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## ARTICLE

# Health care utilization and behavior changes after workplace genetic testing at a large US health care system



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### ABSTRACT

**Purpose:** This study explored employee health behavior changes and health care utilization after workplace genetic testing (wGT). Wellness-program-associated wGT seeks to improve employee health, but the related health implications are unknown.

**Methods:** Employees of a large US health care system offering wGT (cancer, heart disease, and pharmacogenomics [PGx]) were sent electronic surveys. Self-reported data from those who received test results were analyzed. Descriptive statistics characterized responses, whereas logistic regression analyses explored correlates of responses to wGT.

**Results:** 53.9% ( $n = 418/776$ ) of respondents (88.3% female, mean age = 44 years) reported receiving wGT results. 12.0% ( $n = 48/399$ ) received results indicating increased risk (IR) of cancer, 9.5% ( $n = 38/398$ ) had IR of heart disease, and 31.4% ( $n = 125/398$ ) received informative PGx results. IR results for cancer and/or heart disease ( $n = 67$ ) were associated with health behavior changes (adjusted odds ratio: 3.23; 95% CI 1.75, 6.13;  $P < .001$ ) and health care utilization (adjusted odds ratio: 8.60; 95% CI 4.43, 17.5;  $P < .001$ ). Informative PGx results ( $n = 125$ ) were associated with medication changes (PGx-informative: 15.2%; PGx-uninformative: 4.8%;  $P = .002$ ).

**Conclusion:** This study explored employee responses to wGT, contributing to the understanding of the ethical and social implications of wGT. Receiving IR results from wGT may promote health behavior changes and health care utilization in employees.

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## Introduction

Workplace wellness programs are common among larger employers and typically offer activities intended to improve employee health and well-being.<sup>1,2</sup> Some employers also offer genetic testing as part of their wellness programs,<sup>3-7</sup> known as workplace genetic testing (wGT).<sup>3,4,8</sup> Typically, wGT includes analysis of genes associated with cancer, heart disease, and pharmacogenomics (PGx), as seen in other consumer genetic tests (eg, direct-to-consumer genetic testing [DTC-GT], consumer-initiated genetic testing).<sup>4,5,8,9</sup> Hereditary cancer and heart disease testing have demonstrated medical value in those with high risk due to family history and other risk factors.<sup>10-12</sup> However, clinical criteria fail to capture all at-risk individuals.<sup>13,14</sup> Consumer genetic testing may help identify pathogenic variants in those who do not meet criteria based on family history or other factors.<sup>15</sup> In addition, identifying genes associated with response to medications can benefit patient care. A growing consensus suggests that PGx testing may be most useful when performed preemptively at the population level because many individuals may have actionable findings.<sup>16</sup> Whether wGT bridges gaps unaddressed by other genetic testing avenues is currently unclear.

Although employee interest in genetic testing as a workplace benefit has been documented,<sup>3</sup> it is unknown if such testing results in medically relevant findings and health behavior changes.<sup>17-19</sup> Studies suggest that promised wellness program benefits are not often realized in the workplace,<sup>1,20,21</sup> and the specific effect of wGT on employee health outcomes is not known. Determining whether wGT identifies actionable findings and influences employee health behaviors and decisions is a key first step in ascertaining whether it meets the intended goals of improved employee health.<sup>4,6</sup> This study explored the effect of wGT on health behavior changes and health care utilization among employees of a large US health care system offering wGT.

## Materials and Methods

### Setting and participants

The study population was recruited from a large (~30,000 employee) health care system spanning two Eastern US states. The employer established a wGT program in the Fall of 2018 using a third party's Clinical Laboratory Improvement Amendments and College of American Pathologists-certified testing service. All employees  $\geq 18$  years old were eligible to participate in wGT. At the time of our study, according to the third-party laboratory, about 14,000 employees had requested a wGT sample collection kit, and roughly 8,000 submitted their sample ([Supplemental Figure 1](#)). Employees who were eligible for our study needed to (1) be eligible for wGT, (2) be employed  $\geq 60$

days, and (3) have had the opportunity to either pursue or decline wGT.

The wGT was offered to employees at no cost and included analysis of 30 hereditary cancer genes and 30 heart disease genes for pathogenic variants, as well as 14 PGx genes for findings related to medication response. Although the authors did not have direct access to the pre- and post-test counseling process, some information was obtained from the employer and testing laboratory. Employees had multiple options to learn about wGT.<sup>22</sup> Laboratory genetic counselors (GCs) disclosed pathogenic variants associated with cancer and heart disease to participants. For all other results, participants received results via email. Resources made available to employees to learn about wGT are summarized in [Supplemental Table 1](#).

For our study, recruitment approaches included posting invitations on the internal employee website, advertising the study electronically and in print throughout the health system and all affiliated campuses, and including study announcements in employee meetings and newsletters. Participants received a \$25 incentive for survey completion. The survey was administered from December 2021 to May 2022 via SoundRocket's secure web-based platform.

### Survey development

A web survey was developed by a multidisciplinary research team, adapting an approach utilized in the Impact of Personal Genomics study<sup>23</sup> of DTC-GT users and incorporating input from the study team, advisory board, and from literature review. The survey was piloted twice and iteratively revised to include questions adapted from the Impact of Personal Genomics study and a combination of novel and validated questions. We primarily focused our analysis on survey items that were unique to participants who had wGT. All data were self-reported.

