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Differential Use of Available Genetic Tests among Primary Care Physicians in the U.S.: Results of a National Survey

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Abstract

Purpose—This study assesses primary care physicians' (PCPs) experience ordering and referring patients for genetic testing, and whether minority-serving physicians are less likely than those serving fewer minorities to offer such services.

Methods—Survey of a random sample of 2000 PCPs in the United States (n=1120, 62.3% response rate based on eligible respondents) conducted in 2002 to assess what proportion have: (1) ever ordered a genetic test in general or for select conditions; (2) ever referred a patient for genetic testing to a genetics center or counselor, a specialist, a clinical research trial, or to any site of care.

Results—Nationally, 60% of PCPs have ordered a genetic test and 74% have referred a patient for genetic testing. Approximately 62% of physicians have referred a patient for genetic testing to a genetics center/counselor or to a specialist, and 17% to a clinical trial. Minority-serving physicians were significantly less likely to have ever ordered a genetic test for breast cancer, colorectal cancer or Huntington's Disease, or to have ever referred a patient for genetic testing relative to those serving fewer minorities.

Conclusions—Reduced utilization of genetic tests/referrals among minority-serving physicians emphasizes the importance of tracking the diffusion of genomic medicine and assessing the potential impact on health disparities.

INTRODUCTION

Genomic medicine is expected to substantially improve the quality and efficacy of health care by providing new insight into the etiology of disease and facilitating individually-tailored prevention and treatment regimens.[1, 2] Genetic testing is now recommended to guide prevention strategies such as identifying patients at increased risk of breast, ovarian or colon cancer and various treatment decisions.[3-9] Emerging genomics research on highly prevalent complex illnesses (e.g., diabetes, asthma, cardiovascular disease, nicotine dependence) promises wider diffusion of genomic medicine in the future and a greater role for primary care physicians (PCPs) as "frontline providers" of genetic services.[10-13] It is precisely through advances in the treatment and prevention of highly prevalent conditions that genomics has the greatest potential to improve population health and reduce health disparities - but only if PCPs

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are prepared to incorporate genomic medicine into practice and if such interventions reach those most in need.[14, 15]

PCPs face several challenges in utilizing genetic tests to enhance clinical care. Most have little experience or training relevant to genetic testing, and many lack confidence and skill in this area of practice.[16, 17] This lack of knowledge and experience is compounded by pressures to provide a seemingly ever expanding scope of services within the tight time constraints of a typical office visit, making it difficult to deliver preventive or elective services or to incorporate new technologies into practice.[18, 19]

It is likely that primary care practices serving high concentrations of minority, uninsured, low-income, or low English proficiency patients - patient groups that already bear a disproportionate burden of illness - will face even greater difficulties integrating genomic medicine into clinical practice.[20-23] A recent study by Bach and colleagues, for example, found that the 22% of U.S. physicians who serve 80% of all black Medicare beneficiaries were far less likely to be board certified and far more likely to report difficulty providing high quality care for their patients compared to non-minority serving physicians.[24] The few available studies addressing disparities in access to genetic testing focus on cancer susceptibility screening. Early evidence suggests that black women have reduced access to genetic counseling and screening for BRCA1/2.[25] Other studies have documented reduced awareness and use of cancer genetics services among minority patients.[26-28]

No study to date has assessed utilization of currently available genetic tests among PCPs nationally, whether through referral or directly, nor examined whether there is differential use of available genetic tests among policy-relevant subsets of providers - in particular, those who disproportionately serve minority or other vulnerable patient populations. In this study, we assessed physicians' experience ordering or referring patients for available genetic tests among a random sample of 2000 PCPs in the U.S. We also assessed utilization of available genetic tests among providers serving a disproportionate number of minority patients relative to their peers.

MATERIALS AND METHODS

Sample Selection

A simple random sample of 2000 PCPs (defined here as a primary specialty of internal medicine, family practice, or general practice) was randomly drawn from all U.S. PCPs in the AMA Masterfile (N=218,186) through an authorized vendor.[29] The Masterfile lists all U.S. physicians who have met educational and credentialing requirements regardless of whether they are AMA members or not. We restricted eligibility to respondents who practiced direct patient care at least 20 hours per week. Differences between characteristics of our sample and of the underlying population were within range of sampling variation for specialty distribution, age, and sex.[17]

Selection of Genetic Tests to be Studied

Through focus groups with PCPs, review of the literature, and consultation with experts in clinical genetics, we selected four examples of available genetic tests as case studies for exploring the extent to which genomic medicine has been integrated into primary care practice through PCPs' referral to specialty care or direct ordering of tests. Selected cases included testing for inherited risk of breast/ovarian cancer and colon cancer, as leading examples of genetic susceptibility testing to guide preventive care; testing for Huntington's Disease, as a frequently cited example of genetic testing for a rare genetic disease; and sickle cell testing, which is used in the diagnosis of sickle cell disease and in the assessment of reproductive risk

and is of particular importance to African-Americans. Specific guidelines for testing are available for each of these genetic tests.[9, 30-32]

