SUPPLEMENTARY MATERIALS

Supplementary Methods

National Survey of Precision Medicine in Cancer Treatment Survey Design and Analysis Weights

The National Survey of Precision Medicine in Cancer Treatment is a nationally representative survey of medical oncologists that was conducted between February and May 2017 and sponsored by the National Cancer Institute, National Human Genomic Research Institute, and the American Cancer Society. The survey included questions about oncologists' sociodemographic and practice characteristics and use of genomic tests. Information about multi-marker tumor panels used to inform treatment were collected, including BioSpeciFix, CancerSELECT or Cancer Complete, Caris Molecular Intelligence or Target Now, CGI Complete, DecisionDX, FoundationOne, FoundationOneHeme, FoundationACT, GPS Cancer, Guardant360, Mammaprint, Omniseq Comprehensive, Oncotype DX Breast, Oncotype DX Colon, OnkoSight Tumor Panels, Solid Tumor Mutation Panel (ARUP Laboratories) and non-commercial tumor panels performed at academic medical centers.

Prior to fielding the survey, three types of pretesting methodologies were conducted: expert review, cognitive testing, and usability testing. Survey experts and clinicians reviewed content and question and response wording. Cognitive interviewing in practicing oncologists was conducted prior to fielding the survey to ensure that questions were clear and responses were consistent with the intent of the questions. Usability testing was conducted to ensure survey navigation was simple and efficient.

Oncologists were selected from the American Medical Association Physician Masterfile, which covers all licensed physicians in the United States. Practicing physicians under the age of 75 were selected using probability sampling, stratified based on cross-classification of Census region (Midwest, Northeast, South, West), size of metropolitan statistical area (small/medium – fewer than 250,000 in population large -250,000 - 1,000,000 in population, and very large - 1,000,000 or more in population), specialty (Oncologists, Hematologists-oncologists, Hematologists), and sex by age category (female, male <55 years, male ≥55 years).

The sample of 4,904 oncologists was allocated proportionally to the 108 sampling strata with at least 2 oncologists per sampling stratum. In each sampling stratum, the probability of selection was the number of physicians allocated divided by the total number of physicians. Within a sampling stratum, the physicians were sorted in ascending order by a randomly generated uniform random number on the interval from zero to one. Physicians were sequentially selected to be in the sample until the number of physicians selected equaled the allocated number of physicians. For the selected physicians, the design weight was calculated as the inverse of the probability of selection. For the non-selected physicians, the design weight was zero.

Eligibility and contact information were verified by telephone for 3,465 oncologists (71%). The survey was fielded as a sequential mixed mode survey with mailed surveys to the confirmed eligible oncologists with a personalized invitation letter, and an endorsement letter from the NCI and ASCO, followed by email contact with a personalized link to the survey. Up to 2 email reminders and 2 follow-up mailed surveys were sent followed by telephone reminders. A total of 1,281 practicing oncologists

completed the survey via mail or online with a cooperation rate of 38.0%. Participants received a $50 honorarium for completing the survey.

Sample weights

Many of the sampling strata were collapsed to create variance estimation strata with sufficient respondents for stable estimates. A total of 51 variance estimation strata were created from the original 108 sampling strata. Noncontact and noncooperation adjustment factors were calculated within variance estimation strata. Within a variance estimation stratum, the noncontact adjustment factor shifted the weights from the unknown eligibility physicians to the known eligibility physicians, the ineligible physicians were removed from the sample, and noncooperation adjustment factor shifted the weights from the eligible non-respondents to the respondents. That is, for the respondents within a variance estimation stratum, the analysis weights were calculated as the product of the design weight, noncontact adjustment factor, and noncooperation adjustment factor.

Nonresponse bias analyses

Three techniques for evaluating nonresponse bias were conducted: comparison of response rates by subgroups, response propensity models, and a nonresponse follow-up study. Response rates were compared for Census region, MSA category, primary specialty, and gender/age category, the stratification variables for sample selection. There was little variation for Census region, MSA, or specialty. There was more variation for the gender/age strata, although differences were not extreme. Similarly, gender/age was the most

important variable in the contact and cooperation propensity models. Thus, gender/age was considered the most important variable to retain in the collapsing of strata for noncontact and noncooperation adjustments.

