Annals of Internal Medicine ORIGINAL RESEARCH

Consumer Perceptions of Interactions With Primary Care Providers After Direct-to-Consumer Personal Genomic Testing

Cathelijne H. van der Wouden, BSc*; Deanna Alexis Carere, ScD, CGC*; Anke H. Maitland-van der Zee, PharmD, PhD; Mack T. Ruffin IV, MD, MPH; J. Scott Roberts, PhD; and Robert C. Green, MD, MPH, for the Impact of Personal Genomics Study Group†

Background: Direct-to-consumer (DTC) personal genomic testing (PGT) allows individuals to learn about their genetic makeup without going through a physician, but some consumers share their results with their primary care provider (PCP).

Objective: To describe the characteristics and perceptions of DTC PGT consumers who discuss their results with their PCP.

Design: Longitudinal, prospective cohort study.

Setting: Online survey before and 6 months after results.

Participants: DTC PGT consumers.

Measurements: Consumer satisfaction with the DTC PGT experience; whether and, if so, how many results could be used to improve health; how many results were not understood; and beliefs about the PCP's understanding of genetics. Participants were asked with whom they had discussed their results. Genetic reports were linked to survey responses.

Results: Among 1026 respondents, 63% planned to share their results with a PCP. At 6-month follow-up, 27% reported having done so, and 8% reported sharing with another health care provider only. Common reasons for not sharing results with a health care provider were that the results were not important enough (40%) or that the participant did not have time to do so (37%). Among participants who discussed results with their PCP, 35% were very satisfied with the encounter, and 18% were not at all satisfied. Frequently identified themes in participant descriptions of these encounters were actionability of the results or use in care (32%), PCP engagement or interest (25%), and lack of PCP engagement or interest (22%).

Limitation: Participants may not be representative of all DTC PGT consumers.

Conclusion: A comprehensive picture of DTC PGT consumers who shared their results with a health care provider is presented. The proportion that shares results is expected to increase with time after testing as consumers find opportunities for discussion at later appointments or if results become relevant as medical needs evolve.

Primary Funding Source: National Institutes of Health.

Ann Intern Med. 2016;164:513-522. doi:10.7326/M15-0995 **www.annals.org**
For author affiliations, see end of text.
This article was published at www.annals.org on 1 March 2016.
* Ms. van der Wouden and Dr. Carere contributed equally to this work.
† For members of the Impact of Personal Genomics Study group, see the Appendix (available at www.annals.org).

Direct-to-consumer (DTC) personal genome testing (PGT) describes commercial services through which individuals can acquire a range of personalized genetic information, from ancestry and nonmedical traits (such as tongue curling) to disease predisposition and pharmacogenomic response (such as risk for diabetes or warfarin metabolism). Direct-to-consumer PGT services do not require medical requisition and are typically ordered in the privacy of one's home; however, consumers may choose to share their results with a health care provider (HCP).

Nearly a decade after its introduction, DTC PGT remains controversial (1–3), and critics have questioned its analytic validity and clinical utility (4–7). Unlike traditional clinical genetic testing that relies on gene sequencing or targeted testing of rare, high-penetrance, Mendelian mutations, DTC PGT typically estimates risk by genotyping many common, low-penetrance, single-nucleotide polymorphisms. Other concerns include the potential downstream effects of DTC PGT, such as misunderstanding and anxiety when complex information is provided directly to consumers (8) and subsequent unnecessary use of health services (9).

Involvement of a trained HCP may mitigate some of these concerns, and in prior studies, 20% to 30% of DTC PGT consumers reported sharing their results with a physician (10, 11). Moreover, in a survey of hypothetical consumers, 61% believed that physicians have a professional obligation to help interpret results (12). However, although many physicians express interest in incorporating genomic profiling into patient care (13), many also believe they are unprepared to do so (14).

A recent report by Goldsmith and colleagues (15) reviewed HCP perspectives of DTC PGT, but to our knowledge, no study has reported the consumer perspectives of HCP engagement with results. We report data from the PGen (Impact of Personal Genomics) Study, a large, longitudinal study of actual DTC PGT users that combined both survey-level and individual-level genetic data. In particular, we describe the characteristics of 23andMe (16) and Pathway Genomics (17) customers who shared their results with primary care providers (PCPs) and other HCPs, consumer attitudes about the topics of PCP readiness and DTC genomics, and satisfaction with the discussion of results with PCPs.

See also:

Editorial comment 564

EDITORS' NOTES

Context

Patients may share the results of direct-to-consumer personal genome testing with their primary care provider (PCP). Their expectations and experiences with such interactions are unknown.

Contribution

Consumers who reported sharing results with their PCP described positive and negative experiences, along with their perceptions of whether the PCP seemed interested in the results and were willing to act on them.

Caution

The PCP's report of these interactions and whether the results should have influenced care were not available.

Implication

As such testing becomes more widely available, health care providers may need to learn how to engage most productively with patients about the results.

METHODS

Study Design and Procedures

The PGen Study is a collaboration among academic researchers at Brigham and Women's Hospital and Harvard Medical School (Boston, Massachusetts) and the University of Michigan School of Public Health (Ann Arbor, Michigan), research scientists at 23andMe (Mountain View, California) and Pathway Genomics (San Diego, California), and survey experts at SoundRocket (previously Survey Sciences Group, Ann Arbor, Michigan). Details of the academia–industry partnership (18) and study design (19) are published elsewhere. In brief, new customers were recruited between March and July 2012. Invitation e-mails were sent to 3900 23andMe customers who purchased DTC PGT during this period and completed the company's process of informed consent for general research. Pathway customers were recruited via a banner advertisement on the company's Web site or an e-mail sent to approximately 30 000 members of PatientsLikeMe, a health-based social networking site (20). Both channels advertised discounted Pathway testing, and persons who purchased DTC PGT were invited to participate in the PGen Study.

Invitees received a Web link that directed them to the Web-based survey system supported by SoundRocket. In an online consent process, participants agreed to have their deidentified genetic data (stored by the companies) and survey responses (stored by SoundRocket) shared with academic investigators. Participants were then routed to a baseline survey. Follow-up eligibility required completion of the baseline survey before viewing DTC PGT results, and invitations for 2 follow-up surveys were e-mailed to eligible participants 2 weeks and 6 months after results were viewed.

SoundRocket provided logistic support for survey design, administration, and data storage, and the companies provided logistic support for participant recruitment and genetic data storage. The PGen Study data manager (a member of the academic research team) merged the data, and the joint principal investigators (J.S.R. and R.C.G.) oversaw the data analyses. The Partners Human Research Committee (Boston, Massachusetts) and the University of Michigan School of Public Health Institutional Review Boards approved the study.

Variables Measured at Baseline

Basic demographic characteristics, health status (21), and intention to share results (8 categories) were measured at baseline, before results were received. The 2-item Generalized Anxiety Disorder questionnaire was administered to screen for anxiety or panic disorder during the previous 2 weeks. Item frequency was reported on a 4-category scale (0 to 3 points) for a maximum possible score of 6, and a score of 3 or greater was considered a positive result (22). Participants also rated the importance of the following 2 factors in their decision to seek DTC PGT: "desire to learn about my genetic makeup without going through a physician" and "desire to improve my health."

Genome Testing Results

Each company provided a unique set of results in the categories of ancestry and nonmedical traits (such as the ability to curl your tongue or wet vs. dry earwax) (23andMe only) and carrier testing, disease risk, and pharmacogenomics (both companies). We report disease risk and pharmacogenomic results because they are most likely to prompt medical follow-up. Examples of the online reports provided by each company at the time of the study are available in the supplemental material of Ostergren and colleagues (23).

In the main report, 23andMe participants received risk estimates for 29 conditions, and Pathway participants received estimates for 25 conditions. For each condition, 23andMe reported a baseline age-adjusted (and in some cases, sex- and ethnicity-adjusted) 10-year risk; an age-adjusted relative risk (RR) based on the customer's genetic profile; and a revised, genetics-adjusted 10-year risk. Results were presented alongside 2 diagrams, each with 100 human figures; the first diagram was shaded proportionally to represent the baseline risk, and the second was shaded to represent the genetics-adjusted risk. Pathway customers received results on the following 5-category, color-coded scale that corresponded to increasing RR: 1 = lower-than-average, 2 = average, and 3 through 5 = degrees of higher-than-average risk. Most results showing higher-than-average risk were in category 3, which was characterized as follows: "Your genetic profile shows increased susceptibility for these health conditions. You should make an effort to learn the warning signs, contributing lifestyle factors, and your family history for these conditions. Speak with your doctor about developing a prevention plan."

We chose a threshold RR of 1.2 or greater to consistently distinguish between elevated and nonelevated

risk for genetic disease between companies and across analyses. 23andMe reported average risk as being within 20% of the general population risk, and Pathway agreed that this threshold would generally match the cut point between their risk categories 2 and 3. Therefore, results were dichotomized into the following 2 categories: nonelevated genetic risk (RR <1.2; lowest 2 Pathway categories) and elevated genetic risk (RR ≥1.2; highest 3 Pathway categories).

Male customers received 8 pharmacogenomic results, and female customers received 9. Customers of 23andMe received an RR estimate for each adverse drug outcome (or relative benefit for treatment efficacy traits) compared with someone in the general population of the same ethnicity. Pathway customers received "normal," "beneficial effect," or "adverse effect" results for each drug–variant combination. Here, pharmacogenomic results were classified as either positive (increased risk for an adverse drug event or increased or decreased likelihood of therapeutic benefit) or negative (average risk for an adverse event or typical therapeutic response).

Variables Measured at 6-Month Follow-up

At 6 months after disclosure of results, survey items on a Likert scale measured satisfaction with the DTC PGT experience, how many results could be used to improve health, how many were not understood, beliefs about the PCP's understanding of genetics and whether genetic information should be part of the standard medical record, and whether DTC PGT enabled participants to learn how to improve health or learn about their genes without going through a physician. Participants were asked with whom they had discussed their results, including the categories "primary care provider," "genetics specialist (e.g., genetic counselor or clinical geneticist)," and "other medical professional." Participants who did not share their results with an HCP were asked to indicate why they had not done so (3 categories). Participants who discussed their results with a PCP were asked to rate their satisfaction with the discussion and PCP willingness to discuss results and use them in medical care, as well as to provide a free-form explanation of why they were or were not satisfied. They were also asked whether their PCP's interpretation of the results report differed from that of the company; if "yes," they were asked to rate their trust in each party's interpretation.

Data Analysis

We divided the participants' responses regarding with whom they discussed their results, creating the following 4 mutually exclusive groups: PCP, other HCP only, no HCP, and no response. We computed descriptive statistics of baseline characteristics, genetic results, and attitudes after testing. In group 1, we stratified by discussion satisfaction and computed descriptive statistics of DTC PGT results and discussion perceptions. Free-form responses about satisfaction with the PCP discussion were read by 2 authors (C.H.V.D.W. and D.A.C.) who independently identified recurring themes, reached a consensus on final themes, and agreed on the assignment of responses in each. We managed and analyzed data by using SAS Studio, version 3.1 (SAS Institute).

