



Published in final edited form as:

J Health Commun. 2016 ; 21(Suppl 1): 58–68. doi:10.1080/10810730.2016.1144661.

Relationships Between Health Literacy and Genomics-Related Knowledge, Self-Efficacy, Perceived Importance, and Communication in a Medically Underserved Population

Kimberly A. Kaphingst, ScD^{a,b}, Melvin Blanchard, MD^c, Laurel Milam, MA^d, Manusheela Pokharel, MS^b, Ashley Elrick, MA^b, and Melody S. Goodman, PhD^d

^aHuntsman Cancer Institute, University of Utah, Salt Lake City, UT

^bDepartment of Communication, University of Utah, Salt Lake City, UT

^cDepartment of Medicine, Washington University School of Medicine, St. Louis, MO

^dDivision of Public Health Sciences, Washington University School of Medicine, St. Louis, MO

Abstract

The increasing importance of genomic information in clinical care heightens our need to examine how individuals understand, value, and communicate about this information. Based on a conceptual framework of genomics-related health literacy, we examined whether health literacy was related to knowledge, self-efficacy, and perceived importance of genetics and FHH and communication about FHH in a medically underserved population. The analytic sample was comprised of 624 patients at a primary care clinic at a large urban hospital. About half of participants (47%) had limited health literacy; 55% had no education beyond high school and 58% were Black. In multivariable models, limited health literacy was associated with lower genetic knowledge ($\beta=-0.55$; $SE=0.10$, $p<.0001$), lower awareness of FHH ($OR=0.50$; 95% $CI=0.28,0.90$, $p=.020$), greater perceived importance of genetic information ($OR=1.95$; 95% $CI=1.27,3.00$, $p=.0022$) but lower perceived importance of FHH information ($OR=0.47$; 95% $CI=0.26,0.86$, $p=.013$), and more frequent communication with a doctor about FHH ($OR=2.02$; 95% $CI=1.27,3.23$, $p=.0032$). The findings highlight the importance of considering domains of genomics-related health literacy (e.g., knowledge, oral literacy) in developing educational strategies for genomic information. Health literacy research is essential to avoid increasing disparities in information and health outcomes as genomic information reaches more patients.

Introduction

Genomic information is playing an increasingly important role in clinical care and public health initiatives. Whole genome and exome sequencing are already being used for clinical purposes (Biesecker & Green, 2014; Guttmacher, McGuire, Ponder, & Stefansson, 2010), and sequencing is likely to become more important to patient care (Pasche & Absher, 2011) as advances in technology will mean greater availability of patients' individual genomic

information (Biesecker & Green, 2014; Mardis, 2008). Genomic information in the form of family health history (FHH) is also critical to improving individuals' health (Guttmacher, Collins, & Carmona, 2004). Family history is an important contributing risk factor for many common, chronic diseases, reflecting shared genetic, behavioral, and environmental risk (Yoon et al., 2004; Yoon, Scheuner, Jorgensen, & Khoury, 2009). Assessment of FHH has been recognized as an important tool in disease prevention efforts (Valdez, Yoon, Qureshi, Green, & Khoury, 2010). It is therefore critical to examine how individuals understand and value FHH and genetic information and communicate about FHH.

Health literacy may be an important factor affecting communication about genomic information (Hurle et al., 2013; Lea, Kaphingst, Bowen, Lipkus, & Hadley, 2011). Although different definitions of health literacy exist, the Institute of Medicine (IOM) defined health literacy as the degree to which individuals can obtain, process, and understand the basic health information and services needed to make appropriate health decisions (Nielsen-Bohlman, Panzer, Kindig, eds, 2004). The IOM operationalized health literacy as having the following components: conceptual and cultural knowledge; oral literacy (listening and speaking skills); print literacy (reading and writing skills); and numeracy (quantitative skills) (Nielsen-Bohlman et al., 2004). Prior research has shown that individuals with limited health literacy have, on average, less health-related knowledge, increased incidence of chronic disease, lower utilization of preventive health services, and poorer self-reported health (Berkman et al., 2011; Nielsen-Bohlman et al., 2004). Studies have also found that health literacy impacts provider-patient communication (Schillinger, Bindman, Wang, Stewart, & Piette, 2004; Schillinger et al., 2003; Williams, Davis, Parker, & Weiss, 2002). However, less is known about how health literacy impacts knowledge, skills, and communication in the domain of genomics.

Prior studies have found substantial gaps in genetics-related knowledge in the general public (Lea et al., 2011). Qualitative research has shown that although individuals may be familiar with genetics-related terms, they have limited understanding of the underlying concepts (Catz et al., 2005; Lanie et al., 2004; Mesters, Ausems, & De Vries, 2005). Results from larger quantitative studies support this conclusion. In a telephone survey conducted with 1009 adults, Molster, Charles, Samanek, & O'Leary (2009) found that although most respondents were aware of the connection between genes, inheritance and disease risk, significantly fewer understood the biological mechanisms underlying these relationships. Haga et al. (2013) found that 300 adults from the general public had higher knowledge about inheritance and causes of disease compared with biological knowledge about genes, chromosomes, and cells. These prior findings therefore suggest that individuals in the general public may have greater knowledge related to FHH and inheritance than knowledge about genetics concepts or genetic testing, although research conducted among medically underserved populations is still limited.

In studies examining genetic or genomic knowledge, lower educational attainment is consistently associated with lower knowledge (Carlsbeek, Morren, Bensing, & Rijken, 2007; Haga et al., 2013; Henneman, Timmermans, & van der Wal, 2004; Ishiyama et al., 2008; Jallinoja & Aro, 1999; Molster et al., 2009; Rose, Peters, Shea, & Armstrong, 2005). Older age has also been associated with lower knowledge (Ashida et al., 2011; Carlsbeek et al.,

2007; Henneman et al., 2004; Ishiyama et al., 2008; Jallinoja & Aro, 1999; Molster et al., 2009; Rose et al., 2005). Because educational attainment and age are significantly associated with health literacy in most studies (Kutner, Greenberg, Jin, Paulsen, & White, 2006; Nielsen-Bohlman et al., 2004; Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005), these findings suggest that health literacy may also be associated with knowledge about genetics and genomics. However, studies are needed to directly examine these associations.

Although the question of how health literacy affects communication of genetic or genomic information has received less attention than levels of genetic knowledge in the public, a few prior studies have examined this issue. In a study conducted with 163 post-treatment breast cancer patients, Lillie et al. (2007) found that after reading written information about a genomic test individuals with lower health literacy had lower recall of the information and lower preference for active participation in decision making about the test. In a subsequent study, Brewer et al. (2009) found that health literacy impacted how women interpreted visual risk information about recurrence. In their work on oral communication, Erby, Roter, Larson, & Cho (2008) developed a genetics-related word recognition measure called the Rapid Estimate of Adult Literacy in Genetics (REAL-G), based on a common, validated measure of general health literacy (Davis et al., 1993). The authors found that individuals with lower REAL-G scores had lower knowledge scores after viewing videotaped genetic counseling sessions, suggesting less learning from verbally presented genetic information (Erby et al., 2008). This team also found that more difficult oral language during a genetic counseling session was associated with less satisfaction (Roter, Erby, Larson, & Ellington, 2007). These prior studies have therefore indicated that individuals with limited health literacy may understand less from written and oral communication about genomic information and may engage less in discussions with health care providers about the information. However, more research is needed to better understand how health literacy impacts communication about FHH, as well as individuals' confidence in their ability to communicate about genomics topics (i.e., their self-efficacy). Health literacy has been shown to affect self-efficacy (Bandura, 1986) in other domains of behavior (Osborn, Cavanaugh, Wallston, & Rothman, 2010; von Wagner, Semmler, Good, & Wardle, 2009; Wolf et al., 2007), but the effect of health literacy on communication self-efficacy needs further study. In addition, the existing research is limited because many of the studies in this area have included highly educated or predominantly white populations.