A one-page follow-back survey was mailed to the nonresponding physicians. It was completed by 14.3% of nonresponding physicians to the main survey. Responses from respondents and non-respondents were compared on a question about the use of Oncotype DX that was asked of both groups. There were no statistically significant differences between the main study and the follow-back study for any of the subgroups used as stratification variables for sample selection.

Supplementary Table 1. Exact Wording of Questions, Response Options, and Variable Construction from the National Survey of Precision Medicine in Cancer Treatment, 2017

Variable description	Question(s) in the survey	Response options
Frequency of cost discussion	"In the past 12 months, when you or your staff discussed any form of genomic testing with your cancer patients or their families, how often did you discuss the likely costs of the testing and related treatment?"	Never Rarely Sometimes Often Did not discuss genomic testing with patients in past 12 months
Types of tumors treated	This variable is constructed from the survey question: "On average, how many unique patients with the following cancers do you see for evaluation or treatment each month?" Response options included none, 1-10, 11-25, 26+ patients per month. Cancers included breast cancer, colorectal cancer, glioma, gynecological cancer, hematological cancer, lung cancer, melanoma, stomach (Gastric) cancer, and other solid tumors. Any cancer types other than hematological cancer were classified as solid tumors. If oncologists responded only saw hematological cancer, they were categorized as treated hematologic cancers only; If oncologists responded saw any cancer types except hematological cancer, they were categorized as treated solid cancers only; If oncologists responded saw both hematological cancer and solid cancer, they were categorized as treated both hematologic cancers and solid tumors.	
Percentage of time providing patient care	"During a typical month, approximately what percentage of your professional time do you spend in the following activities?"	X % time providing patient care
Affiliation with medical school or hospital	"Is your primary practice affiliated with an academic institution such as a medical school or teaching hospital? Do not include where your practice only has admissions privileges."	Yes No
Formal training in genomic testing	"Have you received any formal training (e.g., instruction during residency/fellowship, professional lectures or seminars, symposiums, conferences, CMEs) in use of genomic testing?"	Yes No
Uses next-generation sequencing gene panel tests	This variable is constructed from 2 survey questions. The first question is: "How of many of your cancer patients received the following multi-marker tumor panels within the past 12 months? Please include tests that were ordered by other physicians and tests performed by pathology." Response options included not familiar with this test, familiar with this test, but not used in the past 12 months, 1-10 patients in the past 12 months, and 11+ patients in the past 12 months. The tests included Breast Cancer IndexSM (BioTheranostics), CancerSELECT® or CancerComplete® (Personal Gene Diagnostics [PGDx]), Caris Molecular Intelligence® or Target Now™ (Caris Life Sciences®), CGI Complete™ (Cancer Genetics Incorporated [CGI]), FoundationOne® (Foundation Medicine®), FoundationOne® Heme (Foundation Medicine®), FoundationACT™(Foundation Medicine®), GPS Cancer™ (NantOmics),	

	Guardant360™ (Guardant Health), Mammaprint® (Agendia®), myPlan® Lung Cancer (Myriad®), OmniSeq ComprehensiveSM (OmniSeq®), Oncotype DX® Breast (Genomic Health®), Oncotype DX® Colon (Genomic Health®), OnkoSight™ Tumor Panels (GenPath Diagnostics), Prosigna® (NanoString Technologies®), Solid Tumor Mutation Panel (ARUP® Laboratories), Non-commercial tumor panel performed at an academic medical center, and other. CancerSELECT® or CancerComplete® (Personal Gene Diagnostics [PGDx]), Caris Molecular Intelligence® or Target Now™ (Caris Life Sciences®), CGI Complete™ (Cancer Genetics Incorporated [CGI]), FoundationOne® (Foundation Medicine®), FoundationOne® Heme (Foundation Medicine®), FoundationACT™(Foundation Medicine®), GPS Cancer™ (NantOmics), Guardant360™ (Guardant Health), OmniSeq ComprehensiveSM (OmniSeq®), OnkoSight™ Tumor Panels (GenPath Diagnostics), and Solid Tumor Mutation Panel (ARUP® Laboratories) were next-generation sequencing gene panel tests. The second question is: "In the past 12 months, for what percentage of your patients receiving multi-marker tumor panels, excluding Oncotype DX testing, did you use the results to guide patient care decisions?" If oncologists responded that they use any of the above mentioned next-generation sequencing gene panel tests and answered >0 percent of their patients receiving multi-marker tumor panels, excluding Oncotype DX testing, they were defined as used next-generation sequencing gene panel tests.	
Practice type	"Is your primary practice a …"	Solo practice Single specialty group Multi-specialty group Other
Patient volume per month	"Of the total patients you see for evaluation or treatment each month, how many are cancer patients?"	XX unique cancer patients per month
Primary practice provides internal policies or protocols for genomic tests	"Does your primary practice have the following genomic testing services?" --Internal policies or protocols for use of genomic and biomarker testing.	Yes No
Primary practice has electronic medical record alerts for genomic tests	"Does your primary practice have the following genomic testing services?" --An EMR that alerts providers when a genomic test is recommended for a particular patient or before ordering a particular drug.	Yes No
Primary practice provides genomic/molecular tumor board for genomic tests	"Does your primary practice have the following genomic testing services?" --Genomic/Molecular Tumor board.	Yes No