### Survey measures

#### Demographics and personal and family health history

Self-reported demographics included age, sex, gender, race and ethnicity, occupation, education, marital status, and children. Perceived health status, time since last discussion with a clinician, screening history, medication use, smoking history, prior genetic testing, and personal/family history of cancer and heart disease were also ascertained.

#### wGT results

Participants were asked to indicate if they learned about an increased risk for cancer or heart disease through wGT, or if they received results that might inform the use of prescription medications (*Yes*, *No*, and *Don't know*). Respondents endorsing receipt of these types of results were then asked what they learned about their increased risk of cancer or heart disease or their use of prescription

medications. We describe self-reported cancer and heart disease-related wGT results as “increased risk” (IR) or “no increased risk” (NIR) in this paper. Given the prevalence of actionable PGx variants in the general population,<sup>16,24</sup> PGx results were analyzed separately from IR/NIR results. PGx results were described as “informative” if participants self-indicated results might inform their use of prescription medications and “uninformative” if otherwise.

### Perceived utility, feelings, and beliefs about wGT

Perceived utility of wGT was assessed through survey items asking about test usefulness, ease of understanding results, risk perceptions, and information learned through testing. Additionally, participants were asked about psychological responses to wGT experienced within a week after receiving results on a Likert scale (1 = *Not at all* to 5 = *A great deal*). The four subscales from the validated Feelings About Genomic Testing Results (FACToR) questionnaire<sup>25</sup> (negative emotions, positive feelings, uncertainty, and privacy concerns associated with genetic testing) were adapted into 12 items to fit the wGT scenario. Cronbach’s alpha coefficients and confidence intervals were calculated for each subscale as a standard measure of scale reliability and internal consistency.

### Health care utilization and health behavior changes due to wGT results

Health behavior changes and health care utilization, specifically prompted by receipt of wGT results, were obtained across several domains: specific lifestyle alterations (eg, diet, exercise, smoking, alcohol, and vitamins), medical consultations, cancer/cardiovascular screening and risk-reducing surgeries, and medication changes. Confidence in clinicians’ understanding of wGT results, types of clinicians consulted, result inclusion in medical records, and diagnoses after wGT were also ascertained. Health behavior changes and health care utilization were self-reported via multiple-response (select-all-that-apply) questions.

### Financial behavior changes due to wGT results

Health-related financial behavior changes based on wGT results were identified through multiple-response questions about insurance, financial/retirement plans, and other advance planning.

### Communication and resources used for test results

Communication of results and use of resources to learn more about the implications of test results were obtained through multiple-response items querying the sharing of results (eg, with relatives). Information sources sought by participants in response to wGT results were also ascertained through multiple-response questions, and participants rated the utility of resources on a Likert scale (1 = *Not at all useful* to 3 = *Very useful*).

## Data analysis

Descriptive statistics characterized participants who had wGT and reported receiving their results.  $\chi^2$  analyses examined differences between respondents reporting IR vs NIR results in terms of their specific health behavior changes/health care use and perceived utility. Proportional *z*-tests compared frequencies of (1) unknown results among test types and (2) personal/family history of relevant disease among those with IR results. Two binary logistic regression models, focusing on those who received IR or NIR results, were conducted to assess the effect of independent variables, including age, sex, race and ethnicity, education, wGT results (IR vs NIR), and personal/family history of cancer/heart disease on health behavior changes and health care utilization. Logistic regression modeled the probability of individuals making any health behavior change and of individuals making any change to health care service use based on the aforementioned independent variables. Of note, missing responses were excluded from the total when calculating percentages and when conducting  $\chi^2$  and regression analyses. Therefore, the denominators reported in the results differed because of missing responses.

Subscales adapted from the FACToR questionnaire<sup>25</sup> were scored by summing the individual items. The subscales for negative emotions, positive feelings, and uncertainty ranged from 0 to 12, whereas the privacy concerns subscale was 0 to 8. Items assessing positive feelings were reverse-coded as part of tabulating the total score.<sup>25</sup> Higher scores on the positive feelings subscale indicated fewer positive feelings, whereas higher scores on the negative feelings, uncertainty, and privacy concern subscales indicated a greater extent of these feelings. The Wilcoxon rank sum test was used, given the non-normal distribution of variables. Analyses were completed using R version 4.2.3 and RStudio Version 2023.09.1+494.

## Results

### Demographics and personal and family health history

A total of 776 eligible participants responded to the survey, of whom 53.9% ( $n = 418/776$ ) reported they had undergone wGT and received their results (this cohort of  $n = 418$  will be referred to as “participants”; see [Supplemental Figure 1](#)). Most participants (mean age = 44 years) were white and non-Hispanic (80.6%), female (88.3%), college-educated (72.0%), married (61.5%), and had biological children (56.7%). Few participants reported a personal history of cancer or heart disease, but more than 70% had a positive family history ([Table 1](#)).