Survey Design and Administration

Development of the survey instrument was informed by five focus groups and semi-structured interviews with PCPs; comments from key physician organizations; and review of the literature. Data collection was conducted from May to November, 2002. This survey was approved by the institutional review boards of Georgetown University (Principal Investigator's former institution) and UMASS-Boston. Given our interest in surveying the attitudes of physicians engaged primarily in clinical practice, only those who spent a minimum of 20 hours per week in direct patient care were included in the study. The final response rate, adjusted for ineligible cases, was 62.3%. Further details of survey design and administration procedures are available elsewhere.[17]

Measures

Dependent Variables

Experience Ordering Available Genetic Tests: We asked PCPs whether they had ever ordered a genetic test for four specific conditions (breast cancer, colon cancer, Huntington's Disease, or sickle cell) or "for any other condition" (yes/no). A summary variable ("ever ordered") was constructed identifying physicians who had ever ordered any of the four specific genetic tests or "any other genetic test."

Experience Referring Patients for Genetic Testing: We asked PCPs: "Have you ever referred a patient *for a genetic test* to: "(a) a genetic counseling center or a genetic counselor; (b) a specialist for the patient's condition; (c) a clinical research trial; or (d) any other site of care?" A summary variable identifying experience referring to any of these sites of care was also constructed.

Finally, we created an overall summary variable indicating physicians who reported having "ever ordered" a genetic test or having "ever referred" a patient to any other site for genetic testing.

Independent Variables—Key to this analysis was the self-reported proportions (0-100%) of physicians' patient panels comprised of patients from racial/ethnic minority communities. For our purposes, minority-serving physicians were defined as those physicians ranking within the top quintile in the distribution of the respondents' self-reported proportion of patients who are from minority communities. Among this group of "minority-serving physicians," more than 50% of their patients were from minority communities.

Indicators for physicians serving a high proportion of patients on Medicaid, who had a primary language other than English, or who were uninsured were similarly constructed and used as control variables in all analyses. The top quintile in the distribution of each of these patient subpopulations represented physicians whose patient panels included 30% or more Medicaid patients, 20% or more patients with a primary language other than English, and 15% or more patients who were uninsured, respectively.

Physician characteristics included age, self-identified race/ethnicity, primary specialty, and whether one had a full-time faculty appointment. Practice size was characterized as 1-2 physicians or larger. Practice location was characterized according to Census region.

We assessed whether physicians had received any formal training in clinical genetics and, if so, whether they had received training in medical school or medical residency and/or in

continuing medical education (CME) courses. Knowledge of existing privacy and anti-genetic discrimination protections as they relate to health insurance was assessed with the question, "Under current federal law, can health insurance companies use genetic test results to increase patients' health insurance premiums or deny health insurance coverage in: (a) the group market? and (b) the individual market?", with "yes," "no," and "don't know" response options for each. Those responding correctly that current protections in HIPAA apply only to those with group health insurance coverage were identified as having accurate knowledge of current legal protections.[33]

To assess physicians' preparedness to incorporate genetics into clinical practice, we asked, "How prepared do you feel to counsel patients considering a genetic test?" and, "How confident are you in your ability to interpret the results of a genetic test?" We also asked physicians how optimistic they were that genetics research will lead to significant improvements in the treatment of complex traits. Responses to each of these three items were scaled as "very", "somewhat", "a little", and "not at all." For our analyses, we dichotomized responses as "very" versus less than "very." Finally, we assessed the impact of individual physicians' attitudes toward new treatments or technologies by identifying those physicians who said they tended to offer new diagnostic tests "before most of their peers."

Statistical Analysis

Bivariate analyses were conducted to assess relationships between experience ordering genetic tests or referring patients for genetic testing and each of the independent variables using chi-square statistics. Separate multivariate logistic regressions were conducted to identify factors associated with each of the 10 dependent variables. All analyses were conducted using Intercooled Stata 9.2 for Microsoft Windows (Stata Corporation, College Station, TX). Our final models included the following set of covariates: patient-mix characteristics (high proportion minority, Medicaid, patients with a primary language other than English, and uninsured patients); practice characteristics (number of physicians, practice setting, and region), physician characteristics (age, self-identified race/ethnicity, and specialty); training in clinical genetics via medical school/residency or CME; knowledge of current privacy protections affecting the impact of genetic information on access to affordable health insurance; preparedness to counsel patients considering genetic testing; confidence interpreting genetic test results; and self-identification as an early adopter of new diagnostic tests. All statistics were adjusted using survey weights designed to correct for minor differences in response rate across specialties relative to the national distribution of internists, family practitioners, and general practitioners in the AMA Masterfile. For any given variable, there were fewer than 4.9% missing observations and no observed patterns of missing data.

