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Bumps along the translational pathway: anticipating uptake of tailored smoking cessation treatment

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Abstract

Aim—To assess potential barriers to clinical integration of tailored smoking cessation treatment among African American and white smokers in the USA.

Methods—A total of 392 smokers (203 white and 189 African American) identified within a national random digit dial survey (response rate: 40.1%; 81.2% among households with whom we were able to make contact) of 1200 African Americans and 1200 white Americans. Respondents answered several closed-ended survey items addressing beliefs regarding what influences a smoker's ability to quit, past pharmacotherapy use, and their willingness to undergo genetic assessment in order to be matched to optimal treatment, among other items.

Results—In this first nationally representative survey of US smokers, 77% of respondents expressed willingness to undergo genetic testing in order to be matched to optimal pharmacotherapy, yet only 18% had ever used pharmacotherapy in a previous quit attempt. Smokers who rated 'medications and counseling' as very important in quitting were significantly more likely to endorse genetic testing (odds ratio [OR]: 8.94; 95% CI: 1.86–43.06), while those rating 'having God's help' as very important were significantly less likely to express willingness to undergo testing (OR: 0.11; 95% CI: 0.02–0.71). African American smokers were more likely than white smokers to express willingness to undergo genetic testing (OR: 3.80; 95% CI: 1.09–13.22), despite lower rates of previous pharmacotherapy use.

Conclusion—While smokers reported high rates of willingness to undergo genetic testing to be matched to optimal treatment, these results suggest that smokers' willingness to use medications indicated by genetic test results may prove a significant barrier to realizing the promise of tailored smoking cessation treatment. The role of spirituality in smokers' willingness to use medication is an area for further study.

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Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

Keywords

genetic testing; pharmacogenomics; pharmacogenomic treatment for smoking; pharmacotherapy; racial differences in pharmacotherapy use; smoking

The decade following the completion of the Human Genome Project has seen important developments in pharmacogenomic (PGx) treatment strategies that promise to achieve improved outcomes by matching patients to optimal therapy based on their individual profiles [1]. The challenges associated with translating these improved treatment strategies into clinical practice, however, are many [2]. Understanding patients' attitudes and beliefs, and how these are likely to affect uptake of efficacious new PGx applications, will be critical to successful clinical integration and realizing subsequent health improvements. To the extent that novel treatment strategies improve quit rates, differential uptake among patient subpopulations may exacerbate existing racial/ethnic and socioeconomic disparities in smoking-related morbidity and mortality. We use the case of individualized smoking cessation to probe these issues and elucidate patient-focused challenges to translating PGx medicine into practice.

Smoking remains a leading cause of mortality, responsible for 443,000 deaths in the USA [3] and 730,000 deaths in the EU each year [4,5], creating a global health crisis [6,7]. Despite aggressive prevention campaigns, 19% of adults in the USA [8] and 28% in the EU [9] smoke. Pharmacotherapy (including nicotine replacement therapy and other medications, such as bupropion and varenicline) represents the best available cessation treatment [10,11], but only approximately 32–35% of smokers use pharmacotherapy in a quit attempt [12,13]. Among smokers that use approved cessation medications, only approximately 25% of smokers are able to quit [14], perhaps due to the fact that there is up to a fivefold interindividual variability in therapeutic response [15–17].

The need for improved smoking cessation treatment strategies has spurred research into PGx approaches to match patients to smoking cessation medications based on their individual profile, resulting in improved cessation rates [12,18–29]. One of the most promising PGx developments within smoking cessation treatment is the Nicotine Metabolite Ratio, a genetically informed biomarker that provides a stable individualized measure of the rate of nicotine clearance [25]. Retrospective trials have shown that slower nicotine metabolizers respond well to nicotine patch therapy, while faster metabolizers will likely require a non-nicotine-based therapy (bupropion or varenicline) to succeed in quitting [30–32]. A prospective trial to validate these results is currently underway. The success of these emerging PGx smoking treatments will require that, first, smokers be willing to undergo genetic testing (e.g., provide a cheek swab) to receive tailored treatment recommendations, and, second, that they be willing to take medications indicated by test results.

Numerous studies have documented substantially lower rates of pharmacotherapy use among minority smokers [12,20,27–29], raising questions about the impact on health disparities of PGx smoking treatment strategies, which require a willingness to use medications. If emerging PGx treatment strategies for smoking are indeed efficacious, reduced willingness to take medications among African American smokers will likely translate into ever-increasing racial disparities between smoking-related morbidity and mortality [20].

