Designing a Web-Based, Participatory Education Program Curriculum on Clinical Applications of Whole Genome Sequencing Utilizing Lessons Learned from Previous Participatory Genomics Courses

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Abstract

Background: Until recently, human genetics has primarily been used for research or targeted clinical testing. With the decreased cost and ease of access to genetic testing, there has been an expansion of the application of genetics to health and chronic disease states. The scalability of genetic testing has ushered in the era of Precision Medicine with integration of predictive modeling and genomics into health care. Historically, clinical genetics was limited geneticists supported by genetic counselors. However, with the massive expansion in access to genomic service, this prior model will not be able to meet the growing demand as genetics will now play a role in all areas of medicine. To integrate genetic services across the health care system, critical educational gaps will need to be addressed. Participatory genomic educational courses have been gaining popularity within genetics education because they include the opportunity for participants to undergo genetic testing and integrated applied learning modules. Test2Learn is a participatory education platform designed to teach adult learners about pharmacogenomics which was shown to increase the engagement of the learners by integrating the participatory element. Test2Learn has now been expanded to teach pharmacists, nurses, and primary care residents about pharmacogenomics and key precision medicine concepts. In the most recent iteration presented in this thesis, Test2Lean has been expanded to provide education of whole genome sequencing (WGS) to a broad array of clinicians and key opinion leaders.

Objective: Create an online, participatory WGS and Precision Medicine educational program delivered in the Test2Learn platform that is scalable for different populations.

Design: Develop a participatory educational program integrating the use of WGS data for adult, educated learners utilizing lessons learned from previous participatory genomics courses offered on the Test2Learn platform.

Assessment: Analyze pre- and post- program surveys to gather data to enhance the development of the Mellon Whole Genome Sequencing (MWGS) course.

Conclusion: Preliminary data in pilot programs shows that participation in the Test2Learn course significantly increased participants genetic knowledge and comfort level discussing genetic related issues with patients. Analysis of these results and current literature enhanced the creation of a novel, participatory WGS education program.

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Preface

Thank you so much to everyone who helped me with my thesis and graduate school experience. I would like to give special thanks to my thesis committee: Mylynda Massart, MD, PhD, Andrea L. Durst, MS, DrPH, LCGC, and Todd Bear, PhD. Their tireless edits, supportive guidance, and invaluable expertise have allowed me to create this thesis and public health essay. To my thesis advisor, Mylynda Massart, I would like to give extra thanks for always going above and beyond in supporting me in my academic and career goals, and always encouraging me to reach my full potential while maintaining my mental health. Additionally, I would like to thank Phil Empey, PharmD, PhD for his assistance with my thesis project.

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Abbreviations

Frequently Used Abbreviations:

WGS = Whole Genome Sequencing

DTC-GT = Direct-to-Consumer Genetic Testing

FDA = U.S. Food and Drug Administration

GC = Genetic Counselor

PGx = Pharmacogenomics

T2L = Test2Learn

MDR = Monogenic Disease Risk

PCP = Primary Care Physician

OB-GYN = Obstetrics and Gynecology

ACMG = American College of Medical Genetics

KOLs = Key Opinion Leaders

1.0 Introduction

Historically, genetic testing has mainly been used for research or targeted clinical testing for specific indications. With the expansion of precision medicine initiatives, increase in direct-to-consumer genetic test (DTC-GT) utilization, and growth in understanding of the role of genetics in different diseases, genetics has become more of a routine clinical tool similar to blood work or imaging. Some instances in which genetic testing has become more commonplace include cancer risk and family health history assessment, prenatal risk assessment, the genetics of chronic disease, and pharmacogenomics. Public surveys have shown that physicians believe that due to the innovation of next-generation sequencing (NGS), genetic testing use in clinical care will one day be the norm, but the viability of widespread implementation is still being explored through precision medicine research projects [1-3]. Many barriers still exist to widespread implementation of genetic testing including the lack of clinician knowledge and comfort talking about genetics, insurance coverage of testing, electronic health record (EHR) integration of results, and others. This thesis aims to address barriers to clinician knowledge and comfort working with genetics and to increase awareness of the clinical applications of whole genome sequencing (WGS) for both clinicians and key opinion leaders who may be involved in insurance and health system decision making around genomics.

As testing becomes more available, many patients are turning to primary care physicians to help them manage their genetic results. Clinical management of genetic conditions and explanations of results is beyond current standard medical practice of primary care physicians. It is important to increase clinician knowledge and comfort discussing genetics to allow for appropriate medical management of patients. Incorporation of genetic advances in general medical

education has been significantly lacking over time despite the rise in genetic testing availability and utilization, which has resulted in current physicians not graduating with the knowledge necessary to meet the rapid growth of genetic technology and its application to health care [4-7]. It is well recognized that a major barrier to the implementation of genetic testing in clinical care is this lack of education for clinicians and the resulting lack of confidence in including this information in medical management [7-10]. To date, there are few genetic medical education programs centered around the use of clinical grade genetic testing, such as whole genome sequencing and its use in clinical practice [4]. Similarly, there are no genetic education programs for key opinion leaders such as stakeholders in the payer process, policy decision makers and health care leadership. These individuals can help enable better insurance coverage for genetic testing, which would encourage the use of testing in the appropriate individuals. For widespread WGS use to be successful, more novel education opportunities are needed for clinicians and key opinion leaders (KOLs).

One of the methods of education that has been integrated in genetics training over the last decade is participatory education. Participatory education is where participants use their own data in the educational program. This method has been shown to be an effective method of education, however, it has not been implemented very frequently. A few leading-edge educators have attempted to enhance graduate medical genetic education using participatory education. Some of these attempts have included utilization of student and resident personal genetic testing information for educational purposes. Studies have found that this method encouraged student motivation and engagement [11]. Two such participatory educational programs are analyzed as part of this thesis project the Family Medicine Resident (FMR) program, offered through the University of Pittsburgh Test2Learn platform to family medicine residents, and the ACCOUNT

program, offered to select providers and community members from federally qualified health centers in Pittsburgh and Chicago.

The Test2Learn (T2L) platform was created at the University of Pittsburgh specifically to enhance genomics educational programs through the use of personal genomic testing (PGT) and real genetic data [12]. One of the goals for development of the T2L platform was to ensure privacy of results. This goal was carried out through secure relay of PGT results to participants without retention of the results through the T2L platform and prevention of course faculty from accessing information regarding participant personal data. Previous studies using the T2L platform have shown increase in participant comfort and knowledge of genetics [12]. While the T2L platform has only been used for PGT like 23andMe, it has been expanded to integrate WGS data by other members of the research team in parallel to the work completed for this thesis project.

Given the prior success of T2L to deliver high fidelity genetics education, the T2L team at the University of Pittsburgh was tasked and funded by the RK Mellon Foundation to develop a participatory WGS educational program, referred to as the Mellon Whole Genome Sequencing (MWGS) program. Once created, this program hopes to help close the gap in clinician knowledge of genetics and WGS, increase clinician comfort discussing and working with genetics, and increase KOLs awareness of genetic testing to advance access to genetic testing. Specifically, this program will integrate WGS data collected from course participants who choose to undergo sequencing as part of their educational program. The participatory educational MWGS program will be offered on the T2L and Canvas educational platforms to integrate genetic information and the educational materials online for ease of access and future scalability of the course. The sequencing will be completed at the UPMC Genome Center, a CAP/CLIA certified lab. Certain results of the sequencing will be chosen and made available to course participants through the T2L

platform for use in overall learning objectives for the program. The curriculum development team includes a clinical pharmacist, physician, bioethicists, genetic counselors, and two graduate students, to ensure a comprehensive program. With the implementation of the CAP/CLIA certified genome center, nationally recognized Test2Learn educational program platform, and rich environment of genetic leaders and educators, the University of Pittsburgh is ideally situated to develop and implement this educational program.

This thesis project is completed in parallel to the overall MWGS program development. The goals of this thesis are 1) to evaluate current literature involving genomics, including precision medicine projects and currently available genetic educational programs, and previous participatory educational programs including the T2L platform and 2) to create an educational program curriculum focused on the use of whole genome sequencing (WGS) in clinical care for both clinicians and key opinion leaders (KOLs) while using lessons learned from the evaluation conducted in the first goal to inform curriculum creation.

1.1 Specific Aims

1.1.1 Specific Aim 1

Analysis of Previous Courses

The Test2Learn program has been pioneering genetic education programs over the past eight years, with the most recent iteration of this program focused on educating family medicine residents (FMR), healthcare providers, and community leaders as part of the FMR and ACCOUNT

programs. These programs have published pre- and post- course data to give insight into the different areas of success and areas for improvement for both the MWGS curriculum and course evaluation materials. Analysis of this previous data will allow for iteration in the development of the curriculum for the MWGS course and the accompanying surveys.

1.1.2 Specific Aim 2

Curriculum Development

A participatory course educating clinicians and KOLs on the clinical uses of WGS data in clinical care will be developed through utilization of literature searches and previous program analysis. The course will include input from team members with varying backgrounds to ensure a well-rounded and comprehensive curriculum that prepares clinicians to engage with patients about their genetics and the implication for WGS in healthcare for KOLs. The course will be offered on the Test2Learn platform and include opportunities to practice utilizing WGS data in an educational setting. A core set of learning modules will be developed with unique modules for the clinicians and KOLs relevant to their science background and anticipated implementation needs.

2.0 Literature Review

As part of this thesis project, the currently published literature related to precision medicine and genomic medicine is reviewed to highlight key findings regarding genomics in medicine. The main purpose of this literature review is to provide insight into the need for genomic education, gaps in current genomic education availability, and identify topics to include/emphasize in the MWGS program curriculum.

2.1 Precision Medicine Research Initiatives

Many precision medicine projects are researching the benefits and limitations of using WGS in clinical spaces with the guidance of genetics professionals. Some programs also include evaluation of clinicians' perceptions of working with genomic data, which can provide information on how to present genomic education effectively. Prior project data has been used to analyze the clinical utility of WGS and applicability of sequencing data in medical management. Unfortunately, most projects do not provide education for primary providers on long-term use and implications of the data returned to their patients, a gap the MWGS program is hoping to fill. While many of these projects are new and may still be ongoing, preliminary results for several of them have been published. These preliminary results help to shape what is needed in a novel WGS educational program curriculum.

The PeopleSeq Consortium was created to analyze healthy adults that had undergone genome sequencing due to a genetic predisposition. This Consortium surveyed participants that

had received predisposition sequencing through one of four projects: HealthSeq, Personal Genome Project, Understand Your Genome, and Young Presidents' Organization and MD/PhD Genome Projects. The goal of this consortium project was to examine the medical, behavioral, and economic outcomes of returning genomic sequencing information to healthy adults [13]. Of the 1359 individuals from the projects included in the consortium, 543 completed surveys after receiving their genomic results and were included in this analysis [13]. Survey analysis revealed that participants were not deterred from pursuing testing by privacy or insurance discrimination concerns, an outcome also evaluated by the FMR and ACCOUNT programs and analyzed in this document.

About half of participants who completed the surveys reported discussing their results with a healthcare provider, with PCPs cited as the healthcare provider in 81.1% of cases. This result emphasizes the need to provide educational resources to these providers. Testing decision regret was evaluated, which showed that 60.3% of participants reported no decision regret at all, and less than 3% of participants reported regretting their decision to have genetic testing or experiencing harm due to their decision [13]. The PeopleSeq Consortium is continuing to add additional projects and enroll additional participants as more precision medicine projects report genetic testing results to healthy individuals [13]. As additional projects enroll participants, there will be more healthy individuals with WGS data that will turn to their clinicians for assistance in medical management based on their results. It is important to ensure these clinicians have the educational resources to help them utilize this genomic data in their practice, supporting the need for a course such as T2L MWGS.