RESULTS

Descriptive Results

Of the 2000 PCPs selected from the AMA Masterfile, 1798 met the eligibility criterion of practicing direct patient care at least 20 hours per week. Of these, 1120 (62.3%) completed the survey.

Nationally, approximately 60% of PCPs reported having ever ordered a genetic test for any condition, 74% of physicians reported having ever referred a patient for genetic testing, and 82% had ever ordered or referred a patient for genetic testing (Table 1). With respect to specific conditions, 27% of physicians had ever ordered a genetic test for breast cancer, 17% for colon cancer, 37% for sickle cell disease, and 17% for Huntington's Disease (Table 2). With respect to referrals for genetic testing, approximately 62% of physicians reported having referred a

patient to a genetics center or counselor, 62% to a specialist for the patient's condition, and 17% to a clinical trial.

Minority-serving physicians were significantly less likely to have ever ordered a genetic test to assess breast cancer risk (18% versus 29%; p=0.01), colon cancer risk (11% versus 18%, p=0.05), or Huntington's Disease (6% versus 18%; p<0.001) compared to those serving fewer minority patients (Table 2). Minority-serving physicians were also significantly less likely to have ever referred a patient for genetic testing to a genetics center or counselor (52% versus 64%; p<0.001), a specialist for the patient's condition (52% versus 64%; p<0.001), a clinical trial (10% versus 18%; p=0.03), or to any site of care (63% versus 76%; p<0.001).

Adjusted Analyses

Experience Ordering Available Genetic Tests: Controlling for a broad range of physician and practice characteristics, as well as patient-mix characteristics, minority-serving physicians were significantly less likely than their peers who serve fewer minority patients to have ever ordered a genetic test for breast cancer (OR: 0.42; 95% CI: .0.23-0.79; p<0.01), colon cancer (OR: 0.39; 95% CI: 0.19-0.80; p<0.01), and Huntington's Disease (O.R.: 0.21; 95% CI: 0.08-0.53; p<0.001) (Table 3).

Physicians over age 65 were less likely to have ever ordered a genetic test relative to younger physicians (O.R.: 0.51; 95% CI: 0.30-0.86; p<0.05). Physicians who had received training in clinical genetics in medical school or through CME courses had nearly double the odds of having ever ordered a genetic test relative to peers without such training to (OR: 1.89, 95% CI: 1.39-2.57; p<0.001 and OR: 1.80, 95% CI: 1.34-2.43; p<0.001, respectively), as were physicians with an accurate knowledge of current privacy and anti-genetic discrimination protections (OR: 2.09, 95% CI: 1.19-3.69; p<0.05). Those who felt very prepared to counsel patients considering genetic testing (OR 3.13, 95% CI: 1.20-8.17; p<0.05) and early adopters of new diagnostic tests (OR: 2.03; 95% CI: 1.31-3.13; p<0.01) were also more likely to have ever ordered a genetic test.

Experience Referring Patients for Genetic Testing: With respect to referrals for genetic testing, minority-serving physicians were less likely to have ever referred a patient to a clinical trial for genetic testing (OR: 0.46; 95% CI: 0.22-0.96; p<0.05) or referred a patient to any site of care for genetic testing (OR: 0.60; 95% CI: 0.36-0.99; p<0.05) compared to physicians serving fewer minority patients (Table 4). Physicians serving a disproportionate share of Medicaid patients were also significantly less likely than those serving fewer Medicaid patients to have ever referred a patient to a genetics center or counselor for genetic testing (OR: 0.58; 95% CI: 0.37-0.92; p<0.05) or referred a patient to any site of care for genetic testing (OR: 0.49; 95% CI: 0.30-0.80; p<0.01).

PCPs in solo or two-physician practices were less likely (OR: 0.65; 95% CI: 0.44-0.97; p<0.05) than those in larger practices to have ever referred a patient for genetic testing, as were older physicians. Those in family practice had more than twice the odds of having ever referred a patient for genetic testing relative to internists (OR: 2.56; 95%CI: 1.81-3.61; p<0.001). Physicians who had received training in clinical genetics through CME courses were significantly more likely (OR: 2.21; 95% CI: 1.56-3.13; p<0.001) to have ever referred a patient for a genetic test compared to peers without such training, while those with an accurate knowledge of current privacy and anti-discrimination statutes as they pertain to access to affordable health insurance had 6 times the odds (OR: 6.13; 95% CI: 2.21-16.99; p<0.001) of ever having referred a patient for genetic testing compared to those without such knowledge.