We therefore conducted a study in a medically underserved population to examine the association between health literacy and individuals' knowledge about genetics and FHH, perceived importance of genetics and FHH, self-efficacy to engage in communication about genetics and FHH, and communication about FHH. We examined perceived importance since this might encourage individuals to elaborate on a topic and communicate about it (Petty, Barden, & Wheeler, 2002). Based on the prior literature and our conceptualization of genomics-related health literacy (Hurle et al., 2013; Lea et al., 2011), we hypothesized that: (1) individuals with limited health literacy would have lower knowledge about genetics and FHH than those with adequate health literacy; (2) individuals with limited health literacy would have lower self-efficacy related to genetics and FHH than those with adequate health literacy; (3) individuals with limited health literacy would have less communication about

health and FHH than those with adequate health literacy; and (4) the association between health literacy and communication about FHH would be mediated by knowledge, self-efficacy, and perceived importance.

Methods

Setting

We conducted this study in the primary care clinic of a large urban hospital, the Center for Outpatient Health (COH) at Barnes-Jewish Hospital in St. Louis, MO, which serves as the site for ambulatory care training for a large internal medicine residency with about 150 residents. Resident trainees provide primary care to patients and have a continuous relationship with them over their three years of training. The COH serves a large and diverse patient population. In one year the clinic saw 16,907 unique patients, 64% of whom were Black and 30% were White. The majority of patients seen are female (67%), between 35–64 years of age (59%) and live in St. Louis City (46%) or the surrounding county (31%).

Participants

Participants were recruited between July 2013 and April 2014. Inclusion criteria were that participants be at least 18 years of age, a patient at the COH, and speak English. Visitors in the waiting rooms were approached by trained data collectors and asked to complete a survey in English. Surveys were administered on different days of the week and at different times of day throughout the recruitment period; data collectors approached all visitors in the waiting room during their shift. Participants were asked to complete a self-administered written questionnaire followed by a set of verbally administered measures. The latter component included the assessment of health literacy, as described below in the Measures section. Any participant could request that the written questionnaire was verbally administered. All participants completed a verbal consent process and then signed a written consent form before completing the survey. This study was approved by the Human Research Protection Office at the Washington University School of Medicine.

Approximately 26% ($n=1,111$) of those approached were ineligible to participate in the study because they were not patients, did not speak English, or had previously taken the survey. Among eligible participants, 44% ($n=1380$) agreed to participate and completed the consent process. Of these 1380 patients, 975 (71%) completed the written questionnaire without substantial missing data (i.e., completed at least 75% of items). Although 602 completed all verbally administered measures, 624 completed the health literacy measure and were included in the analytic sample (see Figure 1). Participants completed the questionnaires and verbally-administered measures while waiting for their appointment. The primary reason for incomplete surveys was inadequate time before the clinic was ready to begin the patient evaluation. There were no significant differences in gender between individuals with complete surveys and those with incomplete surveys; a higher proportion of those not completing the survey were African Americans (75%) compared with those who completed the survey (63%; $p=0.003$). Survey respondents were similar to the underlying COH patient population with respect to gender, age, race, and location of residence.

Measures

Health literacy—The primary predictor, health literacy, was assessed using the Rapid Estimate of Adult Literacy in Medicine – Revised (REALM-R), a validated word recognition measure in which the participant is asked to pronounce eight health-related words (Bass, Wilson, & Griffith, 2003; Davis et al., 1993). The REALM-R was verbally administered following standard procedures. We summed the number of words pronounced correctly. For analysis, patients who pronounced 7–8 words correctly were scored as having adequate health literacy and patients who pronounced 0–6 words correctly were scored as having limited health literacy (Agency for Healthcare Research and Quality, 2013).

Outcome measures—The outcome measures were assessed on the written questionnaire. We assessed *genetic knowledge* with an adapted version of the Genetic Knowledge Index (Furr & Kelly, 1999), which we have used in prior studies (McBride et al., 2009; McBride et al., 2008). Participants are asked five true/false questions and the number answered correctly is summed. We modeled genetic knowledge as a continuous score in analysis. We assessed knowledge of FHH as participants' prior *awareness of FHH*: "Before today, had you ever heard of a family health history?" (Kaphingst, Lachance, Gepp, D'Anna, & Rios-Ellis, 2011). We categorized responses as "yes" vs. "no/don't know" for analysis.

We assessed *genetic self-efficacy* (i.e., individuals' confidence in their ability to use genetic information) using a measure developed by Parrott, Silk, Krieger, Harris, & Condit (2004). Participants indicated the extent to which they agreed with each of the following statements on a five-point Likert-type scale from strongly disagree to strongly agree (i.e., "I can explain genetic issues to people"). Scores on these items were averaged and modeled as a continuous variable in analysis (Cronbach's $\alpha = 0.86$). *FHH self efficacy* (i.e., participants' confidence in their ability to communicate about FHH with their family) was assessed using one item: "How sure are you that you could discuss family health history with members of your family?" (Kaphingst et al., 2011). We compared those who answered "very sure" to those who answered "somewhat" or "not at all sure" in analysis.

We used one item to assess the perceived *importance of genetic information*: "How important is it to you to learn more about how your genes, that is the characteristics that are passed from one generation to the next, affect your chance of getting certain health conditions?" Participants responded to this item on a five-point scale from "not at all important" to "very important." Scores were dichotomized as very important vs. other categories for analysis. We measured perceived *importance of FHH* with the item "It is important for my own health to know if diseases like cancer, diabetes, stroke, or heart disease run in my family," which had a five-point response scale from "strongly disagree" to "strongly agree" (Yoon et al., 2004). We dichotomized participants' responses as strongly/somewhat agree vs. neither agree nor disagree/somewhat disagree/strongly disagree for analysis.

We examined three different communication behaviors. Communication with family about FHH and communication with a doctor about FHH were assessed with two separate items: "I talk with family members about our family health history" and "I talk with a doctor about my family health history," respectively (Kaphingst, Goodman, et al., 2012). Both items were

answered on a scale from “not at all often” to “very often” and were dichotomized as “very” vs. “somewhat/not very/not at all” often in analysis. We assessed communication about health with friends or family with the item: “How often do you talk to friends or family members about health,” which had the same response scale and was dichotomized in the same way (National Cancer Institute, 2015).