In this report, we provide results of the first nationally representative survey of African American and white adult smokers in the USA to assess their willingness to undergo genetic testing in order to be matched to optimal treatment and to explore potential patient-centered

barriers to uptake. Specifically, we assessed the effect of past pharmacotherapy use in prior quit attempts and beliefs regarding the relative importance of various factors (i.e., medication, the support of friends and family, having God's help and willpower) in determining one's ability to quit on smokers' stated willingness to undergo genetic assessment in order to be matched to the medication that will work best for them. We also assessed whether smokers' responses differed by race in an effort to understand whether we should anticipate racial differences in the uptake of PGx treatment for smoking.

We focused on potential differences in attitudes and beliefs among white and African Americans because African Americans currently experience the greatest burden of smoking-related illness and death in the USA [33,34]. Identifying and addressing potential barriers to successful uptake of more efficacious treatments among African Americans is thus an important public health concern. We hypothesized that willingness to undergo genetic testing would vary significantly depending on beliefs smokers held regarding which factors determine a smoker's ability to quit. Specifically, we hypothesized that smokers who believed medications or an individual's genetic profile to be very important in determining a person's ability to quit would be positively disposed towards PGx treatment, while those ranking other factors (e.g., having friends and family who support the quit attempt, willpower or having spiritual support) as very important would be less willing to undergo genetic testing in order to receive tailored treatment. Based on previous literature exploring racial differences in patients' willingness to undergo genetic testing in other contexts [35–39] and our previous qualitative study [40], we also further hypothesized that African American smokers would express less willingness than white smokers to undergo genetic testing.

Methods

The data for this study are based on a nationally representative sample of 2400 self-identified African Americans (n = 1200) and white Americans (n = 1200) who completed a random digit dial (RDD) telephone survey between September 2008 and October 2009 to investigate lay attitudes and beliefs regarding factors affecting addiction to nicotine, cocaine and alcohol. The response rate for our RDD survey was 40.1% according to the American Association for Public Opinion Research Method 4 formula and 81.2% among households with whom we were able to make contact. These rates are in keeping with response rates seen in other recent high-quality RDD surveys [41]. Using a dual-sampling frame design to ensure close to an equal number of non-Hispanic black and white respondents, our sampling was performed on three strata:

- Stratum 1, prepared by Marketing Systems Group, was a list of phone numbers created by identifying census block groups throughout the USA with at least 55% expected black or African American households (representing ~45% of all black or African American households in the USA);
- Stratum 2, accessed through GENESYS, was a list of telephone numbers expected to include at least 30% of all African American households (representing ~51% of all African American households in the USA), some of which would also be included in the Stratum 1 list. Any telephone numbers appearing in both strata 1 and 2 were removed from the Stratum 2 list in order to make these two strata nonoverlapping;
- Stratum 3, also accessed through GENESYS, included all telephone exchanges in the country not included in the targeted black or African American exchanges used in Stratum 2, and was designed to be nationally representative of white

Americans. Individuals under age 18 years of age or non-English speaking were excluded from this survey.

Here, we report a secondary analysis conducted using data from the 392 identified smokers in our sample (189 African American and 203 white) who were asked an additional battery of questions.

The additional survey module, addressed only to smokers, included items assessing:

- Smokers' willingness to undergo genetic testing in order to be matched to optimal treatment;
- Intention to quit, level of nicotine dependence, past pharmacotherapy use;
- Opinions and beliefs regarding factors they believed to be most important in determining a smoker's ability to quit;
- Concerns regarding the potential misuse of genetic test information by insurance companies and health insurance status.

The final two variables were excluded from the final model because they were not significant and did not contribute any explanatory power to the model. Response categories and optimal wording for new survey items assessing smokers' beliefs regarding the importance of various factors in determining a smoker's ability to quit were developed via 11 focus groups [40] and 16 one-on-one interviews with smokers in Baltimore, MD (USA) and Montgomery, AL (USA) [40], and cognitive testing. Response categories for these new items included: 'medications or counseling'; 'willpower'; 'having God's help'; 'having friends or family who support the attempt to quit'; and 'a person's genetic make-up'. These and other items in the survey were further tested via a pilot study (n = 100) conducted under actual survey conditions. The response category, 'a person's genetic make-up', for the question assessing respondents' rating of the importance of various factors in determining a smoker's ability to quit was also excluded from our analysis due to the extremely low frequency of this response. Table 1 highlights survey questions and response categories for key items.