DISCUSSION

This study provides baseline estimates regarding the extent to which PCPs in the U.S. have integrated genetic testing and referral into clinical practice. We further evaluated whether PCPs who serve a high proportion of minority and other underserved patient populations were less likely than their peers to have ever ordered a genetic test or to have ever referred a patient for genetic testing to other sites of care.

Our results show that while roughly two-thirds of U.S. PCPs have ever ordered a genetic test and more than three-quarters of physicians have ever referred a patient for genetic testing, minority serving physicians are significantly less likely to have such experience. Specifically, minority-serving physicians were significantly less likely to have ever ordered a genetic test for three of the four cases studied, or to have ever referred a patient to a clinical trial for genetic testing or to any site of care compared to physicians serving proportionately fewer minority patients.

Providers who disproportionately serve minority patients may differ systematically from physicians who serve predominantly white patients, such as the lower rates of board certification and greater difficulty providing high quality care to their patients, as reported by Bach and colleagues.[24] If these differences apply to minority-serving physicians generally, they may indicate obstacles in terms of training and availability of genetic testing that do not affect clinicians serving majority populations.

Minority-serving physicians may also be responding to differences in patient characteristics that track with race/ethnicity. Early studies of women participating in research trials showed that black women had less knowledge and less positive attitudes about the value of genetic testing for BRCA1/2 and were less motivated to pursue testing relative to white women.[34-36] Other studies showed that blacks tended to value predictive genetic testing less than whites.[37] Most recently, Armstrong et al. found that black women with a family history of breast or ovarian cancer were much less likely than white women to undergo genetic counseling for BRCA1/2, controlling for differences in the probability of carrying a BRCA1/2 mutation, socioeconomic status, cancer risk perception, and worry, attitudes about BRCA1/2 testing, or PCP discussions of testing.[25] Several studies report that the prevalence of significant mutations is similar in black and white women with a family history of breast cancer, suggesting that black and white women would be expected to benefit equally from predictive genetic testing.[38, 39] The low rates of ordering genetic tests for HD among minority-serving physicians may reflect early studies suggesting a lower prevalence of HD among blacks compared to whites, although more recent data report similar prevalence rates across white and black populations.[40-42] While minority patients may benefit from genetic testing as much as non-minority patients, if minority patients are sicker and have more complex health needs than majority patients, these health issues may crowd out the provision of genetic services. Further research is needed to understand whether differences in physicians' offers of genetic services reflect patient preferences, patient health, or whether providers are less likely to offer minority patients genetic testing.

Low referral rates to genetics centers, counselors, or other resources among physicians serving a large proportion of Medicaid enrollees also deserve further investigation. The Medicaid program currently covers 44.4% of the nation's low-income patients,[43] and thus is a sentinel population for tracking health disparities along socioeconomic lines. Previous studies have documented reduced access to specialty services and new technologies among Medicaid patients relative to commercially insured patients.[44-46] Recent reductions in Medicaid spending per beneficiary threaten to exacerbate such disparities in access to care.[47]

Study results also emphasize the importance of physician education in preparing physicians to incorporate genetics into clinical practice. In our study, physicians who had received training in clinical genetics in medical school or through CME were far more likely to have ever ordered a genetic test or referred a patient for such testing. Sustained educational efforts aimed at PCPs will be key to successful clinical integration of new genetic applications. Strategies should be developed to ensure that physician education and outreach efforts reach those who disproportionately serve minority patients and other underserved groups.

Physicians in solo or 2-physician practices were substantially less likely to have ever ordered or referred a patient for genetic testing. Innovative strategies will need to be developed in order to minimize the burden of incorporating genetics into clinical practice, particularly for solo and small group practices. The development of clinical guidelines and other mechanisms to support clinical decision-making will be needed.[48]

In our analysis, family practice physicians were significantly less likely than internists to have ever ordered a genetic test, but were far more likely to have referred a patient for genetic testing to a genetics center or counselor, a specialist for the patient's condition, or to any site. In many cases, referral likely reflects an appreciation for the detailed counseling recommended as part of the testing process.[9, 16, 31] Future efforts to monitor access to available genetic tests will need to take into consideration both direct provision of genetics services and referrals for such services.

Results of this study should be viewed within the context of certain study limitations. We relied on physicians' self-report to assess their experience ordering genetic tests or referring patients to other sites for genetic testing. Previous research has demonstrated that self-reported information provided by physicians is closely associated with actual physician practice, and may more accurately reflect physician behavior than chart abstraction, reported results were not validated in claims or other data.[49-51] We similarly relied on physicians' self-report regarding the composition of their patient panels. These estimates may not be precise, yet we believe they are useful and valid for distinguishing physicians with extremely high numbers of minority patients. Although data for this study were collected through 2002, these data provide the first national estimates of PCPs' use and referrals for available genetic tests, and reflect a time frame similar to the most recent estimates on racial differences in genetic testing for BRCA1/2 published in 2006, for which data was collected in 1999-2003.[25]

There has been a dramatic investment in genomics research in recent years, and expectations remain high that genomic medicine will significantly improve clinical outcomes and population health. Our findings raise the possibility that these improvements will be less likely to reach minority and other underserved populations because the PCPs who serve them are less likely to provide access to genomic medicine. To the extent that genomic medicine appreciably improves the quality of care and clinical outcomes, ensuring equitable access to emerging genetic-based treatments will be an essential component of any comprehensive strategy to eliminate health disparities.