**Table 1** Participant demographics and characteristics (*N* = 418)

Population Variables	<i>n</i> (%)
<b>Age, years</b> (mean = 44 years, SD = 12.8)	
20-29	59 (14.1%)
30-39	134 (32.1%)
40-49	71 (17.0%)
50-59	88 (21.1%)
60-69	63 (15.1%)
70-74	3 (0.7%)
<b>Sex<sup>a</sup></b>	
Female	369 (88.3%)
Male	49 (11.7%)
<b>Race and ethnicity</b>	
African American/Black, Non-Hispanic	24 (5.7%)
American Indian/Alaska Native	2 (0.5%)
Asian American	27 (6.5%)
Latino/Hispanic	12 (2.9%)
Middle Eastern/Northern African	1 (0.2%)
White, Non-Hispanic	337 (80.6%)
More than one race	13 (3.1%)
Race not listed	2 (0.5%)
<b>Education</b>	
High school	15 (3.6%)
Some college, technical school, or 2-year degree	102 (24.4%)
Bachelor's degree	150 (35.9%)
Master's or professional degree	151 (36.1%)
<b>Occupation within health system</b>	
Clinical care provider <sup>b</sup>	143 (34.2%)
Clinical support <sup>c</sup>	63 (15.1%)
Corporate services <sup>d</sup>	39 (9.3%)
Clinical administrative staff	36 (8.6%)
Clinical leader/administrator/manager	32 (7.7%)
Other <sup>e</sup>	83 (19.9%)
More than one occupation selected	22 (5.3%)
<b>Personal history of heart disease</b>	
Heart disease history	64 (16.4%)
No heart disease history	327 (83.6%)
Missing	27
<b>Personal history of cancer</b>	
Cancer history	46 (11.8%)
No cancer history	343 (88.2%)
Missing	29
<b>Family history of heart disease</b>	
None	71 (18.4%)
One relative	97 (25.1%)
Two or more relatives	192 (49.7%)
Don't know	26 (6.7%)
Missing	32
<b>Family history of cancer</b>	
None	76 (19.5%)
One relative	85 (21.9%)
Two or more relatives	210 (54.0%)
Don't know	18 (4.6%)
Missing	29

SD, standard deviation.

<sup>a</sup>One individual indicated their sex at birth did not match their gender identity.

<sup>b</sup>(For example, physician, nurse, or therapist).

<sup>c</sup>(For example, case management, pharmacy, lab, sterile processing, coding, EVS, transport, infection control, technician, or clinical education).

<sup>d</sup>(For example, HR, IS&T, marketing, finance, supply chain, OIA, etc).

<sup>e</sup>(For example, researcher, university leader/administrator/manager, university faculty, university staff).

Most participants endorsed good to excellent physical (94.1%, *n* = 370/393) and mental health (87.8%, *n* = 344/392). Additionally, most had a primary care physician (PCP) (93.4%, *n* = 368/394), had contacted a clinician within the last six months (68.6%, *n* = 269/392), and took prescription medications (68.8%, *n* = 260/389). Most (97.2%, *n* = 378/389) were non-smokers, and most reported cardiovascular screenings within the past two years (eg, blood pressure: 95.7%, *n* = 375/392). Forty-five percent (*n* = 79/174) of participants  $\geq 45$  years reported they had undergone colonoscopy or stool screening at least once. Most females  $\geq 40$  years (90.7%, *n* = 175/193) reported breast screening, and most males  $\geq 45$  years (64.7%, *n* = 11/17) reported prostate cancer screening within the past two years. Although most (73.8%, *n* = 290/393) reported no history of genetic testing, some participants had undergone genetic testing via DTC-GT (15.8%, *n* = 62/392), a clinician (9.9%, *n* = 39/393), or research participation (<2%).

## wGT results

A small proportion of participants received results showing IR of cancer (12.0%, *n* = 48/399) or heart disease (9.5%, *n* = 38/398), whereas most (81.6%, *n* = 298/365) had NIR of cancer/heart disease. Notably, 28% (*n* = 19/67) of those with IR results had IR for both cancer and heart disease. Participants with IR had positive family histories of disease (cancer: 80.4%, *n* = 37/46; heart disease: 91.2%, *n* = 31/34) more often than personal histories (cancer: 18.8%, *n* = 9/48; heart disease: 37.8%, *n* = 14/37) (cancer:  $P < .001$ ; heart disease:  $P < .001$ ). Thirty-one percent received informative PGx results (*n* = 125/398), but some did not know their results—an observation more frequent for PGx (20.6%, *n* = 82/398) than cancer (7.0%, *n* = 28/399,  $P < .001$ ) and heart disease (8.8%, *n* = 35/398,  $P < .001$ ) (Supplemental Table 2). Of note, the distribution of demographics for individuals who received IR results for cancer and/or heart disease (*n* = 67) was comparable to the majority, who received NIR results (*n* = 298) (Supplemental Table 3). Additionally, of those who reported receiving IR results, 19.7% (*n* = 13/66) had reported previously undergoing DTC-GT, and 3.0% (*n* = 2/66) reported prior clinical genetic testing.

## Perceived utility, feelings, and beliefs about wGT

Among participants, most reported that learning their wGT results (1) satisfied their curiosity (74.7%), (2) provided reassurance about their health (55.2%), or (3) supported a feeling of control over their health (53.0%) (Table 2). In most cases, those with IR results were statistically more likely to report test usefulness for medical care, whereas those with NIR results were more likely to endorse curiosity, satisfaction, or reassurance (Table 2).

Most participants found their results useful (74.1%, *n* = 294/397) and easy to understand (77.4%, *n* = 308/398).