Proportion of patients insured by Medicaid ≥10% or self-pay or uninsured ≥10%	"In the past 12 months what percentage of your patients were Medicare, Medicaid, and self- pay/ uninsured?"	

Supplementary Table 2. Bivariate Analyses, Intermediate Multivariable Models, and Final Multivariable Models to Evaluate Factors Associated with Frequency of Discussions about Costs of Genomic Testing and Related Treatment*

Characteristics assessed in bivariate and intermediate multivariable models	sometimes vs. never or rarely			often vs. never or rarely			Included in the next-stage model
	OR	95% CI	P†	OR	95% CI	P†	
Step 1. Bivariate analyses							
Physician Characteristics							
Age			0.94			0.25	No
<40 y	ref						
40–49 y	0.94	0.60 - 1.48		1.27	0.85 - 1.90		
50–59 y	1.04	0.64 - 1.67		1.39	0.91 - 2.13		
≥60 y	1.09	0.67 - 1.76		1.54	1.00 - 2.38		
Year since medical school graduation			0.92			0.08	Yes
7-14	ref						
15-24	1.07	0.70 - 1.65		1.17	0.80 - 1.72		
25-34	1.17	0.72 - 1.90		1.62	1.06 - 2.49		
35-51	1.14	0.71 - 1.83		1.53	1.00 - 2.33		
Gender			0.95			0.69	No
Female	ref						
Male	0.99	0.69 - 1.42		1.07	0.78 - 1.46		
Race/ethnicity			0.50			0.10	Yes
White, non-Hispanic	ref						
Other	0.89	0.64 - 1.24		0.78	0.58 - 1.05		
Types of tumors treated			0.32			<0.001	Yes
Hematologic cancers only	ref						
Both hematologic cancers and solid tumors	1.37	0.87 - 2.17		3.07	1.93 - 4.88		
Solid tumors only	1.49	0.85 - 2.63		4.77	2.78 - 8.19		
Percentage of time providing patient care			0.69			0.86	No
<76%	ref						

>=76%	1.08	0.75 - 1.54		0.97	0.71 - 1.33		
Affiliation with medical school or hospital			0.97			0.44	No
No	ref						
Yes	0.99	0.71 - 1.40		0.89	0.66 - 1.20		
Formal training in genomic testing			0.25			<0.001	Yes
No	ref						
Yes	1.22	0.87 - 1.69		1.68	1.26 - 2.25		
Uses next-generation sequencing gene panel tests			0.002			<0.001	Yes
No	ref						
Yes	1.74	1.21 - 2.51		1.11	0.85 - 1.45		
Practice characteristics							
Practice type			0.29			0.10	Yes
Solo	ref						
Single specialty	1.23	0.50 - 3.03		0.91	0.44 - 1.90		
Multispecialty	1.11	0.45 - 2.72		0.73	0.35 - 1.52		
Other	0.68	0.24 - 1.91		0.49	0.21 - 1.13		
Located in Metropolitan Statistical Area			0.21			0.23	No
Small/Medium	ref						
Large	1.19	0.63 - 2.25		1.00	0.55 - 1.82		
Very Large	0.69	0.43 - 1.12		0.75	0.48 - 1.17		
U.S. Geographic region			0.57			0.007	Yes
Northeast	ref						
Midwest	1.32	0.82 - 2.14		1.61	1.05 - 2.45		
South	1.05	0.69 - 1.59		1.04	0.72 - 1.51		
West	1.28	0.75 - 2.17		1.82	1.16 - 2.86		
Patient volume per month			0.02			<0.001	Yes
<99	ref						
100+	1.46	1.05 - 2.04		1.79	1.33 - 2.40		
Practice provides internal policies or protocols for genomic testing			0.44			0.04	Yes