One project, the MedSeq Project, created their own medical genetics education component to prepare the providers with information about how to incorporate WGS and standardized family

history assessment into standard clinical care. [13, 14]. Nine PCPs were recruited who then identified and recruited 8 to 12 of their eligible patients [14]. The education program for physicians included in this project has not been standardized and made widely available. The education included is described as a brief educational course consisting of 4 hours of case based online modules and two 1 hour in person group classes administered before patients were enrolled in the project. This timetable is important to consider when creating the MWGS program since it was short enough that busy clinicians could complete it but could still learn important genomic knowledge.

Educational material included an orientation to the genome report that would be produced, which is an important aspect to appropriate medical management [13]. The WGS reports contained findings that are related to diagnostic indication, monogenic disease risk (MDR), carriers for recessive disorders, PGx for five drugs, blood group antigens, and complex-trait analysis [15]. These findings are commonly included in many laboratory WGS reports and are covered in the MWGS program. This study found that about 1 in 5 generally healthy patients receiving WGS results had a molecular diagnosis but only 1 in 25 had a new clinical diagnosis [16]. This supports that clinically appropriate medical management can result from WGS use in healthy adults, especially in the setting of genomic education and explanation of how to work with a clinical report for clinicians working with genomic data [16].

The Geisinger MyCode Community Health Initiative and the All of Us Research Program are both precision medicine projects that initially focused on collecting health questionnaires and biological samples, such as saliva and blood. These samples were then analyzed and paired with the questionnaire data to make a biobank with phenotypic data so that data for a wide population could be utilized for precision medicine research [17, 18]. Both of these projects have been

recruiting for many years now and were initially focused on collecting data, with no detailed plans to return genetic results to participants [17, 18]. Since their initiation, both programs have now pivoted and launched efforts to begin returning results to participants [18, 19]. As they do so, data about the process of returning genetic results in a healthy population can be gathered to analyze the use of genetic results in medical management over time [20]. So far, the Geisinger MyCode samples have been used to generate molecular data, including high-density genotype and exome sequence data with over 180,000 exomes sequenced [21]. This massive amount of data is helping to further researcher understanding of many realms of the clinical applications of genomics, including polygenic risk scores (PRS) and prevalence rates of mutations, important information to share with providers in the MWGS program.

Since initiation of returning results to participants, the Geisinger MyCode project has returned over 2,000 clinical results reports and continues to analyze the impact of returning these results [21]. The results reports currently include pathogenic or likely pathogenic variants in all of the ACMG SF version 2 genes (59 genes) and specific homozygous findings in the HFE gene [21]. A total of 3.3% participants screened positive in the 60 conditions tested for, which is consistent with detection findings in previous studies. Of those that screened positive, 2.6-2.8% did not have a previous genetic diagnosis [21]. As these results are returned, participants may turn to their non-genetics clinicians for guidance in using them in their medical management. It is important to prepare these clinicians with appropriate resources, such as the MWGS program.

Within the Geisinger MyCode Project, an observational study was conducted that involved returning pathogenic and likely pathogenic variants associated with CDC tier one genetic conditions: hereditary breast and ovarian cancer syndrome, Lynch syndrome, and familial hypercholesterolemia. The CDC defines tier one genomic applications as “those having significant

potential for positive impact on public health based on available evidence-based guidelines and recommendations" [22]. For this study, results were given to 351 participants and then their electronic health record (EHR) was evaluated after disclosure for a prior genetic diagnosis, relevant personal and family history, post disclosure clinical diagnosis, and post disclosure risk management [19]. This study found that 87% of patients with a tier one finding were not previously diagnosed and that of these patients 65% of them had EHR evidence of relevant personal and/or family history of disease. With proper training and education, clinicians can potentially notice these relevant indications and implement genetics into their patients care earlier. This study also found that 70% of those not previously diagnosed had a recommended risk management procedure after results disclosure and 13% of those patients received a relevant clinical diagnosis after results disclosure [19]. Clearly, these results are impacting patient medical management, but it is important to ensure their providers are prepared to implement appropriate care or referrals.

Due to research projects like PeopleSeq, MedSeq, and other precision medicine initiatives, the applications of clinical genetic testing have greatly expanded into a variety of areas of healthcare, such as carrier and cancer screening, tumor analysis, and pharmacogenomics (PGx) [23]. As medical management implications concerning WGS expand, education concerning the use of the results is essential to train clinicians to prepare them to decipher and utilize this information effectively in their clinical practice. These projects showed how far-reaching genomic results can impact clinical care and further support the need for accessible genomic education.

2.2 Integration of Whole Genome Sequencing into Clinical Care

To help test the viability of widespread integration of WGS use in clinical care, evaluation of different facets of implementation has been and continues to be conducted through precision medicine projects. The evaluation conducted by these projects has brought to light both barriers and opportunities for widespread implementation of WGS that are important to address and explain in the MWGS program as clinicians start to use WGS data and KOLs consider the benefits and limitations of covering WGS.

2.2.1 Barriers

Participants who consent to precision medicine research projects have been shown to have a relatively optimistic view of WGS, but perception of the clinical utility of genetic testing results does not necessarily mean the information is actually being used in a clinical setting [24]. In other words, while surveyed populations show a positive perception of clinical utility of genetic testing in the general population and show interest in utilizing this testing, this perception may not be mirrored by evidence-based practice experiences noted by these projects. Absence of actual clinical utility of testing results despite patient perception of utility may result in patients feeling that resistance to integration of genetic testing in clinical care is too paternalistic of KOLs. This tension may present another barrier to widespread integration of WGS use but may be able to be ameliorated with appropriate counseling on genetic testing, which are important factors to highlight in the MWGS curriculum.

Another barrier to widespread implementation of WGS is the complexity of genome sequencing. This could result in a substantial number of individuals being falsely identified as at

risk for disease, which could result in a fatalistic response on the individual level. This can also result in unnecessary surveillance or procedures, or overutilization of healthcare resources [13]. The MedSeq project saw no patients whose molecular diagnoses clearly improved short-term health outcomes and the clinical value of the diagnoses made in this project was unclear [16]. As a program that is meant to educate on WGS, it is important to include this potential outcome of WGS for both clinicians and KOLs.

Lab geneticists are also a limited resource necessary to evaluate novel variants identified by testing. Each novel variant identified requires considerable manual curation to determine their clinical significance, and interpretation of variants might not be apparent in the patient at the time of testing [23]. The burden of variant assessment has been studied and findings emphasize that this burden is the greatest during the initial phases of implementing a population scale genomic screening program [21]. This initial burden with limited lab genetics resources is a large barrier to widespread utilization of WGS. This initial burden of manual curation would also imply that returning carrier status for everyone undergoing WGS would significantly increase the amount of work done by clinical laboratories which may in turn increase turnaround time and cost for reporting all genetic results [23]. Since WGS is casting such a wide net and returns so many results, it is important to discuss this burden and potential impact on turnaround time with clinicians and KOLs as part of the MWGS curriculum.

A barrier to utilization of WGS in clinical care that has been repeatedly noted is the lack of clinician readiness to integrate medical genetics into clinical practice [6, 7, 25-28]. While all doctors can order genetic tests to aid in the care of their patients, there can be unintended negative consequences; due to ordering the wrong test, ordering a test without appropriate patient consent, and wrongly interpreting testing reports; when a provider orders genetic testing without adequate

training. As of 2002, of 1,120 primary care providers randomly surveyed in the United States, 60% of respondents had ordered genetic testing in their clinical practice and 74% had referred a patient for genetic testing [29]. Clinicians are ordering genetic tests and referring patients, and this number has most likely grown since 2002. Despite this, clinicians are still reporting a need for more education to help them integrate genetics into their clinical practice, and without it there is a high potential for unintended negative outcomes for patients.

A study evaluating GCs' negative experiences when non-genetics providers order genetic testing was conducted to exemplify different unintended negative consequences. These could also be used to show opportunities for improved outcomes with educational intervention, which is why this aspect is included in the MWGS curriculum [30]. Phone interviews were conducted with 15 GCs in Minnesota about negative outcomes experienced from genetic testing ordered by non-genetics providers. They identified six domains that these negative consequences could be considered under: psychosocial/emotional effects, inadequate genetic counseling, errors related to genetic tests and screening, medical mismanagement, negative attitude toward medical provider(s), and unnecessary use of health care resources [30]. Regarding errors related to genetic tests and screening, all 13 cases had inaccurate information about interpretation of results, four had inappropriate genetic testing performed, four had incorrect genetic testing performed, and three had incomplete genetic testing [30]. Appropriate medical management of patients is imperative and is included in the MWGS program to help educate clinicians and also KOLs on the needs of clinicians to increase positive patient experiences.

Appropriateness of medical management by non-genetics providers was also evaluated by the MedSeq project and in instances of inappropriate management were judged so because of undervaluation of the variant's disease risk or miscommunication about its significance [16].

Based on these descriptions of the themes and specific examples, implementation of additional education for clinicians and utilization of genetics providers could have prevented these situations from occurring. While this is a major barrier to utilization of genetics in primary care, it is also an opportunity for improvement and reinforces the need for novel education for clinicians, such as the MWGS program, to address this barrier.

2.2.2 Opportunities

Precision medicine projects also identified opportunities that widespread use of WGS may provide, which should be emphasized in a WGS educational program to both clinicians implementing the genetic testing but also KOLs who can support the use of genetic testing. One study noted that in the absence of a significant family history, a genomic screening approach might be the only way to identify an individual's risk as a preventative measure [23]. Looking so widely for harmful changes also gives the chance for WGS to detect changes that can be harmful but not in a way that helps decipher a patient's current symptoms, commonly referred to as secondary findings. Due to the ability to detect these secondary findings (SF), the ACMG published recommendations for providers on how to handle the reporting of these findings [31]. Their recommendations, referred to as ACMG SF, state that pathogenic changes associated with more prevalent mendelian inherited disorders that are adult onset and have treatments available should be offered to patients who undergo WES/WGS with the option to have these variants reported [31]. For example, if a patient undergoing WGS were to opt in to receiving ACMG SF variants in their results, an underlying BRCA mutation could be reported because there is screening and treatment available to patients with these mutations [32]. These types of results are not reported with genetic tests such as panel testing and need to be explicitly reviewed under the MWGS

program for clinicians. The downstream effects of secondary finding results must also be discussed with KOLs who are more interested in the big picture effect of utilizing WGS.

Results of this study also suggest that WGS might also expand the detectable phenotypic spectrum of disorders that are targeted by current newborn screening (NBS), identifying risk for NBS targeted conditions, such as hearing loss, in newborns who passed NBS. WGS can also detect non-classical presentations of disorders included in NBS, such as congenital adrenal hyperplasia, identifying this individual's risk early, which may be beneficial by facilitating early diagnosis and therapies if needed [23]. Due to the wider net being cast by WGS, variants can be found in genes that might not be included on panel testing, either at the time of testing or in the future when genome sequencing data is reanalyzed [15]. WGS use may also expand on the current prevalence estimates of diseases with precision medicine projects detecting a rate higher than the known prevalence of certain conditions in the general population [23]. These are all important points to include in the MWGS curriculum to show the clinical applications of WGS as well as the differences between WGS and other testing technologies commonly used.