Descriptive statistics on all variables were summarized using SAS® 9.2 (SAS Institute Inc. NC, USA) for Windows. We used a binary logistic regression model using the SURVEYLOGISTIC procedure in SAS to conduct the regression analysis, adjusting for sampling weights. Survey sampling-adjusted weights used in this analysis reflect the inverse probability of being selected in the survey and are necessary to make inferences applying to the US population. We used several methods (e.g., the Taylor series approximation and Jack Knife sampling methods [101] for variance correction in a weighted sample) to confirm the robustness of our estimates. Smokers' willingness to undergo genetic testing in order to be matched to optimal treatment was our dependent variable. Response categories were 'yes', 'maybe', 'no' and 'don't know'. Owing to the limited number of 'maybe' responses, sensible estimations were not feasible for this category using a multinomial logit to model three levels of response. After testing different models with three levels of response, we collapsed responses to create a binary variable (yes versus maybe/no/don't know). Variables excluded in our final model had nonsignificant coefficients; their exclusion did not have a significant effect on the final model's discriminatory power (c-statistic = 0.68). The analysis was initially conducted in the overall sample, followed by analyses stratified by race to determine if our independent variables had the same effect among African American and white smokers. In order to test the impact of race on the effect of covariates on willingness to undergo genetic testing, we additionally conducted an interaction analysis. For this purpose, we defined race as a dummy variable (African American = 1; white = 0) and estimated a regression model that included covariates, as well as the interaction of African

American' with all covariates, in a regression model. To provide a complete picture of our analyses, we have reported the results of stratified analysis, as well as of the interaction model, in the results section and related tables.

Results

We identified 392 current smokers (189 African and 203 white Americans) in our national sample of 1086 self-identified white Americans and 1041 self-identified African Americans. Among our sample of smokers, African American and white smokers were similar in most respects; however, a higher proportion of African American smokers reported an annual household income less than US\$20,000 ($p = 0.0123$) and fewer had health insurance ($p = 0.0933$) (Table 2). Overall, 77% of smokers expressed willingness to undergo genetic testing in order to be matched to the smoking cessation treatment most likely to work for them (Table 3). Significantly more African American smokers (90.6%) than white smokers (75.4%) expressed willingness to undergo genetic testing ($p = 0.0416$), although only 32.2% of African American smokers (vs 56.6% of white smokers; $p = 0.10$) reported ever using pharmacotherapy in a previous quit attempt. Despite low pharmacotherapy use, African American smokers were also more likely to rate 'medications or counseling' as a 'very important' factor influencing a person's ability to quit, with 69.9% of African American smokers (vs 34.9% of white smokers) rating 'medications and counseling' as 'very important' ($p = 0.0034$). Finally, 87.5% of African American smokers rated 'having God's help' as a 'very important' influence on determining one's ability to quit versus 63.6% of white smokers ($p = 0.033$).

Results of our final regression model showed that African American smokers were significantly more likely to express willingness to undergo genetic testing in order to be matched to optimal pharmacotherapy than white smokers (odds ratio [OR]: 3.80; 95% CI: 1.09–13.22) (Table 4). Those who viewed 'medication or counseling' as a 'very important' factor influencing a smoker's ability to quit were far more likely to express willingness to undergo genetic testing relative to those rating medications or counseling as less important (OR: 8.94; 95% CI: 1.86–43.06). This effect was shown to be driven by the importance that both African American and white smokers ascribed to medication: in our regression including only African American smokers, those rating the influence of medication as very important had a 15.50 OR of expressing willingness to undergo genetic testing (95% CI: 3.02–79.48; $p < 0.01$); in our model including only white smokers, the comparable OR was 8.08 (95% CI: 1.47–44.53; $p < 0.05$). Smokers who rated 'having God's help' as very important in quitting were far less willing to undergo genetic testing (OR: 0.11; 95% CI: 0.02–0.71). However, in our stratified analyses, this effect was only present among white smokers (OR: 0.10; 95% CI: 0.01–0.73) after controlling for all other covariates. The results of the interaction model, reported in the last two columns of Table 4, also matched with the estimated ORs from stratified analysis in African Americans and whites, suggesting that only the interaction between race and rating 'having God's help' as very important in determining one's ability to quit was statistically significant ($p = 0.0415$).

Discussion

We conducted the first nationally representative analysis examining the willingness of white and African Americans to undergo genetic testing, should it be offered by their physicians, in order to be matched to the medication most likely to help them quit smoking. A total of 77% of smokers said they would be willing to undergo genetic testing for this purpose. This figure is significantly higher than the 38.8% of smokers in The Netherlands who indicated that they planned to "undergo a genetic test to determine which smoking cessation therapy [they] could use best"[23]. Our results resonate, however, with other studies investigating

patients' attitudes towards PGx treatment strategies more generally. A RDD telephone survey of the US population by Haga *et al.*, for example, found that more than 90% of respondents were interested in PGx tests to guide dosing or drug selection [42].