Covariates—We collected data on age, gender, race/ethnicity, educational attainment, marital status, self-reported health, and self-reported family history and personal history of heart disease, diabetes, and cancer. We also examined three psychosocial covariates. We assessed social influences with the item “The people who mean the most to you think you should learn more about ways you can keep yourself healthy,” which had a seven-point response scale from “strongly disagree” to “strongly agree” (Hay et al., 2012). We assessed perceived control using three items (i.e., “There’s a lot I can do to prevent heart disease”), which had five-point response scales from “strongly disagree” to “strongly agree” (Wang et al., 2009). We also assessed behavioral and genetic causal beliefs related to heart disease, diabetes, and cancer using six items (i.e., “How much do you think health habits such as diet, exercise, and smoking determine whether or not a person will get heart disease”), which had a five-point response scale from “not at all” to “completely” (McBride et al., 2009; McBride et al., 2008).

Data Analysis

Data were analyzed using SAS/STAT® Software Version 9.4 for Windows (Cary, NC); statistical significance was assessed as $p < 0.05$. In this analysis, the sample was limited to those who completed the health literacy measure ($n = 624$). We examined descriptive statistics for all variables. We examined the bivariate association between REALM-R score and each outcome using chi-squared tests for categorical outcomes and ANOVA or t-tests for continuous outcomes. We then created multivariable logistic or linear regression models to examine the association between health literacy and outcomes that had a bivariate association with $p < .10$, controlling for potential confounders (Hidalgo & Goodman, 2013). All multivariable models included age, gender, race, and marital status. Age was modeled continuously. Race/ethnicity was categorized as non-Hispanic White; non-Hispanic Black; or other, and marital status was categorized as married or partnered; divorced, separated, or widowed; or never married. We tested possible covariates for entry into the model and retained those with a $p < .10$. We examined mediation using the standard three-step approach for testing mediation in regression models described by Baron & Kenny (1986).

Results

About half of participants had limited health literacy (47%, see Table 1). Less than half had completed any college (45%), 38% had a high school degree or GED and 17% had not completed high school. More than half (58%) self-identified as Black. The mean age was 51 years. Two-thirds (67%) were female and about 24% were married or partnered. A majority described themselves as being in “fair” or “poor” health (62%); 65% had been diagnosed with hypertension and 41% with diabetes. The majority reported having a family history of diabetes (76%), cancer (66%), and heart disease (65%).

On average, participants answered 3 of the 5 genetic knowledge questions correctly ($M=3.5$, $SD=1.1$, see Table 2). Most were aware of FHH (87%). Participants had a moderate degree of genetic self-efficacy on average ($M=3.2$, $SD=1.1$); the majority were very sure that they could talk with their family members about FHH (75%). Over half (54%) rated genetic information as very important, and 75% rated FHH information as very important. About half reported talking very frequently about health with friends and family (50%), although a smaller proportion reported talking very frequently about FHH with their family (27%) or their doctor (25%).

In bivariate analysis, we found a number of significant relationships between health literacy and hypothesized outcome variables. Individuals with limited health literacy had significantly lower genetic knowledge ($t=9.3$, $df=482.5$, $p<.0001$) and awareness of FHH ($\chi^2=21.7$, $p<.0001$) than those with adequate health literacy (see Table 3). Participants with limited health literacy were more likely to perceive genetic information as very important ($\chi^2=9.7$, $p=.0018$) but less likely to perceive FHH as very important ($\chi^2=9.4$, $p=.0022$) than those with adequate health literacy. For communication, individuals with limited health literacy were significantly more likely to report talking about FHH very often with both their families ($\chi^2=5.3$, $p=.021$) and doctors ($\chi^2=14.1$, $p=.0002$). There was a trend toward those with limited health literacy having lower self-efficacy about FHH than those with adequate health literacy ($\chi^2=3.6$, $p=.057$).

In multivariable analysis, we found that health literacy was significantly associated with both knowledge variables (see Table 4). Participants with limited health literacy had significantly lower genetic knowledge than those with adequate health literacy ($\beta=-0.55$; $SE=0.10$, $p<.0001$). In this model, older participants had significantly lower genetic knowledge than younger participants ($\beta=-0.01$; $SE=0.0042$, $p=.0050$), and Black participants had lower genetic knowledge than White participants, on average ($\beta=-0.30$; $SE=0.10$, $p=.0044$). Individuals with limited health literacy were less likely to be aware of FHH than those with adequate health literacy ($OR=0.50$; 95% $CI=0.28, 0.90$, $p=.02$). In this model, men were less likely to be aware of FHH than women ($OR=0.32$; 95% $CI=0.19, 0.55$, $p<.0001$).

Health literacy was also significantly associated with perceived importance of both genetic and FHH information in multivariable models, but these associations had different directions (see Table 5). Individuals with limited health literacy were more likely to think that learning genetic information was very important compared to those with adequate health literacy ($OR=1.95$; 95% $CI=1.27, 3.00$, $p=.0022$). In this model, men were less likely to think learning genetic information was very important compared with women ($OR=0.59$; 95% $CI=0.39, 0.89$, $p=.013$), and compared to White participants, both Black participants ($OR=1.74$; 95% $CI=1.14, 2.65$, $p=.010$) and those of another race/ethnicity ($OR=2.48$; 95% $CI=1.14, 5.38$, $p=.022$) were more likely to rate genetic information as very important. In contrast, individuals with limited health literacy were less likely to think that FHH information was very important compared to those with adequate health literacy ($OR=0.47$; 95% $CI=0.26, 0.86$, $p=.013$). In this model, individuals who reported having a family history of cancer were more likely to think that FHH information was very important compared to those without this family history ($OR=1.75$; 95% $CI=1.01, 3.04$, $p=.045$).

Of the communication outcomes, frequent communication with a doctor about FHH was significantly associated with health literacy in a multivariable model. Individuals with limited health literacy were more likely to report discussing FHH with their doctor very often compared to those with adequate health literacy (OR=2.02; 95% CI=1.27, 3.23, $p=.0032$). In this model, men were less likely to report frequently discussing FHH with a doctor compared with women (OR=0.48; 95% CI=0.29, 0.78, $p=.0030$).

We did not find significant associations between health literacy and self-efficacy related to genetics or FHH, communication about health, or communication with family about FHH in multivariable models. Because self-efficacy was not associated with health literacy, we did not test whether self-efficacy was a mediator between health literacy and communication with a doctor about FHH. We tested whether genetic knowledge or perceived importance of genetic and FHH information mediated this association, but did not find evidence of mediation, either because the variable was not associated with the outcome (perceived importance of FHH) or adding the variable did not change the effect of health literacy in a multivariable model (genetic knowledge, perceived importance of genetic information).