**Table 2** Differences in perceived test utility and test-related beliefs among participants who reported they knew their cancer and heart-disease-related wGT results

Statement	Known Cancer and/or Heart Disease Test Result ( <i>n</i> = 364 <sup>b</sup> ) <i>n</i> (%)	Cancer and/or Heart Disease—IR ( <i>n</i> = 67) <i>n</i> (%)	Cancer and Heart Disease—NIR ( <i>n</i> = 297 <sup>b</sup> ) <i>n</i> (%)	<i>P</i> Value <sup>c</sup>
<b>Learning my genetic test results...</b>				
Provided me interesting information/satisfied my curiosity	272 (74.7%)	38 (56.7%)	234 (78.8%)	<b>&lt;.001</b>
Reassured me that I am healthy	201 (55.2%)	14 (20.9%)	187 (63.0%)	<b>&lt;.001</b>
Helped me feel like I have more control over my health	193 (53.0%)	37 (55.2%)	156 (52.5%)	.69
Informed decisions I make about my medical care	159 (43.7%)	38 (56.7%)	121 (40.7%)	<b>.02</b>
Gave me information about specific diseases that I am concerned about	126 (34.6%)	35 (52.2%)	91 (30.6%)	<b>&lt;.001</b>
Informed how I make plans for my future	121 (33.2%)	33 (49.3%)	88 (29.6%)	<b>.002</b>
Helped me learn more about the disease risks of other biological relatives	111 (30.5%)	34 (50.7%)	77 (25.9%)	<b>&lt;.001</b>
Helped explain a family history of disease	86 (23.6%)	32 (47.8%)	54 (18.2%)	<b>&lt;.001</b>
Helped reduce my chances of getting sick <sup>a</sup>	38 (10.4%)	10 (14.9%)	28 (9.4%)	.19
Helped tailor treatment(s) to me specifically <sup>a</sup>	37 (10.2%)	15 (22.4%)	22 (7.4%)	<b>.001</b>
Has made me worried about my future health <sup>a</sup>	17 (4.7%)	11 (16.4%)	6 (2.0%)	<b>&lt;.001</b>
Has added stress to my life <sup>a</sup>	16 (4.4%)	11 (16.4%)	5 (1.7%)	<b>&lt;.001</b>
<b>Belief Statements</b>				
I am confident in the quality and accuracy of my genetic test results.	238 (65.4%)	43 (64.2%)	195 (65.7%)	.82
I believe my results will not be shared with my employer without my consent.	185 (50.8%)	35 (52.2%)	150 (50.5%)	.80
I am disappointed that my results did not tell me more information. <sup>a</sup>	75 (20.6%)	12 (17.9%)	63 (21.2%)	.62
I believe my results will be more useful to me in the future than they are now. <sup>a</sup>	78 (21.4%)	11 (16.4%)	67 (22.6%)	.32
I am unsure what to do with my test results. <sup>a</sup>	41 (11.3%)	9 (13.4%)	32 (10.8%)	.52

IR, increased risk; NIR, no increased risk.

<sup>a</sup>Denotes Fisher's test used due to small group sizes.

<sup>b</sup>Differences in *n* for groups by results are due to missing responses: *n* = 364/365 with known results responded to these questions and *n* = 297/298 of those with results of NIR responded to these questions.

<sup>c</sup>Responses of those with IR results (cancer or heart disease—IR, *n* = 67) were compared with those with NIR results (cancer and heart disease—NIR, *n* = 297) using  $\chi^2$  analysis and Fisher's test. Statistically significant values are shown in bold.

Among those with IR of cancer, 58.3% (*n* = 28/48) reported higher cancer risk perception, 29.2% (*n* = 14/48) reported no change in risk perception, and 12.5% (*n* = 6/48) reported lower risk perception. Although roughly half of the participants with NIR of cancer reported no change in cancer risk perception (50.8%, *n* = 163/321), it was lower for 44.5% (*n* = 143/321) and higher for 4.7% (*n* = 15/321). For heart disease risk perception, a similar pattern was observed in those with IR for heart disease (higher: 52.6%, *n* = 20/38; no change: 31.6%, *n* = 12/38; lower: 15.8%, *n* = 6/38) and those with NIR for heart disease (no change: 58.2%, *n* = 188/323; lower: 36.5%, *n* = 118/323; higher: 5.3%, *n* = 17/323).

The adapted FACToR subscales demonstrated good internal consistency: the Cronbach's alpha coefficients were 0.85 (negative emotions: 95% CI 0.82, 0.87), 0.72 (positive feelings: 95% CI 0.67, 0.77), 0.80 (uncertainty: 95% CI

0.76, 0.83), and 0.86 (privacy concerns: 95% CI 0.83, 0.88). Participants with IR experienced fewer positive feelings and more negative emotions, uncertainty, and privacy concerns about wGT vs those with NIR results (*P* < .001) (Supplemental Table 4).

### Health behavior changes and health care utilization due to wGT results

Overall, 44.4% (*n* = 176/396) of all participants (regardless of test results) reported at least one health behavior change in response to wGT results, and 29.3% (*n* = 116/396) reported more than one health behavior change. Furthermore, 32.8% (*n* = 129/393) reported at least one change to health care utilization, and 19.1% (*n* = 75/393) reported more than one related change. Participants most frequently made

**Table 3** Differences based on wGT results in health behavior changes after wGT among participants who reported they knew their cancer and heart disease-related genetic test results