Most previous studies examining patients' willingness to undergo genetic assessment in order to receive tailored treatment have focused on established genetic tests (e.g., in the context of breast/ovarian or colorectal cancer) and document a general willingness to undergo genetic testing [42–45]. African Americans, however, have been shown to be approximately half as likely as white Americans to undergo genetic assessment for colorectal cancer risk [46]. Willingness to undergo testing has been shown to be inversely related to factors such as knowledge about genetics [46], being tested by a specialist [47], race-specific marketing [47] and disclosure of test results to insurers [47]. Of the few studies to examine actual testing uptake, genetic testing rates remained low, even when stated willingness to be tested [48] and knowledge of *BRCA1/2* testing [49] or *BRCA1/2* counseling rates [50] were high. For example, of smokers related to lung cancer patients, only 45% of those who said that they 'definitely would' take a genetic test to assess lung cancer risk actually underwent testing [48]. Even fewer studies have assessed the extent to which patients follow treatment recommendations indicated by test results [51].

The results of this study suggest that the majority of smokers in the USA, regardless of race, are willing to undergo genetic testing for the purposes of tailoring their smoking cessation treatment. Individuals motivated to quit, those who had previously used cessation medication in a past quit attempt, and those believing that the use of medications and counseling is a very important factor determining a smoker's ability to quit were especially willing to undergo genetic assessment. The effect of other factors, including level of nicotine dependence and previous experience with cessation medications, although not statistically significant, seem to contribute to our model's prediction power and were observable for both white and African Americans. Individual characteristics (sex, age, education and income) were not significant influences on willingness to be tested among African or white American smokers.

African American smokers in our sample were significantly more likely to express such willingness to be tested relative to white smokers (90 vs 75%, respectively). These results remained significant in our multivariate analyses, which showed African American smokers having nearly four-times the odds of white smokers of saying that they were willing to undergo PGx testing, controlling for a host of smoking-related and attitudinal covariates. The higher rate of African American smokers' willingness to undergo genetic testing was contrary to our hypothesis. In our previous qualitative research with African American and white smokers in Alabama and Maryland (USA) [40], 62% of African American smokers versus 91% of white smokers stated a willingness to undergo genetic testing in order to be matched to the medication most likely to work for them. However, these focus groups also included discussions of pleiotropic associations of genotypes likely to be used to match patients to treatment with other, more socially stigmatized conditions (e.g., addiction to cocaine and alcohol, suicide, depression or compulsive activity) [52], which may have dampened enthusiasm. Studies that have explored patients' willingness to undergo genetic testing to guide treatment in other contexts have reported African Americans to be less likely to possess favorable attitudes towards genetic testing and more likely than other groups to believe that genetic testing will be misused [35,53,54], used to label their racial/ethnic group as inferior [36] or lead to racial discrimination [55]. By contrast, Haga and colleagues' more recent study found no racial differences in the proportion of respondents interested in PGx testing to guide drug selection [42].

The very high rates of stated willingness to undergo genetic testing among African American smokers in this study, however, must be viewed in the context of their willingness to use medications in a quit attempt. While 70% of African American smokers rated the influence of medications and counseling as ‘very important’ in determining a person’s ability to quit, only 32% of African American smokers report ever having used medication in a previous quit attempt. This misalignment poses a potential barrier to effective clinical integration of PGx treatment strategies among African American smokers. Ultimately, the value of PGx treatment is dependent on patients’ willingness to follow treatment recommendations indicated by test results.

For those concerned about the impact of differential diffusion of PGx medicine on already dramatic racial disparities in the burden of smoking-related illness and death, an overemphasis on smokers’ willingness to undergo genetic testing misses a fundamental issue, namely, smokers’ willingness to use medications indicated by test results. Smokers may be willing to undergo genetic assessment, if only out of curiosity, but unless they are equally willing to take the medications indicated by the test results, the clinical benefit of tailored treatment will not be realized.