Discussion

In this study, we examined the associations between health literacy and individuals' knowledge about genetics and FHH, self-efficacy to communicate about genetics and FHH, perceived importance of genetics and FHH, and communication about health and FHH in a medically underserved population. We found support for our first hypothesis, that individuals with limited health literacy would have lower knowledge about genetics and FHH. These results, in addition to the consistent findings described in the Introduction that individuals with lower educational attainment have lower genetic knowledge, suggest that there is a strong need to examine why differences exist in knowledge about genomics by both health literacy and education. Prior research has also found disparities in awareness of FHH across subgroups (Yoon et al., 2004), but we do not yet understand why these differences exist. Other researchers have suggested that differences in knowledge across population subgroups might be due to differences in exposure to genetic information (Hughes et al., 1997), differences in information sources (Catz et al., 2005; Parrott et al., 2004), or different levels of formal education about genetics (Furr & Kelly, 1999), but empirical research is limited.

In addition, the finding that individuals with limited health literacy have lower genetic knowledge suggests that it is critical to consider health literacy in developing approaches to educating individuals about genomics. Currently, the way in which this information is presented is likely to be too difficult for many adults (Lachance, Erby, Ford, Allen, & Kaphingst, 2010; Wang, Gallo, Fleisher, & Miller, 2011). Some prior studies have examined various educational approaches for genetic and genomic information, for example, education during genetic counseling (Edwards et al., 2008; Kelly et al., 2004; Lerman et al., 1997), computer-based educational approaches (Green et al., 2004; Meilleur & Littleton-Kearney, 2009), and culturally-tailored educational approaches led by lay health advisors (Kaphingst et al., 2011). However, these studies have not investigated whether the effectiveness of different educational approaches varies by health literacy. A number of researchers have

suggested genomics educational approaches based on the health literacy literature (Kaphingst & McBride, 2010; Lea et al., 2011; Syurina, Brankovic, Probst-Hensch, & Brand, 2011), but research is limited. Future studies should incorporate theoretical and conceptual work that has been conducted to identify relevant components of genomic knowledge that inform health decision making (Decruyenaere, Evers-Kiebooms, Welkenhusen, Denayer, & Claes, 2000; Smerecnik, Mesters, de Vries, & de Vries, 2008). In particular, the conceptual distinction between awareness knowledge, how-to knowledge, and principles knowledge related to genetics developed by Smerecnik et al. (2008) could allow us to identify and focus educational efforts on the most salient aspects of genomics for improving health. Such studies could also examine what types of genomic knowledge are relevant for an individual at different times in the lifespan (Condit, 2010; Syurina et al., 2011).

Our second hypothesis was not supported; we found no significant association between health literacy and self-efficacy related to genetics and FHH. This could be for a number of reasons. We may need to measure different aspects of communication self-efficacy related to genetics and FHH. It is also possible that health literacy is related to actual communication behaviors as suggested by prior literature (Schillinger et al., 2004), but not to individuals' confidence in their ability to perform these communication behaviors. A recent study found that direct-to-consumer genetic testing lowered genetic self-efficacy, and the authors suggest that this might reflect an appropriate reevaluation by consumers in response to receiving complex genetic information (Carere, Kraft, Kaphingst, Roberts, & Green, 2015). The relationship between health literacy and genomics self-efficacy may be challenging to investigate because of the unfamiliarity of this complex topic for many individuals.

For our third hypothesis, we found an association between health literacy and communication about FHH, although not in the hypothesized direction since individuals with limited health literacy were more likely to report frequent communication with a doctor about FHH. We hypothesize that this unexpected result may be due in part to more frequent health care provider visits among those with limited health literacy, since there is some evidence that patients with limited health literacy have greater health care utilization (Berkman et al., 2011). For our fourth hypothesis, the variables that we proposed (i.e., knowledge, self-efficacy, perceived importance) did not act as mediators in the relationship between health literacy and communication behaviors. A priority for future research will be to examine the pathways underlying the relationship between health literacy and communication about genomic information (Williams et al., 2002).

Interestingly, health literacy was not associated with communication about FHH with family members or communication about health with friends and family. While we examined the frequency of communication because researchers have emphasized the importance of ongoing conversations about FHH to generate and maintain an accurate record (Acheson, Weisner, Zyzanski, Goodwin, & Stange, 2000; Medalie, Zyzanski, Langa, & Stange, 1998), it may be that health literacy is related to the quality of provider-patient communication rather than the frequency of this communication (Schillinger et al., 2004; Schillinger et al., 2003; Williams et al., 2002). Observational and longitudinal studies that investigate provider and patient communication behaviors by level of health literacy could help to disentangle

this issue and examine how quality and quantity of communication affect downstream behaviors. It is also important to note that we did not measure frequency of communication about genetics with a doctor or with family members, because genetic testing is not yet common among medically underserved patients. As genomic information diffuses to an increasingly greater proportion of the population (McBride et al., 2010), this will be an important issue to examine.

Our data highlighted that patients with limited health literacy did not place equal value on genetic and FHH information. We found that these patients were more likely to view genetic information as very important, but less likely to view FHH information as very important, compared to those with adequate health literacy. This finding suggests that messages about the importance and usefulness of FHH may not be reaching individuals with limited health literacy, or that they may not understand these messages, and that we need to develop new ways of communicating this information to reach a broader population (Kaphingst et al., 2011). Our prior work has indicated that individuals with limited health literacy may be more interested in receiving an assessment of genomic risk based on genetic testing than those with higher health literacy (Kaphingst et al., 2015), and other researchers have found that genetics-related literacy may impact how patients evaluate the utility of genetic testing (Hooker et al., 2014). Assessing knowledge of the benefits of genetic technologies separately from knowledge of the limitations may be important to understand the association between health literacy and knowledge (Kaphingst, Facio, et al., 2012).

The findings from this study should be interpreted in light of its limitations. Because we conducted the study in a busy primary care clinic, we were not always able to complete the verbally-administered health literacy measure with those who agreed to participate, reducing our analytic sample size. In order to reduce patient burden we were only able to ask a limited number of questions for each construct, and some constructs were assessed only with a single item. The REALM-R only assesses a part of the construct of health literacy, and future studies are needed to examine how other domains (e.g., oral literacy, numeracy) affect these outcomes. We did not make statistical adjustment for multiple comparisons. We were not able to assess other variables that might impact provider-patient communication behaviors, such as the quality of the provider-patient relationship. We were not able to examine related questions such as who initiated communication about FHH and whether participants felt that the frequency of communication about FHH met their needs. The findings may not generalize to other patient populations, particularly patients from other racial and ethnic groups or younger patients. Since we have previously found that age is related to genetic knowledge and beliefs (Ashida et al., 2011), the research questions on which this study focused are important to investigate in other patient populations. Because many patients in this sample had already developed chronic conditions, they may have different communication behaviors about genomic information than a younger, healthy population. However, it is still important to examine communication behaviors among older adults, as they are an important source of information about inherited risks within the family (Ashida et al., 2011).