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Table 1

Bivariate Results: Primary Care Physicians' Experience Ordering or Referring Patients for Available Genetic Tests, by Physician Characteristics

	Distribution of Population Characteristics	Experience Ordering or Referring Patients for Genetic Testing		
		Ever Ordered	Ever Referred	Ever Ordered or Referred
Total		60%	74%	81%
High Proportion Minority Patients				
> 50%	147	54%	63%†	73%**
≤ 50%	925	61%	76%	82%
High Proportion Medicaid Patients				
>30%	150	52%*	59%†	70%†
≤ 30%	915	61%	77%	83%
High Proportion Patients with Primary Language other than English				
> 20%	169	57%	69%	77%
≤ 20%	910	60%	75%	82%
High Proportion Uninsured Patients				
> 15%	196	57%	68%	75%*
≤ 15%	873	60%	75%	82%
Size of Practice				
1-2 Doctors in Practice	414	57%**	68%†	75%†
3+	676	62%	77%	84%
Region in which practice is located				
Northeast	236	65%	77%	85%
Midwest	291	55%	75%	79%
West	238	60%	72%	80%
South	355	57%	70%	78%
Practice Type				
Independent Practice	686	60%	73%	80%
Group/Staff Model HMO	95	56%	73%	79%
Hospital Outpatient Dept.	83	70%	77%	88%
Hospital CHC	67	50%	71%	76%
Free-standing CHC	75	62%	77%	88%
Other	97	57%	71%	75%
Age				
27 – 44	375	63%†	80%†	84%†
45 – 64	588	60%	73%	82%
65 +	128	43%	54%	61%
Specialty				
Family Practice/General Medicine	616	60%	82%†	85%†
Internal Medicine	504	58%	66%	76%
Full-Time Faculty Appointment				
No	915	58%	72%	80%
Yes	147	63%	78%	81%
Received Training in Clinical Genetics in Medical School				
Yes	676	67%†	80%†	86%†
No	433	46%	63%	73%
Received Training in Clinical Genetics in CME				
Yes	515	68%†	81%†	88%†
No	590	51%	67%	75%
Accurate Knowledge of Current Legal Protections				
Yes	105	77%†	94%†	98%†
No	1005	57%	71%	79%
Confident Interpreting Genetic Test Results				
Yes	59	72%*	84%	86%
No	1048	58%	73%	80%
Feels Prepared to Counsel Patients Considering a Genetic Test				
Yes	47	85%†	91%†	94%*
No	1061	58%	72%	80%
Early adopter of New Diagnostic Tests				
Yes	160	75%†	78%	90%**
No	942	56%	73%	79%
Optimistic that Genetics will Improve Treatment				
Yes	154	60%	70%	74%
No	955	59%	74%	86%

Note: Descriptive analyses included all respondents, but may not always be based on the same number of respondents due to a small number of missing observations. All percentages account for sample weighting.

*Chi Square statistics results: $p<0.05$

**Chi Square statistics results: $p<0.01$

†Chi Square statistics results: $p<0.001$

Table 2

Experience Ordering or Referring Patients for Genetic Testing among Physicians Serving Minority of Other Vulnerable Patient Populations