Parents also anticipated benefits to testing healthy children that clinicians did not, including the ability to prepare and the benefit of knowledge for its own sake [24]. WGS data can be used throughout an individual's lifetime for analyses of adult-onset disease risk and PGx for drugs used in the adult population. As more data is gathered through the years, polygenic risk estimates for complex traits could also be able to be used clinically [23]. Parents of children identified as high risk with adult-onset disease who are tested as a trio can also be detected as high risk and receive interventions they may not have considered or been eligible for without this information [23]. WGS allows detection of carrier status for a wide range of disorders that are not currently available in expanded carrier screening panels, an important point to show in the MWGS curriculum.

Having WGS done at an early age allows genomic information to be analyzed and put into an individual's medical record, that can be specifically interrogated for new indications and inform personalized medicine applications to be accessible throughout an individual's lifetime, a benefit of WGS that KOLs should be educated on. While WGS data might not be the most appropriate test at the time it is conducted, indication based analysis that takes a look at the WGS data based on new symptomology can be done as a rapid first tier test as the information is already available [13]. New gene-disease associations, novel disease variants, and new evidence on existing variants continue to be identified and can be used to reanalyze the sequencing data, which was done in the MedSeq project and resulted in new findings or updated results for participants [15]. Full reanalysis and reinterpretation of WGS results on an annual basis is likely to continue to yield new findings for individuals with sequencing data [15]. Widespread use of WGS would also require a reduced number of tests that must be maintained and validated as well as the ability to rapidly test individuals as new genes are implicated in disease since their results would only require reanalysis [15]. While any identified variants would require manual curation, the number of newly observed variants that would require manual curation within a cohort has been shown to drastically decreases as the size of the cohort increases [33]. So as more and more patients receive WGS, the burden of manual curation will decrease, another downstream effect of implementing WGS earlier that is important to emphasize to KOLs.

Table 1: Key findings from precision medicine programs to include/emphasize in the MWGS curriculum

Project	Publication	Area for Inclusion/Emphasis in MWGS Curriculum
BabySeq	Ceyhan-Birsoy, O., et al. (2019)	In the absence of a significant family history, a genomic screening approach might be the only way to identify an individual's risk as a preventative measure.
		WGS can also detect non-classical presentations of disorders, identifying an individual's risk early which may be beneficial by facilitating early diagnosis and therapies if needed.

		WGS use may expand on the current prevalence estimates of diseases with precision medicine projects detecting a rate higher than the known prevalence of certain conditions in the general population
		As more data is gathered through the years, polygenic risk estimates for complex traits could be able to be used clinically.
		Parents of children identified as high risk with adult-onset disease who are tested as a trio can also be detected as high risk and receive interventions they may not have considered or been eligible for without this information.
	Pereira, S., et al. (2019)	Parents anticipated benefits to testing healthy children that clinicians did not, including the ability to prepare and the benefit of knowledge for its own sake.
		WGS data can be used throughout an individual's lifetime for analyses of adult-onset disease risk and PGx for drugs used in the adult population.
MedSeq	Machini, K., et al. (2019)	Due to the wider net being cast by WGS, variants can be found in genes that might not be included on panel testing, either at the time of testing or in the future when genome sequencing data is reanalyzed.
		New gene-disease associations, novel disease variants, and new evidence on existing variants continue to be identified and can be used to reanalyze the sequencing data, which was done in the MedSeq project and resulted in new findings or updated results for participants.
		Full reanalysis and reinterpretation of WGS results on an annual basis is likely to continue to yield new findings for individuals with sequencing data.
		Widespread use of WGS would also require a reduced number of tests that must be maintained and validated as well as the ability to rapidly test individuals as new genes are implicated in disease since their results would only require reanalysis.
	Vassy, J.L., et al. (2017)	In instances of inappropriate medical management by non-genetics providers were judged so because of undervaluation of the variant's disease risk or miscommunication about its significance.
PeopleSeq	Zoltick, E.S., et al. (2019)	Indication based analysis that takes a look at the WGS data based on new symptomology can be done as a rapid first tier test if WGS has already been conducted prior as the information is already available.
Geisinger MyCode	Mirshahi, U.L., et al. (2019)	While any identified variants would require manual curation, the number of newly observed variants that

		would require manual curation within a cohort has been shown to drastically decreases as the size of the cohort increases. As more and more patients receive WGS, the burden of manual curation will decrease
CSER	Amendola, L.M., et al. (2016)	The downstream effects of secondary finding results identified by WGS.

2.3 Current Medical Education and Graduate Medical Education

Current medical education and graduate medical education are reviewed as part of this literature review to assess what genetic education is currently available to medical students and medical residents to assess overall clinicians' preparedness on genomics. This review highlights the gaps in current education and also lessons learned from current non-participatory educational programs to utilize for the MWGS program.

An attempt to survey the extent of genetic material covered in current medical education, was conducted in 2004 by the Indiana University School of Medicine. In the United States and Canada, 149 medical genetics course directors or curricular deans were surveyed about the material covered, number of contact hours, year in which courses were offered, and what departments sponsored the courses [10]. This data provided valuable baseline data about genetics curricula with a 75.2% response rate. A major conclusion of the survey analysis was that improving the genetics curriculum in medical education would help train physicians that are knowledgeable of genetics concepts and comfortable discussing these concepts with patients while answering any questions the patient may have [10]. Of those programs that responded, 77% taught medical genetics in the first year with 66% devoting 20 to 40 hours to this instruction, largely focusing on general genetics concepts rather than practical applications of genetics [4, 10]. The

general genetics concepts most commonly reported to be taught were cancer genetics, multifactorial inheritance, mendelian disorders, clinical cytogenetics, and patterns of inheritance [10]. While most medical education programs include genetic information, it is usually fairly simple and does not prepare them for practical applications in genetics or the extent of genetic information being used in current healthcare practice [4]. This review confirmed that medical students are not getting enough medical genetics education, especially in practical applications in genetics. Due to this, a large portion of the application of genetics in medical management is included in the MWGS program.

Recommendations on how to address these knowledge gaps and improve current medical education were published by Guttmacher in 2007, suggesting the utilization of patient care in addition to lectures on broad concepts to help strengthen medical education of practical applications of genetics [34]. These recommendations go on to state that medical student training should enable students to be able to correctly identify patients who require referrals to genetic specialists, understand frontline genetic testing and the interpretation of their results, and be able to provide informed consent to genetic testing [34]. In addition to addressing the knowledge gap in medical education on medical genetics, this would increase exposure to role models in medical genetics, an important factor in engaging medical students in medical genetics [34-38]. By training clinicians on medical genetics with the MWGS program, they can potentially impart this knowledge on their residents and students as well and further engaging medical students in learning about the applications of genetics in medicine.

In 2014, the National Human Genome Research Institute convened an Inter-Society Coordinating Committee for Physician Education in Genomics to develop competencies that apply to all areas of practice on basic genomic skills. The working group developed five entrustable

professional activities: eliciting, documenting, and acting on relevant family history pertinent to the patient's clinical status; using genomic testing to guide patient management; using genomic information to make treatment decisions; using genomic information to guide the diagnosis and management of cancer and other disorders involving somatic genetic changes; and using genomic tests that identify microbial contributors to human health and disease, as well as genomic test that guide therapeutics in infectious diseases [39]. These activities are included in the MWGS curriculum to help clinicians meet these competencies.

While medical genetics is working its way into the medical education curriculum in a more profound way, many are also attempting to integrate genetic and genomic education into graduate medical education. In 2015, the Core Cardiology Training Symposium proposed that cardiology fellows should know principles of genetics, genomics, proteomics, metabolomics, and pharmacogenomics by the end of their fellowship to satisfy training requirements [40]. In 2017, the Brigham Genomic Medicine program was founded and proposed being used as a laboratory for education in clinical genomics to satisfy these training requirements, asking general cardiology fellows to present a clinical case to the program as an opportunity for exposure to medical genetics, enhancing their cardiology fellowship [41]. In 2019, the American Academy of Family Physicians published their revised recommended curriculum guidelines for family medicine residents in medical genetics which listed competencies, attitudes and behaviors, knowledge, and skills for family medicine residents [42]. These recommendations included competencies focused on the management of a clinical case involving genetics, from being able to conduct and communicate a risk assessment for a patient based off of personal and family history to recognizing their limitations and seeking appropriate consultation with other medical genetics providers [42]. These recommendations showed progress in medical programs attempting to bridge the genetics

knowledge gap with additional medical education and follow the framework proposed by the Competencies Working Group of the Inter-Society Coordinating Committee for Physician Education in Genomics [39, 42]. These recommendations and competencies were used heavily in the creation of the FMR program and will also help to shape the MWGS curriculum, aiming to help clinicians achieve these competencies.

2.3.1 Participatory Programs

Current participatory medical education and graduate medical education are reviewed as part of this literature review to assess what genetic education is currently available to medical students and medical residents. This review highlights the gaps in current education and lessons learned from current participatory educational programs to utilize for the MWGS program.

An elective participatory genetic education program, where students could opt to undergo personal DTC-GT for analysis during the course, was developed in 2010 by the Stanford University School of Medicine for medical and graduate students [43]. This program was similar to the FMR and the MWGS program, with quantitative evaluation that provides insight for the creation of the MWGS program. Evaluation of the student experience of this course was mostly focused on qualitative outcomes of undergoing DTC-GT as part of the course and comparing knowledge gains between students who did and did not undergo genetic testing [43, 44]. Interview comment consensus with students who underwent DTC-GT fell under common themes: the pedagogical value of genotyping, attitudes towards clinical utility and application of genotyping results, perspectives on consultative support received, and experiences of informed consent [44]. Students that underwent DTC-GT agreed that utilizing their own genetic information throughout the course was personally motivating, engaging them in the course material and self-reporting a

better understanding of genetics because of pursuing testing, while also giving them perspective on what it is like to undergo genetic testing like their patients may choose to, giving them a personal experience they may share with a patient [43, 44]. This was supported with pre- and post-course knowledge assessments that showed significantly higher knowledge than students who did not undergo DTC-GT [43]. Despite the positive reports of undergoing testing, students still relayed skepticism over the clinical utility of results concerned with complex disease and behavior, something many genetics professionals and the FDA, also regard with high skepticism [44-47]. As part of this course students could seek independent genetic counseling services and even though only one participant had training in clinical genetics, none of the students felt that utilization of these services should be required by the course [44]. One student stated plainly that as a biosciences student they could interpret the data themselves, but that the general public should be required to go through their doctors to get similar information [44]. While many reported they found the most utility in attempting to analyze the raw data from testing, they were dismayed that due to the anonymity of the course they could not utilize instructors as a resource to help in this analysis, showing a uniform need for help in analysis of their results [44]. In addition, when asked about details from the consent process of submitting their information for DTC-GT, none of the students could recall details of the consent agreement or any details of the biobanking agreement, although no students expressed any regret over pursuing testing despite having no recollection of the legal terms of this decision [44]. This experience emphasizes the need of inter-disciplinary discussions of the ethical, legal, and social implications of having students undergo genetic testing as part of a course and also the need for deliberate course topic management to educate on the risks, benefits, and limitations of different types of genetic testing, especially in the clinical setting.

In efforts to enhance the personalized medicine and genetic medical school curriculum at Tufts University School of Medicine, a multidisciplinary faculty group deliberated on the most appropriate way to introduce genomic education. The faculty group initially proposed that a small subset of first year medical students in the year 2009 would undergo DTC-GT as part of their genetics course and complete surveys and interviews to help examine the impact that this could have on student education without exposing the whole class, in case negative side effects were seen [48]. After discussions both within the faculty group and with the IRB, it was decided that all students should have engagement with DTC-GT but that it would be with randomized data provided by 23andMe [48]. While this course didn't directly involve a participatory aspect for students, the creation of the course did reveal many considerations programs should take before implementing personalized genetics into their medical school curriculum [48]. While they agreed that integration of genomic education into the curriculum is necessary to prepare students, a multidisciplinary team should be involved in the creation of the course and the IRB team should be involved very early in the process, a plan should be in place to protect privacy of students especially in the case of abnormal results that may require follow up, and discussion of the benefits, limitations, and potential harms of testing should be included in the curriculum [48]. Early interrogators of the integration of DTC-GT into the medical school curriculum such as Stanford and Tufts have provided important groundwork for the implementation of personal testing into medical education course work.