Recent data suggest we have a long way to go in convincing smokers to use pharmacotherapy. In a 2008 study by Cokkinides *et al.* of 4756 smokers who participated in the 2005 National Health Interview Survey, only 24.3% of African American smokers had used pharmacotherapy in a quit attempt, compared with 37.7% of white smokers [12]. A study of 12,027 US daily smokers aged 18 years and older who made a quit attempt in the prior year found only 17% of African American smokers to have used pharmacotherapy in a quit attempt, compared with 29% of white smokers [13]. These racial differences persist when both pharmacotherapy and behavioral interventions are jointly assessed (e.g., 38% among African American smokers vs 51% among white smokers) [56]. Studies among African American smokers have documented concerns about cost, addiction and side effects as explanations for lower use pharmacotherapy in quit attempts [57,58]. Although some have suggested cost of medications is a key barrier [57–59], similar racial differences in pharmacotherapy use persist when medications are provided at no charge [60], suggesting cultural or other barriers. Absent the ability to motivate smokers to use medication in a quit attempt, the potential clinical benefit of improved treatment strategies will not be realized. Given that African American men currently develop lung cancer at twice the rate of white Americans [33], differential success in implementing PGx treatment strategies (including use of recommended medications) across subsets of smokers could dramatically exacerbate existing disparities in lung cancer and other smoking-related illnesses.

An important outstanding question, and one on which the success of PGx treatment for smoking cessation hinges, is the extent to which the possibility of receiving individualized smoking treatment will motivate smokers who have never used pharmacotherapy as a medication in a quit attempt. The hope is that the dramatic improvements in quit rates made possible through PGx treatment will encourage far more smokers to attempt quitting and to be willing to include medications in their efforts to quit. Individualized treatment recommendations may potentially motivate some smokers to use pharmacotherapy. Smokers’ willingness to use PGx-guided smoking treatment will also probably be affected by data not yet available regarding the percentage increase in quit rates possible through tailored treatment. Much research has focused on patients’ willingness to undergo genetic testing; more research is needed to understand the critical issue of barriers to patients’ willingness to use medications indicated by test results.

Finally, the role of spirituality in smokers’ willingness to undergo genetic testing and to use medications to assist them in quitting is an area that warrants further investigation. Smokers

rating ‘having God’s help’ as very important in quitting were far less willing to undergo genetic testing, controlling for race and other influences. This is in line with other studies finding high religiosity to be associated with negative attitudes toward genetic testing [61,62] and lower adherence to medications [63,64]. Results related to ‘having God’s help’ remained significant in the stratified analyses for white smokers only. The relationship between spirituality and attitudes towards PGx treatments, and how this relationship may differ across racial/ethnic communities, deserves further study. Previous research has found African Americans to express greater religiosity than whites [65,66] and to be more likely to use religion/spirituality to cope with health issues [65,67]. African Americans have also been found to rank prayer as more important than medications for improving health outcomes [65]. The relationship between spirituality and willingness to use medications is a critically understudied area of research exploring barriers to and facilitators of integrating PGx medicine into clinical practice. Developing effective outreach and education interventions to reach spiritually-motivated smokers could have a significant effect on the potential success of PGx treatment for smoking.

Limitations

The results of this study are limited to assessing anticipated behavior in response to being offered PGx treatment for smoking and do not measure actual behavior. There are bound to be important differences between stated willingness to undergo genetic assessment and actual willingness once offered a test. While some studies have shown that stated intentions often correlate with actual behavior [68], others have shown a gap between stated willingness and actual uptake [48]. We measured smokers’ willingness to undergo genetic testing using the response categories of ‘yes’, ‘maybe’ or ‘no’. Capturing willingness to undergo genetic testing as a continuous variable may have strengthened our analysis. We employed past use of smoking cessation medications as a proxy for willingness to use medication in the future; however, the correlation between past and future pharmacotherapy use can be affected by several factors, including changes in insurance coverage, health status, or social and personal circumstances. Even though point estimates suggest that this proxy variable (i.e., use of medication in the past) is positively correlated with willingness to use genetic testing, we acknowledge that assessing future willingness to use medication would have strengthened our analysis. Our analysis would have been further strengthened had we asked respondents directly about their willingness to use pharmacotherapy in the future if a genetic test indicated it would help them quit and even their willingness to use medication in general. This would have allowed for the disaggregation of willingness to undergo testing and willingness to use medications indicated by the test result. Although it is impossible to anticipate actual uptake rates once PGx treatments are available to smokers, our findings are useful for anticipating and addressing potential barriers to successful clinical integration.

Our study was also limited to self-identified white and African American smokers due to the costs associated with conducting a national RDD survey and does not include smokers from other groups. We chose to focus on African Americans because this group suffers the greatest burden of smoking-related illness and death. Similar studies are needed that include all subpopulations of smokers in order to understand how best to deliver PGx treatment across all patient communities. Our RDD methodology included landlines only and thus excluded smokers who rely on cell phones and do not have landlines [69]. Finally, we had insufficient sample size and variation in our dependent variable to support a model including all interaction terms (race $\times$ each covariate) in assessing potential racial differences in attitudes toward genetic testing in this context. A future, larger study is needed to fully explore these issues. Our stratified analyses, however, do offer new insight into important issues to address in these two subsets of smokers. Despite these limitations, we provide the

first nationally representative estimates of white and African American smokers' stated willingness to undergo genetic testing to guide smoking treatment in the USA, and factors influencing smokers' willingness.