	High Proportion Minority		High Proportion Medicaid		High Proportion with Primary Language other than English		High Proportion Uninsured		Total
	Top Quintile	Lower Quintiles	Top Quintile	Lower Quintiles	Top Quintile	Lower Quintiles	Top Quintile	Lower Quintiles	
	n (p value)		n (p value)		n (p value)		n (p value)		
Experience Ordering Genetic Tests									
Breast Cancer	18.1%	28.5%	23.9%	27.9%	23.9%	27.5%	24.1%	28.1%	26.9%
	1058 (0.01)		1052 (0.32)		1065 (0.35)		1056 (0.27)		
Colon Cancer	10.9%	17.7%	18.1%	16.6%	17.9%	16.3%	18.8%	16.3%	16.6%
	1057 (0.05)		1052 (0.66)		1063 (0.63)		1055 (0.40)		
Sickle Cell Anemia	35.0%	37.1%	28.8%	38.0%	38.8%	36.4%	33.4%	37.1%	36.8%
	1056 (0.63)		1052 (0.03)		1062 (0.56)		1055 (0.35)		
Huntington's Disease	5.67%	18.0%	13.5%	16.6%	13.6%	17.0%	13.0%	6.8%	16.5%
	1053 (<0.001)		1048 (0.35)		1059 (0.28)		1052 (0.20)		
Any Genetic Test	54.0%	60.5%	51.9%	60.7%	57.0%	59.8%	57.2%	59.8%	59.6%
	1065 (0.14)		1059 (0.05)		1022 (0.50)		1063 (0.51)		
Experience Referring Patients for Genetic Testing									
Genetic Center or Counselor	51.7%	63.6%	46.2%	64.5%	58.0%	62.5%	53.9%	63.4%	61.8%
	1063 (<0.001)		1057 (<0.001)		1070 (0.28)		1061 (0.02)		
Specialist for Patients' Condition	51.5%	64.1%	50.6%	64.1%	56.2%	63.4%	58.1%	63.1%	62.3%
	1057 (0.004)		1053 (0.002)		1064 (0.08)		1056 (0.21)		
Clinical Trial	10.2%	17.7%	13.3%	17.3%	15.8%	16.9%	16.3%	17.0%	16.7%
	1050 (0.03)		1045 (0.23)		1057 (0.74)		1049 (0.82)		
Any Site of Care	62.5%	76.0%	59.4%	76.7%	69.0%	75.1%	68.4%	75.3%	74.1%
	1065(<0.001)		1059 (<0.001)		1072 (0.11)		1063 (0.05)		

Note: All percentages account for sample weighting

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Table 3

Factors Associated with Physicians' Having Ever Ordered a Genetic Test

	Breast Cancer	Colon Cancer	Sickle Cell	Huntington's Disease	Any Genetic Test
	N=938	N=938	N=940	N=936	N=944
	OR (95% CI)				
CHARACTERISTICS OF PHYSICIANS' PATIENT PANELS					
High Proportion Minority Patients	**0.42 (0.23-0.79)** **	**0.39 (0.19- 0.80)** **	0.74 (0.45-1.21)	**0.21 (0.08-0.53)** †	0.67 (0.42-1.07)
High Proportion Medicaid Patients	1.15 (0.68-1.96)	1.59 (0.87-2.92)	0.82 (0.51-1.31)	1.25 (0.67-2.34)	0.96 (0.61-1.51)
High Proportion Patients with Primary Language other than English	0.75 (0.44-1.28)	0.91 (0.50-1.65)	1.41 (0.90-2.20)	0.98 (0.54-1.78)	0.92 (0.60-1.42)
High Proportion Uninsured Patients	0.95 (0.61-1.49)	1.43 (0.87-2.34)	0.93 (0.62-1.39)	1.00 (0.58-1.72)	1.03 (0.69-1.55)