In 2012, the Icahn School of Medicine at Mt. Sinai implemented a two-part laboratory style genomics course that allowed students to analyze their own whole genome. Initially with the introduction of the "Practical Analysis of Your Personal Genome" course (PAPG), many students expressed interest in undergoing sequencing, but many reported decisional conflict [49]. In 2013,

to prepare students for the PAPG course and address the decisional conflict reported prior, students were required to complete the prerequisite "Introduction to Human Genome Sequencing" workshop (IHGS) [50]. Significant reduction in reported decisional regret was noted in 2013 after the addition of the IHGS workshop, but no analysis between students who did and did not undergo testing was available at this time because all 19 students decided to undergo personal genome sequencing [50]. This class also reported a significant increase in technical WGS knowledge, with interview analysis additionally suggesting that personal genome sequencing increased student motivation to learn and also understanding of the patient genetic testing experience [50].

Additional analysis of this class was done, including data collected from students enrolled in the IHGS workshop and subsequent PAPG course in 2013, 2014, and 2015. Of the 59 students enrolled in the PAPG course, 56 chose to undergo genome sequencing with baseline decisional conflict decreasing through the years [11]. This longitudinal analysis reinforced the previous report, also reporting a significant increase in technical WGS knowledge, with interview analysis additionally suggesting that personal genome sequencing enhanced the genomics pedagogy, increasing student motivation to learn and also understanding of the patient genetic testing experience [11]. Additionally, the vast majority (90%) of students also reported spending time outside of mandated assignments analyzing their genome, similar to the students enrolled in the Stanford program [11, 43]. This course showed the merit in including personal genome sequencing in medical education, but further analysis will be necessary to quantitively show whether or not PGS is more effective than other educational approaches, such as having students use anonymous data or personal DTC-GT as part of a participatory medical educational program in genetics.

Here at the University of Pittsburgh in 2016, a genetics educational platform, Test2Learn, was initially developed to teach pharmacogenomics to pharmacy students with the ability to

integrate a participatory aspect with testing from 23andMe in the Test2Learn platform. For this program, 122 second-year Doctor of Pharmacy (PharmD) students in a required course were offered DTC-GT for personal genetic testing (PGT) as part of a larger program approach to teach pharmacogenomics [12]. Participating students could choose to either go through PGT and use these results during the course or utilize randomized, anonymous data provided by the research team, with 100 students (82%) choosing to undergo PGT [12]. Analysis showed significant improvements in knowledge on multiple assessments, with genotyped students reporting a greater increase in confidence in understanding test results and self-perceived ability to empathize with patients compared to those not genotyped [12]. Additionally, most students (71%) reported that PGT was an important part of the course, with 60% reporting they had a better understanding of pharmacogenomics specifically because of the opportunity to undergo PGT [12]. While this program is not for medical students or residents, it piloted the Test2Learn program, which has since been used in additional participatory graduate medical education programs at the University of Pittsburgh.

Family medicine residents at the University of Pittsburgh were offered the opportunity to participate in an innovative, CE-accredited program incorporating optional PGT using 23andMe and/or working with anonymous genetic data to achieve the genomics competencies established by the AAFP and Korf et al [39, 42]. Analysis of this program data is completed and discussed later in this document as part of the lessons learned aspect of this project.

2.4 Current Continuing Medical Education

Current continuing medical education programs are reviewed as part of this literature review to assess what genetic education is currently available to clinicians. This review highlights the gaps in current education and resources from non-participatory educational programs to utilize for the MWGS program.

The AMA has a page on their website dedicated to education and resources in genetics and personalized medicine for physicians that were reviewed for the MWGS curriculum. They include links to educational modules they have created, the Genetics in Primary Care Institute resource repository, and also the Genetics/Genomics Competency Center (G2C2) [51]. The G2C2 educational material repository collects and catalogues educational resources according to the National Human Genome Research Institute Inter-Society Coordinating Committee for Physician Education in Genomics competencies that apply to all areas of practice on basic genomic skills for physicians [39, 52]. The educational material included in G2C2 comes in various formats, from webinars to fact sheets and self-study activities, many of which allow physicians to earn continuing medical education credits [52]. While G2C2 contains a large amount of educational material, as genetic technology continues to advance and our understanding of the clinical applications of genetic information increases, educational materials will continue to be developed to educate providers and added to this repository [52]. Many believe the next step in the evolution of these educational materials is participatory continuing medical education programs such as the MWGS course since the efficacy of participatory continuing and graduate medical education is shown [7, 25, 53].

2.4.1 Participatory Programs

Current continuing medical education programs are reviewed as part of this literature review to assess what genetic education is currently available to clinicians. This review highlights the gaps in current education and lessons learned from participatory educational programs to utilize for the MWGS program.

A participatory aspect was included in a recent study by Haga et. al. where primary care professionals obtained DTC-GT and, while it wasn't paired with medical education, the experience of undergoing personal genetic testing reportedly increased providers' comfort in discussing genetics with their patients [7]. In this study, 130 primary care physicians underwent DTC-GT and answered pre- and post-testing surveys, with 62% indicated they had not received any formal genetics training, with the majority of those indicating undergoing genetics education stating that it was received in medical school. Of note, respondents that indicated they had some formal medical genetic education in medical school had graduated more recently than those who had not had any genetic education exposure in medical school [7]. In surveying the impact of undergoing PGT on PCP's, self-reported comfort discussing patient's health status, genetics, and disease risk race/ethnicity increased significantly, with 53% of participants also indicating that they planned to participate in genomic medicine educational activities, such as a CME course or conference [7]. When asked about preferred mode of educational activity, the modality ranked first most consistently was online CME programs, with 42% of respondents ranking this modality as their preferred mode of education for genomic medicine. The indicated preference of online based CME program and significant reports of increased comfort in discussing genetics with patients highlights a unique opportunity to combine these two aspects into an educational program for providers on genomics.

As part of the FMR program, family medicine residents at the University of Pittsburgh were offered the opportunity to participate in an innovative, CE-accredited program incorporating optional PGT from 23andMe and/or working with anonymous genetic data to achieve the genomics competencies established by the AAFP and G2C2. As part of the ACCOUNT program, healthcare providers and community leaders in Pittsburgh and Chicago collaborated with the T2L team to assess the feasibility of a participatory educational PGx program designed to enhance participant knowledge. Participants were given the option to undergo PGT from 23andMe or work with anonymous genetic data during the program [54]. Analysis of the data from these programs was completed as part of this project.

3.0 Manuscript

3.1 Background

Genetic literacy is low among non-genetics medical providers, a knowledge deficit that is widely reported by providers in primary care [25, 55, 56]. Despite this known knowledge deficit, patients report that they expect their primary care providers to be involved in integrating their genetic information into their clinical care, while providers report that they are open to discussing genetics but require better resources [1, 6, 25, 55]. With an increasing number of patients considering genetics to be instrumental to their healthcare, equipping providers and collecting data on the impact of genetics in clinical care is more necessary than ever [57]. In addition to genetic education in medical school, continuing education in genetics should be widely available for clinicians as well as key opinion leaders (KOLs), such as those in the insurance industry or hospital executive officers [34].

In 2019, the Robert K Mellon Foundation funded the creation of a high-fidelity, web-based participatory educational program on whole genome sequencing (WGS) use in clinical care after identifying the critical need for engaging and accessible education. This program, known as the Mellon Whole Genome Sequencing (MWGS) program, aims to drive genomic knowledge, facilitate WGS result interpretation, and explore the utility of genetic testing. The educational resources of this program are web-based and available on Canvas and the Test2Learn (T2L) platform as scalable educational opportunities. Previous participatory educational programs using the T2L platform have shown marked improvements in many surveyed areas, including a significant increase in participant comfort discussing genetics with patients. Participants are

expected to be frontline practitioners, emerging professionals, and KOLs who are ideally positioned to rapidly advance WGS in clinical practice. The recruitment of program participants and release of the educational program, including collection of pre- and post-course evaluations, are scheduled to launch in September 2021 at the Precision Medicine World Conference (PMWC) being held at the University of Pittsburgh.

To prepare for the development of the curriculum for the MWGS program, review of the current literature was conducted to examine current precision medicine implementation projects, current state of medical and post-medical education in genomics and participatory genomics education. This review yielded several key findings including: participants of programs receiving WGS results are turning to non-genetics clinicians for help interpreting their results into their clinical care; the current lack of education available to clinicians to help them understand the complexities of genetic results and the need to introduce clinicians to resources that can help them implement genetic results into patient care; the need for novel education for KOLs in insurance to educate them on the expanding uses of genetics and the need for increased insurance coverage and access; and the increase in access to genetic testing that widespread education of clinicians and increased coverage of genetic testing by insurance could bring to patients.

Review of current educational programs available to medical students, residents, and clinicians was also done to highlight areas to include and emphasize in the MWGS program curriculum. These areas included the differences between different genetic testing technologies, the difference between genetic testing results, and the application of genetic testing results in clinical care. Review of programs confirmed that most medical students are not graduating with the knowledge needed to understand and interpret genetic results. Two of the programs reviewed were the Pitt implemented Test2Learn programs, ACCOUNT and FMR.

To prepare for the pre- and post-course survey development for the MWGS course, analysis was done on the data collected from two previous T2L iterations, including the ACCOUNT and FMR educational programs. As part of the ACCOUNT educational program, 43 providers, 14 in Chicago and 29 in Pittsburgh, and 18 community members, 8 in Chicago and 10 in Pittsburgh, were recruited to complete a participatory educational program using the T2L platform. This program aimed to educate participants on precision medicine with the option of undergoing personal genetic testing. Pre- and post-course survey data was collected from participants. The Family Medicine Resident (FMR) educational program is part of a study testing personal genetic testing as a method of teaching essential genomic competencies for family medicine residents. Specifically, this program aimed to create a genomics education program that is designed to achieve competencies outlined by the Genetics-Genomics Competency Center (G2C2) and the American Academy of Family Practice. As part of this study, 65 participants completed pre-course surveys and 18 participants completed post-course surveys. The literature review findings along with analysis of the ACCOUNT and FMR programs will give insight into the gaps in current educational programs, areas for emphasis in the MWGS curriculum, and effectiveness of previous medical genetic education programs.

3.2 Methods

The FMR and ACCOUNT studies were approved under Expedited Review, with a waiver of informed consent and HIPAA authorization, by the University of Pittsburgh Institutional Review Board (IRB) and University of Chicago Institutional Review Board (IRB), respectively

(PRO17040285, 2018-0449) (**Appendix A**). As the subsequent curriculum creation has not recruited participants or gathered data, no IRB approval was necessary. Once the course is created and ready to be launched, IRB approval will be pursued in compliance with University of Pittsburgh Institutional Review Board research requirements.

