non-Hispanic

TABLE 1. Patient Characteristics

Patient Characteristic	No.	%
Gene group of PV		
BRCA1/2 or other breast cancer–related genes	1,621	83.4
Lynch syndrome or other GI cancer–related genes	323	16.6
Cancer anatomic site		
Female breast	1,237	63.6
Colorectal	116	6.0
Ovary	107	5.5
Endometrial	86	4.4
Prostate	73	3.8
Melanoma	60	3.1
Other gynecologic	44	2.3
Thyroid	26	1.3
Lung	21	1.1
Pancreatic	20	1.0
Kidney	19	1.0
Other genitourinary	18	0.9
Stomach	18	0.9
Head and neck	14	0.7
Male breast	12	0.6
Other GI	12	0.6
Anus	6	0.3
Other	55	2.8
Sex		
Male	221	11.4
Female	1,723	88.6
Race and ethnicity		
Non-Hispanic White	1,250	64.3
Black	178	9.2
Asian	160	8.2
Hispanic	343	17.6
Other	13	0.7
Family size (No. of first-degree relatives)		
1-3	740	38.1
4-6	814	41.9
7 or more	390	20.1
Age at diagnosis, years		
19-45	551	28.3
46-55	534	27.5
56-65	492	25.3
>65	367	18.9
Education		
High school or less	303	16.2
Some college	537	28.7
College graduate	541	28.9
Graduate degree	490	26.2

Abbreviation: PV, pathogenic variant.

White, 9.2% Black, 17.6% Hispanic, and 8.2% Asian. Approximately one quarter (28.3%) of patients were diagnosed at age 45 years or younger; 38.1% reported having 1-3 first-degree relatives, 41.9% reported 4%-6%, and 20.1% reported seven or more. Nearly half (44.9%) of patients had less education than a college degree.

Clinician Involvement by Cancer Type and Gene Group

Patients reported varying involvement by clinicians in notification and testing of relatives. Most (85.0%) patients reported a genetic counseling visit, and genetic counselors were the most engaged clinicians regarding family communication (Figs 1A, 1B, and 1C). Among the 15% of patients who did not report a dedicated genetic counseling visit, 93% reported some conversation with a clinician about genetic testing. Most patients (71.5% with a PV in the breast gene group, hereafter breast, 69.1% with a PV in the GI gene group, hereafter GI) reported that genetic counselors encouraged them to talk to relatives about results, approximately half (55.0% breast, 54.0% GI) said that genetic counselors gave them advice about how to talk to relatives, and one third (33.5% breast, 33.2% GI) reported that genetic counselors talked directly to relatives; by contrast, these proportions were lower for medical oncologists (encouraged: 33.4% breast, 29.3% GI; gave advice: 18.0% breast, 15.0% GI; and talked: 12.6% breast, 10.3% GI) and cancer surgeons (encouraged: 19.4% breast, 19.8% GI; gave advice: 9.1% breast, 7.8% GI; and talked: 7.2% breast, 7.0% GI). Chi-square tests showed no statistically significant differences in clinician involvement by PV gene group ($P > .1$, Fig 1), nor by cancer anatomic site, association of the cancer type with affected gene, or demographic features (Appendix Table A1).

Patient Attitudes About Communication of Genetic Test Results to Relatives

Most patients reported that they understood results well enough to talk to their relatives (74.1% breast, 77.1% GI), that results were useful to their relatives (88.1% breast, 88.8% GI), and that it was their responsibility to share results with their family (86.8% breast, 91.7% GI). In chi-square tests, there were no statistically significant differences by PV gene group ($P > .1$, Fig 2), nor by cancer anatomic site, association of cancer type with affected gene, or demographic features (Appendix Table A1).

Patient Report of Communication With Relatives About Genetic Test Results

Patients reported telling most (86.8% breast, 87.5% GI) of their first-degree relatives and approximately half (44.9% breast, 42.2% GI) of their second-degree relatives about PV results, without statistically significant differences by gene group (t-test $P > .1$, Fig 3), nor by cancer anatomic site or demographic features (Appendix Table A1).