Role of the Funding Source

This study was funded by the National Human Genome Research Institute, National Institutes of Health. The funding source had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript.

RESULTS

A total of 1249 23andMe customers and 589 Pathway customers consented to participate in the PGen Study, of which 947 and 517, respectively, were eligible for follow-up. The 2-week and 6-month surveys were submitted by 1046 (71.4%) and 1042 (71.2%) participants, respectively (**Appendix Figure**, available at www.annals.org). Basic demographic information on the 3900 23andMe invitees suggests that eligible participants and invitees were similar with respect to Hispanic/Latino ethnicity and age but were more likely to be women (56.9% vs. 47.8%) (19). Demographic data for PatientsLikeMe users and visitors to the Pathway Web site were not available.

At baseline, 909 of 1464 participants (62.1%) planned to discuss their results with an HCP, including 814 (55.6%) who planned to discuss them with their PCP. Data on PCP discussion status at 6-month follow-up were available for 1026 participants, of whom 646 (63.0%) and 586 (57.1%) reported at baseline that they planned to discuss their results with an HCP or their PCP, respectively.

Table 1 shows baseline characteristics, stratified by PCP discussion status. Among 1026 respondents, 278 (27%) reported sharing their results with a PCP, 78 (8%) reported sharing their results with some other type of HCP, and 670 (65%) reported not sharing them with any HCP. Health care providers with whom 2 or more participants reported sharing results included physician assistants/nurses (n = 17); genetic specialists (n = 12); obstetricians/gynecologists (n = 8); cardiologists, oncologists, neurologists, and psychiatrists/psychologists (n = 5); ophthalmologists and rheumatologists (n = 4); emergency medicine physicians and endocrinologists (n = 3); and pediatricians, naturopathic physicians, and immunologists (n = 2). Most participants who discussed with a PCP or other HCP indicated that the desire to improve their health was very important in their decision to seek DTC PGT, and these participants more frequently were women, did not have a college degree (PCP group only), were parents, had a positive screen for baseline anxiety, and were Pathway customers.

Table 2 shows the DTC PGT results and attitudes after testing, stratified by PCP discussion status. Genetic reports were available from 983 respondents (96%). In all groups, the mean proportion of conditions designated as "elevated risk" on an individual participant's report was approximately 20%, and the mean

Table 1. Baseline Participant Characteristics, by PCP and HCP Discussion Status, at 6-mo Follow-up*

Characteristic	Discussed Results With PCP	Discussed Results With Other HCP Only	Did Not Discuss Results With Any HCP	No Response
Participants, *n (percentage of baseline cohort)*	278 (19.0)	78 (5.3)	670 (45.8)	438 (29.9)
Mean age (SD) [range], *y*	51 (14) [20–76]	45 (13) [23–73]	46 (16) [19–94]	49 (15) [19–88]†
Male	100 (36.0)	21 (26.9)	290 (43.3)	156 (35.7)†
Race				
White	247 (88.9)	70 (89.7)	564 (84.2)	353 (80.6)
African American	4 (1.4)	0 (0)	19 (2.8)	14 (3.2)
Asian	3 (1.1)	1 (1.3)	29 (4.3)	17 (3.9)
Other/multiracial	24 (8.6)	7 (9.0)	58 (8.7)	54 (12.3)
Hispanic/Latino	14 (5.0)	2 (2.6)	36 (5.4)	29 (6.6)
Highest education level				
No college degree	78 (28.1)‡	11 (14.1)§	120 (17.9)‖	110 (25.1)‡
College degree	64 (23.0)	22 (28.2)	226 (33.7)	136 (31.1)
Some graduate school	100 (36.0)	37 (47.4)	231 (34.5)	145 (33.1)
Doctoral-level degree	36 (12.9)	8 (10.3)	93 (13.9)	47 (10.7)
Annual household income				
<$40 000	50 (18.2)‡	17 (22.7)‡	108 (16.3)‖	67 (15.6)§
$40 000–$69 999	57 (20.7)	6 (8.0)	124 (18.7)	85 (19.8)
$70 000–$99 999	55 (20.0)	23 (30.7)	129 (19.4)	81 (18.9)
$100 000–$199 999	77 (28.0)	21 (28.0)	216 (32.5)	143 (33.3)
≥$200 000	36 (13.1)	8 (10.7)	87 (13.1)	53 (12.4)
Marital status				
Single	35 (12.6)	11 (14.1)	160 (23.9)	75 (17.1)
Married	163 (58.6)	43 (55.1)	331 (49.4)	259 (59.1)
Widowed	10 (3.6)	0 (0)	17 (2.5)	11 (2.5)
Divorced/separated	33 (11.9)	7 (9.0)	65 (9.7)	43 (9.8)
Domestic partner	37 (13.3)	17 (21.8)	97 (14.5)	50 (11.4)
≥1 child	166 (59.7)	39 (50.0)	303 (45.2)	248 (56.6)
Self-reported health				
Excellent	41 (14.8)†	8 (10.3)	105 (15.7)†	68 (15.5)
Very good	86 (31.1)	30 (38.5)	294 (44.0)	168 (38.4)
Good	86 (31.1)	26 (33.3)	193 (28.9)	137 (31.3)
Fair	48 (17.3)	9 (11.5)	57 (8.5)	47 (10.7)
Poor	16 (5.8)	5 (6.4)	20 (3.0)	18 (4.1)
Health insurance	263 (95.0)†	77 (98.7)	638 (95.4)†	408 (93.4)†
Positive results on GAD-2 screening	51 (18.4)	17 (21.8)	96 (14.3)	65 (14.8)
Motivation				
Desire to improve health				
Not at all important	21 (7.6)	9 (11.5)	116 (17.3)†	76 (17.3)
Somewhat important	98 (35.2)	25 (32.1)	275 (41.1)	172 (39.3)
Very important	159 (57.2)	44 (56.4)	278 (41.6)	190 (43.4)
Ability to learn genetic makeup without going through a physician				
Not at all important	129 (46.4)	29 (37.2)	253 (37.8)	160 (36.6)†
Somewhat important	78 (28.1)	23 (29.5)	221 (33.0)	142 (32.5)
Very important	71 (25.5)	26 (33.3)	196 (29.2)	135 (30.9)
Prior DTC PGT	31 (11.2)	7 (9.0)	68 (10.2)	46 (10.5)
Pathway customer	127 (45.7)	42 (53.9)	220 (32.8)	128 (29.2)

DTC = direct-to-consumer; GAD-2 = 2-item Generalized Anxiety Disorder questionnaire; HCP = health care provider; PCP = primary care provider; PGT = personal genomic testing.
* Values are numbers (percentages) unless otherwise indicated. Percentages may not sum to 100 due to rounding.
† Data are missing for 1 participant.
‡ Data are missing for 3 participants.
§ Data are missing for 9 participants.
‖ Data are missing for 6 participants.

proportion of drug responses designated as "atypical" was 20% to 24% (**Appendix Table 1**, available at www.annals.org, shows detailed genetic results, stratified by discussion status). Among participants who did not report sharing their results with an HCP, 55 (8.5%) had concerns about the results becoming a part of their medical record, 269 (41.6%) did not believe that their results were important enough to share, and 248 (38.4%) still planned to discuss their results with an HCP but had not yet had time to do so.

Participants who reported sharing their results with a PCP more frequently reported being extremely satisfied with their decision to obtain DTC PGT and that all of their results could be used to improve their health (**Table 2**). In addition, they were the most likely to strongly agree that their PCP had adequate understanding of genetics and that genetic information should be part of a standard medical record. Of note, participants who reported sharing their results with a PCP were also most likely to strongly disagree that their PCP had an adequate understanding of genetics.

Among the 277 participants who shared their results with a PCP, 35% were very satisfied with the discussion (**Table 3**). These participants most frequently reported that their PCP adequately understood genetics, was very willing to both discuss and use their results

in their medical care, and did not differ in the interpretation of results from the company report. The 18% of participants who were not at all satisfied with the discussion were the most likely to report that their PCP's interpretation of results differed from the company's interpretation. Among participants who reported a difference in interpretation between the report and their PCP, those who were very satisfied with the discussion seemed to trust the PCP and company interpretations equally, whereas those who were not at all satisfied seemed to put more trust in the company's interpretation. Distribution of elevated genetic disease risk and

Table 2. Genetic Testing Results and Attitudes After Testing, by PCP and HCP Discussion Status, at 6-mo Follow-up*

Variable	Discussed Results With PCP (*n* = 278)	Discussed Results With Other HCP Only (*n* = 78)	Did Not Discuss Results With Any HCP (*n* = 670)
Genetic testing results			
Results available, *n (%)*	264 (95.0)	77 (98.7)	642 (95.8)
Disease risk: mean proportion of conditions†‡ designated "elevated risk" (SD) [range], %	20.2 (7.5) [0–41.3]	20.3 (8.1) [0–41.4]	20.3 (7.7) [0–44.8]
Pharmacogenomics: mean proportion of drug responses‡§ designated "atypical" (SD) [range], %	22.1 (12.8) [0–62.5]	23.8 (12.7) [0–55.6]	20.3 (11.6) [0–62.5]
Attitudes after testing, *n (percentage within discussion category)*			
In general, how satisfied are you about your decision to obtain DTC PGT?			
Not at all	0 (0)‖	1 (1.3)¶	7 (1.1)**
A little	6 (2.2)	4 (5.2)	28 (4.3)
Somewhat	32 (11.6)	8 (10.4)	121 (18.5)
Very	109 (39.5)	33 (42.9)	286 (43.7)
Extremely	129 (46.7)	31 (40.3)	212 (32.4)
How many of your results can be used to improve your health?			
None	20 (7.3)‖	8 (10.4)¶	99 (15.1)††
A few	117 (42.4)	36 (46.8)	336 (51.3)
Many	86 (31.2)	21 (27.3)	146 (22.3)
All	44 (15.9)	8 (10.4)	54 (8.2)
Not sure	9 (3.3)	4 (5.2)	20 (3.1)
How many of your results do you not understand?			
None	134 (48.6)‖	32 (41.6)¶	313 (47.8)††
A few	114 (41.3)	33 (42.9)	249 (38.0)
Many	17 (6.2)	7 (9.1)	47 (7.2)
All	2 (0.7)	1 (1.3)	7 (1.1)
Not sure	9 (3.3)	4 (5.2)	39 (6.0)
I believe my PCP understands genetics well enough to advise me on the implications of my results for my health.			
Strongly disagree	38 (13.7)	8 (10.3)	57 (8.5)‖
Somewhat disagree	40 (14.4)	21 (26.9)	121 (18.1)
Neither agree nor disagree	65 (23.4)	25 (32.1)	299 (44.8)
Somewhat agree	92 (33.1)	17 (21.8)	139 (20.8)
Strongly agree	43 (15.5)	7 (9.0)	52 (7.8)
I believe genetic information should be part of a standard medical record.			
Strongly disagree	16 (5.8)‡‡	5 (6.5)¶	59 (9.0)§§
Somewhat disagree	15 (5.5)	10 (13.0)	73 (11.2)
Neither agree nor disagree	40 (14.6)	11 (14.3)	145 (22.2)
Somewhat agree	80 (29.1)	26 (33.8)	189 (28.9)
Strongly agree	124 (45.1)	25 (32.5)	187 (28.6)
The information I received from DTC PGT allowed me to find out how I can improve my health.			
Not at all	15 (5.4)	8 (10.3)	135 (20.2)
Somewhat	154 (55.4)	47 (60.3)	371 (55.4)
Very much	109 (39.2)	23 (29.5)	164 (24.5)
The information I received from DTC PGT allowed me to learn about my genes without going through a physician.			
Not at all	46 (16.6)	9 (11.5)	102 (15.3)‖
Somewhat	92 (33.1)	28 (35.9)	249 (37.3)
Very much	140 (50.4)	41 (52.6)	317 (47.5)

DTC = direct-to-consumer; HCP = health care provider; PCP = primary care provider; PGT = personal genomic testing.
* Percentages may not sum to 100 due to rounding.
† Total of 29 for 23andMe and 25 for Pathway.
‡ The **Appendix** (available at www.annals.org) explains the complete breakdown of results.
§ Total of 8 for men and 9 for women.
‖ Data are missing for 2 participants.
¶ Data are missing for 1 participant.
** Data are missing for 16 participants.
†† Data are missing for 15 participants.
‡‡ Data are missing for 3 participants.
§§ Data are missing for 17 participants.