Health Behavior Change	Known Cancer or Heart Disease Test Result ( <i>n</i> = 363 <sup>c</sup> ) <i>n</i> (%)	Cancer and/or Heart Disease—IR <sup>c</sup> ( <i>n</i> = 67) <i>n</i> (%)	Cancer and Heart Disease—NIR <sup>c</sup> ( <i>n</i> = 296 <sup>c</sup> ) <i>n</i> (%)	<i>P</i> Value <sup>d</sup>
<b>Diet</b>	<b>111 (30.6%)</b>	<b>34 (50.7%)</b>	<b>77 (26.0%)</b>	<b>&lt;.001</b>
Ate less overall/reduced my intake of calories	31 (27.9%)	7 (20.6%)	24 (31.2%)	
Ate more overall/increased my intake of calories	1 (0.9%)	—	1 (1.3%)	
Ate more fruits and vegetables	31 (27.9%)	10 (29.4%)	21 (27.3%)	
Ate fewer unhealthy foods	46 (41.4%)	16 (47.1%)	30 (39.0%)	
Ate more unhealthy foods	1 (0.9%)	1 (2.9%)	—	
Other	1 (0.9%)	—	1 (1.3%)	
<b>Physical activity and exercise</b>	<b>116 (32.0%)</b>	<b>29 (43.3%)</b>	<b>87 (29.4%)</b>	<b>.03</b>
Somewhat increased my amount of exercise	97 (83.6%)	24 (82.8%)	73 (83.9%)	
Greatly increased my amount of exercise	19 (16.4%)	5 (17.2%)	14 (16.1%)	
Exercised less	—	—	—	
<b>Smoking and tobacco use<sup>a</sup></b>	<b>7 (1.9%)</b>	<b>2 (3.0%)</b>	<b>5 (1.7%)</b>	<b>.62</b>
Quit smoking	6 (85.7%)	2 (100%)	4 (80.0%)	
Reduced amount of smoking	1 (14.3%)	—	1 (20.0%)	
<b>Alcohol use<sup>a</sup></b>	<b>23 (6.3%)</b>	<b>12 (17.9%)</b>	<b>11 (3.7%)</b>	<b>&lt;.001</b>
Quit drinking all alcohol	5 (21.7%)	2 (16.7%)	3 (27.3%)	
Reduced my alcohol intake	17 (73.9%)	9 (75.0%)	8 (72.7%)	
Increased my alcohol intake	1 (4.3%)	1 (8.3%)	—	
<b>Use of vitamins or supplements</b>	<b>58 (16.0%)</b>	<b>17 (25.4%)</b>	<b>41 (13.9%)</b>	<b>.02</b>
Started to take new vitamins or supplements	49 (84.5%)	12 (70.6%)	37 (90.2%)	
Increased amount of vitamins or supplements	6 (10.3%)	3 (17.6%)	3 (7.3%)	
Stopped or reduced vitamins/supplements	1 (1.7%)	—	1 (2.4%)	
Other	1 (1.7%)	1 (5.9%)	—	
<b>Other<sup>a,b</sup></b>	<b>14 (3.9%)</b>	<b>9 (13.4%)</b>	<b>5 (1.7%)</b>	<b>&lt;.001</b>
<b>None of the above</b>	<b>193 (53.2%)</b>	<b>20 (29.9%)</b>	<b>173 (58.4%)</b>	

IR, increased risk; NIR, no increased risk; SD, standard deviation.

<sup>a</sup>Denotes Fisher's test used because of small group sizes.

<sup>b</sup>Other responses referred to changes in health care utilization, medication changes, and weight loss.

<sup>c</sup>Differences in *n* for groups by results are due to missing responses: *n* = 363/365 with known results responded to these questions and *n* = 296/298 of those with results of NIR responded to these questions.

<sup>d</sup>Responses of those with IR results (cancer or heart disease—IR, *n* = 67) were compared with those with NIR results (cancer and heart disease—NIR, *n* = 296) using  $\chi^2$  analysis and Fisher's test. Statistically significant values are shown in bold.

changes to diet (30.6%, *n* = 111/363) and exercise (32.0%, *n* = 116/363) (Table 3). Receiving IR results was associated with a higher likelihood of a range of health behavior changes, including a healthier diet, more frequent exercise, lower use of alcohol, and use of vitamins/supplements (Table 3). Fifteen percent (*n* = 62/396) of participants scheduled appointments with clinicians, 20.7% (*n* = 82/396) had cancer screening, 14.2% (*n* = 56/395) had heart disease screening, and 8.6% (*n* = 34/394) made medication changes. IR and informative PGx results were associated with medication changes. Participants with IR were more likely to pursue related follow-up care (Table 4). Participants who consulted clinicians to discuss results most frequently sought PCPs (74.2%, *n* = 46/62) or GCs from the wGT laboratory (40.3%, *n* = 25/62). Fewer participants

engaged non-laboratory GCs (19.4%, *n* = 12/62), oncologists (16.1%, *n* = 10/62), or cardiologists (4.8%, *n* = 3/62). Other clinicians (21.0%, *n* = 13/62) included OB/GYN, mental health professional, GI specialist, and/or breast surgeon. Thirty-three percent (*n* = 36/108) of those who pursued appointments or screenings reported that results were added to their medical record, and most (92.6%, *n* = 100/108) were confident in their clinician's understanding of their results.