3.2.1 Data Analysis of ACCOUNT and FMR Programs

Pre- and post- course surveys were available on either paper or on Qualtrics and completed by educational program participants for both the ACCOUNT and FMR education programs. Surveys that were completed on paper were entered into Qualtrics for ease of research team access. Provider participants of the ACCOUNT program received a copy of the pre-course survey included in **Appendix B.1.1** and post-course surveys included in **Appendix B.1.3.** Community participants of the ACCOUNT program received a copy of the pre-course survey included in **Appendix B.1.2** and post-course surveys included in **Appendix B.1.4.** Participants of the FMR program received a copy of the pre-course survey included in **Appendix B.2.1** and post-course surveys included in **Appendix B.2.2.** The pre- and post-course surveys for each program and population were similar but not identical. Survey questions were divided into sections on demographics, knowledge of genetics and pharmacogenomics, and attitudes and perceptions regarding the use of pharmacogenomics and precision medicine in primary care. Analysis of survey questions included below is organized in the order that it appears in the surveys.

FMR program and ACCOUNT Pittsburgh program data was accessed through Qualtrics 2021 and downloaded to both Microsoft Excel and IBM SPSS for analysis. ACCOUNT Chicago program data was accessed through Microsoft Excel sent from the Chicago research team. This data was then manually entered into SPSS for statistical analysis. The coding for each SPSS

document was automatically created when the data was downloaded from Qualtrics and was not consistent between SPSS documents and required manual entry in certain cases. Additionally, some variable types were incorrectly imported and were manually changed to accurately reflect the variables recorded. Data sets were manually combined in SPSS for analysis and additional variables were entered that were not originally included in the surveys to delineate data sets for analysis. For example, a pre-/post- variable was added in all data sets.

Attitudes and perception questions data from the FMR and ACCOUNT surveys was analyzed using Qualtrics 2021 and Microsoft Excel for descriptive statistical analysis. The survey data for the ACCOUNT and FMR programs was downloaded from Qualtrics to be cleaned (removal of excluded data) and analyzed using IBM SPSS Statistics 27 for quantitative statistical analysis. Data that was excluded were participant surveys that did not complete at least 50% of the knowledge questions in either the pre- or post- course survey as this was deemed the most important data point by the research team. The survey responses were not paired between pre- and post-course surveys due to issues with the linkage system. True/false knowledge question data was analyzed using Mann-Whitney U test or Welch's t-test and self-assessment of genetics knowledge was analyzed using Mann-Whitney test as initial analysis showed unequal variances in the data. For the self-assessment of genetics knowledge questions, analysis was done on the topic areas of pharmacogenomics, genetics of complex diseases, basic genetic principles, and precision medicine for provider participants. For analysis of community member participants, analysis was done on the topic areas of understanding of the concept of pharmacogenomics and understanding of the concept of precision medicine. This analysis was selected due to the relevance to the MWGS educational program.

Available survey data that was used for analysis is outlined in the table below. All participants completed a pre-course survey, and all subsequent descriptive analysis utilizes these numbers for calculations.

Table 2: Surveys available for analysis by program, population, and timepoint

Program	Population	Pre-Course Surveys Completed	Post-Course Surveys Completed
FMR Program	Healthcare Provider	65	18
ACCOUNT Program	Healthcare Provider	43	30
	Community Member	19	16

3.2.2 Curriculum Development

A participatory medical genetic education program curriculum will be created for both clinicians and KOLs focusing on WGS data. The educational modules will be available to participants on the Canvas teaching platform, as web-based, scalable educational modules with access to WGS through the T2L platform.

To create the curriculum, a landscape analysis of educational programs was completed. Search strategy queried 1) EMBASE and PubMed with keywords “whole genome sequencing”, “medical education”, “participatory education”, “health care personnel”, and “education program” from inception to 2020; 2) NHGRI’s Genetics-genomics competency center (G2C2) website using search terms “genetics” and “clinical genetics”; and 3) internet searches to identify programs that may be unpublished. Titles and abstracts were evaluated, and full articles reviewed when deemed applicable (i.e., describing WGS educational programs). Similar records were then sought in EMBASE using keywords derived from highly relevant articles to extend the search. Abstracted

information focused on education methods including program goals, target audience, length of program and its structure, learning methods, topics, and learner outcome metrics analyzed. A multidisciplinary group with expertise spanning primary care, ethics, basic science, informatics, clinical implementation, public health, and pharmacogenomics completed a gap analysis and, in alignment with G2C2 competencies, developed topics targeting unmet needs for specific audiences of clinicians and KOLs. Consensus learning objectives were constructed through iterative development within each topic with the intent of being used in continuing education approved programs.

3.3 Results

3.3.1 Analysis of Previous Genomic Educational Programs

The FMR program has been implemented at UPMC Altoona Family Medicine and UPMC Shadyside Family Medicine in Pennsylvania and the Family Medicine Rural Residency Programs of Caldwell and Nampa Idaho. There are 67 total participants from the FMR program included in this analysis. The ACCOUNT program has been implemented in Chicago and Pittsburgh, including providers and community members in both locations. There are 43 total healthcare provider participants and 18 community leader participants from the ACCOUNT program included in this analysis. Pre- and post-course surveys responses from each location were pooled before analysis. The survey sections that are included in this analysis are divided into three parts: demographics, knowledge of genetics and pharmacogenomics, and attitudes/perceptions regarding the use of pharmacogenomics and precision medicine.

3.3.1.1 Demographics

Demographics for participants is summarized in **Table 3** below, all demographic data was pulled from pre-course surveys as post-course surveys did not include demographic questions. Out of FMR respondents, the most commonly reported age group (71.6%, n=48) was reported to be between 25 and 34 years of age, believed to be due to the targeted resident population of this program. The fewest number of respondents (1.5%, n=1) were reported to be between 18 and 24 years of age and over 64 years of age. Out of ACCOUNT respondents, the majority of participants indicated they were over 35 years of age, with the largest proportion of community member respondents indicating they were over 64 years of age. Out of all respondents, the majority identify as female (62.5%, n=80). Ethnicity was only surveyed in ACCOUNT community members so there is no analysis of this information. The majority of FMR respondents (68.7%, n=46) identified that they were physician residents. The majority of ACCOUNT provider respondents identified that they were either doctors (25.6%, n=11) or nurses/medical assistants (30.2%, n=13). All ACCOUNT community respondents identified that they were either community board members (44.4%, n=8) or "other" (55.6%, n=10). Providers were then surveyed on when they completed their advanced degree, including MD, DO, and PharmD as examples of advanced degrees. The majority of FMR respondents indicated after the year 2011 (74.6%, n=50) while the most commonly reported answer for ACCOUNT providers was "not applicable" (32.6%, n=14) by nurses, staff, and "other" that did not feel that their education qualified as an advanced degree. Additionally, providers were surveyed on their highest level of previous genetic education with 10.2% (n=13) indicating no previous genetics education, 43.8% (n=56) indicating a biology course as their previous education, 28.1% (n=36) indicating they had taken a specific course on genetics, 1.6% (n=2) indicating they had taken a specific course or training on pharmacogenomics.

Table 3: Demographics of previous program participants by program and participant group

Demographic	FMR Program Participants (N=67)	ACCOUNT Provider Participants (N=43)	ACCOUNT Community Participants (N=18)	Total (N=128)
Current Age				
18 to 24 years	1.5% (n=1)	2.3% (n=1)	5.6% (n=1)	2.3% (n=3)
25 to 34 years	71.6% (n=48)	11.6% (n=5)	0% (n=0)	41.4% (n=53)
35 to 44 years	10.4% (n=7)	23.2% (n=10)	5.6% (n=1)	14.1% (n=18)
45 to 54 years	9.0% (n=6)	34.9% (n=15)	38.9% (n=7)	21.9% (n=28)
55 to 64 years	6.0% (n=4)	23.2% (n=10)	5.6% (n=1)	11.7% (n=15)
65 or more years	1.5% (n=1)	4.7% (n=2)	44.4% (n=8)	8.6% (n=11)
Gender Identity				
Male	40.3% (n=27)	23.2% (n=10)	44.4% (n=8)	35.2% (n=45)
Female	55.2% (n=37)	76.7% (n=33)	55.6% (n=10)	62.5% (n=80)
Not Listed	4.5% (n=3)	0% (n=0)	0% (n=0)	2.3% (n=3)
Current Position				
Physician Resident	68.7% (n=46)	0% (n=0)	0% (n=0)	35.9% (n=46)
MD/DO	19.4% (n=13)	25.6% (n=11)	0% (n=0)	18.8% (n=24)
NP/PA	3.0% (n=2)	11.6% (n=5)	0% (n=0)	5.5% (n=7)
RN/MA	0% (n=0)	30.2% (n=13)	0% (n=0)	10.2% (n=13)
Staff	0% (n=0)	14.0% (n=6)	0% (n=0)	4.7% (n=6)
Other	6.0% (n=4)	16.3% (n=7)	55.6% (n=10)	16.4% (n=21)

Community Board Member	0% (n=0)	0% (n=0)	44.4% (n=8)	6.3% (n=8)
Year of advanced degree completion (MD, DO, PharmD)				
Before 1990	4.5% (n=3)	14.0% (n=6)	n/a	7.0% (n=9)
1991-1995	6.0% (n=4)	4.7% (n=2)	n/a	4.7% (n=6)
1996-2000	1.5% (n=1)	11.6% (n=5)	n/a	4.7% (n=6)
2001-2005	0% (n=0)	4.7% (n=2)	n/a	1.6% (n=2)
2006-2010	6.0% (n=4)	14.0% (n=6)	n/a	7.8% (n=10)
2011+	74.6% (n=50)	11.6% (n=5)	n/a	43.0% (n=55)
N/a	4.5% (n=3)	32.6% (n=14)	n/a	13.3% (n=17)
Previous Genetic Education				
None	6.0% (n=4)	20.9% (n=9)	n/a	10.2% (n=13)
Biology Course	52.2% (n=35)	48.8% (n=21)	n/a	43.8% (n=56)
Specific Course on Genetics	37.3% (n=25)	25.6% (n=11)	n/a	28.1% (n=36)
Specific Course/Training in Pharmacogenomics	1.5% (n=1)	2.3% (n=1)	n/a	1.6% (n=2)

3.3.1.2 Knowledge of Genetics and Pharmacogenomics

Efficacy evaluation of the FMR and ACCOUNT programs focused on analysis of the knowledge question responses to first ensure that these programs had significant impacts on

participant knowledge. The knowledge assessment was divided into two parts: self-assessment of genetics knowledge and true/false genetics quiz questions.

The self-assessment of genetics knowledge analysis compared the participants reported level of understanding on a scale of one to five (1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding) for the independent pre- and post-course survey responses. Analysis of the FMR participant data shows that average comfort level for the topic areas of pharmacogenomics ($p=0.025$), genetics of complex disease ($p=0.022$), and precision medicine ($p=0.001$) increased significantly but did not for basic genetic principles ($p=0.108$). Similar results were found when analyzing ACCOUNT provider participant data, showing that average comfort level for the topic areas of pharmacogenomics ($p=<0.001$), genetics of complex disease ($p=<0.001$), and precision medicine ($p=<0.001$) increased significantly but did not for basic genetic principles ($p=0.781$). Analysis of community member data showed that average comfort level for the topic areas of understanding of the concept of pharmacogenomics ($p=<0.001$) and precision medicine ($p=<0.001$) both increased significantly.

The true/false genetics quiz question knowledge analysis compared mean knowledge score for pre- and post-course surveys. Since the pre- and post-course surveys were not linked, individual participant score increases could not be evaluated. Each survey included questions that were unique to the population being surveyed since each population received educational materials targeted to them. Some of the survey questions were the same but some were not. All questions that were used had been previously validated to show participant genetic knowledge and can be found in the surveys included in **Appendix B**. Mean knowledge score is based on the number of true and false questions answered correctly out of the 11 questions in the FMR program survey. The average score for pre-course participants was 8.57 (77.9%) and 9.60 (87.2%) for post-course

participants. Statistical analysis for the FMR program showed a significant increase in knowledge for participants (p=0.006) as shown in Table 4.