Patient Report of Family Genetic Testing

Nearly one third (31.9%) of patients received surveys including the question about relatives' testing: response rates

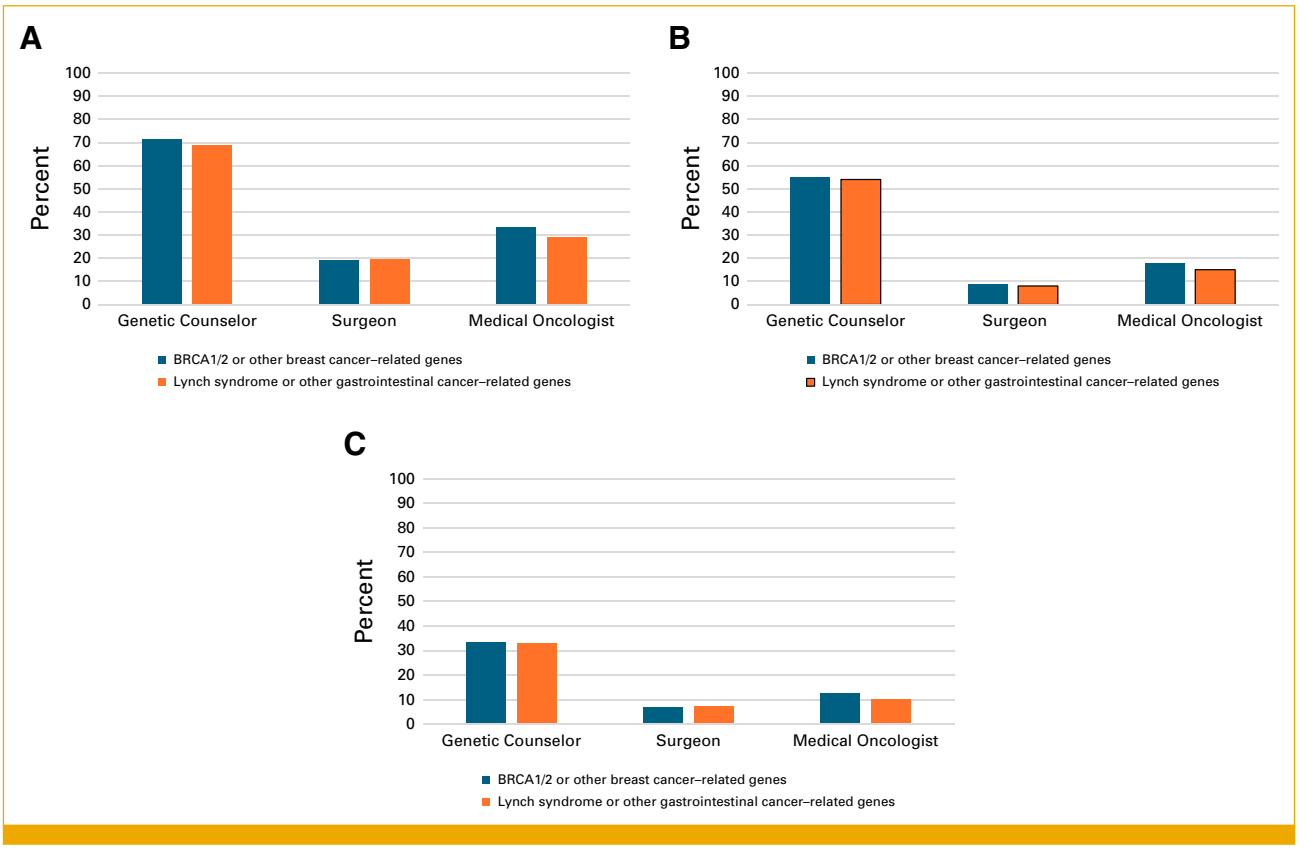

FIG 1. Patient report of clinician involvement in cascade genetic testing by gene group (primarily associated with breast cancer *v* with gastrointestinal cancers): (A) Encouraged to talk about test results with relatives, (B) gave advice about how to talk to relatives about test results, and (C) talked directly with relatives about whether to get genetic testing.

for this subsample were the same as those for others, with no difference in patient characteristics. In this subsample, 29.0% of patients reported that no relatives underwent testing after the patient received results; 22.7% reported that one relative was tested, 30.1% reported that two to three relatives were tested, and 18.3% reported that four or more