No	ref						
Yes	1.14	0.82 - 1.58		1.35	1.01 - 1.81		
Practice has electronic medical record alerts for genomic testing			<0.001			<0.001	Yes
No	ref						
Yes	2.32	1.38 - 3.90		2.56	1.59 - 4.12		
Practice has genomic/molecular tumor board for genomic testing			0.65			0.08	Yes
No	ref						
Yes	1.08	0.76 - 1.54		1.31	0.96 - 1.78		
Proportion of patients insured by Medicaid >=10% or self-pay or uninsured >=10%			0.005			0.02	Yes
No	ref						
Yes	1.70	1.14 - 2.47		1.47	1.07 - 2.02		
Area-level characteristics							
Mean per capita personal income			0.07			<0.001	Yes
>$60,000	ref						
$45,000-$60,000	1.43	0.95 - 2.14		1.98	1.39 - 2.82		
<=$ 45,000	1.61	1.05 - 2.45		1.59	1.09 - 2.33		
% Persons 25+ with 4+ years College			0.009			0.01	Yes
>45%	ref						
30%-45%	1.63	1.06 - 2.51		1.68	1.16 - 2.42		
<=30%	2.01	1.27 - 3.18		1.71	1.14 - 2.55		
Median gross rent (in $)			0.15			0.003	Yes
>1000	ref						
850-1000	1.14	0.77 - 1.67		1.07	0.77 - 1.50		
<=850	1.50	0.99 - 2.27		1.80	1.24 - 2.61		
Step 2. Intermediate multivariable models							
Physician Characteristics							
Year since medical school graduation			0.75				

7-14	ref						
15-24	1.09	0.70 - 1.69		1.26	0.83 - 1.90	0.02	Yes
25-34	1.30	0.78 - 2.15		1.95	1.23 - 3.08		
35-51	1.22	0.74 - 2.02		1.67	1.05 - 2.65		
Race/ethnicity							
White, non-Hispanic	ref		0.68			0.33	No
Other	0.93	0.65 - 1.32		0.85	0.62 - 1.17		
Types of tumors treated							
Hematologic cancers only	ref						
Both hematologic cancers and solid tumors	1.29	0.80 - 2.07	0.52	2.80	1.73 - 4.51	<0.001	Yes
Solid tumors only	1.35	0.76 - 2.39		4.00	2.29 - 6.99		
Formal training in genomic testing							
No	ref		0.32			0.002	Yes
Yes	1.19	0.84 - 1.68		1.64	1.21 - 2.24		
Uses next-generation sequencing gene panel tests							
No	ref		0.004			<0.001	Yes
Yes	1.72	1.18 - 2.49		2.20	1.57 - 3.09		
Practice characteristics							
Practice type							
Solo	ref						
Single specialty	1.08	0.43 - 2.70	0.33	0.74	0.35 - 1.54	0.01	Yes
Multispecialty	0.90	0.36 - 2.29		0.49	0.23 - 1.04		
Other	0.61	0.22 - 1.74		0.38	0.16 - 0.88		
U.S. Geographic region							
Northeast	ref						
Midwest	1.41	0.85 - 2.32	0.48	1.66	1.06 - 2.59	0.002	Yes
South	1.05	0.68 - 1.63		1.07	0.73 - 1.59		
West	1.29	0.76 - 2.21		2.06	1.29 - 3.31		
Patient volume per month			0.06			<0.001	Yes
<99	ref						

100+	1.39	0.99 - 1.96		1.77	1.30 - 2.40		
Practice provides internal policies or protocols for genomic testing			0.85			0.19	Yes
No	ref						
Yes	1.04	0.70 - 1.53		1.25	0.90 - 1.74		
Practice has electronic medical record alerts for genomic testing			0.003			<0.001	Yes
No	ref						
Yes	2.22	1.26 - 3.90		2.26	1.37 - 3.73		
Practice has genomic/molecular tumor board for genomic testing			0.64			0.03	Yes
No	ref						
Yes	1.10	0.73 - 1.67		1.48	1.03 - 2.12		
Proportion of patients insured by Medicaid >=10% or self-pay or uninsured >=10%			0.02			0.02	Yes
No	ref						
Yes	1.57	1.07 - 2.30		1.14	0.52 - 2.50		
Area-level characteristics							
Mean per capita personal income			0.89			0.03	Yes
>$60,000	ref						
$45,000-$60,000	1.14	0.68 - 1.90		1.70	1.07 - 2.71		
<=$ 45,000	1.11	0.60 - 2.07		1.23	0.70 - 2.16		
% Persons 25+ with 4+ years College			0.16			0.76	Yes
>45%	ref						
30%-45%	1.52	0.92 - 2.51		1.19	0.76 - 1.89		
<=30%	1.81	0.96 - 3.42		1.18	0.66 - 2.10		
Median gross rent (in $)			0.75			0.20	No
>1000	ref						
850-1000	0.91	0.59 - 1.42		0.87	0.59 - 1.26		
<=850	1.09	0.65 - 1.83		1.46	0.93 - 2.29		