Overall, those with IR results had 3.23 times the odds of reporting any behavior change (95% CI 1.75, 6.13; *P* < .001) and 8.60 times the odds of reporting any health care utilization (95% CI 4.43, 17.5; *P* < .001) compared with those who had NIR results. Increased age was associated with an increased likelihood of reporting any health



**Table 4** Differences in health care utilization after wGT by specific result types

Type of Health Care Utilization	wGT Results	<i>n</i> (%)	<i>P</i> Value <sup>c</sup>
<b>Made an appointment to discuss results with a health care provider</b>	Cancer and/or heart disease—IR <sup>a</sup> ( <i>n</i> = 67)	26 (38.8%)	<b>&lt;.001</b>
	Cancer and heart disease—NIR <sup>a</sup> ( <i>n</i> = 296 <sup>b</sup> )	34 (11.5%)	
	PGx—informative ( <i>n</i> = 125)	26 (20.8%)	
	PGx—uninformative ( <i>n</i> = 188 <sup>b</sup> )	27 (14.4%)	
<b>Cancer screening</b>	Cancer—IR <sup>a</sup> ( <i>n</i> = 48)	27 (56.3%)	<b>&lt;.001</b>
	Cancer—NIR <sup>a</sup> ( <i>n</i> = 321 <sup>b</sup> )	49 (15.3%)	
<b>Surgeries/other procedures to reduce cancer risk</b>	Cancer—IR <sup>a</sup> ( <i>n</i> = 48)	15 (31.3%)	<b>&lt;.001</b>
	Cancer—NIR <sup>a</sup> ( <i>n</i> = 319 <sup>b</sup> )	13 (4.1%)	
<b>Heart disease screening</b>	Heart disease—IR <sup>a</sup> ( <i>n</i> = 38)	15 (39.5%)	<b>&lt;.001</b>
	Heart disease—NIR <sup>a</sup> ( <i>n</i> = 322 <sup>b</sup> )	32 (9.9%)	
<b>Made changes to use of medications</b>	Cancer and/or heart disease—IR <sup>a</sup> ( <i>n</i> = 66 <sup>b</sup> )	10 (15.2%)	<b>.02</b>
	Cancer and heart disease—NIR <sup>a</sup> ( <i>n</i> = 295 <sup>b</sup> )	19 (6.4%)	
	PGx—informative ( <i>n</i> = 124 <sup>b</sup> )	19 (15.3%)	
	PGx—uninformative ( <i>n</i> = 187 <sup>b</sup> )	9 (4.8%)	

<sup>a</sup>IR, increased risk; NIR, no increased risk.

<sup>b</sup>Differences in *n* for groups by results are due to missing responses for types of health service use.

<sup>c</sup>Statistically significant values are shown in bold.

care utilization (adjusted odds ratio: 1.03; 95% CI 1.01, 1.06; *P* = .007). No other significant predictors of any health behavior change or health care utilization were identified. Table 5 summarizes binary logistic regression analyses with other independent variables.

Among participants who pursued cancer screening because of wGT, mammograms (50%, *n* = 41/82), colon cancer screening (45.1%, *n* = 37/82), and skin exams (41.5%, *n* = 34/82) were the most common. Fewer participants pursued clinical breast exams (26.8%, *n* = 22/82), breast magnetic resonance images (14.6%, *n* = 12/82), or prostate-specific antigen screenings (4.9%, *n* = 4/82). The most common risk-reducing procedures after wGT were related to ovarian cancer (24.1%, *n* = 7/29) and breast cancer (10.3%, *n* = 3/29). Cardiovascular screenings following wGT results included cholesterol (71.4%, *n* = 40/56), blood pressure (62.5%, *n* = 35/56), electrocardiogram, computed tomography, or ultrasound (46.4%, *n* = 26/56), stress tests (28.6%, *n* = 16/56), and others (eg, calcium score) (7.1%, *n* = 4/56). Among those reporting medication changes, 41.1% (*n* = 14/34) started new medications, 29.4% (*n* = 10/34) stopped taking medications (7/10 without a clinician's recommendation), 26.5% (*n* = 9/34) adjusted dosage, and 14.7% (*n* = 5/34) made other changes. Medications reportedly stopped by participants without a clinician's recommendation included tricyclic antidepressants and oral contraceptive pills and two over-the-counter medications (eg, nonsteroidal anti-inflammatory drugs and melatonin).

Some participants (5.4%, *n* = 21/392) reported that receiving wGT led to being diagnosed later with a medical condition, and 13 of them (61.9%) had IR results. Diagnoses

reported by participants included cancer (33.3%, *n* = 7/21), heart disease (14.3%, *n* = 3/21), and "other" (23.8%, *n* = 5/21) (eg, Lynch syndrome, colon or GYN-tract polyps, precancerous skin lesions, and diabetes).

### Financial behavior changes due to wGT results

Few participants reported making changes to health (2.8%, *n* = 11/395), life (2.5%, *n* = 10/395), disability (2.3%, *n* = 9/395), or long-term care insurance (1.3%, *n* = 5/395). Two percent made financial/retirement changes (*n* = 6/395), and two individuals (0.5%, *n* = 2/395) endorsed other advance planning (eg, advance medical directives). Reported insurance changes included increasing existing coverage (50%, *n* = 12/24), adding new coverage (25%, *n* = 6/24), and decreasing existing coverage (12.5%, *n* = 3/24). However, no specific pattern was observed regarding IR/informative PGx wGT results and the likelihood of making insurance changes, and overall, most (92.2%, *n* = 364/395) made no financial changes.

### Communication and resources used for test results

The majority of participants (78.3%, *n* = 310/396) shared test results with family members, including spouses/significant others (75.2%, *n* = 233/310), parents (46.1%, *n* = 143/310), siblings (41.6%, *n* = 129/310), and children (21.0%, *n* = 65/310).