Table 4: Statistical analysis of provider knowledge scores in the FMR Program

Provider Analysis	Mean Knowledge Score out of 11 questions	p-value
Pre-course	8.57	0.006
Post-course	9.60	

Mean knowledge score is based on the number of true and false questions answered correctly out of the 14 questions in the ACCOUNT provider program survey. The average score for pre-course participants was 9.00 (64.3%) and 11.04 (78.9%) for post-course participants. Statistical analysis for the ACCOUNT provider participants showed a significant increase in knowledge (p=<0.001) as shown in Table 5.

Table 5: Statistical analysis of provider knowledge scores in the ACCOUNT Program

Provider Analysis	Mean Knowledge Score out of 14 questions	p-value
Pre-course	9.00	<0.0001
Post-course	11.04	

Mean knowledge score is based on the number of true and false questions answered correctly out of the 7 questions in the ACCOUNT community program survey. The average score for pre-course participants was 4.11 (58.7%) and 5.375 (76.9%) for post-course participants. Statistical analysis was also significant for an increase in knowledge in community members (p=0.003) as shown in Table 6.

Table 6: Statistical analysis of community member knowledge scores in the ACCOUNT Program

Community Member Analysis	Mean Knowledge Score out of 7 questions	p-value
Pre-course	4.111	0.003
Post-course	5.375	

This analysis confirms a significant impact on provider participant knowledge for both the ACCOUNT and FMR programs but shows area for improvement for evaluation materials for both providers and non-providers.

3.3.1.3 Attitudes/Perceptions Regarding the Use of Pharmacogenomics and Precision Medicine

Attitudes and perceptions of participants of the FMR and ACCOUNT programs focused on multiple choice questions where participants could indicate their preference or plans as participants as well as questions ranking their attitudes towards specific genetic tests. The preference question analysis includes the potential answers participants could indicate and was different for each question. Specific answer options for these questions are included in the analysis below. For the questions concerning participants attitudes and perceptions towards testing options and provider knowledge, the research team focused on four broad categories of testing: pharmacogenomics, prenatal carrier, cancer risk, and direct to consumer testing. For the questions indicating participant perceptions of clinical utility, the responses participants could choose included 1=none, 2=minimal, 3=moderate, and 4=very useful. For the questions indicating participant perceptions of provider preparedness, the responses participants could choose included 1=none, 2=minimal, 3=moderate, 4=above average, and 5=expert. For the questions indicating

participant perceptions of general statements, the responses participants could choose included 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.

For initial preference analysis, almost all respondents for both FMR and ACCOUNT programs, except for 3 pre-course survey respondents for the FMR program, indicated they would benefit from additional education/training in genomic medicine. Additionally, provider participants for both programs were surveyed on their preferred mode of learning about medical genetics. The results of this are shown below in Figure 1. While the highest number of participants indicated a preference for in-person CME learning, the second most preferred mode of learning was online CME learning.

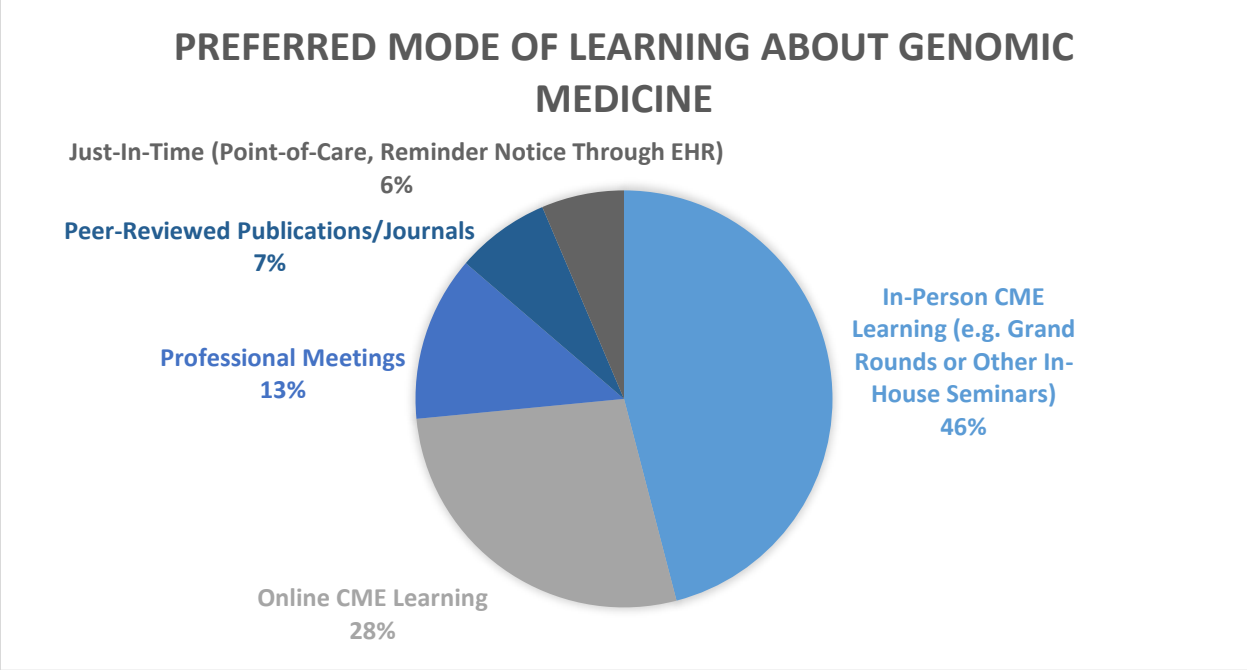

Figure 1: Preferred mode of learning about genomic medicine indicated by provider participants of the FMR and ACCOUNT programs

For the FMR program, 66% of pre-course survey respondents indicated they had undergone personal genetic testing (PGT) as part of the educational program, with 34% of survey respondents

choosing to utilize deidentified, random genetic data. The ratio of respondents indicating they had undergone PGT to respondents indicating they had not remained the same for the post-course survey. For the ACCOUNT program, 70.6% of pre-course community respondents and 69% of pre-course healthcare provider respondents indicated they had undergone PGT as part of the educational program, with 29.4% and 31% of each group choosing to utilize deidentified, random genetic data respectively. The ratio of respondents indicating they had undergone PGT to respondents indicating they had not changed drastically for both provider and community respondents. For ACCOUNT provider post-course respondents, only 41.4% had indicated they had undergone PGT and 58.6% indicated they had not. For ACCOUNT community post-course respondents, only 25% had indicated they had undergone PGT and 75% indicated they had not. The results of this question analysis are outlined below in **Table 7**. This allowed for data analysis of participant data from both participatory and non-participatory survey respondents in populations with a majority of participatory respondents and also non-participatory respondents.

Table 7: Percentage of respondent groups for pre- and post-survey indicating they had undergone PGT as part of the course

	FMR Program		ACCOUNT Provider		ACCOUNT Community	
	Pre	Post	Pre	Post	Pre	Post
Yes	66%	67%	69%	41.4%	70.6%	25%
No	34%	33%	31%	58.6%	29.4%	75%

Analysis of pre- and post-course surveys from the FMR program show that there was no significant change in participant attitudes about the clinical utility of DTC, cancer carrier, prenatal carrier, and pharmacogenetic testing. Upon further analysis, both the pre- and post-surveys showed a high response of "moderately useful" for all types of testing surveyed about, with a noted absence

of any participants indicating they felt that any of the testing types were not useful at all (Figure 2 and 3). This was found for ACCOUNT provider participants as well.

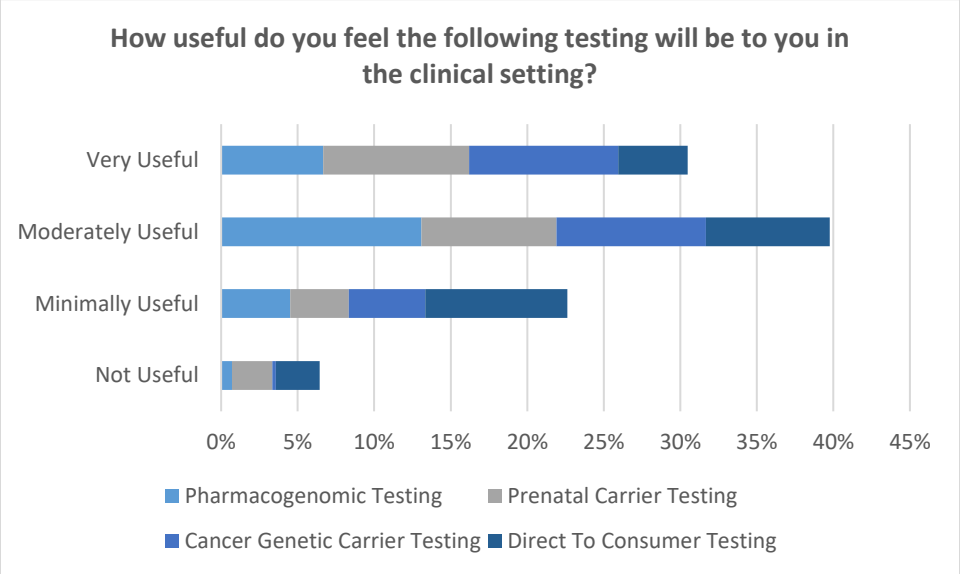

Figure 2: Percentage of pre-survey responses indicating perceived utility of different genetic test types

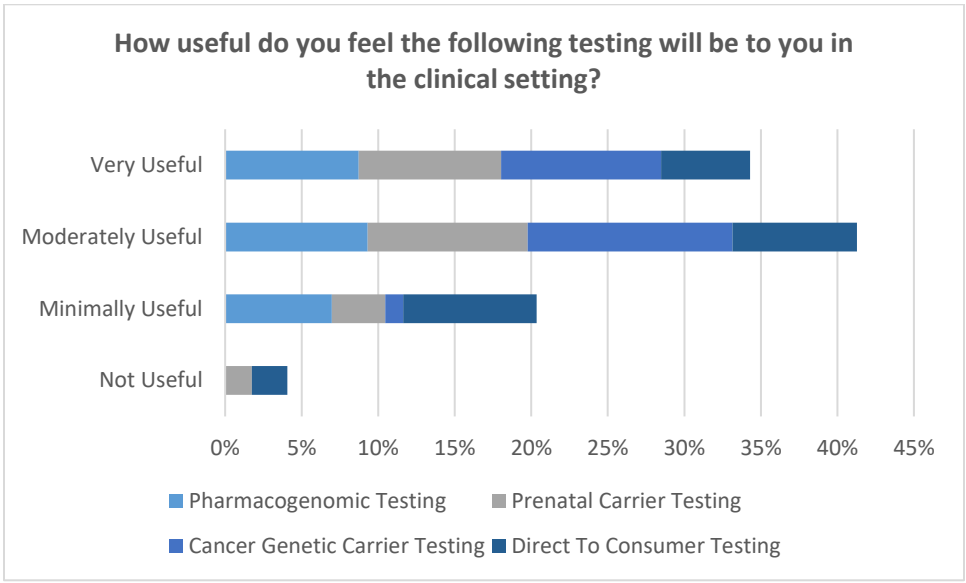

Figure 3: Percentage of post-survey responses indicating perceived utility of different genetic test types

Similar results were noted for pre- and post-course survey analysis of the questions "most primary care physicians have enough knowledge to help individuals interpret the results of the testing options listed" and "most primary care physicians have enough knowledge to ensure

patients understand the risks and benefits surrounding the testing options listed". These questions asked participants to report their perception of provider preparedness on a 5-point Likert scale. The majority of participants indicated the response "disagree" or "neutral" for both the pre- and post-course surveys for both questions with no significant change.