Despite these limitations, this study added to the existing literature in a number of important ways. We investigated whether health literacy was related to a number of outcomes (i.e.,

knowledge, self-efficacy, perceived importance, communication) suggested by our conceptualization of genomics-related health literacy (Hurle et al., 2013; Lea et al., 2011) among a medically underserved patient population, an important group often overlooked in genetics-related research. We found support for some aspects of our framework. Health literacy was related to knowledge about genomic information and the reported frequency of communication with providers about FHH. Although further research is needed to investigate these effects and other types of provider-patient communication about genomics, the findings do suggest that the domains of knowledge and oral literacy are important aspects of genomics-related health literacy. We also found that individuals with limited health literacy placed greater value on genetic information than FHH information, despite the current greater usefulness of the latter for most individuals (Kaphingst et al., 2015; Valdez et al., 2010). This result highlights the need to investigate the underlying mechanisms further and develop messages regarding the importance of FHH for individuals with limited health literacy. As genomic information plays an increasingly important role in medicine and public health, health literacy research is critically necessary in order to avoid increasing existing health inequalities in information, services, and health outcomes (De Viron, Suggs, Brand, & Van Oyen, 2013; Hurle et al., 2013).

Acknowledgments

This study and the work of the project team was supported by the Barnes-Jewish Hospital Foundation, Siteman Cancer Center (National Cancer Institute, National Institutes of Health grant P30 CA91842), Washington University School of Medicine (WUSM), and the WUSM Faculty Diversity Scholars Program. KAK was supported by funding from the Huntsman Cancer Institute and University of Utah. The funding agreement ensured the authors' independence in designing the study, interpreting the data, writing, and publishing the report. We would like to thank the study participants, data collection and data entry team, Center for Outpatient Health Primary Care Clinic staff, administrators, and residents for their contributions to our work.

References

- Acheson LS, Weisner GL, Zyzanski SJ, Goodwin MA, Stange KC. Family history-taking in community family practice: Implications for genetic screening. *Genetics in Medicine*. 2000; 2(3): 180–185. [PubMed: 11256663]
- Agency for Healthcare Research and Quality. Rapid Estimate of Adult Literacy in Medicine-Revised, shorter version (REALM-R). 2013. from <http://www.ahrq.gov/professionals/quality-patient-safety/pharmhealthlit/realm-r.html>
- Ashida S, Goodman M, Pandaya C, Koehly LM, Lachance C, Stafford JD, Kaphingst KA. Age differences in genetic knowledge, health literacy, and causal beliefs for health conditions. *Public Health Genomics*. 2011; 14(4–5):307–316. [PubMed: 20829577]
- Bandura, A. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice Hall; 1986.
- Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*. 1986; 51:1173–1182. [PubMed: 3806354]
- Bass PF III, Wilson JF, Griffith CH. A shortened instrument for literacy screening. *Journal of General Internal Medicine*. 2003; 18(12):1036–1038. [PubMed: 14687263]
- Berkman, N., Sheridan, S., Donahue, K., Halpern, D., Viera, A., Crotty, K., ... Viswanathan, M. Evidence Report/Technology Assessment No 1999. Rockville, MD: Agency for Healthcare Research and Quality; 2011. Health Literacy Interventions and Outcomes: An Updated Systematic Review.
- Biesecker LG, Green RC. Diagnostic clinical genome and exome sequencing. *New England Journal of Medicine*. 2014; 370:2418–2025. [PubMed: 24941179]

- Brewer NT, Tzeng JP, Lillie SE, Edwards AS, Peppercorn JM, Rimer BK. Health literacy and cancer risk perception: implications for genomic risk communication. *Medical Decision Making*. 2009; 29:159–166.
- Carere D, Kraft P, Kaphingst KA, Roberts J, Green R. Consumers report lower confidence in their genetics knowledge following direct-to-consumer personal genomic testing. *Genetics in Medicine*. 2015 in press.
- Carlsbeek H, Morren M, Bensing J, Rijken M. Knowledge and attitudes towards genetic testing: a two year follow-up study in patients with asthma, diabetes mellitus and cardiovascular disease. *Journal of Genetic Counseling*. 2007; 16(4):493–504. [PubMed: 17318450]
- Catz DS, Green NS, Tobin JN, Lloyd-Puryear MA, Kyler P, Umemoto A, ... Wolman F. Attitudes about genetics in underserved, culturally diverse populations. *Community Genetics*. 2005; 8:161–172. [PubMed: 16113533]
- Condit C. Public understandings of genetics and health. *Clinical Genetics*. 2010; 77:1–9. [PubMed: 20092586]
- Davis TC, Long SW, Jackson RH, Mayeaux EJ, George RB, Murphy PW, Crouch MA. Rapid Estimate of Adult Literacy in Medicine: A shortened screening instrument. *Family Medicine*. 1993; 25:391–395. [PubMed: 8349060]
- De Viron S, Suggs LS, Brand A, Van Oyen H. Communicating genetics and smoking through social media: are we there yet? *Journal of Medical Internet Research*. 2013; 15(9):e198. [PubMed: 24018012]
- Decruyenaere M, Evers-Kiebooms G, Welkenhusen M, Denayer L, Claes E. Cognitive representations of breast cancer, emotional distress and preventive health behaviour: a theoretical perspective. *Psycho-Oncology*. 2000; 9:528–536. [PubMed: 11180588]
- Edwards A, Gray J, Clarke A, Dundon J, Elwyn G, Gaff C, ... Thornton H. Interventions to improve risk communication in clinical genetics: Systematic review. *Patient Education and Counseling*. 2008; 71:4–25. [PubMed: 18207694]
- Erby L, Roter D, Larson S, Cho J. The Rapid Estimate of Adult Literacy in Genetics (REAL-G): A means to assess literacy deficits in the context of genetics. *American Journal of Medical Genetics*. 2008; 146A:174–181. [PubMed: 18076116]
- Furr LA, Kelly SE. The Genetic Knowledge Index: Developing a standard measure of genetic knowledge. *Genetic Testing*. 1999; 3(2):193–199. [PubMed: 10464667]
- Green MJ, Peterson SK, Baker MW, Harper GR, Friedman LC, Rubinstein WS, Mauger DT. Effect of a computer-based decision aid on knowledge, perceptions, and intentions about genetic testing for breast cancer susceptibility: A randomized controlled trial. *JAMA*. 2004; 292:442–452. [PubMed: 15280342]
- Guttmacher AE, Collins FS, Carmona RH. The family history - More important than ever. *The New England Journal of Medicine*. 2004; 351(22):2333–2336. [PubMed: 15564550]
- Guttmacher AE, McGuire AL, Ponder B, Stefansson K. Personalized genomic information: Preparing for the future of genetic medicine. *Nature Reviews Genetics*. 2010; 11:161–165.
- Haga SB, Barry WT, Mills R, Ginsberg GS, Svetkey LP, Sullivan J, Willard HF. Public knowledge of and attitudes toward genetics and genetic testing. *Genetic Testing and Molecular Biomarkers*. 2013; 17(4):327–335. [PubMed: 23406207]
- Hay J, Kaphingst K, Baser R, Li Y, Alford SH, McBride CM. Skin cancer concerns, social influences, and genetic risk information-seeking in primary care. *Public Health Genomics*. 2012; 15(2):57–72. [PubMed: 21921576]
- Henneman L, Timmermans DRM, van der Wal G. Public experiences, knowledge and expectations about medical genetics and the use of genetic information. *Community Genetics*. 2004; 7:33–43. [PubMed: 15475669]
- Hidalgo B, Goodman M. Multivariate or multivariable regression? *American Journal of Public Health*. 2013; 103(1):39–40. [PubMed: 23153131]
- Hooker GW, Peay H, Erby L, Bayless T, Biesecker BB, Roter DL. Genetic literacy and patient perceptions of IBD testing utility and disease control: a randomized vignette study of genetic testing. *Inflammatory Bowel Diseases*. 2014; 20(5):901–908. [PubMed: 24691112]