Table 3. Genetic Testing Results and Consumer Perceptions of the PCP Discussion of PGT Results, by Satisfaction Level*

Variable	How Satisfied Were You With the Discussion of Your Results With Your PCP?		
	Not at All	Somewhat	Very
Participants, *n (percentage of total group)*†	51 (18.4)	128 (46.2)	98 (35.4)
Genetic testing results			
Results available, *n (%)*	49 (96.1)	124 (96.9)	90 (91.8)
Disease risk: mean proportion of conditions designated "elevated risk" (SD) [range], %	20.5 (8.0) [4.0–40.0]	20.2 (7.7) [0–41.4]	20.0 (7.1) [4.0–37.9]
Pharmacogenomics: mean proportion of drug responses designated "atypical" (SD) [range], %	19.1 (12.3) [0–44.4]	23.4 (13.2) [0–55.6]	21.9 (12.3) [0–62.5]
Attitudes after testing, *n (percentage within discussion category)*			
I believe my PCP understands genetics well enough to advise me on the implications of my results for my health.			
Strongly/somewhat disagree	36 (70.6)	31 (24.2)	11 (11.2)
Neither agree nor disagree	10 (19.6)	38 (29.7)	17 (17.3)
Somewhat/strongly agree	5 (9.8)	59 (46.1)	70 (71.4)
Discussion perceptions, *n (percentage within satisfaction category)*			
How willing was your PCP to discuss the meaning of your results?			
Not at all	22 (43.1)	4 (3.1)	0 (0)
Somewhat	25 (49.0)	100 (78.1)	16 (16.3)
Very	4 (7.8)	24 (18.8)	82 (83.7)
How willing was your PCP to use your results in your medical care?			
Not at all	31 (60.8)	22 (17.2)	2 (2.0)
Somewhat	19 (37.3)	84 (65.6)	30 (30.6)
Very	1 (2.0)	22 (17.2)	66 (67.4)
Did the interpretation of your results provided by your PCP differ from the interpretation provided by the DTC PGT company?			
No	38 (74.5)	114 (89.1)	94 (95.9)
Yes	13 (25.5)	14 (10.9)	4 (4.1)
Among those who responded "yes":			
How much do you trust the interpretation from your PCP?			
Not at all	3 (23.1)	0 (0)	0 (0)
A little	4 (30.8)	4 (28.6)	0 (0)
Somewhat	4 (30.8)	6 (42.9)	1 (25.0)
Very	1 (7.7)	4 (28.6)	2 (50.0)
Extremely	1 (7.7)	0 (0)	1 (25.0)
How much do you trust the interpretation from the DTC PGT company?			
Not at all	0 (0)	0 (0)	0 (0)
A little	0 (0)	1 (7.1)	0 (0)
Somewhat	4 (30.8)	8 (57.1)	1 (25.0)
Very	8 (61.5)	5 (35.7)	2 (50.0)
Extremely	1 (7.7)	0 (0)	1 (25.0)

DTC = direct-to-consumer; PCP = primary care provider; PGT = personal genomic testing.
* Percentages may not sum to 100 due to rounding.
† The total group was composed of 277 participants. One participant did not report his or her satisfaction with the PCP discussion or respond to the 3 items under discussion perceptions and was therefore excluded from this table.

positive pharmacogenomic results was also relatively consistent among the groups (Appendix Table 2, available at www.annals.org, shows detailed genetic results, stratified by discussion status).

A total of 159 participants who discussed their DTG PGT results with their PCP provided text explanations of their satisfaction level. Ten themes were identified, and the most frequent were "actionability/use in care" (how and whether the results could be or were used [32%]) and "engagement/interest" (that PCPs were interested and willing to discuss the results [25%]). Table 4 shows examples of each, and Appendix Table 3 (available at www.annals.org) shows the complete list of responses. Two additional examples are shown in Table 5 in the context of case reports.

DISCUSSION

To our knowledge, this is the first description of the interactions between DTC PGT consumers and their PCP from the consumers' perspective in a longitudinal study. The frequency with which consumers reported sharing their reports in the PGen Study (35%, inclusive of all HCPs) is similar to that seen in the Scripps Genomic Health Initiative (a study of PGT among employees of a medical research institute) (10) and a cross-sectional survey of DTC PGT customers (11). The baseline frequency of the intention to share results with an HCP (>60% in our study) was considerably higher and was similar to estimates of 78% among hypothetical consumers (12) and greater than 90% of early PGT adopters (24). Participant responses suggest that the

discrepancy between pretest intentions and posttest behaviors may in large part be explained by an initial overestimation of the expected importance or actionability of results and the relatively short follow-up period in which these behaviors were measured. Therefore, the effect of DTC PGT on health care use may not be fully realized for some time and may hinge on the perceived utility of results as an individual's medical needs evolve.

The profile of participants who reported sharing their results with an HCP (for example, women and parents) may reflect the larger context in which DTC PGT takes place. For example, women are typically greater users of health care services compared with men (25), and parents may have additional reasons to discuss their results with an HCP, such as the implications for children or grandchildren (a testing motivation endorsed by nearly 50% of early PGT users [24]). Moreover, we have previously shown that education level is positively associated with both genetics knowledge and self-efficacy (one's confidence to apply genetics knowledge) in the PGen Study (26); therefore, consumers without a college degree may have a greater need for consultation after they receive complex genetic information. Finally, the nature of the testing offered by Pathway (disease risk and pharmacogenomic information only) compared with 23andMe (which also provided ancestry and benign trait data) suggests that Pathway consumers may have had a more focused, health-related interest in obtaining DTC PGT.

Regardless of whether consumers reported discussing their results with their HCPs, satisfaction with the decision to obtain DTC PGT was high, and most participants agreed that it enabled them to learn about their genes without going through a physician. Other attitudes after testing varied by discussion status, but the directionality of this relationship is unclear. For example, the finding that participants who reported sharing their results with a PCP were more likely to agree that their results could be used to improve their health and less likely to express concerns about their results being added to their medical record may explain why they sought consultation in the first place. Conversely, beliefs about PCPs' understanding of genetics among participants who reported sharing their results with a PCP were probably shaped, at least in part, by the interaction (for example, these participants were the most likely to express a strong opinion of PCP understanding [either positive or negative rather than neutral]).

A minority of participants was not at all satisfied with the PCP interaction, and a few explanations are possible. First, considerable evidence suggests that nongenetics specialists are ill-prepared for the integration of genomics into primary and preventive care (27–30), and patient dissatisfaction may reflect the PCP's inability to adequately respond to patient inquiries and concerns. This interpretation is supported by the fact that the participants who were most dissatisfied with the PCP encounter were also the least likely to report high PCP willingness to discuss results and the many free-form responses described PCPs being unwilling or "afraid" to even look at the DTC PGT report. A patient's perception (whether correct or incorrect) that the PCP lacks competence in genetics could also undermine their trust in the provider, which has been linked to patient dissatisfaction (31).

Given the increasing importance of genetic considerations in primary care over the past decade (32–34) and repeated calls for physician education initiatives in genomics (35–37), all PCPs should have adequate clinical skills to at least engage in a discussion about genetic testing that describes its benefits and limitations and provides an account of why further action is or is not recommended. Prior research on predictors of patient satisfaction suggests that such discussions, to the

Table 4. Consumer Perceptions of the PCP Discussion of DTC PGT Results: A Sample of Free-Form Responses, by Theme*

Actionability/use in care (*n* = 51 [32%])	"My doctor was most interested in the medication-related results. She felt that the knowledge could help her medication choices in the future. She did not have time to discuss any other results."
Inclusion in medical records (*n* = 17 [11%])	"I wanted to talk to him about it without it becoming part of my medical record. I think he felt either it was serious and legitimate (and therefore should be part of my medical record) or it was just a joke/entertainment and shouldn't be. . . ."
Engagement/interest (*n* = 39 [25%])	"My provider is AWESOME and open to learn new things. She was really impressed with the report from Pathway and read the entire thing."
Lack of engagement/interest (*n* = 35 [22%])	"My regular PCP moved and I am now seeing her replacement. She was not as willing to look at the results . . . I had to insist that she look over them . . . I made her a copy and had it put in my records but I don't think she even looked at it. . . ."
Skepticism (*n* = 11 [7%])	"She doesn't believe in this type of testing. I sent the results from [23andMe] to her and she never looked. She told me it wasn't needed and not to believe the results."
Lack of knowledge (*n* = 24 [15%])	"PCP—Backed away from the report like it was something to be afraid of . . . lacked training in this area and preferred not to review and discuss."
More information needed (*n* = 6 [4%])	"The doctor was objective about the results but seemed to want more specific information prior to any kind of committed statement."
Not enough time (*n* = 17 [11%])	"The issue is the length of time you get to see the doctor. Even though I scheduled to discuss the results the appointment was less than 15 minutes."
Negative effect on patient–provider relationship (*n* = 4 [3%])	"He [said] saliva testing was unreliable and a waste of money. I now see someone else."

DTC = direct-to-consumer; PCP = primary care provider; PGT = personal genomic testing.
* Proportion of responses that contained elements related to each theme. 159 of 278 consumers who discussed their results with a PCP responded to the following prompt: "Please tell us why you were or were not satisfied with your discussion of your DTC PGT results with your PCP." Responses were classified under as many themes as applicable. See **Appendix Table 3** (available at www.annals.org) for a full list of responses and theme classifications.