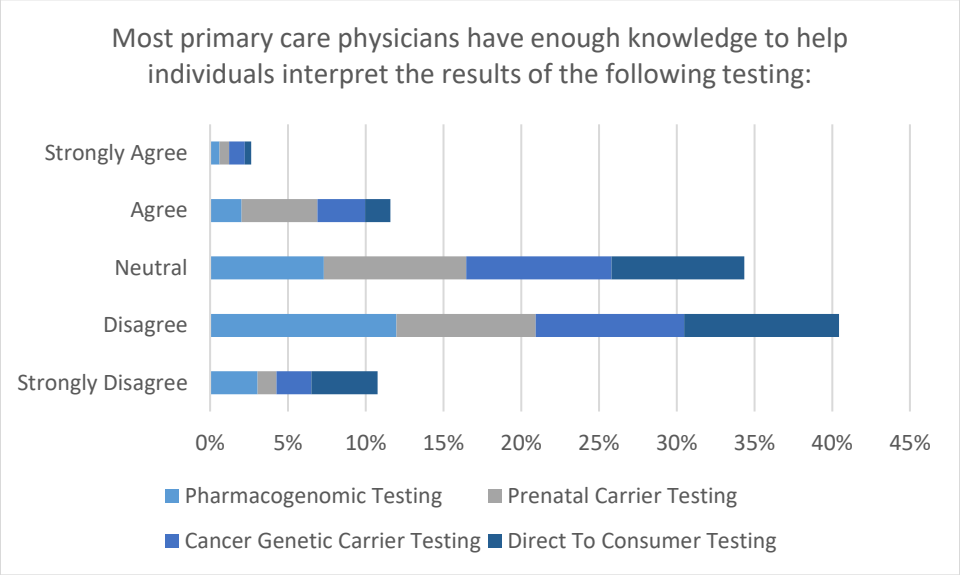

Figure 4: Pre-survey responses indicating perceived knowledge of the general PCP population to interpret results for different genetic test types by response option

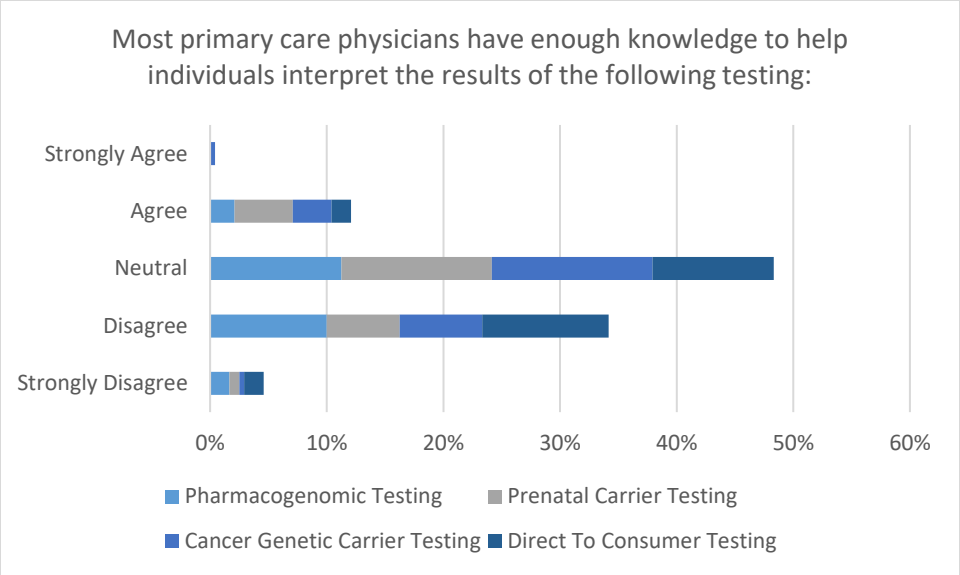

Figure 5: Post-survey responses indicating perceived knowledge of the general PCP population to interpret results for different genetic test types by response option

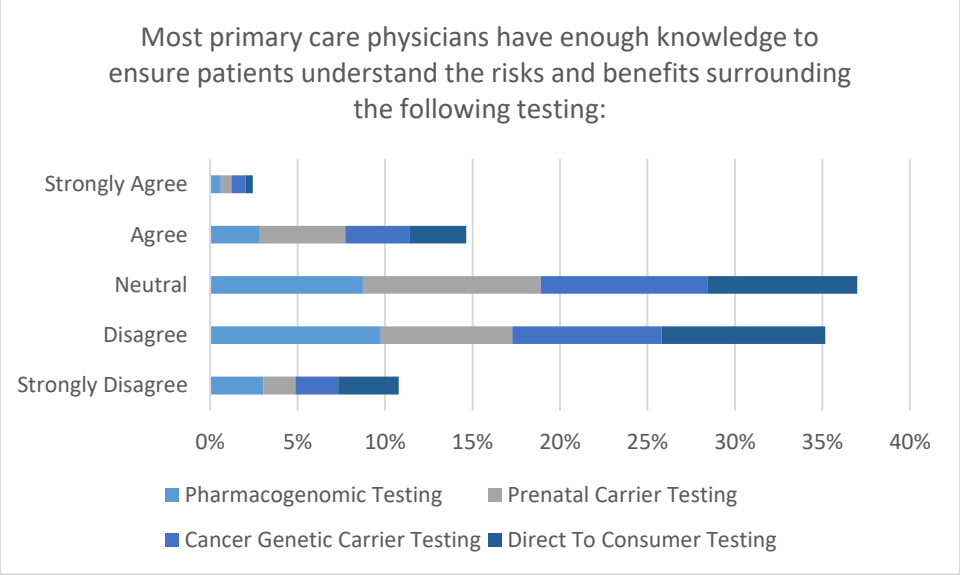

Figure 6: Pre-survey responses indicating perceived knowledge of the general PCP population to understand risks and benefits for different genetic test types by response option

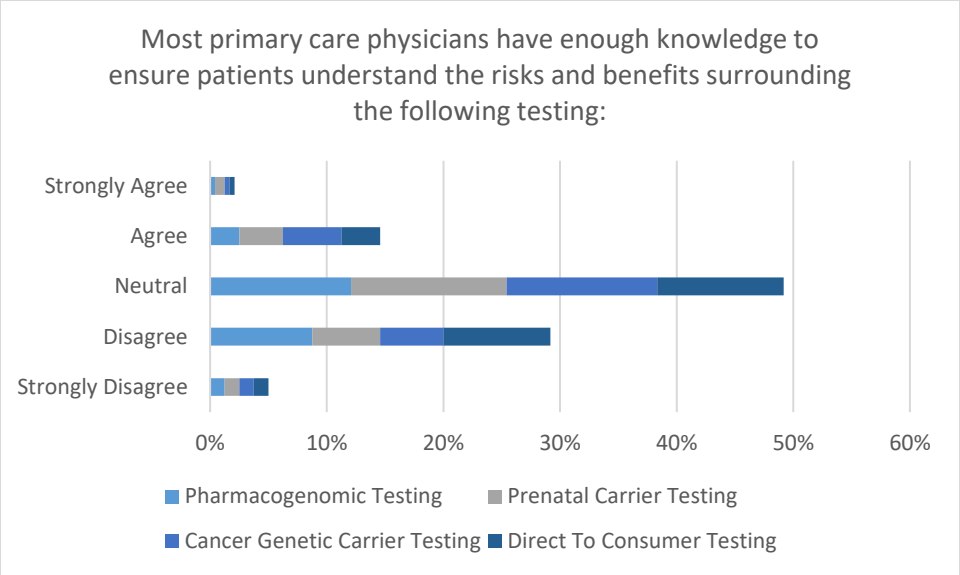

Figure 7: Post-survey responses indicating perceived knowledge of the general PCP population to understand risks and benefits for different genetic test types by response option

Similarly, there was no significant change in participants perception of the general public's ability to accurately interpret their PGT results, with the majority of participants disagreeing with this statement both before and after completing the FMR or ACCOUNT educational program. There was also no significant change for this question for ACCOUNT community members, with the majority disagreeing or remaining neutral with this statement both before and after the educational program.

Additionally, a significant increase ($p=0.018$) was found between FMR pre- and post-course surveys for the participants comfort in discussing genetics in general with patients. This question was not included in the ACCOUNT provider survey and could not be assessed. ACCOUNT community members indicated no significant increase in their comfort level discussing genetics in general with their primary care provider.

With the increase in consumer utilization of PGT, providers were also surveyed on their awareness of direct-to-consumer testing. Only 85.7% of FMR provider participants indicated they

were previously aware of direct-to-consumer testing, which increased to 100% after this course due to the participatory nature of the educational program. Providers were then surveyed on if they had ever had a patient bring a genetic test result to them, though there was not an option to clarify what kind of genetic test result had been brought by the patient. While the majority of participants indicated that they had not had a patient bring genetic results to them, 20-30% of FMR participants and approximately 16% of ACCOUNT providers indicated that a patient had brought in genetic results into their clinical practice (**Table 8**).

Table 8: Percentage of providers that have had patients bring a genetic test result to them in their clinical practice

	FMR providers	ACCOUNT providers
	Pre (n=65)	Pre (n=43)
Yes	21.5% (n=14)	16.3% (n=7)
No	73.8% (n=48)	83.7% (n=36)

In addition to provider awareness of DTC-GT, provider experience ordering or using different genetic testing modalities to manage their patients was surveyed. While the largest proportion of respondents for both FMR and ACCOUNT pre- and post-course surveys indicated that this question was not applicable to them, many others indicated having used a genetic testing method for patient management. Respondents were allowed to pick more than one option if applicable and not every respondent answered the question. Both pre- and post-course surveys were evaluated since participants could have had additional experiences between the administration of the pre- and post-course surveys. The most commonly reported technologies ordered or used across all groups was karyotype, with single gene tests as the second most

indicated technology (**Table 9**). Multi-gene panels and microarray were equally indicated with targeted sequencing and whole exome/genome sequencing having the least reports (**Table 9**).

Table 9: Percentage of reported testing technologies ordered or used by provider participants to manage their patients

	FMR providers	ACCOUNT providers
	Pre (n=65)	Pre (n=43)
Not applicable	50.8% (n=33)	69.8% (n=30)
Karyotyping	15.4% (n=10)	11.6% (n=5)
Single gene tests	15.4% (n=10)	2.3% (n=1)
Multiple gene panels	7.7% (n=5)	7.0% (n=3)
Microarray	6.2 (n=4)	7.0% (n=3)
Targeted sequencing	0% (n=0)	0% (n=0)
Whole genome or exome sequencing	1.5% (n=1)	2.3% (n=1)
Not sure of the type	15.4% (n=10)	7.0% (n=3)

Comparatively, ACCOUNT community participants were surveyed on the technologies that had been offered to them as part of their clinical care. The options for community members were very different from the options for providers and surveyed about pharmacogenomics, diagnostic, carrier, or cancer risk genetic testing offered to participants in their care. Responses showed no clear genetic technology was used significantly more than the others, showing no inclination towards or familiarity with one testing type over another. However, there was a difference between testing technologies indicated in the pre- and post-survey. This difference could be due to multiple reasons but since the answers are not linked the specific participant

changes could not be tracked. A likely cause is that participants were not aware they had genetic testing or what type it was until after the educational course, but we cannot know for sure.