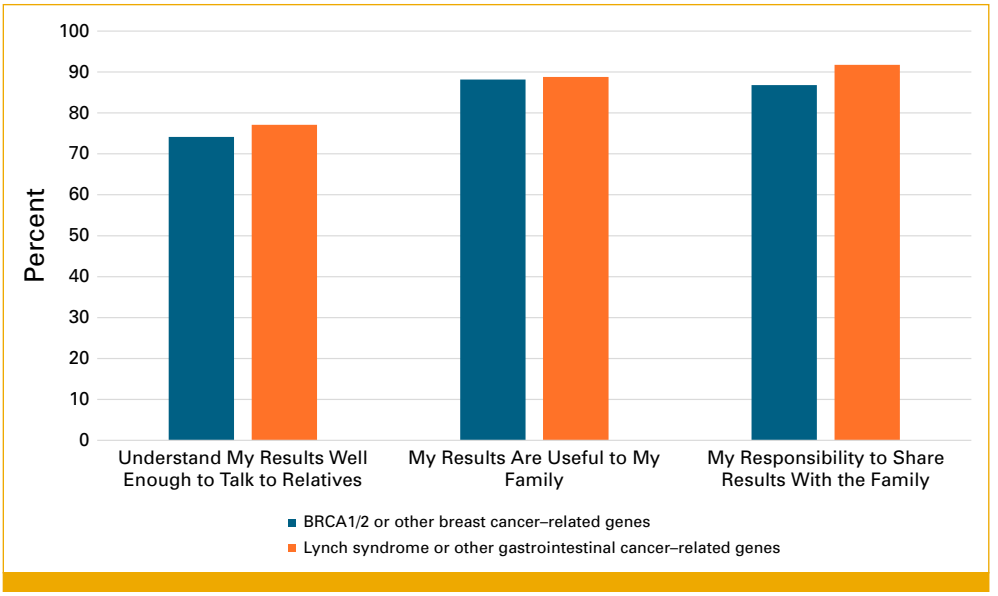

FIG 2. Patient attitudes about communication of genetic testing results with their family by gene group (primarily associated with breast cancer *v* with gastrointestinal cancers), shown by the percentage of patients who reported that each statement was "quite true" or "very true".

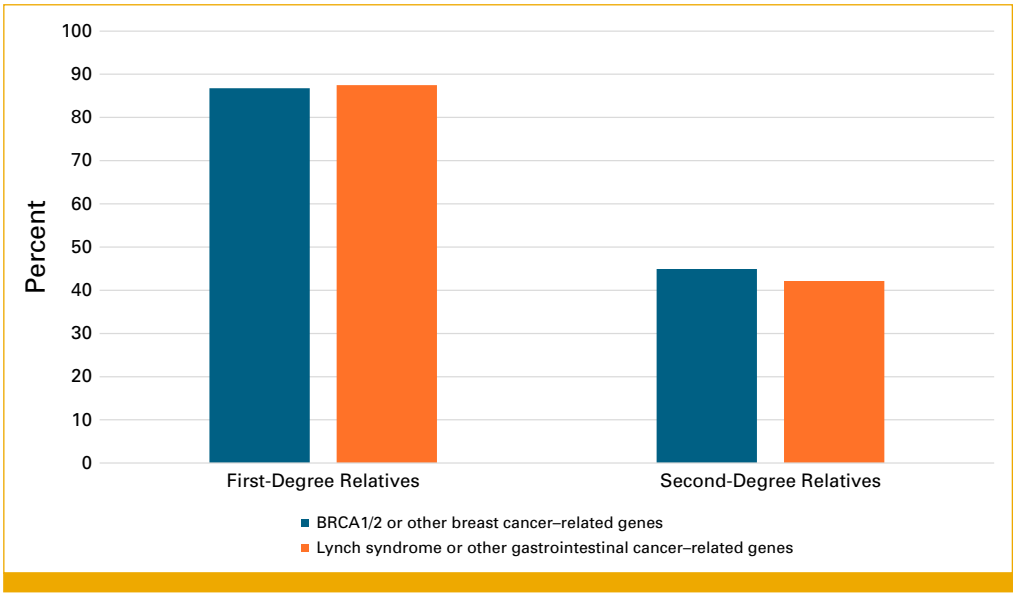

FIG 3. Patient report of the proportion of first-degree and second-degree relatives with whom the patient shared genetic testing results, by gene group (primarily associated with breast cancer *v* with gastrointestinal cancers).

were tested. There was no statistically significant difference in the distribution of relatives testing by PV gene group (chi-square $P = .166$, Table 2), cancer anatomic site, or demographic features (Appendix Table A1).