Conclusion

In this first national study assessing white and African American smokers' willingness to undergo genetic testing in order to be matched to optimal smoking cessation treatment, we found that three-quarters of smokers report willingness to undergo testing if it were offered by their physician, with significantly higher rates of endorsement among African American smokers. However, we also found low rates of past pharmacotherapy use and low assessment of the importance of medication in influencing a smoker's ability to quit among this same group of smokers. These conflicting views suggest that understanding why so few smokers use pharmacotherapy may be key to the success of emerging PGx treatment strategies for smoking.

Ultimately, there are many potential barriers to clinical integration of PGx treatment for smoking that need to be addressed. These include providers' readiness and capacity to deliver such care, adequate reimbursement for these new services, patients' willingness to participate in testing and follow treatment recommendations, and affordable options for obtaining recommended medications. In this report, we focus on patients' willingness to undergo genetic testing in order to be matched to optimal treatment, smokers' attitudes and prior experience using pharmacotherapy, and the implications of the misalignment between these two factors for the diffusion of PGx medicine. Effective translation of PGx treatment to smoking seems more likely to hinge on smokers' willingness to use medication to help them quit than their willingness to undergo genetic assessment in the first place. The process of translating improved PGx treatment strategies into practice may be more complicated than once thought. Now is the time to identify and address barriers to successful translation of new, more effective treatment strategies for smoking into clinical practice so that the full potential of PGx advances in treatment can be realized for all.

Future perspective

Emerging research may lead to individually tailoring smoking cessation treatment – matching patients to the particular pharmacotherapy most likely to work for them – in order to improve quit rates. Based on recent research and studies underway, we anticipate that PGx treatment for smoking may become available within the next 5–8 years. In previous work, we addressed barriers to translation related to physician readiness and capacity to deliver PGx treatment for smoking in primary care settings [2,70–74]. In this report, we focus on several potential 'bumps along the road' in translating emerging PGx treatment strategies into clinical practice and improved health outcomes. Smokers' resistance to using medication to help them quit smoking remains a major barrier to translation. Overcoming the hurdle of winning patients' trust with respect to undergoing genetic testing to tailor treatment will be of no value unless smokers are willing to then use the medications recommended based on test results in the quit attempt. Developing effective communication and education strategies that address these underlying barriers to pharmacotherapy use among smokers will be essential to improving outcomes and reducing the burden of smoking on population health. As this emerging PGx application to tailor smoking treatment becomes routinely available, data on the actual increase in quit rates made possible by tailored treatment may motivate more smokers to attempt quitting and be willing to use medication in doing so. The magnitude of improvement possible through tailored treatment and how effectively this is communicated to smokers can be expected to affect take-up rates.

Communication strategies may therefore also be needed to help smokers fully understand the benefits of PGx treatment [23].

Further research is needed, in particular, to understand African American smokers' lower rates of pharmacotherapy use. Unless effective strategies for addressing low pharmacotherapy use among African American smokers are developed, the dissemination of PGx strategies for smoking cessation are likely to exacerbate already dramatic racial disparities in smoking-related illnesses. Finally, our study suggests that spiritual/religious beliefs play a significant role in determining smokers' willingness to use PGx treatment strategies for smoking cessation. Understanding the role of spirituality in determining pharmacotherapy use and harnessing this information to develop more effective outreach and education efforts that meet the needs of subsets of smokers, remains an important, unexplored area for future research.

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Executive summary

- The successful translation of emerging pharmacogenomic treatment to nicotine addiction will require that patients are willing to undergo genetic testing in order to be matched to treatment and willing to use medications indicated by test results. This study of patients' willingness to participate in tailored smoking cessation treatment, if offered by their physician, highlights several patient-centered challenges to successful clinical integration.
- In the first national study of smokers' willingness to use pharmacogenomic treatment strategies in the USA, we found that 77% of smokers were willing to undergo genetic testing to be matched to optimal treatment, despite few respondents ever having used pharmacotherapy in a previous quit attempt and low ratings of the importance of medication and counseling in determining a person's ability to quit.
- Successful pharmacogenomic translation requires attending not only to patients' willingness to undergo genetic testing, but perhaps even more to smokers' willingness to use medications indicated by test results.
- In multivariate analyses, smokers who rated medications and counseling as very important in determining a smoker's ability to quit were significantly more likely to state a willingness to undergo genetic testing, as were African American smokers. Those rating 'having God's help' as an important factor influencing one's ability to quit were significantly less willing to undergo genetic testing. Understanding the effect of spirituality/religiosity on attitudes towards genetic testing and using medication to quit is an important area for future investigation.