Table 5. Case Reports

Case A: high satisfaction with the PCP discussion of results

Mrs. A is a married, multiracial woman aged 40 y who has no children. She is college-educated, has a household income of <$40 000 per year, and has health insurance. She reports being in fair health and rated the desire to improve her health as a very important factor in her decision to order DTC PGT. She has a history of retinal migraine, ulcers, a heart murmur, right ventricular enlargement, osteoarthritis, and rheumatoid arthritis; elsewhere, she mentions that she has Ehlers–Danlos syndrome.

Mrs. A's DTC PGT results indicate an elevated risk for exfoliating glaucoma, coronary heart disease, amyotrophic lateral sclerosis, and myocardial infarction and an increased sensitivity to warfarin.

Six months after testing, she somewhat agreed that DTC PGT allowed her to find out how to improve her health, and, overall, she is extremely satisfied with her decision to have testing. She is also very satisfied with the discussion of results she had with her PCP, who was very willing to discuss her results and somewhat willing to use them in her medical care. About this encounter, she writes, "I told my doctor about the testing and how I wasn't prepared to have the results submitted to my medical health file just yet. She was completely on board with my decision but was very interested to see my results for her knowledge as we moved forward. I appreciated that she respected my decision to not put it in the file, but that she wanted the knowledge to aid in my medical future."

She also notes that she shared her results with a genetics specialist but is only somewhat satisfied with the experience so far: "I submitted my info to my geneticist but have yet to hear back from him regarding the results, so I'm not too happy with that."

Case B: low satisfaction with the PCP discussion of results

Mr. B is a married, white man aged 41 y who has children. He is college-educated, has a household income of $100 000–$200 000 per year, and has health insurance. He reports being in very good health and rated the desire to improve his health as a somewhat important factor in his decision to order DTC PGT. He receives no medications; has a history of asthma; and has a family history of leukemia, breast cancer, unknown heart disease, high cholesterol, and arthritis.

Mr. B's DTC PGT results indicate an elevated risk for prostate cancer, psoriasis, rheumatoid arthritis, age-related macular degeneration, multiple sclerosis, atrial fibrillation, venous thromboembolism, restless leg syndrome, esophageal squamous cell carcinoma, and stomach cancer. He also has an increased sensitivity to warfarin.

After testing, he did not at all agree that DTC PGT allowed him find out how to improve his health and is only somewhat satisfied with his decision to order this testing. He was not at all satisfied with the discussion of results he had with his PCP, who was reportedly not at all willing to discuss or use his results in his medical care. About this encounter, he writes, "He was not interested in the printable summary of my results without digging into the underlying genome data. But the underlying data was hard to get and impossible to print out, so I couldn't really share it with him."

DTC = direct-to-consumer; PCP = primary care provider; PGT = personal genomic testing.

degree that they incorporate patient-centered questioning techniques, explanations, and health education and information sharing (38), can potentially improve patient satisfaction with the PCP interaction. Engagement with DTC PGT may also benefit the provider. For example, these encounters may serve as an education opportunity for a provider, initiated by "empowered patients" engaged in "participatory medicine" (39), a notion supported by the following comments from a PGen Study participant: "I think by my diligence I can help expose my [doctors] to consider the advantages of such genetic information. I took this test, knowing full well that it was a new tool in the medical treatment and diagnosis. I saw it as my part to participate in this new era in medicine."

However, another important contributor to dissatisfaction may be the differences between consumer expectations and PCP training with respect to how DTC PGT results should be integrated into care. Individuals who seek DTC PGT probably believe it has value, at least as it pertains to their particular goals in testing (such as learning about their ancestry or determining their risk for cancer). These beliefs may originate from various sources (such as company marketing, media reports on genetic testing and genealogy, or science education programs) and may or may not be accurate, but they nonetheless contribute to the context in which results are discussed between consumers and PCPs. Consumer expectations are probably further shaped by the experience of DTC PGT itself and particularly the way in which results are presented. For example, PGen Study participants who received an elevated risk result from Pathway accompanied by the phrase, "Speak with your doctor about developing a prevention plan," might have reasonably expected their PCP to both discuss the results with them and actively use them to guide preventive care. Thus, the ways in which companies and their advocates promote and present DTC PGT may be a factor in how consumers view these services and may have an important (and perhaps negative) effect on patient–physician interactions.

Unmet expectations are a strong predictor of patient dissatisfaction at both immediate and longer-term follow-up after a primary care appointment (40, 41). A participant may have believed that they were inadequately served if the PCP did not act on a result they pinpointed as being particularly important, even though such inaction may have been the medically appropriate course (for example, in the case of an increased risk for Alzheimer disease, bipolar disorder, or leukemia). Some patient dissatisfaction may stem from the disconnect between how companies market (and their customers perceive) the utility of DTC PGT and how the medical community describes (and its members perceive) it. In a commentary on DTC medical advertising, Leah Rosenberg (42) argues that the marketing of unproven medical technologies has a pernicious effect on the patient–provider relationship in that it "undermine[s] an essential element of the therapeutic encounter: trust." However, she concludes by encouraging provider engagement:

> Rather than categorically refusing all patient requests for unproven screening tests, one possible solution entails using the query as an entry-point for important physician–patient discussions about risk, planning, and prevention. When viewed another way, the advertising may activate patients toward greater agency in their healthcare and promote stronger collaborations of information exchange.

Strengths of the PGen Study include its recruitment of actual DTC PGT customers, longitudinal data collection, and access to individual genetic results. Limita-

tions include the potential for selection bias inherent to voluntary survey data and the significant nonresponse rate at 6-month follow-up. Most important, our findings reflect the consumer perspective and do not relay the facts of the provider encounter. We could not discern how participants communicated with their providers (such as by phone or in person), which specific results were discussed, or the length of the encounters. Moreover, the number of participants in certain analysis groups was small (such as those who reported a disagreement between company and PCP interpretation of results), and results from these groups should be interpreted with caution. Finally, our findings are not necessarily generalizable to other DTC PGT consumers, particularly because the profile of such consumers changes over time from early adopters to more mainstream individuals. Participants in the PGen Study may have also been more likely to believe that their results had clinical utility and therefore were more frequently dissatisfied with the PCP encounter when medical action was not initiated.

In summary, to our knowledge, we have presented the first comprehensive picture of DTC PGT consumers who report sharing their results with an HCP, including consumer descriptions of these encounters. Our results suggest that a minority of consumers share their results with an HCP, most are satisfied with the HCP discussion of results, and both of these outcomes may be related to a consumer's perception that their results can potentially affect their care.

From Brigham and Women's Hospital, the Broad Institute, Harvard Medical School, and Partners HealthCare Personalized Medicine, Boston, Massachusetts; Utrecht Institute for Pharmaceutical Sciences, Utrecht University, Utrecht, the Netherlands; McMaster University and Genetic and Molecular Epidemiology Laboratory, Population Health Research Institute, Hamilton Health Sciences, Hamilton, Ontario, Canada; and University of Michigan and University of Michigan School of Public Health, Ann Arbor, Michigan.

Acknowledgment: The authors thank Margaret Helm (PGen Study project manager), Clara Chen (PGen Study data manager), and Dr. Adrienne Cupples (PGen Study statistical consultant) for their logistic support and intellectual contributions.

Grant Support: By the National Human Genomic Research Institute, National Institutes of Health (grant R01-HG005092). Ms. van der Wouden was supported by the K.F. Hein Fonds, De Stichting Jo Kolk Studiefonds Voor Vrouwen, and De Koninklijke Nederlandse Maatschappij Pharmacie Stipendiafonds. Dr. Carere was supported by a Canadian Institutes of Health Research Doctoral Foreign Study Award. Dr. Green was also supported by additional grants from the National Institutes of Health (grants U01-HG006500, U19-HD077671, and R01-HG002213).

Disclosures: Dr. Maitland-van der Zee reports grants from GlaxoSmithKline, Prediction Adverse Drug Reactions Project, and European–Pharmacogenomics of Anticoagulant Therapy outside the submitted work. Dr. Roberts reports grants from the National Institutes of Health and nonfinancial support from 23andMe and Pathway Genomics during the conduct of the study. Dr. Green reports grants from the National Institutes of Health during the conduct of the study; personal fees from Illumina, Invitae, Prudential, AIA, Helix, and Bina outside the submitted work; and grants from the Brin Wojcicki Foundation outside the submitted work. Authors not named here have disclosed no conflicts of interest. Forms can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M15-0995.

Reproducible Research Statement: *Study protocol, statistical code and data set*: Available from Dr. Green (e-mail, rcgreen@genetics.med.harvard.edu).

Requests for Single Reprints: Robert C. Green, MD, MPH, Genomes2People Research Program, Brigham and Women's Hospital, EC Alumnae Building, Suite 301, 41 Avenue Louis Pasteur, Boston, MA 02115; e-mail, rcgreen@genetics.med.harvard.edu.

Current author addresses and author contributions are available at www.annals.org.

References

1. **Evans JP, Green RC.** Direct to consumer genetic testing: avoiding a culture war. Genet Med. 2009;11:568-9. [PMID: 19606051] doi:10.1097/GIM.0b013e3181afbaed
2. **Frueh FW, Greely HT, Green RC, Hogarth S, Siegel S.** The future of direct-to-consumer clinical genetic tests. Nat Rev Genet. 2011;12:511-5. [PMID: 21629275] doi:10.1038/nrg3026
3. **Green RC, Farahany NA.** Regulation: the FDA is overcautious on consumer genomics. Nature. 2014;505:286-7. [PMID: 24436984]
4. **Janssens AC, Gwinn M, Bradley LA, Oostra BA, van Duijn CM, Khoury MJ.** A critical appraisal of the scientific basis of commercial genomic profiles used to assess health risks and personalize health interventions. Am J Hum Genet. 2008;82:593-9. [PMID: 18319070] doi:10.1016/j.ajhg.2007.12.020
5. **Offit K.** Genomic profiles for disease risk: predictive or premature? JAMA. 2008;299:1353-5. [PMID: 18349097] doi:10.1001/jama.299.11.1353
6. **Janssens AC, van Duijn CM.** An epidemiological perspective on the future of direct-to-consumer personal genome testing. Investig Genet. 2010;1:10. [PMID: 21092344] doi:10.1186/2041-2223-1-10
7. **Hunter DJ, Khoury MJ, Drazen JM.** Letting the genome out of the bottle–will we get our wish? N Engl J Med. 2008;358:105-7. [PMID: 18184955] doi:10.1056/NEJMp0708162
8. **Samuel GN, Jordens CF, Kerridge I.** Direct-to-consumer personal genome testing: ethical and regulatory issues that arise from wanting to 'know' your DNA. Intern Med J. 2010;40:220-4. [PMID: 20446967] doi:10.1111/j.1445-5994.2010.02190.x
9. **McGuire AL, Burke W.** An unwelcome side effect of direct-to-consumer personal genome testing: raiding the medical commons. JAMA. 2008;300:2669-71. [PMID: 19066388] doi:10.1001/jama.2008.803
10. **Darst BF, Madlensky L, Schork NJ, Topol EJ, Bloss CS.** Characteristics of genomic test consumers who spontaneously share results with their health care provider. Health Commun. 2014;29:105-8. [PMID: 23384116] doi:10.1080/10410236.2012.717216
11. **Kaufman DJ, Bollinger JM, Dvoskin RL, Scott JA.** Risky business: risk perception and the use of medical services among customers of DTC personal genetic testing. J Genet Couns. 2012;21:413-22. [PMID: 22278220] doi:10.1007/s10897-012-9483-0
12. **McGuire AL, Diaz CM, Wang T, Hilsenbeck SG.** Social networkers' attitudes toward direct-to-consumer personal genome testing. Am J Bioeth. 2009;9:3-10. [PMID: 19998099] doi:10.1080/15265160902928209