- Hughes C, Gomez-Caminero A, Benkendorf J, Kerner J, Isaacs C, Barter J, Lerman C. Ethnic differences in knowledge and attitudes about BRCA1 testing in women at increased risk. *Patient Education and Counseling*. 1997; 32(1–2):51–62. [PubMed: 9355572]
- Hurle B, Citrin T, Jenkins JF, Kaphingst KA, Lamb N, Roseman J, Bonham VL. What does it mean to be genomically literate? National Human Genome Research Institute meeting report. *Genetics in Medicine*. 2013; 15:658–663. [PubMed: 23448722]
- Ishiyama I, Nagai A, Muto K, Tamakoshi A, Kokado M, Mimura K, ... Yamagata Z. Relationship between public attitudes toward genomic studies related to medicine and their level of genomic literacy in Japan. *American Journal of Medical Genetics*. 2008; 146A:1696–1706. [PubMed: 18546279]
- Jallinoja P, Aro AA. Knowledge about genes and heredity among Finns. *New Genetics and Society*. 1999; 18(1):101–110.
- Kaphingst K, McBride C. Patient responses to genetic information: Studies of patients with hereditary cancer syndromes identify issues for use of genetic testing in nephrology practice. *Seminars in Nephrology*. 2010; 30(2):203–214. [PubMed: 20347649]
- Kaphingst KA, Facio FM, Cheng MR, Brooks S, Eidem H, Linn A, ... Biesecker LG. Effects of informed consent for individual genome sequencing on relevant knowledge. *Clinical Genetics*. 2012; 82(5):408–415. [PubMed: 22694298]
- Kaphingst KA, Goodman M, Pandya C, Garg P, Stafford JD, Lachance C. Factors affecting frequency of communication about family health history with family members and doctors in a medically underserved population. *Patient Education and Counseling*. 2012; 88(2):291–297. [PubMed: 22197261]
- Kaphingst KA, Lachance CR, Gepp A, D'Anna LH, Rios-Ellis B. Educating underserved Latino communities about family health history using lay health advisors. *Public Health Genomics*. 2011; 14(4–5):211–221. [PubMed: 20051669]
- Kaphingst KA, Stafford JD, McGowan LDA, Seo J, Lachance CR, Goodman MS. Effects of racial and ethnic group and health literacy on responses to genomic risk information in a medically underserved population. *Health Psychology*. 2015; 34(2):101–110. [PubMed: 25622080]
- Kelly K, Leventhal H, Marvin M, Toppmeyer D, Baran J, Schwalb M. Cancer genetics knowledge and beliefs and receipt of results in Ashkenazi Jewish individuals receiving counseling for BRCA1/2 mutations. *Cancer Control*. 2004; 11(4):236–244. [PubMed: 15284715]
- Kutner, M., Greenberg, E., Jin, Y., Paulsen, C., White, S. The health literacy of America's adults: Results from the 2003 National Assessment of Adult Literacy. Washington, DC: National Center for Education Statistics; 2006.
- Lachance C, Erby LH, Ford BM, Allen VC, Kaphingst KA. Informational content, literacy demands, and usability of websites offering health-related genetic tests directly to consumers. *Genetics in Medicine*. 2010; 12(5):304–312. [PubMed: 20386454]
- Lanie AD, Jayaratne TE, Sheldon JP, Kardias SLR, Anderson ES, Feldbaum M, Petty EM. Exploring the public understanding of basic genetic concepts. *Journal of Genetic Counseling*. 2004; 13(4):305–320. [PubMed: 19736696]
- Lea DH, Kaphingst KA, Bowen D, Lipkus I, Hadley DW. Communicating genetic information and genetic risk: An emerging role for health educators. *Public Health Genomics*. 2011; 14(4–5):279–289. [PubMed: 20407217]
- Lerman C, Biesecker B, Berkendorf JL, Kerner J, Gomez-Caminero A, Hughes C, Reed MM. Controlled trial of pretest education approaches to enhance informed decision-making for BRCA1 gene testing. *Journal of the National Cancer Institute*. 1997; 89(2):148–157. [PubMed: 8998184]
- Lillie SE, Brewer NT, O'Neill SC, Morrill EF, Dees EC, Carey LA, Rimer BK. Retention and use of breast cancer recurrence risk information from genomic tests: the role of health literacy. *Cancer Epidemiology, Biomarkers and Prevention*. 2007; 16(2):249–255.
- Mardis ER. The impact of next-generation sequencing technology on genetics. *Trends in Genetics*. 2008; 24(3):133–141. [PubMed: 18262675]
- McBride CM, Alford SH, Reid RJ, Larson EB, Baxevanis AD, Brody LC. Characteristics of users of online personalized genomic risk assessments: Implications for physician-patient interactions. *Genetics in Medicine*. 2009; 11(8):582–587. [PubMed: 19606049]