When seeking information about results, many participants utilized the laboratory's educational materials (44.9%,

**Table 5** Binary logistic regressions exploring potential predictors of health behavior changes and health care utilization

Independent Variables	Dependent Variables <sup>a,e</sup>					
	Any Health Behavior Change <sup>a</sup>			Any Health Care Utilization <sup>b</sup>		
	aOR	95% CI	P Value <sup>f</sup>	aOR	95% CI	P Value <sup>f</sup>
<b>Age</b>	1.01	0.99, 1.03	.4	1.03	1.01, 1.06	<b>.007</b>
<b>Sex</b>						
Male						
Female	1.42	0.70, 3.00	.3	1.88	0.81, 4.85	.2
<b>Race and ethnicity</b>						
White, non-Hispanic						
Asian American	2.06	0.72, 6.09	.2	0.79	0.19, 2.74	.7
African American/Black, non-Hispanic	2.26	0.80, 6.70	.13	2.06	0.68, 5.90	.2
Latino/Hispanic	0.52	0.07, 2.44	.4	0.51	0.03, 3.09	.5
More than one race	0.52	0.11, 2.00	.4	1.65	0.38, 6.49	.5
Other <sup>d</sup>	1.16	0.08, 30.2	>.9	0.34	0.01, 5.45	.5
<b>Education</b>						
High school						
Some college, technical school, or 2-year degree	2.15	0.43, 10.9	.3	0.29	0.04, 1.63	.2
Bachelor's degree	0.84	0.17, 4.13	.8	0.26	0.03, 1.45	.14
Master's or professional degree	1.03	0.22, 5.01	>.9	0.23	0.03, 1.25	.11
<b>Genetic test result<sup>c</sup></b>						
No increased risk						
Increased risk	3.23	1.75, 6.13	<b>&lt;.001</b>	8.60	4.43, 17.5	<b>&lt;.001</b>
<b>Personal history of heart disease</b>						
No						
Yes	0.84	0.43, 1.62	.6	1.03	0.50, 2.11	>.9
<b>Personal history of cancer</b>						
No						
Yes	1.22	0.57, 2.58	.6	1.03	0.44, 2.36	>.9
<b>Family history of heart disease and/or cancer</b>						
None						
One relative	1.32	0.47, 3.75	.6	1.73	0.55, 5.98	.4
Two or more relatives	1.04	0.41, 2.70	>.9	1.17	0.41, 3.70	.8

aOR, adjusted odds ratio; CI, confidence interval.

<sup>a</sup>See Table 3.

<sup>b</sup>See Table 4.

<sup>c</sup>Refers to reported wGT results associated with increased risk (IR) for cancer and/or heart disease only.

<sup>d</sup>Other, North African or American Indian/Alaska Native.

<sup>e</sup> $n = 338$  for "Any health behavior change" and  $n = 336$  for "Any health care utilization" due to missing responses.

<sup>f</sup>Statistically significant values are shown in bold.

$n = 178/396$ ), which most found useful (96.1%,  $n = 171/178$ ). Fewer participants specifically indicated they sought clinicians for more information about their test results (14.6%,  $n = 58/396$ ), and 91.4% ( $n = 53/58$ ) found them useful. Notably, three participants who selected other useful resources explored PGx genetic counseling. Alternatively, 43.4% ( $n = 172/396$ ) did not consult any resources.

## Discussion

We surveyed employees of a large US health care system who received wGT, including cancer, heart disease, and PGx testing, to characterize employees' reported responses to results. In our study cohort, we found that 12.0% reported IR for cancer and 9.5% reported IR for heart disease. Other

studies that have also assessed genetic testing in populations unselected for known risk factors of genetic disease have reported similar yields of results showing IR for cancer/heart disease.<sup>26,27</sup> Most participants in our study reported they did not make any changes based on their wGT results. However, a key finding of our study was that receiving IR results for cancer and/or heart disease was associated with a higher likelihood of health behavior changes and health care utilization in addition to a higher perceived test utility. As a whole, our results were consistent with findings that have shown (1) evidence of individuals making changes is variable based on involvement in wellness programs<sup>20,21</sup> or genetic testing,<sup>17-19,28</sup> (2) consumer genetic testing is perceived as useful for informing medical decisions,<sup>29</sup> (3) results showing increased disease risk (eg, for colon cancer) may prompt health care engagement,<sup>30</sup> and (4) consumer

genetic testing can prompt health behavior changes in some individuals.<sup>31</sup>

We explored a range of variables that have been shown in other genetic testing studies (eg, DTC-GT) to predict behavioral responses, with mixed findings. Some variables, such as IR results, were predictive in our model, whereas others were not (eg, personal history and family history). Increased age was associated with a higher likelihood of health care utilization, as has been well established.<sup>32</sup> Although personal/family histories alone were not predictors of health care utilization or health behavior changes, most participants with IR results reported relevant family history of cancer or heart disease.

Although most participants reported that their results were useful and easy to understand, some endorsed potentially inaccurate risk perceptions (eg, reporting a lower cancer risk perception based on IR or NIR results), potentially due to insufficient understanding of test implications. Some with NIR had a potentially false sense of reassurance based on their results because some reported lower post-test risk perceptions, and many reported that their results reassured them about their personal health status. Studies have shown individuals may have incorrect risk perceptions after DTC-GT despite reporting their results as easily understood, highlighting the importance of genetic counseling to aid in correct risk interpretation.<sup>33</sup>

Because those with NIR results were less likely to share them with a clinician, wGT programs may consider encouraging employees to do so, regardless of findings, given the potential for medical management recommendations based on family history and other risk factors. Our findings demonstrated that PCPs were the type of clinician most frequently consulted about wGT results among all participants who made appointments with providers (74.2%), highlighting PCPs as likely initial contacts after wGT. This finding is consistent with prior literature, such as DTC-GT studies wherein PCPs were sought by roughly 20% to 30% of participants compared with only about 1% seeking a GC.<sup>30,34</sup> However, some PCPs may be unprepared for increased wGT prevalence, and counseling patients on the implications of test results for their health care may be out of their realm of expertise.<sup>35</sup> Our findings also indicated participants with IR results were significantly more likely to consult clinicians and experience negative emotions, uncertainty, and privacy concerns after testing compared with those with NIR results, suggesting a need for psychosocial support from clinicians. Additionally, although most participants had biological children, less than one-fourth reported sharing their wGT results with them. This suggests that patient education regarding the implications of genetic test results for relatives would be helpful. Overall, strategies related to education, time, and staff support for clinicians will need to be considered.