DISCUSSION

In this large, contemporary, population-based cohort, we observed no difference by PV gene group (primarily breast cancer–associated *v* GI cancer–associated) in terms of clinician, patient, and relative involvement in cascade testing. Patients diagnosed with all types of cancers reported telling >80% of first-degree relatives about their PV results. However, patients reported low clinician involvement in facilitating family communication. Consistent with prior studies,[7,11,15] far too few relatives were tested: 62.1% of patients reported having four or more first-degree relatives, but only 15.9% reported that four or more relatives were tested. Regardless of the affected gene, there was a bottleneck in the cascade process between talk (patient-relative communication) and action (relatives' completion of testing) that calls for urgent development and evaluation of novel intervention strategies.

The finding of no difference in cascade testing engagement by PV gene group is reassuring. The results may reflect a modern cohort with greater genetic awareness and align with the increasing routine use of multiple gene testing panels whose scope is broader than any single cancer type.[16-18] However, given the previously identified GI gap in genetic testing of patients with GI versus breast cancers,[5-7] our findings may not reflect the experiences of all patients with GI cancers, particularly those who did not receive genetic testing. We observed no statistically significant variation in outcomes by other patient characteristics (cancer anatomic site or sociodemographics). Overall, these results offer reassurance that patients thought they understood their PV results well enough to communicate with relatives

TABLE 2. Number of First-Degree Relatives Who Had Genetic Testing, by Pathogenic Variant Gene Group

Relatives Tested	No. (%) *BRCA1/2* or Other Breast Cancer–Related Genes[a]	No. (%) Lynch Syndrome or Other Gastrointestinal Cancer–Related Genes[a]	No. (%) Total
Relatives tested, No.			
0	158 (29.9)	21 (23.3)	179 (29.0)
1	123 (23.3)	17 (18.9)	140 (22.7)
2-3	157 (29.7)	29 (32.2)	186 (30.1)
4-8	80 (15.2)	18 (20.0)	98 (15.9)
9 or more	10 (1.9)	5 (5.6)	15 (2.4)

[a]No statistically significant difference by gene group (chi-square $P = .166$).

about their test results and were motivated to do so, regardless of whether their PV was primarily associated with breast or GI cancers.

Despite patients' strong motivation to notify relatives of test results, clinician support was low. Patients reported that surgeons and medical oncologists rarely encouraged or facilitated engagement with relatives, which likely reflects competing clinical priorities, limited genetics expertise, and absent financial incentives. This raises the question of how much involvement is reasonable to expect from cancer clinicians who lack genetics expertise. A genetic counselor shortage and the treatment relevance of results have prompted oncologists, surgeons, and advanced practice providers (nurse practitioners and physician associates) to initiate germline testing, with acceptable outcomes.[19-23] However, the low clinician involvement with at-risk relatives that we observed suggests much room for improvement. Interventions to increase cascade testing, including educational materials and care coordination, have had mixed results.[24] Genetics certification programs for cancer clinicians may enhance their capacity to facilitate patient and family education and cascade testing.[25,26] But more attention is needed to address barriers to education related to restrictive and sometimes conflicting testing guidelines. Additional research is needed to identify reasons that clinicians are insufficiently engaged on the topic of cascade genetic testing, which may guide targeted education strategies.

Despite the inadequate national supply of genetic counselors, a remarkable 85% of patients in this population-based sample reported a genetic counseling visit, suggesting effective referral. Yet, substantial gaps in cascade testing persisted. One potential explanation is that even among genetic counselors, direct engagement with relatives was low. Studies of direct contact between patients' clinicians and relatives have reported high cascade testing rates.[11,13,27,28] However, serious barriers to direct contact between genetic counselors (or other clinicians) and relatives need to be addressed. Barriers include privacy concerns, such as the mandate that a clinician obtain patient consent to speak directly to a relative; insurance coverage; the complex dynamics of family communication; and consequently, patients' uncertainty about which relatives might be willing to engage directly with their genetic counselor or other clinician. Furthermore, prior studies have reported variability in patients' willingness to notify relatives themselves, with some patients requiring more clinician support.[29]