- McBride CM, Bowen D, Brody LC, Condit CM, Croyle RT, Gwinn M, ... Valente TW. Future health applications of genomics: Priorities for communication, behavioral, and social sciences research. *American Journal of Preventive Medicine*. 2010; 38(5):566–561. [PubMed: 20409504]
- McBride CM, Hensley-Alford S, Reid RJ, Larson EB, Baxevanis AD, Brody LC. Putting science over supposition in the arena of personalized genomics. *Nature Genetics*. 2008; 40(8):939–942. [PubMed: 18665132]
- Medalie JH, Zyzanski SJ, Langa D, Stange KC. The family in family practice: is it a reality? *Journal of Family Practice*. 1998; 46(5):390–396. [PubMed: 9597996]
- Meilleur KG, Littleton-Kearney MT. Interventions to improve patient education regarding multifactorial genetic conditions: A systematic review. *American Journal of Medical Genetics*. 2009; 149A:819–830. [PubMed: 19291763]
- Mesters I, Ausems A, De Vries H. General public's knowledge, interest and information needs related to genetic cancer: An exploratory study. *European Journal of Cancer Prevention*. 2005; 14:69–75. [PubMed: 15677898]
- Molster C, Charles T, Samanek A, O'Leary P. Australian study on public knowledge of human genetics and health. *Community Genetics*. 2009; 12(2):84–91.
- National Cancer Institute. Health Information National Trends Survey. 2015. from <http://hints.cancer.gov/questions/index.jsp>
- Nielsen-Bohlman, L. Panzer, AM., Kindig, DA., editors. *Health Literacy: A Prescription to End Confusion*. Washington, DC: National Academies Press; 2004.
- Osborn CY, Cavanaugh K, Wallston KA, Rothman RL. Self-efficacy links health literacy and numeracy to glycemic control. *Journal of Health Communication*. 2010; 15:146–158. [PubMed: 20845200]
- Paasche-Orlow MK, Parker RM, Gazmararian JA, Nielsen-Bohlman LT, Rudd R. The prevalence of limited health literacy. *Journal of General Internal Medicine*. 2005; 20:175–184. [PubMed: 15836552]
- Parrott R, Silk K, Krieger JR, Harris T, Condit C. Behavioral health outcomes associated with religious faith and media exposure about human genetics. *Health Communication*. 2004; 16(1):29–45. [PubMed: 14979850]
- Pasche B, Absher D. Whole-genome sequencing: a step closer to personalized medicine. *Journal of the American Medical Association*. 2011; 305(15):1596–1597. [PubMed: 21505140]
- Petty, RE., Barden, J., Wheeler, SC. The elaboration likelihood model of persuasion. In: DiClemente, RJ. Crosby, RA., Kegler, MC., editors. *Emerging Theories in Health Promotion Practice and Research: Strategies for Improving Public Health*. San Francisco, CA: Jossey-Bass; 2002. p. 71-99.
- Rose A, Peters N, Shea JA, Armstrong K. The association between knowledge and attitudes about genetic testing for cancer risk in the United States. *Journal of Health Communication*. 2005; 10:309–321. [PubMed: 16036738]
- Roter DL, Erby LH, Larson S, Ellington L. Assessing oral literacy demand in genetic counseling dialogue: preliminary test of a conceptual framework. *Social Science and Medicine*. 2007; 65(7):1442–1457. [PubMed: 17614177]
- Schillinger D, Bindman A, Wang F, Stewart A, Piette J. Functional health literacy and the quality of physician-patient communication among diabetes patients. *Patient Education and Counseling*. 2004; 52:315–323. [PubMed: 14998602]
- Schillinger D, Piette J, Grumbach K, Wang F, Wilson C, Daher C, ... Bindman AB. Closing the loop: Physician communication with diabetic patients who have low health literacy. *Archives of Internal Medicine*. 2003; 163:83–90. [PubMed: 12523921]
- Smerecnik CM, Masters I, de Vries NK, de Vries H. Educating the general public about multifactorial genetic disease: applying a theory-based framework to understand current public knowledge. *Genetics in Medicine*. 2008; 10(4):251–258. [PubMed: 18414207]
- Syurina EV, Brankovic I, Probst-Hensch N, Brand A. Genome-based health literacy: a new challenge for public health genomics. *Public Health Genomics*. 2011; 14:201–210. [PubMed: 21734434]

- Valdez R, Yoon PW, Qureshi N, Green RF, Khoury MJ. Family history in public health practice: A genomic tool for disease prevention and health promotion. *Annual Review of Public Health*. 2010; 31:69–87.
- von Wagner C, Semmler C, Good A, Wardle J. Health literacy and self-efficacy for participating in colorectal cancer screening: the role of information processing. *Patient Education and Counseling*. 2009; 75(3):352–357. [PubMed: 19386461]
- Wang C, Gallo RE, Fleisher L, Miller SM. Literacy assessment of family health history tools for public health prevention. *Public Health Genomics*. 2011; 14(4–5):222–237. [PubMed: 20090283]
- Wang C, O'Neill SM, Rothrock N, Gramling R, Sen A, Acheson LS, ... Ruffin MT. Comparison of risk perceptions and beliefs across common chronic diseases. *Preventive Medicine*. 2009; 48:197–202. [PubMed: 19073208]
- Williams MV, Davis T, Parker RM, Weiss BD. The role of health literacy in patient-physician communication. *Family Medicine*. 2002; 34(5):383–389. [PubMed: 12038721]
- Wolf MS, Davis TC, Osborn CY, Skripkauskas S, Bennett CL, Makoul G. Literacy, self-efficacy, and HIV medication adherence. *Patient Education and Counseling*. 2007; 65(2):253–260. [PubMed: 17118617]
- Yoon PW, Scheuner MT, Gwinn M, Khoury MJ, Jorgensen C, Hariri S, Lyn S. Awareness of family history as a risk factor for disease -- United States, 2004. *Morbidity and Mortality Weekly Report*. 2004; 53(44):1044–1047. [PubMed: 15538320]
- Yoon PW, Scheuner MT, Jorgensen C, Khoury MJ. Developing Family Healthware, a family history screening tool to prevent common chronic diseases. *Prev Chronic Dis*. 2009; 6(1):1–11.

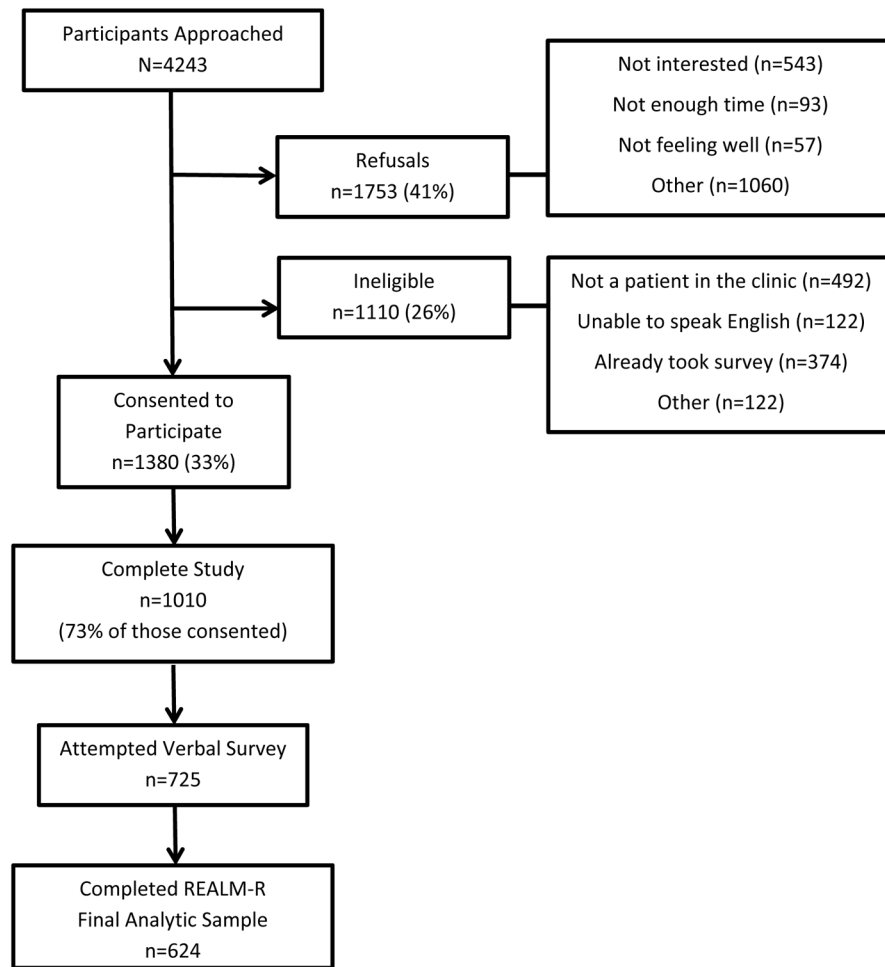


Figure 1.
Recruitment of study participants.

Table 1

Characteristics of study participants.