In our study cohort, 31.4% reported informative PGx findings, and among the three panels, participants were most likely not to know their PGx results. The discrepancy between this rate of informative PGx results and the documented 90% to 95% prevalence<sup>16</sup> of actionable PGx findings

in the general population, including when using the same test platform,<sup>24</sup> could be due to our reliance on participant self-reporting. Participants may not have perceived informative PGx results to be actionable because of (1) lack of relevance to current medications, (2) difficulty understanding test results,<sup>36</sup> and/or (3) absence of genetic counseling because post-test counseling for PGx results was only by employee request unless they also had IR results disclosed through a laboratory GC. Although few, those who pursued PGx genetic counseling found this useful. Those with informative PGx results were additionally more likely to report medication changes, also seen in a study of PGx test consumers.<sup>28</sup> Seven out of ten participants in our study who stopped taking any medication did so without a clinician's recommendation, including two individuals who stopped prescription medications. These self-directed changes may or may not have been indicated based on PGx results and could have been associated with adverse health consequences. Overall, post-test PGx counseling with a qualified clinician is important to help ensure that individuals do not unnecessarily stop medications based on PGx test results. Pharmacist-embedded employee PGx testing programs, for example, have demonstrated benefits in some settings.<sup>9</sup>

Health-related financial changes based on wGT results were minimally reported, indicating that participants may have been unaware of implications and available financial options or did not feel their wGT results necessitated such changes. Studies of responses to genetic susceptibility testing for Alzheimer's disease have found that those at elevated risk are more likely to report changes to their long-term care insurance plans.<sup>37</sup> However, our study participants did not learn their genetic risk for Alzheimer's disease or other late-onset conditions in which financial planning may have been relevant.

This study provides real-world data about employees who underwent wGT, a relatively unexplored type of workplace benefit. We conducted a detailed assessment across multiple domains, including health behavior changes and health care utilization, responsive to calls in the field for this kind of data.<sup>6</sup> Our study findings suggest that receiving IR results from wGT may promote health behavior changes and health care utilization among employees. In summary, this research provided foundational insights and captured actions taken after testing from a large sample of individuals who underwent wGT, contributing to the overall understanding of related ethical and social issues.

However, our findings should be interpreted in light of several study limitations. This study focused on a single health system, with participants who were majority white, non-Hispanic, female, and college-educated. Study participants were all employees of a health care system that offered wGT and may have been more familiar with genetic testing or its implications for their health than other populations. Therefore, our results may not generalize to wGT programs in different populations and settings. Given that about 8,000 employees submitted a sample for testing, but less than 500 test takers who received results responded to our survey, our

findings represent only a fraction of the population sampled. Non-response bias was not formally assessed. In addition, for several outcomes, we relied on novel survey items not formally evaluated for psychometric properties. Also, wGT results and outcomes were self-reported by employees and therefore may be subject to self-report bias. Test results and use of health care services were not independently confirmed from medical records, and it is unknown if actions taken after testing were medically indicated. Therefore, comparisons made based on result type should be viewed as exploratory and in need of further study. Additionally, study results in certain domains could have been influenced by a ceiling effect because participants reported considerable engagement in their health care before undergoing wGT. Finally, the overall lack of reported health care utilization and health behavior changes post-wGT, although consistent with some wellness program outcomes<sup>1,20</sup> and other studies of health behaviors after genetic testing,<sup>17,19</sup> could also be due to participants completing the web survey shortly after wGT with limited time to act upon their results.

Our findings suggest that wGT is an avenue for identifying actionable genetic findings in individuals unselected for clinical criteria, which may provide opportunities for early intervention. Future studies should seek to understand if health behavior changes or health service use following wGT translates to improved health outcomes. Although wGT may increase access to genetic testing, this research highlights needs for fully realizing the benefits of wGT, informing future health service delivery studies.

## Data Availability

The authors will make relevant data available for the purposes of verifying or contextualizing the conclusions we have drawn in this publication. Any disclosure will be constrained by the need to protect the privacy of respondents. Requests should be sent to the corresponding authors, C.L. and J.S.R., with a description of the reason for the request and the qualifications of those requesting the data. The corresponding authors will also accept requests for a copy of the survey instrument.

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## Ethics Declaration

This study was approved by the Institutional Review Board of The Jackson Laboratory (IRB #2021-065), and all institutions involved in human research participation received local IRB approval. Before beginning the survey, participants were provided with a study information sheet within the online survey platform. The information sheet indicated that consent was implied through the submission of a response to the survey.

## Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the author(s) used ChatGPT Version 3 in order to improve the conciseness and readability of some sentences early in the writing process. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

## The INSIGHT @ WORK CONSORTIUM

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### Conflict of Interest

The authors declare no conflicts of interest.

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