OTHER PRACTICE CHARACTERISTICS					
Size of Practice 1-2 Doctors	0.73 (0.51-1.05)	1.10 (0.73-1.67)	1.08 (0.78-1.50)	1.00 (0.66-1.50)	0.74 (0.53-1.04)
≥ 2 Doctors	REF	REF	REF	REF	REF
Region Northeast	1.49 (0.95-2.35)	1.40 (0.83-2.35)	0.82 (0.54-1.24)	1.39 (0.78-2.47)	1.37 (0.89-2.10)
Midwest	1.10 (0.71-1.70)	0.73 (0.43-1.23)	0.96 (0.65-1.40)	**1.87 (1.14-3.08)** *	0.94 (0.64-1.39)
West	1.47 (0.90-2.38)	0.90 (0.52-1.58)	0.78 (0.51-1.19)	**1.81 (1.02-3.24)** *	1.02 (0.67-1.54)
South	REF	REF	REF	REF	REF
PHYSICIAN CHARACTERISTICS					
Age < 45	REF	REF	REF	REF	REF
45-64	1.00 (0.70-1.43)	1.07 (0.70-1.62)	0.86 (0.63-1.18)	0.98 (0.65-1.48)	0.88 (0.64-1.22)
≥ 65	0.87 (0.47-1.61)	0.98 (0.46-2.11)	**0.44 (0.25-0.79)** **	1.12 (0.57-2.21)	**0.51 (0.30-0.86)** *
Self-Identified Race Black	1.90 (0.63-5.74)	0.82 (0.14-4.73)	1.82 (0.69-4.76)	2.04 (0.66-6.31)	2.01 (0.63-6.39)
Hispanic	1.86 (0.82-4.19)	2.38 (0.97-5.84)	1.14 (0.53-2.46)	1.65 (0.62-4.35)	1.15 (0.51-2.56)
Asian	1.12 (0.70-1.81)	1.67 (0.99-2.83)	0.93 (0.60-1.43)	0.79 (0.41-1.51)	1.00 (0.66-1.51)
Other Race	0.70 (0.27-1.83)	1.93 (0.70-5.28)	0.75 (0.32-1.77)	1.12 (0.39-3.25)	0.72 (0.31-1.66)
White Specialty Family Practice	REF **0.61 (0.44-0.85)** **	REF 0.79 (0.54-1.17)	REF 1.23 (0.92-1.65)	REF 1.32 (0.90-1.94)	REF 0.97 (0.72- 1.31)
Internal Medicine	REF	REF	REF	REF	REF
Full-time Faculty Appointment	1.34 (0.79-2.28)	1.13 (0.62-2.09)	1.48 (0.95-2.29)	1.61 (0.86-3.03)	1.00 (0.63-1.60)
PHYSICIAN CHARACTERISTICS RELATED TO GENETICS					
Received Training in Clinical Genetics in Medical School	**1.60 (1.12-2.30)** *	**1.74 (1.13-2.69)** *	**1.94 (1.41-2.66)** †	1.41 (0.91-2.17)	**1.89 (1.39-2.57)** †
Received Training in Clinical Genetics in CME	**2.18 (1.57-3.01)** †	**1.77 (1.20-2.62)** **	**1.51 (1.13-2.01)** **	**1.73 (1.17-2.55)** **	**1.80 (1.34-2.43)** †
Accurate Knowledge of Current Legal Protections	1.00 (0.57-1.74)	1.23 (0.69-2.21)	1.49 (0.91-2.42)	1.00 (0.54-1.87)	**2.09 (1.19-3.69)** *
Confident Interpreting Genetic Test Results	0.59 (0.27-1.32)	0.45 (0.18-1.15)	0.56 (0.27-1.16)	0.46 (0.19-1.16)	0.69 (0.31-1.51)
Feels Prepared to Counsel Patients Considering a Genetic Test	1.83 (0.76-4.39)	**2.81 (1.18-6.71)** *	**2.25 (1.02-5.00)** *	**3.60 (1.53-8.43)** **	**3.13 (1.20-8.17)** *
Early Adopter of New	1.20 (0.77-1.87)	1.40 (0.85-2.29)	1.10 (0.75-1.63)	1.31 (0.80-2.15)	**2.03 (1.31-3.13)** **