This study has limitations and strengths. Patients' awareness of genetic testing in their family members may be incomplete, which is a potential limitation in interpreting their responses. In addition, patients were surveyed approximately 4.5 years after their cancer diagnosis and might have had variable recall of relatives' engagement and cascade testing. The survey response rate was 53.5%; while this equals or exceeds that of comparable studies and includes patients with all cancer types, we cannot comment on the experiences of nonresponders. Patients were not asked about the age of their relatives when they were notified of the patient's PV results. We also do not know about the circumstances of clinician communication with relatives—whether it occurred in the examination room when relatives accompanied the patient to an appointment (which might circumvent privacy concerns about clinician-relative contact outside of a patient visit) or in another context. We do not know whether engagement by surgeons and oncologists was limited because they preferentially referred patients to genetic counselors affiliated with their practice or for other reasons. Furthermore, we do not know whether patients perceived an unmet need for communication with clinicians about genetic testing for their relatives. Because of the small number of respondents who carried PVs in genes other than those primarily associated with breast or GI cancers, we excluded them from analysis. The study's limitations are balanced by considerable strengths, including a representative, contemporary, population-based sample accrued through two statewide SEER registries, and linked germline results obtained directly from clinical testing laboratories.

The results of this study have implications for patient care. They demonstrate that cancer patients with PVs are highly motivated to communicate results to relatives, with no difference according to the affected gene or spectrum of cancer risk. However, few surgeons or oncologists are substantially involved and relatives' testing rates remain too low. Most patients lack specialized knowledge about genetics or oncology and are not well-equipped to educate relatives about the medical implications and logistics of genetic testing. Moreover, relatives can weigh the pros and cons of genetic testing over time—which offers opportunities to reinforce the cascade-testing message across multiple points of care. We and others are evaluating online tools that facilitate patient-family education and communication about the importance of testing and implications of PV results and reduce logistical barriers to testing.[30-35] This study's results suggest that such initiatives could catalyze cascade genetic testing and improve precision cancer risk reduction in families across a broad array of patient clinical and sociodemographic characteristics.

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APPENDIX

TABLE A1. Patient Report of Clinician Communication to Relatives, Patient Attitudes About Responsibility for Sharing Test Results, Patient Communication of Results to First-Degree Relatives, and Patient Report of Relatives' Testing, by Patient Characteristics