13. **Bernhardt BA, Zayac C, Gordon ES, Wawak L, Pyeritz RE, Gollust SE.** Incorporating direct-to-consumer genomic information into patient care: attitudes and experiences of primary care physicians. Per Med. 2012;9:683-692. [PMID: 23795206]
14. **Powell KP, Cogswell WA, Christianson CA, Dave G, Verma A, Eubanks S, et al.** Primary care physicians' awareness, experience and opinions of direct-to-consumer genetic testing. J Genet Couns. 2012;21:113-26. [PMID: 21769569] doi:10.1007/s10897-011-9390-9
15. **Goldsmith L, Jackson L, O'Connor A, Skirton H.** Direct-to-consumer genomic testing from the perspective of the health professional: a systematic review of the literature. J Community Genet. 2013;4:169-80. [PMID: 23322235] doi:10.1007/s12687-012-0135-8
16. 23andMe. Accessed at www.23andme.com on November 2014.
17. Pathway Genomics. Accessed at www.pathway.com on November 2014.
18. **Lehmann LS, Kaufman DJ, Sharp RR, Moreno TA, Mountain JL, Roberts JS, et al.** Navigating a research partnership between academia and industry to assess the impact of personalized genetic testing. Genet Med. 2012;14:268-73. [PMID: 22241103] doi:10.1038/gim.2011.59
19. **Carere DA, Couper MP, Crawford SD, Kalia SS, Duggan JR, Moreno TA, et al; PGen Study Group.** Design, methods, and participant characteristics of the Impact of Personal Genomics (PGen) Study, a prospective cohort study of direct-to-consumer personal genomic testing customers. Genome Med. 2014;6:96. [PMID: 25484922] doi:10.1186/s13073-014-0096-0
20. PatientsLikeMe. Accessed at www.patientslikeme.com on September 1 2015.
21. **Ware JE Jr, Gandek B.** Overview of the SF-36 Health Survey and the International Quality of Life Assessment (IQOLA) Project. J Clin Epidemiol. 1998;51:903-12. [PMID: 9817107]
22. **Ebell MH.** Diagnosis of anxiety disorders in primary care. Am Fam Physician. 2008;78:501-2. [PMID: 18756659]
23. **Ostergren JE, Gornick MC, Carere DA, Kalia SS, Uhlmann WR, Ruffin MT, et al; PGen Study Group.** How well do customers of direct-to-consumer personal genomic testing services comprehend genetic test results? Findings from the Impact of Personal Genomics Study. Public Health Genomics. 2015;18:216-24. [PMID: 26087778] doi:10.1159/000431250
24. **Gollust SE, Gordon ES, Zayac C, Griffin G, Christman MF, Pyeritz RE, et al.** Motivations and perceptions of early adopters of personalized genomics: perspectives from research participants. Public Health Genomics. 2012;15:22-30. [PMID: 21654153] doi:10.1159/000327296
25. **Pinkhasov RM, Wong J, Kashanian J, Lee M, Samadi DB, Pinkhasov MM, et al.** Are men shortchanged on health? Perspective on health care utilization and health risk behavior in men and women in the United States. Int J Clin Pract. 2010;64:475-87. [PMID: 20456194] doi:10.1111/j.1742-1241.2009.02290.x
26. **Carere DA, Kraft P, Kaphingst KA, Roberts JS, Green RC.** Consumers report lower confidence in their genetics knowledge following direct-to-consumer personal genomic testing. Genet Med. 2016;18:65-72. [PMID: 25812042] doi:10.1038/gim.2015.34
27. **Baars MJ, Henneman L, Ten Kate LP.** Deficiency of knowledge of genetics and genetic tests among general practitioners, gynecologists, and pediatricians: a global problem. Genet Med. 2005;7:605-10. [PMID: 16301861]
28. **Bottorff JL, Blaine S, Carroll JC, Esplen MJ, Evans J, Nicolson Klimek ML, et al.** The educational needs and professional roles of Canadian physicians and nurses regarding genetic testing and adult onset hereditary disease. Community Genet. 2005;8:80-7. [PMID: 15925883]
29. **Houwink EJ, van Luijk SJ, Henneman L, van der Vleuten C, Jan Dinant G, Cornel MC.** Genetic educational needs and the role of genetics in primary care: a focus group study with multiple perspectives. BMC Fam Pract. 2011;12:5. [PMID: 21329524] doi:10.1186/1471-2296-12-5
30. **Powell KP, Christianson CA, Cogswell WA, Dave G, Verma A, Eubanks S, et al.** Educational needs of primary care physicians regarding direct-to-consumer genetic testing. J Genet Couns. 2012;21:469-78. [PMID: 22207397] doi:10.1007/s10897-011-9471-9
31. **Safran DG, Taira DA, Rogers WH, Kosinski M, Ware JE, Tarlov AR.** Linking primary care performance to outcomes of care. J Fam Pract. 1998;47:213-20. [PMID: 9752374]
32. **Burke W, Emery J.** Genetics education for primary-care providers. Nat Rev Genet. 2002;3:561-6. [PMID: 12094234]
33. **Guttmacher AE, Porteous ME, McInerney JD.** Educating healthcare professionals about genetics and genomics. Nat Rev Genet. 2007;8:151-7. [PMID: 17230201]
34. **Feero WG.** Genetics of common disease: a primary care priority aligned with a teachable moment? Genet Med. 2008;10:81-2. [PMID: 18281913] doi:10.1097/GIM.0b013e3181639a6d
35. **Feero WG, Green ED.** Genomics education for health care professionals in the 21st century. JAMA. 2011;306:989-90. [PMID: 21900139] doi:10.1001/jama.2011.1245
36. **Frueh FW, Gurwitz D.** From pharmacogenetics to personalized medicine: a vital need for educating health professionals and the community. Pharmacogenomics. 2004;5:571-9. [PMID: 15212593]
37. **Nelson EA, McGuire AL.** The need for medical education reform: genomics and the changing nature of health information [Editorial]. Genome Med. 2010;2:18. [PMID: 20236478] doi:10.1186/gm139
38. **Beck RS, Daughtridge R, Sloane PD.** Physician-patient communication in the primary care office: a systematic review. J Am Board Fam Pract. 2002;15:25-38. [PMID: 11841136]
39. **Boguski MS, Boguski RM, Berman MR.** Personal genotypes are teachable moments. Genome Med. 2013;5:22. [PMID: 23514125] doi:10.1186/gm426
40. **Jackson JL, Chamberlin J, Kroenke K.** Predictors of patient satisfaction. Soc Sci Med. 2001;52:609-20. [PMID: 11206657]
41. **Bell RA, Kravitz RL, Thom D, Krupat E, Azari R.** Unmet expectations for care and the patient-physician relationship. J Gen Intern Med. 2002;17:817-24. [PMID: 12406352]
42. **Rosenberg L.** Does direct-to-consumer marketing of medical technologies undermine the physician–patient relationship? Am J Bioeth. 2009;9:22-3. [PMID: 19326306] doi:10.1080/15265160802716852

Current Author Addresses: Ms. van der Wouden: Utrecht University, Faculty of Science, PO Box 80082, 3508 TB Utrecht, the Netherlands.
Dr. Carere: Genetic and Molecular Epidemiology Laboratory, David Braley Cardiac, Vascular and Stroke Research Institute, 237 Barton Street East, Hamilton, Ontario L8L 2X2, Canada.
Dr. Maitland-van der Zee: Faculteit Farmaceutische Wetenschappen, Universiteitsweg 99, 3584 CG Utrecht, the Netherlands.
Dr. Ruffin: Department of Family Medicine, University of Michigan Health System, 1018 Fuller Street, Ann Arbor, MI 48104-1213.
Dr. Roberts: University of Michigan School of Public Health, School of Public Health I Building, Room 2834, 109 South Observatory, Ann Arbor, MI 48109.
Dr. Green: Genomes2People Research Program, Brigham and Women's Hospital, EC Alumnae Building, Suite 301, 41 Avenue Louis Pasteur, Boston, MA 02115.