Table 1

Description of survey items included in the analysis.

Survey items	Response categories
<i>Willingness to undergo genetic testing</i>	
If your doctor had a genetic test that could tell you the best medication to help you quit smoking, would you want your doctor to test you and give you a recommendation based on the information in your genes?	Yes/maybe/no/don't know
<i>Intention to quit</i>	
Are you seriously thinking of quitting smoking?	Yes/no/don't know/NA
<i>Nicotine dependence</i>	
How soon after you wake up in the morning do you smoke your first cigarette?	Within 5 min after you wake up/between 6 and 30 min/between 31 and 60 min/after 60 min
<i>Prior pharmacotherapy use</i>	
Have you ever used any smoking cessation medication to help you quit smoking?	Yes/no/don't know/NA
<i>Importance of each of the following influences on a person's ability to quit smoking</i>	
Would you say using medications or smoking cessation counseling is	Very important/somewhat important/not very important/not at all important/don't know/NA
Would you say willpower is	Very important/somewhat important/not very important/not at all important/don't know/NA
Would you say having God's help is	Very important/somewhat important/not very important/not at all important/don't know/NA
Would you say having friends or family who support the attempt to quit is	Very important/somewhat important/not very important/not at all important/don't know/NA
<i>Worry about misuse of genetic information by insurance companies</i>	
Are you worried that once a person is identified as having a certain gene, the information will be used in some way by insurance companies to make it hard for a person to get health insurance or make them pay more for health insurance?	Yes/no/don't know/NA
<i>Insurance coverage</i>	
Do you have any kind of healthcare coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare?	Yes/no/don't know/NA

HMO: Health Maintenance Organization; NA: Not applicable.

Table 2

Characteristics of respondents (392 current smokers).

Characteristic	All (%); n=392	African American (%); n = 189	White (%); n = 203	p-value *
<i>Sex</i>				
Female	43.3	37.3	44.0	0.6516
Male	56.7	62.7	56.0	
<i>Age</i>				
More than 45 years	36.2	29.1	37.1	0.5070
Between 18 and 45 years	63.8	70.8	62.9	
<i>Education</i>				
Some college or more	56.8	55.9	56.9	0.9467
High school or less	43.2	44.1	43.1	
<i>Household income</i>				
Over 20,000	74.7	43.2	78.6	0.0125**
20,000 or less	25.3	56.8	21.4	
<i>Self-reported religiosity</i>				
Very religious	21.2	30.0	20.1	0.3957
Moderately/slightly/not religious	78.2	70.0	79.9	
<i>Self-reported health status</i>				
Excellent/very good	55.3	63.9	54.2	0.4535
Good/fair/poor	44.7	36.1	45.8	
<i>Have insurance coverage</i>				
Yes	72.8	49.4	75.6	0.0933
No	27.2	50.6	24.4	

* Reported p-values reflect the results of the Rao–Scott χ^2 test.

** Significant at 5% confidence level.

Note: percentages do not total 100 due to weighted analyses. The average numbers reported in 'All' columns are not simply weighted average of whites and African Americans; each observation in our sample had a distinct probability weight, which has been incorporated throughout our analysis using SAS® (SAS Institute Inc. NC, USA) procedures.

Table 3

Participants' responses to survey items.

Question and response	All (%); n = 392	African American (%); n = 189	White (%); n = 203	p-value*
<i>Willingness to undergo genetic testing</i>				
Yes	77.0	90.6	75.4	0.0416**
No/maybe/don't know	23.0	9.4	24.6	
<i>Serious intention to quit</i>				
Yes	79.3	88.7	78.2	0.1862
No/don't know	20.7	11.3	21.8	
<i>Time to first cigarette in the morning</i>				
Less than 5 min	25.0	27.9	24.6	0.7790
After 30 min	75.0	72.1	75.4	
<i>Ever used medication for smoking cessation</i>				
Yes	54.0	32.2	56.6	0.0980
No	46.0	67.8	43.4	
<i>Ever used counseling for smoking cessation</i>				
Yes	18.6	11.7	19.3	0.4181
No	81.4	88.3	80.7	
<i>Influence of medications/counseling on ability to quit</i>				
Very important	38.7	69.9	34.9	0.0034***
Somewhat/not very/not at all important	61.3	30.1	65.1	
<i>Influence of willpower on ability to quit</i>				
Very important	92.2	95.8	91.8	0.2382