Step 3. Final multivariable models							
Physician Characteristics							
Year since medical school graduation							
7-14	ref						
15-24	1.08	0.68 - 1.70	0.67	1.21	0.78 - 1.87	0.001	
25-34	1.35	0.80 - 2.26		2.28	1.40 - 3.71		
35-51	1.24	0.73 - 2.12		1.97	1.19 - 3.25		
Types of tumors treated							
Hematologic cancers only	ref		0.44			<0.001	
Both hematologic cancers and solid tumors	1.31	0.75 - 2.30		2.82	1.58 - 5.02		
Solid tumors only	1.47	0.81 - 2.69		4.01	2.21 - 7.29		
Formal training in genomic testing							
No	ref		0.44			<0.001	
Yes	1.15	0.80 - 1.66		1.74	1.25 - 2.42		
Uses next-generation sequencing gene panel tests							
No	ref		0.02			<0.001	
Yes	1.59	1.07 - 2.37		1.93	1.34 - 2.77		NA
Practice characteristics							
Practice type							
Solo	ref						
Single specialty	1.18	0.43 - 3.18	0.60	0.75	0.33 - 1.71	0.35	
Multispecialty	1.11	0.40 - 3.07		0.61	0.26 - 1.41		
Other	0.78	0.26 - 2.37		0.50	0.19 - 1.29		
U.S. Geographic region							
Northeast	ref						
Midwest	1.25	0.74 - 2.11	0.53	1.60	0.98 - 2.62	0.006	
South	0.93	0.57 - 1.52		0.98	0.62 - 1.53		
West	1.28	0.72 - 2.29		1.92	1.15 - 3.21		
Patient volume per month							
<99	ref		0.10			0.009	

100+	1.35	0.94 - 1.92		1.53	1.11 - 2.10		
Practice provides internal policies or protocols for genomic testing			0.80			0.24	
No	ref						
Yes	1.06	0.70 - 1.59		1.25	0.86 - 1.79		
Practice has electronic medical record alerts for genomic testing			0.007			0.001	
No	ref						
Yes	2.09	1.19 - 3.69		2.22	1.30 - 3.79		
Practice has genomic/molecular tumor board for genomic testing			0.48			0.07	
No	ref						
Yes	1.19	0.74 - 1.90		1.47	0.96 - 2.25		
Proportion of patients insured by Medicaid >=10% or self-pay or uninsured >=10%			0.02			0.02	
No	ref						
Yes	1.60	1.09 - 2.36		1.55	1.09 - 2.20		
Area-level characteristics							
Mean per capita personal income			0.91			0.07	
>$60,000	ref						
$45,000-$60,000	1.12	0.65 - 1.92		1.84	1.09 - 3.09		
<=$ 45,000	1.08	0.56 - 2.07		1.55	0.81 - 2.97		
% Persons 25+ with 4+ years College			0.15			0.66	
>45%	ref						
30%-45%	1.57	0.91 - 2.71		1.27	0.75 - 2.16		
<=30%	1.96	0.98 - 3.90		1.19	0.62 - 2.28		

*A data-driven stage-wise approach was used to identify other physician, practice and area-level covariates for inclusion in intermediate and final adjusted models. First, bivariable analyses were conducted to identify covariates significantly associated with the frequency of cost discussions; those that were statistically significant at $p<0.20$ were included in one of 3 intermediate multivariable models of physician, practice, or area-level characteristics and cost discussions. The final model included covariates

statistically significant at $p<0.20$ in any of the 3 intermediate models. Collinearity diagnostics were performed for the 3 intermediate and final multivariable regression models.

†P values were calculated using the two-sided Chi-square test.