Patient Characteristic	No.	% (95% CI) Clinician Communication: Genetic Counselor Talked Directly to Relatives	% (95% CI) Patient Attitudes: Felt Responsibility to Share Results With Relatives	% (95% CI) Patient Communication: Percent of First-degree Relatives With Whom Results Were Shared	No.[a]	% (95% CI) Relatives Tested: Percent of Patients With Two or More First-Degree Relatives Who Had Genetic Testing
Gene group of PV						
BRCA1/2 or other breast cancer–related genes	1,621	34.2 (31.9 to 36.6)	87.0 (85.4 to 88.7)	87.1 (85.9 to 88.2)	528	46.8 (42.5 to 51.1)
Lynch syndrome or other gastrointestinal cancer–related genes	323	34.4 (29.2 to 39.6)	92.8 (89.9 to 95.6)	87.8 (85.1 to 90.5)	90	57.8 (47.4 to 68.2)
Cancer anatomic site						
Female breast	1,237	32.8 (24.1 to 41.4)	89.5 (83.8 to 95.2)	87.2 (82.3 to 92.1)	415	47.5 (42.6 to 52.3)
Colorectal	116	31.4 (21.4 to 41.4)	85.9 (78.3 to 93.4)	90.4 (86.5 to 94.4)	32	46.9 (28.6 to 65.2)
Ovary	107	35.2 (32.6 to 37.9)	87.9 (86.1 to 89.7)	87.3 (86.1 to 88.6)	34	41.2 (23.7 to 58.6)
Endometrial	86	31.6 (8.6 to 54.6)	84.2 (66.2 to 100)	85.3 (75.1 to 95.5)	30	53.3 (34.4 to 72.3)
Prostate	73	33.3 (11.3 to 55.3)	71.4 (50.4 to 92.5)	88.6 (75.4 to 100)	21	33.3 (11.3 to 55.3)
Melanoma	60	23.3 (12.3 to 34.4)	87.9 (79.3 to 96.6)	82.0 (73.9 to 90.1)	14	64.3 (35.6 to 93.0)
Other gynecologic	44	43.0 (33.5 to 52.5)	86.7 (80.1 to 93.3)	86.7 (82.1 to 91.4)	15	60.0 (31.9 to 88.1)
Thyroid	26	35.0 (12.1 to 57.9)	90.0 (75.6 to 100)	94.0 (87.6 to 100)	8	75 (36.3 to 100)
Lung	21	27.4 (16.9 to 37.9)	87.3 (79.4 to 95.3)	81.7 (74.5 to 88.9)	3	66.7 (0 to 100)
Pancreatic	20	33.3 (2.0 to 64.6)	91.7 (73.3 to 100)	75.7 (55.3 to 96.1)	7	71.4 (26.3 to 100)
Kidney	19	66.7 (12.5 to 100)	100	78.5 (43.4 to 100)	4	50.0 (0 to 100)
Other genitourinary	18	28.6 (1.5 to 55.6)	76.9 (50.4 to 100)	91.7 (81.5 to 100)	2	50.0 (0 to 100)
Stomach	18	16.7 (8.1 to 41.4)	90.9 (70.7 to 100)	85.6 (65.1 to 100)	8	62.5 (19.2 to 100)
Head and neck	14	33.3 (9.2 to 57.5)	94.1 (81.6 to 100)	94.1 (85.1 to 100)	3	33.3 (0 to 100)
Male breast	12	40.9 (25.8 to 56)	95.3 (88.8 to 100)	88.2 (79.7 to 96.6)	5	40.0 (0 to 100)
Other gastrointestinal	12	44.4 (19 to 69.9)	88.2 (71.2 to 100)	95.6 (90.3 to 100)	1	0.0 (0 to 100)
Anus	6	30.8 (11.8 to 49.8)	92.0 (80.6 to 100)	83.1 (73.1 to 93.1)	2	50.0 (0 to 100)
Other	55	20.0 (9.1 to 30.9)	90.7 (82.8 to 98.7)	88.6 (82.5 to 94.7)	14	50.0 (20 to 80)
Sex						
Male	221	28.1 (22.1 to 34.0)	90.7 (86.8 to 94.6)	85.3 (81.7 to 88.8)	64	43.8 (31.3 to 56.2)
Female	1,723	35.1 (32.8 to 37.3)	87.6 (86.1 to 89.2)	87.4 (86.3 to 88.5)	554	48.9 (44.7 to 53.1)
Race and ethnicity						
Non-Hispanic White	1,250	31.4 (28.9 to 34.0)	88.6 (86.8 to 90.4)	88.8 (87.5 to 90.1)	369	49.6 (44.5 to 54.7)
Black	178	36.0 (28.8 to 43.1)	83.4 (77.9 to 89.0)	82.3 (78.6 to 85.9)	46	34.8 (20.5 to 49.1)
Asian	160	40.0 (32.3 to 47.7)	87.3 (82.0 to 92.5)	86.9 (82.6 to 91.3)	63	44.4 (31.8 to 57.1)
Hispanic	343	41.4 (36.2 to 46.6)	88.6 (85.2 to 92.0)	84.1 (81.4 to 86.7)	136	51.5 (43.0 to 60.0)
Other	13	23.1 (0 to 49.6)	84.6 (61.9 to 100)	88.3 (74.8 to 100)	4	50.0 (0 to 100)
Family size (No. of first-degree relatives)						
1 to 3	740	31.3 (27.9 to 34.6)	87 (84.5 to 89.4)	89.0 (87.1 to 90.9)	239	35.1 (29.0 to 41.2)
4 to 6	814	35.3 (32.0 to 38.5)	89.1 (87 to 91.3)	89.3 (88.0 to 90.6)	256	55.9 (49.7 to 62.0)
7 or more	390	38.2 (33.4 to 43)	87.5 (84.2 to 90.8)	79.6 (76.8 to 82.3)	123	58.5 (49.7 to 67.4)
Age at diagnosis, years						
19 to 45	551	39.0 (34.9 to 43.1)	88.4 (85.7 to 91.1)	87. (85.1 to 88.8)	215	47.9 (41.2 to 54.6)

(continued on following page)

TABLE A1. Patient Report of Clinician Communication to Relatives, Patient Attitudes About Responsibility for Sharing Test Results, Patient Communication of Results to First-Degree Relatives, and Patient Report of Relatives' Testing, by Patient Characteristics (continued)