Question and response	All (%); n = 392	African American (%); n = 189	White (%); n = 203	p-value*
Somewhat/not very/not at all important	7.8	4.2	8.1	
<i>Influence of having God's help on ability to quit</i>				
Very important	66.2	87.5	63.6	0.0328**
Somewhat/not very/not at all important	34.7	12.5	36.4	
<i>Influence of having friends or family who support the attempt to quit</i>				
Very important	77.8	90.3	76.3	0.0659
Somewhat/not very/not at all important	22.2	9.7	23.7	
<i>Worry about misuse of genetic information by insurance companies</i>				
Yes	55.4	45.4	56.6	0.4932
No/maybe/don't know	44.6	54.6	43.4	

* Reported p-values reflect the results of Rao-Scott χ^2 test.

** Significant at 5% confidence level.

*** Significant at 1% confidence level.

Note: percentages do not total 100 due to weighted analyses. The average numbers reported in 'All' columns are not simply weighted average of whites and African Americans; each observation in our sample had a distinct probability weight, which has been incorporated throughout our analysis using SAS[®] procedures.

Table 4

Estimated model with 'willingness for genetic testing' as the dependent variable.

Parameter	OR (95% CI)			Interaction between African American race and covariates [†]	p-value of interaction term
	All (n = 392)	African American (n = 189)	White (n = 203)		
<i>Serious intention to quit</i>					
Yes	1.47(0.25–8.61)	1.49(0.032–7.04)	1.57(0.22–11.27)	0.95	0.9628
No/don't know	Ref	Ref	Ref		
<i>How soon after you wake up do you smoke</i>					
Less than 5 min	3.59(0.56–23.00)	1.45(0.40–5.31)	3.87(0.48–31.04)	0.38	0.4157
After 5 min	Ref	Ref	Ref		
<i>Ever used medication for smoking cessation</i>					
Yes	2.70(0.66–11.07)	4.20(0.85–20.83)	2.72(0.62–11.90)	1.55	0.6799
No	Ref	Ref	Ref		
<i>Influence of medication/counseling on ability to quit</i>					
Very important	8.94(1.86–43.06)**	15.50(3.02–79.48)**	8.08(1.47–44.53)*	1.97	0.6222
Somewhat/not very/not at all important	Ref	Ref	Ref		
<i>Influence of willpower on ability to quit</i>					
Very Important	0.76(0.13–4.36)	1.42(0.10–19.72)	0.71 (0.11–4.43)	1.93	0.5165
Somewhat/not very/not at all important	Ref	Ref	Ref		
<i>Influence of having God's help on ability to quit</i>					
Very important	0.11 (0.02–0.71)*	1.36(0.28–6.72)	0.10(0.01–0.73)*	13.90	0.0415
Somewhat/not very/not at all important	Ref	Ref	Ref		
<i>Influence of having friends or family who support the attempt to quit</i>					
Very important	2.80(0.58–13.55)	2.75(0.61–12.50)	2.92(0.53–16.15)	0.94	0.9562
Somewhat/not very/not at all important	Ref	Ref	Ref		
<i>Sex</i>					
Female	3.26(0.80–13.24)	2.80(0.85–9.22)	3.42(0.77–15.16)	0.82	0.8391
Male	Ref	Ref	Ref		
<i>Age</i>					
More than 45 years	0.62 (0.17–2.29)	1.02(0.30–3.49)	0.61 (0.15–2.48)	1.67	0.5884
Between 18 and	Ref	Ref	Ref		

Parameter	OR (95% CI)			Interaction between African American race and covariates [†]	p-value of interaction term
	All (n = 392)	African American (n = 189)	White (n = 203)		
45 years					
Race					
African American	3.80(1.09–13.22)*	–	–	–	–
White	Ref				
Statistics					
Likelihood ratio (p-value for H0: $\beta = 0$)	16,034,575 (<0.0001)	998,066 (<0.0001)	14,590,028 (<0.0001)	–	–
Wald statistics (p-value for H0: $\beta = 0$)	31.9(0.0004)	22.13(0.0084)	23.66(0.0049)	–	–
C-statistic	0.68	0.71	0.73	–	–

* p < 0.1.

** p < 0.05.

[†] African American and white races have been dummy coded as 1 and 0, respectively, in the interaction model.

OR: Odds ratio; Ref: Variable levels that have been used as reference when calculating odds ratios.