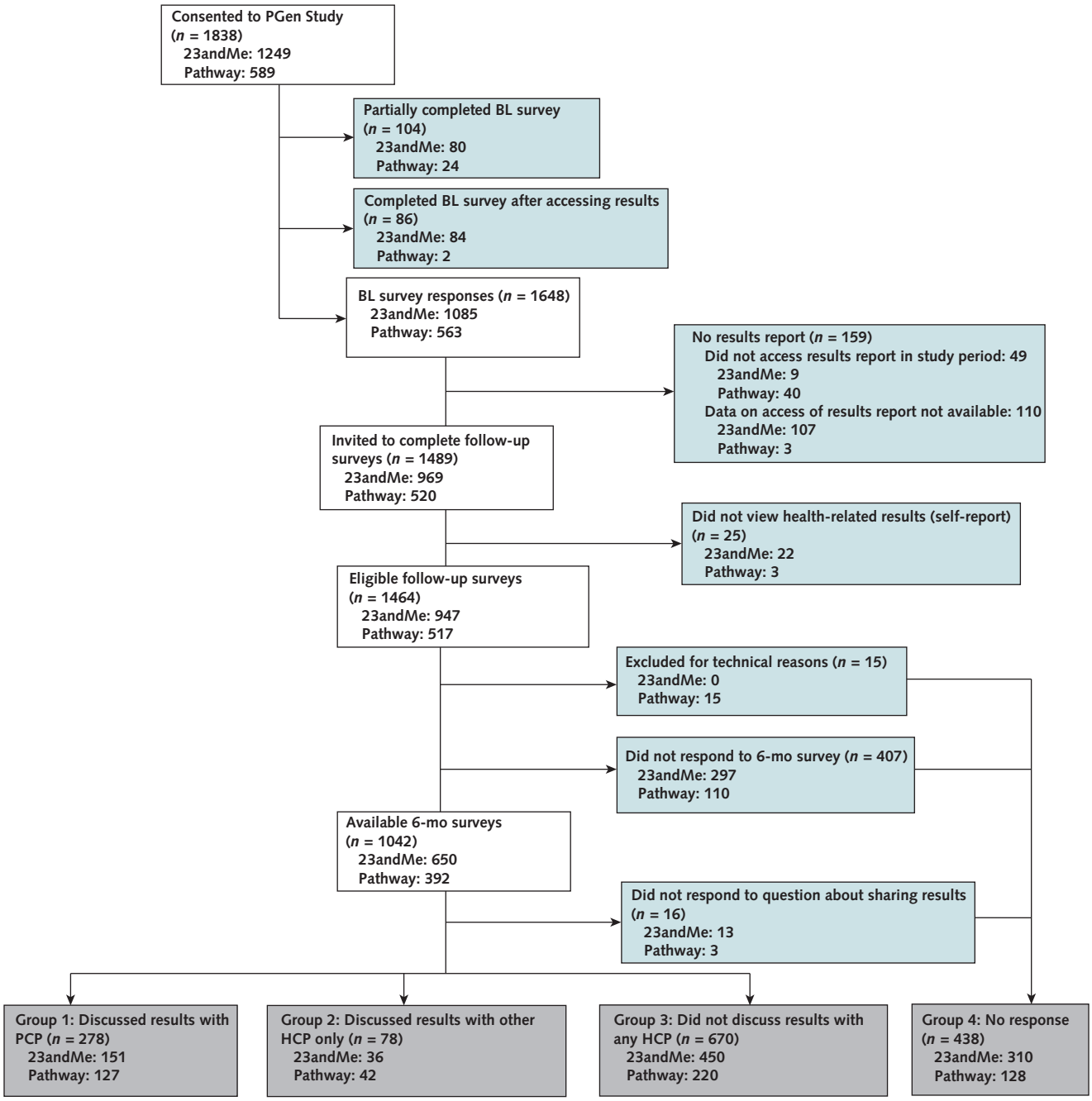
Author Contributions: Conception and design: C.H. van der Wouden, D.A. Carere, M.T. Ruffin, J.S. Roberts, R.C. Green.
Analysis and interpretation of the data: C.H. van der Wouden, D.A. Carere, A.H. Maitland-van der Zee, M.T. Ruffin.
Drafting of the article: C.H. van der Wouden, D.A. Carere, M.T. Ruffin, R.C. Green.
Critical revision of the article for important intellectual content: C.H. van der Wouden, D.A. Carere, A.H. Maitland-van der Zee, M.T. Ruffin, J.S. Roberts, R.C. Green.
Final approval of the article: C.H. van der Wouden, D.A. Carere, A.H. Maitland-van der Zee, M.T. Ruffin, J.S. Roberts, R.C. Green.
Statistical expertise: D.A. Carere.
Obtaining of funding: J.S. Roberts, R.C. Green.
Administrative, technical, or logistic support: C.H. van der Wouden, J.S. Roberts, R.C. Green.
Collection and assembly of data: C.H. van der Wouden, J.S. Roberts.

Appendix: PGen Study Group Members

Members of the PGen Study group who authored this work are: Robert C. Green (Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts), Deanna Alexis Carere (Harvard School of Public Health, Boston, Massachusetts), Mack T. Ruffin IV (University of Michigan School of Public Health, Ann Arbor, Michigan), and J. Scott Roberts (University of Michigan School of Public Health, Ann Arbor, Michigan).

Members of the PGen Study group who contributed to this work but did not author it are: Joel B. Krier, Margaret H. Helm, and Lisa S. Lehmann (Harvard Medical School and Brigham and Women's Hospital, Boston, Massachusetts); Peter Kraft (Harvard School of Public Health, Boston, Massachusetts); Lan Q. Le and Jenny Ostergren (University of Michigan School of Public Health, Ann Arbor, Michigan); Wendy R. Uhlmann and Mick P. Couper (University of Michigan, Ann Arbor, Michigan); Joanna L. Mountain and Amy K. Kiefer (23andMe, Mountain View, California); Glenn D. Braunstein (Pathway Genomics, San Diego, California); Scott D. Crawford (Survey Sciences Group/SoundRocket, Ann Arbor, Michigan); L. Adrienne Cupples, Clara A. Chen, and Catharine Wang (Boston University School of Public Health, Boston, Massachusetts); Stacy W. Gray (Dana-Farber Cancer Institute, Boston, Massachusetts); Barbara A. Koenig (University of California, San Francisco, San Francisco, California); Kimberly Kaphingst (University of Utah, Salt Lake City, Utah); and Sarah Gollust (University of Minnesota, Minneapolis, Minnesota).

Appendix Figure. Survey data collection in the PGen Study, detailing the recruitment and survey administration process.



The white boxes show the progression of the sample composition of the study. The green boxes represent points of exclusion or loss to follow-up. The gray boxes indicate the 4 mutually exclusive "discussion status" groups created for this analysis. BL = baseline; HCP = health care provider; PCP = primary care provider; PGen = Impact of Personal Genomics.

Appendix Table 1. Complete Genetic Testing Results, by Status of PGT Results Discussion at 6-mo Follow-up*

Variable	Discussed Results With PCP (*n* = 278)	Discussed Results With Other HCP (*n* = 78)	Did Not Discuss Results With Any HCP (*n* = 670)
DTC PGT reports available, *n (%)*	264 (95)	77 (99)	642 (96)
Elevated risk for disease or positive result, %			
Type 2 diabetes mellitus	12	16	15
Type 1 diabetes mellitus	6	4	12
Prostate cancer†	27	0	26
Psoriasis	14	12	16
Rheumatoid arthritis	12	13	15
Parkinson disease	11	9	13
Alzheimer disease	25	20	22
Age-related macular degeneration	22	16	21
Melanoma	21	10	12
Ulcerative colitis	15	20	22
Multiple sclerosis	21	22	15
Exfoliating glaucoma	28	22	22
Obesity	17	21	11
Coronary heart disease	23	31	21
Atrial fibrillation	25	22	26
Lung cancer	18	23	17
Colorectal cancer	21	25	25
Breast cancer‡	11	9	11
Venous thromboembolism with estrogen supplementation‡	10	14	5
Abacavir hypersensitivity	7	7	6
Clopidogrel efficacy	21	29	21
Warfarin sensitivity	61	68	64
23andMe customers only§			
Chronic kidney disease	31	31	27
Primary biliary cirrhosis	27	26	26
Scleroderma	23	37	22
Venous thromboembolism	17	31	22
Restless leg syndrome	45	31	40
Esophageal squamous cell carcinoma	34	37	35
Crohn disease	11	20	12
Stomach cancer	27	20	30
Celiac disease	18	17	25
Gallstones	12	11	12
Bipolar disease	15	9	13
Response to hepatitis C treatment	57	63	65
Alcohol consumption, smoking, and risk for esophageal cancer	0	0	1
Fluorouracil toxicity	0	0	2
Pseudocholinesterase deficiency	4	6	5
Thiopurine methyltransferase deficiency	10	3	9
Pathway customers only‖			
Amyotrophic lateral sclerosis	14	7	11
Asthma	29	31	28
Hypertension	45	45	54
Leukemia	7	10	11
Myocardial infarction	56	67	54
Osteoarthritis	11	21	13
Peripheral artery disease	46	52	50
Aminoglycoside-induced hearing loss	0	2	0
Carbamazepine hypersensitivity	0	0	1
Methotrexate toxicity	59	48	
Statin therapeutic benefit	64	64	58
Statin-induced myopathy	17	31	18

DTC = direct-to-consumer; HCP = health care provider; PCP = primary care provider; PGT = personal genomic testing.
* Italicized text indicates pharmacogenomic variant. Unless otherwise noted, proportions are computed among all individuals for whom genetic testing reports were available; however, not all consumers for whom a report is available received estimates of risk for every disease. Some results were not reported on an individual because of ancestry or technical considerations determined by the companies.
† Proportions among men only: PCP, *n* = 95; other HCP, *n* = 20; no HCP, *n* = 280.
‡ Proportions among women only: PCP, *n* = 169; other HCP, *n* = 57; no HCP, *n* = 362.
§ Proportions among 23andMe customers only: PCP, *n* = 137; other HCP, *n* = 35; no HCP, *n* = 422.
‖ Proportions among Pathway customers only: PCP, *n* = 127; other HCP, *n* = 42; no HCP, *n* = 220.

Appendix Table 2. Complete Genetic Testing Results, by PCP Discussion Satisfaction Level*

Variable	How Satisfied Were You With the Discussion of Your Results With Your PCP?		
	Not at All Satisfied (*n* = 51)	**Somewhat Satisfied (*n* = 128)**	**Very Satisfied (*n* = 98)**
DTC PGT reports available, *n (%)*	49 (96)	124 (97)	90 (92)
Elevated risk for disease or positive result, %			
Type 2 diabetes mellitus	12	13	10
Type 1 diabetes mellitus	10	76	6
Prostate cancer†	46	15	39
Psoriasis	16	13	14
Rheumatoid arthritis	10	10	17
Parkinson disease	10	8	15
Alzheimer disease	22	23	28
Age-related macular degeneration	20	22	23
Melanoma	27	19	19
Ulcerative colitis	10	16	14
Multiple sclerosis	20	21	21
Exfoliating glaucoma	27	31	26
Obesity	16	19	16
Coronary heart disease	29	27	14
Atrial fibrillation	31	24	23
Lung cancer	22	15	19
Colorectal cancer	16	23	21
Breast cancer‡	0	12	18
Venous thromboembolism with estrogen supplementation‡	14	12	4
Abacavir hypersensitivity	2	8	8
Clopidogrel efficacy	12	26	18
Warfarin sensitivity	31	40	48
23andMe customers only§			
Chronic kidney disease	48	24	30
Primary biliary cirrhosis	33	31	21
Scleroderma	24	27	17
Venous thromboembolism	14	23	11
Restless leg syndrome	43	45	47
Esophageal squamous cell carcinoma	48	31	34
Crohn disease	10	10	13
Stomach cancer	33	18	34
Celiac disease	10	16	21
Gallstones	5	18	8
Bipolar disease	19	15	13
Response to hepatitis C treatment	24	47	45
Alcohol consumption, smoking, and risk for esophageal cancer	0	0	0
Fluorouracil toxicity	0	0	0
Pseudocholinesterase deficiency	0	6	4
Thiopurine methyltransferase deficiency	14	8	9
Pathway customers only‖			
Amyotrophic lateral sclerosis	11	11	22
Asthma	32	34	19
Hypertension	43	45	46
Leukemia	0	11	5
Myocardial infarction	68	50	57
Osteoarthritis	7	15	8
Peripheral artery disease	32	50	49
Aminoglycoside-induced hearing loss	0	0	0
Carbamazepine hypersensitivity	0	0	0
Methotrexate toxicity	54	60	62
Statin therapeutic benefit	57	66	65
Statin-induced myopathy	4	3	3

DTC = direct-to-consumer; PCP = primary care provider; PGT = personal genomic testing.
* Italicized text indicates pharmacogenomic variant. Unless otherwise noted, proportions are computed among all individuals for whom genetic testing reports were available; however, not all consumers for whom a report is available received estimates of risk for every disease. Some results were not reported for an individual because of ancestry or technical considerations determined by the companies.
† Proportions among men only: not at all satisfied, *n* = 13; somewhat satisfied, *n* = 48; very satisfied, *n* = 33.
‡ Proportions among women only: not at all satisfied, *n* = 36; somewhat satisfied, *n* = 76; very satisfied, *n* = 57.
§ Proportions among 23andMe customers only: not at all satisfied, *n* = 21; somewhat satisfied, *n* = 62; very satisfied, *n* = 53.
‖ Proportions among Pathway customers only: not at all satisfied *n* = 28; somewhat satisfied, *n* = 62; very satisfied, *n* = 37.