		% (95% CI)	% (95% CI)	% (95% CI)		% (95% CI)
Patient Characteristic	No.	Clinician Communication: Genetic Counselor Talked Directly to Relatives	Patient Attitudes: Felt Responsibility to Share Results With Relatives	Patient Communication: Percent of First-degree Relatives With Whom Results Were Shared	No.[a]	Relatives Tested: Percent of Patients With Two or More First-Degree Relatives Who Had Genetic Testing
46 to 55	534	32.4 (28.4 to 36.4)	88.7 (86 to 91.4)	86.8 (84.7 to 88.8)	165	47.9 (40.2 to 55.6)
56 to 65	492	35.0 (30.7 to 39.2)	89.2 (86.4 to 92.0)	88.0 (85.9 to 90.1)	148	48.0 (39.8 to 56.1)
>65	367	28.9 (24.2 to 33.5)	84.7 (80.9 to 88.4)	87.0 (84.4 to 89.6)	90	51.1 (40.6 to 61.6)
Educationb						
High school or less	303	43.9 (38.3 to 49.5)	85.9 (81.9 to 89.9)	84.9 (82.0 to 87.8)	95	55.8 (45.6 to 66.0)
Some college	537	34.6 (30.6 to 38.7)	88.9 (86.2 to 91.6)	86.4 (84.5 to 88.3)	170	40.6 (33.1 to 48.0)
College graduate	541	33.3 (29.3 to 37.3)	87.3 (84.4 to 90.1)	88.0 (86.0 to 90.0)	178	51.7 (44.3 to 59.1)
Graduate degree	490	29.4 (25.3 to 33.4)	89.6 (86.9 to 92.4)	88.1 (86.0 to 90.2)	149	46.3 (38.2 to 54.4)

Abbreviation: PV, pathogenic variant.

[a]Only the final one third of surveyed patients were asked to report the number of relatives tested.

[b]73 survey respondents had missing information on education.

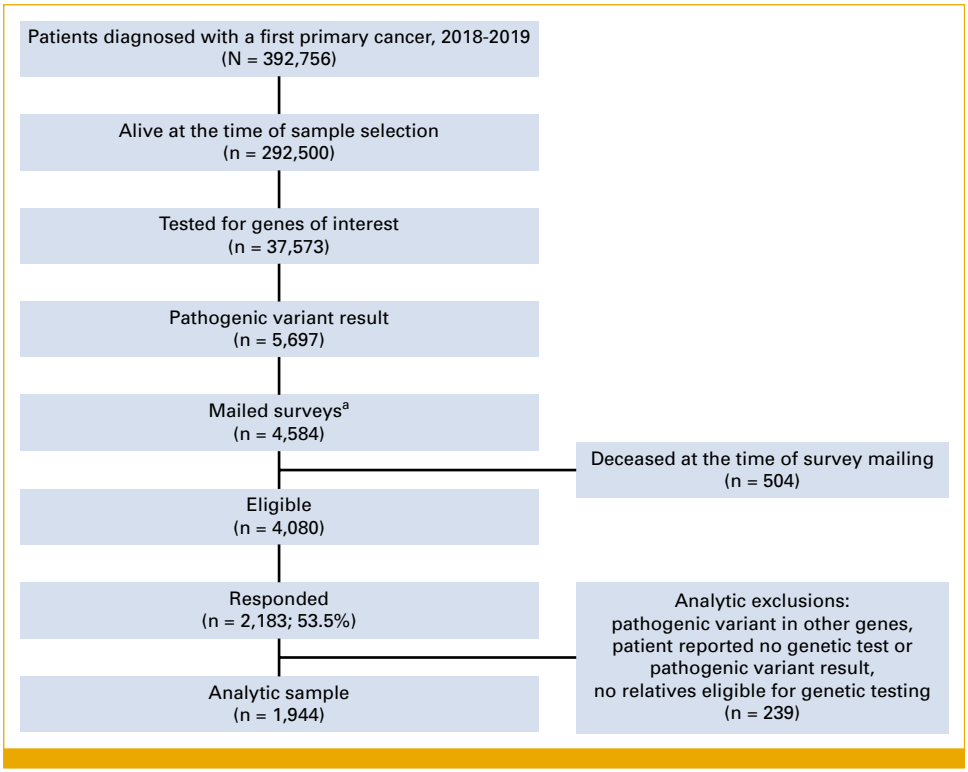

FIG A1. Flow of patients into the analytic sample. [a]A stratified random sample was taken, including all non–breast cancer patients and a sample of patients with breast cancer.