Characteristic	Mean	Standard Deviation (SD)
Age (n=588)	50.9	11.6
	N	%
Limited health literacy (n=624)	290	46.5
Female (n=603)	405	67.2
Race		
White	198	31.7
Black	363	58.2
Other	63	10.1
Marital status (n=598)		
Married or partnered	145	24.3
Separated, widowed, or divorced	248	41.5
Never married	205	34.3
Educational attainment (n=596)		
Less than high school	97	16.6
High school degree or GED	224	38.2
Some college or higher	265	45.2
Self-reported health (n=605)		
Poor	98	16.2
Fair	274	45.3
Good	171	28.3
Very good	48	7.9
Excellent	14	2.3
Personal history of		
Hypertension (n=592)	384	64.9
Diabetes (n=585)	241	41.1
Cancer (n=563)	83	14.7
Heart disease (n=586)	133	22.7
Family history of		
Diabetes (n=583)	443	76.0
Cancer (n=540)	356	66.0
Heart disease (n=544)	351	64.5

Table 2

Frequencies for genomics-related knowledge, self-efficacy, importance, and communication behaviors.

Characteristic	Mean	Standard Deviation (SD)
Genetic knowledge (n=589)	3.5	1.1
Genetic self-efficacy (n=596)	3.2	1.1
	N	%
Awareness of FHH (n=611)		
Yes	529	86.6
No	67	11.0
Not Sure	15	2.5
FHH self-efficacy (n=607)		
Very sure	456	75.1
Somewhat sure	120	19.8
Not at all sure	31	5.1
Importance of genetic information (n=600)		
Very important	321	53.5
Pretty important	120	20.0
Somewhat important	104	17.3
A little bit important	32	5.3
Not at all important	23	3.8
Importance of FHH (n=613)		
Strongly disagree	52	8.5
Somewhat disagree	16	2.6
Neither agree nor disagree	23	3.8
Somewhat agree	65	10.6
Strongly agree	457	74.6
Frequency of communication about health with friends or family (n=617)		
Very often	306	49.6
Somewhat often	191	31.0
Not very often	98	15.9
Not at all	22	3.6
Frequency of communication about FHH with family (n=616)		
Very often	163	26.5
Somewhat often	264	42.9
Not very often	142	23.1
Not at all	47	7.6
Frequency of communication about FHH with doctor (n=612)		
Very often	150	24.5
Somewhat often	213	34.8
Not very often	183	29.9
Not at all	66	10.8

FHH= family health history

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

Bivariate associations between health literacy and genomics-related knowledge, self-efficacy, importance, and communication behaviors.

Characteristic	Test Statistic	df	p-value
Genetic knowledge (n=589)	9.3	482.5	<0.0001
Awareness of FHH (n=611)	21.7	1	<0.0001
Genetic self-efficacy (n=596)	-1.1	594	0.2867
FHH self-efficacy (n=607)	3.6	1	0.0571
Importance of genetic information (n=600)	9.7	1	0.0018
Importance of FHH (n=613)	9.4	1	0.0022
Communication about health with friends or family (n=617)	2.0	1	0.1623
Communication about FHH with family (n=616)	5.3	1	0.0211
Communication about FHH with doctor (n=612)	14.1	1	0.0002

df= degrees of freedom

Table 4

Associations between health literacy and knowledge about genetics and family health history in multivariable models.

Characteristic	Genetic knowledge (n=525)			Awareness of family health history (n=541)		
	β	SE	p-value	OR	95% CI	p-value
Limited health literacy	-0.55	0.10	<0001	0.50	(0.28, 0.90)	0.0203
Age	-0.01	0.004	0.0050	0.99	(0.97, 1.02)	0.6336
Gender						
Female	ref	ref	ref	ref	ref	ref
Male	-0.08	0.10	0.4404	0.32	(0.19, 0.55)	<0001
Race						
White	ref	ref	ref	ref	ref	ref
Black	-0.30	0.10	0.0044	0.66	(0.34, 1.29)	0.2251
Other	-0.09	0.18	0.6354	0.57	(0.20, 1.66)	0.3027
Marital status						
Married/partnered	ref	ref	ref	ref	ref	ref
Separated/widowed/divorced	-0.10	0.12	0.4124	0.58	(0.28, 1.21)	0.1463
Never married	-0.13	0.12	0.2858	0.63	(0.31, 1.27)	0.1965
Education						
Less than high school	ref	ref	ref	ref	ref	ref
High school degree or GED	0.03	0.13	0.7931	1.56	(0.83, 2.95)	0.1687
At least some college	0.29	0.13	0.0307	3.33	(1.63, 6.82)	0.0010

Table 5

Associations between health literacy and perceived importance of and communication about genetics and family health history in multivariable models.

Characteristic	Importance of genetic information (n=490)				Importance of family health history (n=474)				Frequent communication with doctor about FHH (n=537)			
	OR	95% CI	p-value		OR	95% CI	p-value		OR	95% CI	p-value	
Limited health literacy	1.95	(1.27, 3.00)	0.0022		0.47	(0.26, 0.86)	0.0134		2.02	(1.27, 3.23)	0.0032	
Age	1.00	(0.98, 1.02)	0.9500		0.98	(0.96, 1.01)	0.1720		1.00	(0.98, 1.02)	0.6939	
Gender												
Female	ref	ref	ref		ref	ref	ref		ref	ref	ref	
Male	0.59	(0.39, 0.89)	0.0127		1.20	(0.67, 2.16)	0.5362		0.48	(0.29, 0.78)	0.0030	
Race												
White	ref	ref	ref		ref	ref	ref		ref	ref	ref	
Black	1.74	(1.14, 2.65)	0.0104		1.75	(0.94, 3.25)	0.0774		1.47	(0.88, 2.46)	0.1384	
Other	2.48	(1.14, 5.38)	0.0217		0.76	(0.28, 2.10)	0.5995		1.32	(0.52, 3.37)	0.5615	
Marital status												
Married/partnered	ref	ref	ref		ref	ref	ref		ref	ref	ref	
Separated/widowed/divorced	0.93	(0.58, 1.50)	0.7677		1.10	(0.55, 2.21)	0.7806		1.02	(0.59, 1.77)	0.9501	
Never married	0.83	(0.50, 1.36)	0.4565		0.65	(0.32, 1.31)	0.2272		0.96	(0.54, 1.71)	0.8936	
Education												
Less than high school	ref	ref	ref		ref	ref	ref		ref	ref	ref	
High school degree or GED	0.96	(0.55, 1.68)	0.8858		0.79	(0.37, 1.67)	0.5336		1.69	(0.89, 3.23)	0.1078	
At least some college	1.32	(0.76, 2.31)	0.3292		0.93	(0.44, 1.98)	0.8470		1.69	(0.89, 3.23)	0.1100	
Behavioral causal beliefs												
Diabetes	1.25	(0.80, 1.94)	0.3291		--	--	--		--	--	--	
Heart disease	1.47	(0.95, 2.29)	0.0878		--	--	--		--	--	--	
Family history of Cancer	--	--	--		1.75	(1.01, 3.04)	0.0451		--	--	--	

FHH= family health history