Appendix Table 3. Consumer Perceptions of the PCP Discussion of DTC PGT Results: Free-Form Responses, by Theme*

Responses (n = 159)	Themes†									
	A	B	C	D	E	F	G	H	I	J
"1) Good: He was intrigued by the opportunity to work with a patient who'd had personal genomics 2) Not so good: He pooh-poohed the significance of the results I felt were most important. 3) Good: Despite his cynicism about the results, he initiated changes to my medications, agreed to order new bloodtests [all *sic*], and is cooperating with me on modifying my vitamin protocol in response to the PGen findings."	A		C		E					
"23andMe says I can live to be 100. My mother did. I do not want to. My Dr. laughed. There is not a lot he can do to give me a disease earlier, lol..."	A									
"Added insights into possible treatments"	A									
"Although my primary care provider listened to me, and she was happy for me that my likelihood of getting pancreatic cancer seemed less than I thought (a previous worry to me since my father died of pancreatic cancer), and she placed the 23andMe printout I gave her in her medical file on me, the doctor (of internal medicine) said she didn't really understand the printout I gave her (though she is rated among the "Best Doctors"). (Maybe she didn't want to take the time to look at it in detail.)"		B	C			F		H		
"Appointment time limits"								H		
"Conversation was very brief; would have liked to talk more about it."								H		
"Didn't seem that interested."				D						
"Doctor was only somewhat interested."				D						
"He rejected my results out right despite my quip that recent genetic testing tests are supported by the AMA now! It was not the results, just the idea ... he thought if phoney stuff."					E	F				
"Having a tool that provides a clearer picture of my health and how together with my physician we can keep me healthy."	A									
"He did not see great value in the results; they added little to what was already known about my health."	A			D			G			
"He didn't really care to be honest."				D						
"He didn't really discuss it with me after reviewing the results, so I'm not totally convinced he reviewed it."				D						
"He found it "interesting""			C							
"He had an "oh well" attitude"				D						
"He is certainly not trained in understanding the dynamics of genetics. Doctors don't seem interested in having someone, who is not as learned as they, explain to them what could possibly be an alternative consideration when they believe they know everything."						F				
"He just looked over top findings, didn't spend much time on them. He had done one genetic test already and felt like that had answered important health questions. I will continue to share the 23andMe results as part of my care."				D				H	I	
"He listened and agreed, but didn't really seem excited to see it or to encourage or discourage it."				D						
"He looked at the printouts I gave him and we discussed it, then he put it in my records."		B	C							
"He made note of what I told him onto my medical record but was in too much of a rush to see other patients to sit down and discuss results. I'm considering choosing another doctor."		B						H		J
"He said he didn't know anything about it (in specific, the MTHFR info, therefore couldn't discuss it with me and wasn't interested in learning about it.***My rheumatologist did take note of the drug reaction info and did not prescribe methotrexate as he had planned. Kudos to him!!"	A		C	D		F				
"He said it was a total waste of time"					E					
"He staid saliva testing was unreliable and a waste of money. I now see someone else."					E					J
"He understood what I told him."										
"He used my results to order further tests and to confirm a diagnosis"	A									
"He was interested and engaged in the discussion"			C							
"He was interested but only as the testing could apply to his own wife (she had been adopted). He had no interest in incorporating my results into his file."			C	D						
"He was interested in my genetic makeup and how it would better enable him to provide me with the best medical care possible."	A		C							
"He was not interested in the printable summary of my results without digging into the underlying genome data. But the underlying data was hard to get and impossible to print out, so I couldn't really share it with him."				D			G			
"He was not interested."				D						
"He was very open to the findings and enlightened regarding the obesity-related results."			C							
"He wasn't that interested. He sees it as supplemental information. In the end all information is good information."				D			G			
"I actually emailed him the results; and I am not sure that we discussed them when I later met with him in person."										
"I am now pregnant and my doctor liked that I could see my 44 traits that I would or would not pass on to the babies. (Twins)"	A									
"I am seeing a new primary care person who is not completely familiar with my health history."										
"I am still learning myself about some of my results and the implication of the results. My primary care provider is also learning about the genetics and treatment applications. I would say for both us the 23andMe gave us some talking points re: some health challenges I have faced."	A		C							
"I appreciated that my PCP came up with a plan to follow or be proactive with what was indicated. We would follow my body more than test results."	A									
"I believe he asked me to have a test done that he wouldn't have otherwise."	A									

Continued on following page

Appendix Table 3–Continued

Responses (n = 159)	Themes†									
	A	B	C	D	E	F	G	H	I	J
"I brought the report to my yearly physical, and had limited time to discuss (I wanted to know if I should be further tested for hemachromatosis since I have 2 related markers, or maybe have ferritin/iron/iron binding studies)-he said since my HGB is normal, he didn't recommend further studies, but if I really wanted to pursue it.....I am not post-menopausal, so I'm not planning on doing anything more at this time, but being aware of this result would seek medical help if I experience iron overload symptoms."	A							H		
"I changed to a different doctor after he told me I needed "a shrink""										J
"I discussed one part of my results with my neurologist recently because it relates to diagnosis I have. He was quite interested but unsure of the full meaning it has in my diagnosis. My primary MD has some understanding of the results because one particular test I had done has revealed evidence of this."			C			F				
"I do not think by primary care provider was well-informed as to the validity of the results provided by 23andMe."						F				
"I do tend to worry but my doctor said he would keep track of the tests that he could do."	A									
"I felt that my PCP did not consider it credible"					E					
"I have had very little reason to discuss results and thus, very little reaction to them."										
"I printed the report for her. And we talked about the drug reaction part. But we did not discuss the entire report in detail."		B								
"I send copies to my Primary Care Physician for my files. She did not comment, but added the information to my Medical Profile."		B								
"I think my PCP did not really understand how useful some of the information could be as far as my overall health and was not really willing to discuss information about how to engage in preventative care in relation to some of the illnesses for which I am at risk."				D		F				
"I think my physician is old school. Just not interested"				D						
"I told her I had done this and asked if she would like to look at results. She said no, she did not care. I think she did not understand what this was all about."				D		F				
"I told my doctor about the testing and how I wasn't prepared to have the results submitted to my medical health file just yet. She was completely on board with my decision but was very interested to see my results for her knowledge as we moved forward. I appreciated that she respected my decision to not put it in the file, but that she wanted the knowledge to aid in my medical future."		B	C							
"I wanted him to know about my potential reaction to certain medications."	A									
"I wanted information about genetic tendencies for psychological disorders that may be passed through chromosomes since there is mental health issues on maternal and paternal sides for at least 3 generations. I was under the impression that those tendencies were being tested in the sample."	A									
"I wanted to see if there was a strategy we could employ to monitor or prolong Alzheimers. She didn't have an answer for me."	A					F				
"I wanted to talk to him about it without it becoming part of my medical record. I think he felt either it was serious and legitimate (and therefore should be part of my medical record) or it was just a joke/entertainment and shouldn't be. He did use it as leverage, though, to get me to agree to switch a medication that I had been hesitating about (he wanted me to switch my birth control for a different reason, but he seized the opportunity to use my increased risk for venous thromboembolism as leverage to get me to agree to do so)."	A	B								
"I was happy he even entertained the conversation. I thought he might think it was not something he wanted to spend any time on so I was pleasantly surprised."			C							
"I was satisfied in the terms that this is new to him. But I think by my diligence I can help expose my Dr. to consider the advantages of such genetic information. I took this test, knowing full well that it was a new tool in the medical treatment and diagnosis. I saw it as my part to participate in this new era in medicine. I suffer from Hughes Syndrome, my family has a history of autoimmune disease, Celiacs, I was diagnosed in the late eighties as being slightly autistic (which would be now, Asperger's) and I did find out my haplogroup and where my family came. The mystery that most satisfied me was that even though I have this autoimmune disease I, at 51 yrs old, I don't look my age and have a great muscular physique, I don't look ill. I have bled out to 3.4 hemoglobin and my body adapted to it I walked into the hospital on my own the Drs. said for a male that is 5'10" 225lbs was pretty impressive. So the more I learn the better I feel about 23andMe's data."										
"I wasn't sure he was into it."				D						
"I wish we could have full access to our results and not just the report outputs. It would be very helpful to have all of the information (raw data)."										
"I would have liked my doctor's to have taken the information more seriously. They seemed overwhelmed by the volume of material and did not seem to spend a lot of time on it. I pre-reviewed it for them in advance of my appts and pointed out the specific areas that I wanted to discuss with them, so as to try to make best use of the limited time available during a doctor's visit. My primary doctor agreed to keep the information on file in my medical chart for future reference, which is a good thing."		B		D				H	I	
"I would like my results for the breast cancer gene but unfortunately I indicated that I would not want them originally. How can I get those results for my primary care provider?"										
"I'm a physician and now my primary care person is going to do it too."										
"Insufficient data-I just mentioned the caffeine tolerance thing; I didn't raise an issue of concern or ask for additional treatment or anything."	A									
"It did not seem to interest him-I think he does not feel he has time to read a report like that"				D				H		
"It provided interesting conversational fodder"			C							
"It provided new information genealogical research."										