	Breast Cancer	Colon Cancer	Sickle Cell	Huntington's Disease	Any Genetic Test
	N=938	N=938	N=940	N=936	N=944
	OR (95% CI)				
Diagnostic Tests					
Optimistic that Genetics Will Improve Treatment	**2.56 (1.62-4.04)**†	**2.17 (1.31-3.60)****	0.99 (0.63-1.54)	1.16 (0.68-1.98)	1.11 (0.71-1.74)

Note: Also included in model but not shown: practice setting (independent practice versus those practicing in a health maintenance organization, hospital-based practice, community health center or other setting).

Only those respondents for whom there were complete data were included in each regression analysis, with available cases for individual regressions ranging from 934 (83% of full sample) to 945 (84% of full sample) respondents.

*p<0.05

**p<0.01

†p<0.001

Table 4

Factors Associated with Physicians' Having Ever Referred a Patient for Genetic Testing

	Ever Referred to Genetics Center or Counselor	Ever Referred to Specialist	Ever Referred to a Clinical Trial	Ever Referred to Any Site of Care	Ever Ordered or Ever Referred
	N=943	N=941	N=934	N=945	N=945
	OR (95% CI)				
CHARACTERISTICS OF PHYSICIANS' PATIENT PANELS					
High Proportion Minority Patients	0.73 (0.45-1.18)	0.63 (0.40-1.00)	**0.46 (0.22- 0.96)** *	**0.60 (0.36-0.99)** *	0.61 (0.35-1.07)
High Proportion Medicaid Patients	**0.58 (0.37-0.92)** *	0.64 (0.41-1.01)	1.04 (0.58-1.89)	**0.49 (0.30-0.80)** **	0.60 (0.35-1.05)
High Proportion Patients with Primary Language other than English	1.02 (0.65-1.60)	0.76 (0.50-1.18)	0.78 (0.42-1.45)	0.87 (0.54-1.40)	0.91 (0.54-1.55)
High Proportion Uninsured Patients	0.84 (0.56-1.27)	1.04 (0.70-1.54)	1.28 (0.75-2.19)	0.86 (0.55-1.34)	0.82 (0.51-1.32)
OTHER PRACTICE CHARACTERTICS					
Size of Practice 1-2 Doctors	**0.68 (0.48-0.96)** *	0.77 (0.54-1.08)	1.01 (0.65-1.57)	**0.65 (0.44-0.97)** *	0.63 (0.40-1.00)
≥ 2 Doctors	REF	REF	REF	REF	REF
Region Northeast	**2.17 (1.39-3.39)** †	1.26 (0.82-1.93)	1.05 (0.61-1.82)	**1.68 (1.03-2.74)** *	**2.00 (1.16-3.45)** *
Midwest	**1.72 (1.15-2.59)** **	1.10 (0.74-1.64)	1.27 (0.76-2.13)	1.55 (0.97-2.47)	1.45 (0.85-2.46)
West	1.29 (0.83-2.00)	0.90 (0.59-1.38)	1.61 (0.92-2.82)	1.18 (0.73-1.92)	1.22 (0.70-2.13)
South	REF	REF	REF	REF	REF
PHYSICIAN CHARACTERISTICS					
Age < 45	REF	REF	REF	REF	REF
45-64	**0.62 (0.43-0.88)** **	0.73 (0.52-1.01)	0.97 (0.65-1.45)	**0.57 (0.38-0.85)** **	0.78 (0.50-1.21)
≥ 65	**0.23 (0.14-0.40)** †	**0.35 (0.20-0.59)** †	0.56 (0.26-1.17)	**0.27 (0.15-0.48)** †	**0.29 (0.16-0.54)** †
Self-Identified Race Black	1.38 (0.45-4.21)	1.64 (0.61-4.42)	0.71 (0.13-3.92)	1.77 (0.52-6.00)	3.66 (0.64-20.94)
Hispanic	0.77 (0.30-1.93)	1.70 (0.73-3.93)	1.55 (0.58-4.16)	1.32 (0.49-3.59)	0.82 (0.30-2.25)
Asian	**0.57 (0.37-0.89)** *	1.04 (0.67-1.61)	0.84 (0.46-1.53)	0.79 (0.48-1.28)	0.88 (0.53-1.49)
Other Race	**0.36 (0.15-0.88)** *	1.48 (0.57-3.82)	0.86 (0.24-3.06)	1.09 (0.38-3.09)	0.92 (0.30-2.84)
White	REF	REF	REF	REF	REF
Specialty Family Practice	**3.29 (2.40-4.51)** †	**1.38 (1.02-1.86)** *	0.85 (0.57-1.26)	**2.56 (1.81-3.61)** †	**2.15 (1.44-3.20)** †
Internal Medicine	REF	REF	REF	REF	REF
Full-time Faculty Appointment	1.60 (0.98-2.62)	1.17 (0.73-1.88)	**3.14 (1.76-5.60)** †	1.66 (0.97-2.82)	0.95 (0.53-1.72)
PHYSICIAN CHARACTERISTICS RELATED TO GENETICS					
Received Training in Clinical Genetics in Medical School	1.13 (0.82-1.58)	**1.56 (1.14-2.13)** **	1.01 (0.66-1.55)	1.35 (0.94-1.92)	**1.55 (1.04-2.32)** *
Received Training in Clinical Genetics in CME	**1.53 (1.11-2.10)** **	**2.31 (1.70-3.12)** †	**2.36 (1.58-3.53)** †	**2.21 (1.56-3.13)** †	**2.41 (1.61-3.60)** †
Accurate Knowledge of Current Legal Protections	**2.45 (1.31-4.58)** **	**1.94 (1.10-3.41)** *	**2.20 (1.30-3.72)** **	**6.13 (2.21-16.99)** †	**9.75 (2.32-40.97)** **
Confident Interpreting Genetic Test Results	0.89 (0.41-1.90)	0.64 (0.29-1.43)	0.85 (0.36-2.00)	1.12 (0.44-2.84)	0.72 (0.24-2.13)
Feels Prepared to Counsel	1.31 (0.58-2.93)	2.39 (0.98-5.84)	1.50 (0.65-3.47)	2.43 (0.76-7.74)	2.41 (0.59-9.77)

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	Ever Referred to Genetics Center or Counselor	Ever Referred to Specialist	Ever Referred to a Clinical Trial	Ever Referred to Any Site of Care	Ever Ordered or Ever Referred
	N=943	N=941	N=934	N=945	N=945
	OR (95% CI)				
Patients Considering a Genetic Test					
Early Adopter of New Diagnostic Tests	1.51 (0.97-2.33)	1.20 (0.77-1.87)	1.18 (0.70-1.98)	1.27 (0.76-2.13)	**2.66 (1.34-5.25)** **
Optimistic that Genetics Will Improve Treatment	1.08 (0.67-1.73)	1.11 (0.70-1.76)	0.78 (0.41-1.48)	0.99 (0.59-1.65)	0.88 (0.50-1.53)

Note: Also included in model but not shown: practice setting (independent practice versus those practicing in a health maintenance organization, hospital-based practice, community health center or other setting).

Only those respondents for whom there were complete data were included in each regression analysis, with available cases for individual regressions ranging from 934 (83% of full sample) to 945 (84% of full sample) respondents.

* p<0.05

** p<0.01

† p<0.001