Continued on following page

Appendix Table 3–Continued

Responses (n = 159)	Themes†									
	A	B	C	D	E	F	G	H	I	J
"It was a lot for my doctor to take in because she had no experience with such a service. She was also very interested in it for personal reasons because of how cheap it is versus a single genetic test. It took her some time to figure out what exactly the results meant... ie: if an SNP was this or that. Also, she had to correct me in some of my understanding of the "odds".. which, I think it to be expected with most people. With Clot Factor V (or whatever), I'm at increased risk, but no more than most people of European descent, which I didn't pick up from the website on my own, probably due to my own.. lack of reading. Overall, she was very curious about it... she wouldn't allow me to give her direct access to view on her own though.. she said never to allow anyone access to it. (I'm not as concerned. It's not as if they have access too my raw results.)"			C			F				
"It was mostly FYI for the future. She thought it was very interesting and wanted to know more about it."			C						I	
"It was not an in-depth discussion - I didn't have any "red flags" per se, but my Doctor was interested in the 23andMe process and results."	A		C							
"It was primarily informational. There were no immediate steps to take."	A									
"My GI specialist said the treatment would not change for Crohn's disease based on any genetic results, so he had no interest in whether it was Crohn's or UC. Frustrating"	A			D						
"My PCP and the Infectious Disease Specialist that I spoke with weren't that interested in it. I explained to them that it was legitimate and showed it to them, but it was almost as if they refused to believe it was a viable test. Very frustrating!"				D	E					
"My PCP has downloaded my 23andMe results into my med recs for future use"		B							I	
"My PCP is a genetics researcher at STSI, La Jolla, CA."										
"My PCP looked at the results and with the blood work and labs that he'd had ordered for me, saw nothing to show that the results would be mis-matched. So far so good. :)"	A									
"My PCP was very open to discussing some of the issues in the results that I brought up. She also agreed to do a follow-up test related to one of the risk markers."	A		C							
"My answers don't exactly fit in with this line of questioning. I did mention to my practitioner that I had had the testing done, and for that reason didn't want to take an MAIO. I did not show her the results of my testing, so this question doesn't apply."	A									
"My discussions were primarily with my dermatologist and eye guy."										
"My doctor and I are working together to develop a more comprehensive care plan for me based, in part, on my 23andMe results."	A									
"My doctor didn't think there was anything important to continue on."	A									
"My doctor doesn't know about MTHFR, which was the result with the most immediate importance for my health. I didn't discuss the results in the sense of "how does this affect me" but more in the "this is what I learned" giving him info."	A					F				
"My doctor was concerned that the surveys I completed while my sample was being analyzed somehow affected the results. She did not believe these were 2 separate processes."										
"My doctor was most interested in the medication-related results. She felt that the knowledge could help her medication choices in the future. She did not have time to discuss any other results."	A		C					H	I	
"My doctor was not well versed in genetics and therefore seemed intimidated and distrusting of the results."					E	F				
"My husband and I just got pregnant, so it was very useful to know the genetic risks to our baby."	A									
"My information allowed us to make decisions mostly at the margins, since even a factor of two higher or lower risk, was still not that different from the background population. But it did influence some decisions."	A									
"My PCP was a bit close minded. I have found a new one but have not had time to share the results with her."				D						J
"My primary care doc did not go over this with me much, but my geneticist found it interesting and helpful."			C							
"My primary care doctor is going to mention it to one of her patients that is adopted."										
"My primary care provider accepted the information with little discussion but with a degree of acceptance on his part. My health issues have not been a problem but he is aware of several areas of concern as relates to to possible future medication and treatment."	A		C						I	
"My primary care provider was glad that I had got the testing done and agreed it was needed. However, he only looked over it and then told me that I needed to follow up with a Geneticist in person. I think that he did not know what to do with all the information."			C			F				
"My primary care provider's only response was that personal genetic testing may not be reliable."					E					
"My primary is only interested in cholesterol and blood pressure. I had a brain tumor that was operated on. She was not sure that she would be involved. But she wrote it down as a way of noticing it in my history."	A									
"My provider is AWESOME and open to learn new things. She was really impressed with the report from Pathway and read the entire thing. The report sort of made sense (to me) of my odd symptoms before I have an official diagnosis. So I am going to change things to avoid things getting worse. My provider supports me in this 100%"	A		C							
"My regular PCP moved and I am now seeing her replacement. She was not as willing to look at the results...I had to insist that she look over them...I made her a copy and had it put in my records but I don't think she even looked at it..."		B		D						
"Non issue here"										
"Nothing. We covered everything including how to change what I can in my lifestyle to be healthier, but I'd already made the changes :)"	A									
"Only just discussed last week & we have more follow-up on some of the results so this answer is not final at all."									I	
"PCP - Backed away from the Report like it was something to be afraid of . . . lacked training in this area and preferred not to review and discuss."				D		F				
"Physicians are always rushed for time and I don't think they are interested in helping their patients understand conditions...they just want to shove pills at people to mask symptoms instead of finding the problems and remedies for those problems."								H		

Continued on following page

Appendix Table 3–Continued

Responses (n = 159)	Themes†									
	A	B	C	D	E	F	G	H	I	J
"Primary didn't know about MTHFR mutations, Lyme doctor did and knew how to treat"	A					F				
"Provider followed up with further testing: mammogram, advice about celiac disease, and recommendation for probiotic. He was quite supportive and surprised to see these issues as genetic data"	A		C							
"Provider not confident in meaning of results and direct applicability."						F				
"Seemed not be to be useful or actionable information."	A									
"She did not want to take the time."								H		
"She didn't have enough time to really review it."								H		
"She didn't really know what to do with the information. She took it on face value, whereas some skepticism is warranted (it's not that deterministic)."					E	F				
"She didn't seem concerned that I was sensitive to Warfarin because of the use of other drugs. She did agree that keeping my blood pressure lower was important because of my possibility of heart disease."	A									
"She didn't seem very interested."				D						
"She didn't think there was much significance in the results."					E					
"She didn't understand most of the report but has referred me to a geneticist"						F				
"She doesn't believe in this type of testing. I sent the results from 23andMe to her and she never looked. She told me it wasn't needed and not to believe the results."				D	E					
"She had never seen a genetic study before and needed time to analyze it."						F		H		
"She isn't knowledgeable and really didn't see anything important or actionable"	A					F				
"She just said it was interesting and put it in my file."		B	C							
"She seemed not to be interested, but was willing to talk about it."			C	D						
"She seemed not to know or understand what the implications of a MTHFR and ethylmalonic aciduria would potentially mean for me or my care. Overall the interpretation was that since these are fairly common in "healthy" people it is not important"	A					F				
"She still wanted her tests to provide answers to care. She was interested but not using it definitively."	A		C				G			
"She used the genetic testing to test for heart issues"	A									
"She was very interested, agreed with my need to limit caffeine, and took a look in my eyes."	A		C							
"She was very pleased with it... She thought it was "cool""			C							
"Still need to schedule a more in depth discussion with him."									I	
"Tests were ordered based on results."	A									
"The Doctors have no idea what to do with the information or what it means."						F				
"The carrier status alarmed me. My own interpretation led me to believe that I was at risk for certain health conditions. Although my carrier status showed nothing life threatening or dangerous I thought a careful analysis may allow me to live a healthier life. Whether or not two alleles or one allele provides a healthy phenotype in my opinion is not clear cut. Both the genetic council and primary care doctor indicated that I was too alarmed. Alas I likely was, but it would be nice to have a more in depth analysis."	A									
"The discussion might have been more thorough had the Pathway Genomics included racial elements."										
"The doctor was objective about the results but seemed to want more specific information prior to any kind of committed statement"							G			
"The issue is the length of time you get to see the doctor. Even though I scheduled to discuss the results the appointment was less than 15 minutes."								H		
"The only issues requiring proactive action had been already addressed by me and by my doctor."	A									
"The report was so large I didn't print it off, he also doesn't use e-mail or other electronic storage, so he didn't have access. He requested a hard copy of the report to put in my file, but we didn't really speak about it very much. He acted as if the results were somewhat uninteresting."		B		D						
"There wasn't much need to discuss it."										
"There were few risk factors but it did point to a family history of a-fib and she arranged a screening since my father's health history of a-fib related problems."	A									
"There were only a couple of things that were relevant and my doctor was familiar with them. Nothing was a surprise, so it wasn't a high-stakes discussion."										
"They looked at the big printout for a second and then said they would scan it in. I don't think they intend on ever reading it. Same at OB and child's pediatrician."		B		D						
"They pretty much didn't discuss it with me."				D						
"They were uninterested. But really I think they didn't know what to do with it or how to interpret it. Definitely didn't want to be bothered with it."				D		F				
"Time limits."								H		
"To my surprise he was excited. I was his first customer to use 23andMe."			C							
"Visit was focused on specific issue; will bring up again at annual physical"									I	
"We didn't have enough time to go in depth... but we have plans to talk about them during future appointments. His response that I did the testing was extremely positive and he supports his patients that do this type of personal research."			C					H	I	
"We had insufficient time to discuss the results thoroughly but will do it another time."								H	I	
"We talked about my printout for about 2 minutes and he put the copy in my file. At least he has it."		B								
"We talked about my results on my last visit but I never showed the results to my PCP yet. I plan on talking with her on my next visit and I'll bring the results with me to discuss."									I	
"While they had no immediate relevancy my provider was happy to include them in their records."		B								
"Will help in my care, along with answering questions about my health."	A									
"Basically was another data piece to be included in med record, so discussion was abbreviated as expected"		B								

Continued on following page

Appendix Table 3–Continued

Responses (*n* = 159)	Themes†									
	A	B	C	D	E	F	G	H	I	J
"Doctor just brushed testing off"				D						
"Doctor was open to it. My results were not that dramatic and they did not lead to any big new revelations."			C							
"He didn't seem like he cared, but he did listen"			C	D						
"He doesn't take the time to explain, just took copies of top 2 pages of print-outs-doesn't seem to want to understand how it might connect with my present health issues. (I really don't understand the results anyway.)"		B		D		F				
"He felt it has great relevance in what medications he would choose for certain health conditions; also it was clearly relevant to current health conditions"	A		C							
"He listened and was glad to hear that results of breast cancer gene test were favorable"			C							
"He went thru the report with me and asked if I had any ?s- It said I have a higher risk for getting MS which I do have"			C							
"I have a wonderful primary care doctor who actually listens to what I have to say and is happy to discuss my care and treatments"			C							
"I have brain cancer, and my oncologist said that these results did not help us in finding new ways to treat me."	A									
"My primary care provider said not to put too much stock in the results. That having a genetic marker for something doesn't mean anything. I may or may not develop that illness or condition in the future, it just means I have the possibility to develop it and shouldn't be alarmed."				D						
"Open discussion and curiosity about the results on the part of my family physician"			C							
"Physician was interested in seeing results but has not discussed the results"			C							
"Ultimately I found that in some ways it brought up more questions than answers. For example, caffeine acting unusually in my body, does it change other medications or other systems as well, could it cause my body to absorb less of medications than a normal person, etc."							G			

a-fib = atrial fibrillation; AMA = American Medical Association; DTC = direct-to-consumer; GI = gastroenterologist; HGB = hemoglobin; MAIO = monoamine oxidase inhibitor; MS = multiple sclerosis; OB = obstetrician; PCP = primary care provider; PGEN = Impact of Personal Genomics Study; PGT = personal genomic testing; SNP = single nucleotide polymorphisms; STSI = Scripps Translational Science Institute; UC = ulcerative colitis.
* 13 responses could not be classified under the selected themes but are included in the table.
† A = actionability/use in care (*n* = 51 [32%]); B = inclusion in medical records (*n* = 17 [11%]); C = engagement/interest (*n* = 39 [25%]); D = lack of engagement/interest (*n* = 35 [22%]); E = skepticism (*n* = 11 [7%]); F = lack of knowledge (*n* = 24 [15%]); G = more information needed (*n* = 6 [4%]); H = not enough time (*n* = 17 [11%]); I = future discussion/use (*n* = 12 [8%]); J = negative impact on provider relationship (*n* = 4 [3%]).