Table 10: Percentage of reported testing technologies offered to community member participants

	ACCOUNT community members
	Pre (n=19)
Pharmacogenomics	26.3% (n=5)
Diagnostic genetic testing	5.3% (n=1)
Carrier testing	5.3% (n=1)
Genetic cancer risk testing	26.3% (n=5)

In the post-course FMR program survey, respondents were asked about which specific aspects of the program they found to be valuable in their learning experience. The specific aspects that participants could indicate their attitudes towards on a 5-point Likert scale were the online courses, the live course, the Test2Learn exercises in the live course, the optional reading material, the clear learning objectives, the detailed course outlines, and the interactive exercises in the live course. The majority of participants indicated "neutral" for all aspects.

3.3.2 Curriculum Development

During initial literature reviews, 592 abstracts were identified and 63 were reviewed in PubMed/Embase which identified three WGS education programs. Eight additional programs were found through NHGRI's G2C2 and internet queries. Of these programs, eight provided web-based instruction and one program incorporated analysis of personal genomic testing into a health sciences curriculum to increase student learner engagement and enhance understanding. Audiences

were composed of students, residents, and health care professionals with common topics including ethical, legal, and social implications (ELSI); testing technologies; WGS in various diagnostic contexts; and genomics communication. No courses for KOLs were found. Gaps included addressing infrastructure needs and processes surrounding clinical genomic testing, which reinforce the need for participatory educational programs for front-line clinicians and KOLs.

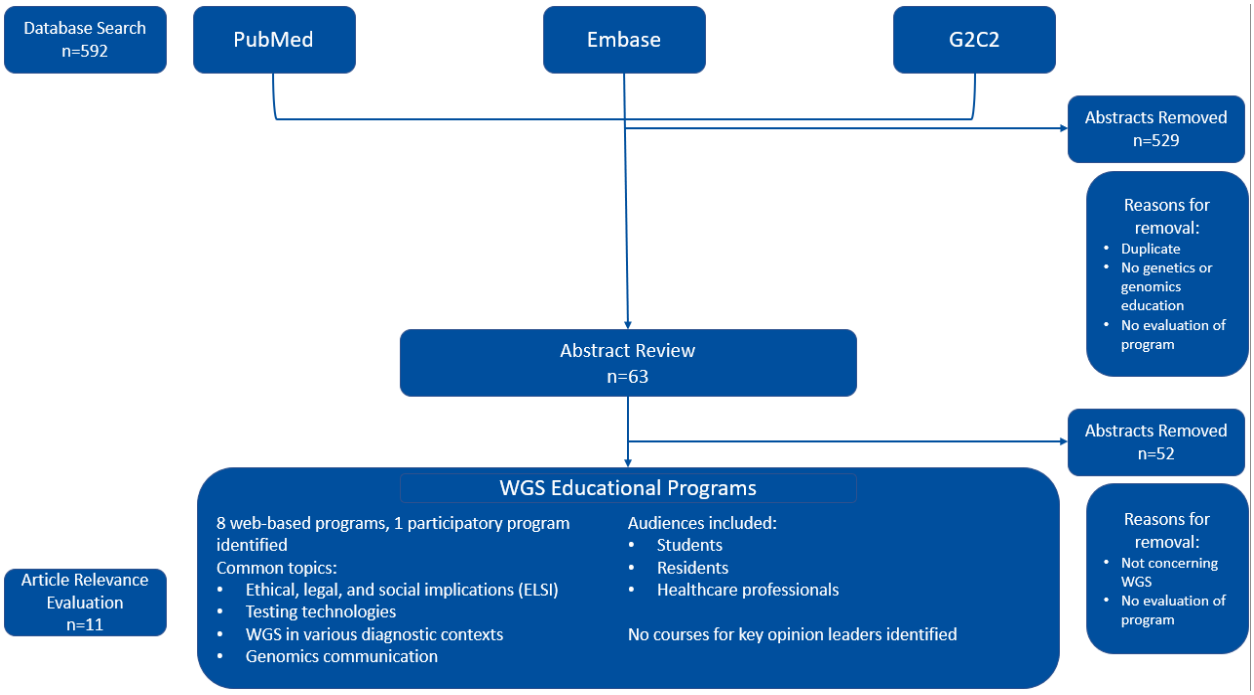

Figure 8: Literature review process for curriculum development

The multidisciplinary team developed eight topics areas for clinicians (e.g., ordering WGS, returning of WGS results, WGS and the patient health record, ELSI) and six topic areas for KOLs (e.g., economics, data warehouses and enterprise infrastructure, ELSI).

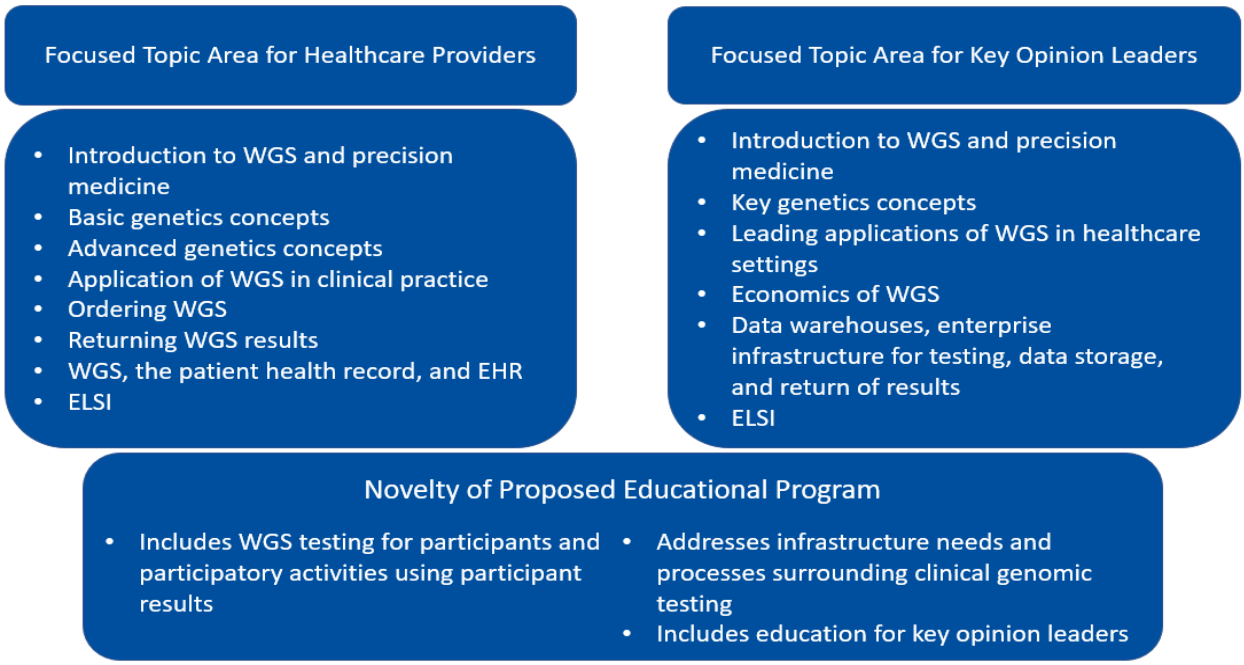

Figure 9: Results of literature review analysis for curriculum development

Within these topics and tailored per audience, a total of 52 unique learning objectives have been constructed between clinician and KOL participants. Knowledge, comfort level, and practice behavior outcomes will be evaluated as important general goals for participants. Learning objectives were created to meet AAFP and G2C2 genomic learning competencies. The drafted curriculum for the healthcare provider participants is shown below in **Table 11**

Table 11: Learning objectives sorted by topic area created for clinician participants of the MWGS program

Why the excitement around whole genome sequencing and precision medicine?
1. Describe innovations in genetic technologies that have advanced scientific knowledge towards precision medicine.
2. Differentiate between different genetic testing technologies.
3. Recognize logistical, ethical, legal, and societal issues that impact genetic testing and data use in the healthcare setting.
Basic genetics concepts
1. Define foundational genetics concepts and nomenclature.
2. Describe mechanisms of genetic variation that can lead to disease and differences in treatment response.
3. Differentiate between the clinical diagnosis of disease informed by genetics and the identification of genetic predisposition to disease.
4. Identify the relevance of genetics in the manifestation and treatment of disease.

5. Recognize the combined impact of behavioral, social, environmental, and genetic factors in the manifestation, prevention, and treatment of disease.
Advanced genetics concepts
1. Compare preemptive versus reactive testing.
2. Identify when genetics is relevant to your practice
3. Explain challenge the uncertainly and evolving knowledge associated with interpretation of certain results. (e.g. VUS, reclassification)
4. Defend the opportunity to make decisions regarding the return of results as opposed to mandatory return
Application of WGS in practice
1. Explain leading applications for WGS in:
- Undiagnosed disease in critically ill infants
- PGx
- Cancer risk assessment and diagnosis
- Complex disease
- Solving diagnostic odyssey
2. Determine which genetic testing technology is most appropriate.
3. Review core concepts in the interpretation WGS results.
Ordering at WGS
1. Identify considerations for selecting a genetic testing laboratory from which to order a test.
2. Develop procedures for appropriate consenting for WGS.
3. Discuss the potential impact of secondary findings in genetic testing.
4. Evaluate the value of WGS testing in a treatment plan for an individual patient.
5. Develop a process to estimate the cost of WGS services in the current reimbursement landscape
Returning of WGS results
1. Assess the source of existing test results (e.g., CAP/CLIA, clinical, vs. direct-to-consumer, research results) and recommend new testing if appropriate.
2. Explain the differences between an informative/noninformative results and issues surrounding evolving knowledge.
3. Identify reliable online resources of genetic information for providers, patients, and those whom patients choose to share information.
4. Use a culturally sensitive approach to patient counseling regarding test results.
5. Identify when and how to refer a patient to a genetic specialist.
WGS, the patient health record, and EHRs
1. Describe best practices proper documentation of test results in patient heath record.
2. Identify challenges associated with the integration of genomic data in the EHR.
3. Describe the benefits of integrated clinical decision support in the EHR.
4. Summarize the need for re-classification of genetic test results based on updated knowledge.
Ethical, legal, and societal implications
1. Explain ethical reasons to protect privacy of genetic data.
2. Discuss duty to inform
3. Describe the ethical considerations regarding genetic testing under the age of 18.
4. Recognize the legal protections against discrimination based on genetic test results (e.g., the Genetic Information Nondiscrimination Act of 2008).

Additionally, the learning objectives for the KOL participants is shown below in **Table 12**.

Table 12: Learning objectives sorted by topic area created for key opinion leader participants of the MWGS program

Why the excitement around precision medicine and whole genome sequencing?
1. Describe innovations in genetic technologies that have advanced scientific knowledge towards precision medicine.
2. Differentiate between different genetic testing technologies.
3. Explain the value of testing as a screening and prevention strategy to improve clinical outcomes at decreased cost.
4. Recognize logistical, ethical, legal, and societal issues that impact genetic testing and data use in the healthcare setting.
Key genetics concepts
1. Define foundational genetics concepts and nomenclature.
2. Describe mechanisms of genetic variation that can lead to disease and differences in treatment response.
3. Differentiate between the clinical diagnosis of disease informed by genetics and the identification of genetic predisposition to disease.
4. Identify the relevance of genetics in the manifestation and treatment of disease.
5. Recognize the combined impact of behavioral, social, environmental, and genetic factors in the manifestation, prevention, and treatment of disease.
Leading application of WGS in the healthcare settings
1. Describe leading scenarios where whole genome sequencing is having a profound impact on healthcare.
a. Undiagnosed disease in critically ill infants
b. PGx
c. Cancer risk assessment
d. Complex disease
e. Solving diagnostic odyssey
2. Distinguish up and coming applications for the use of WGS data
Economics [payors/reimbursements/cost savings]
1. Explain the cost, cost–effectiveness and reimbursement by insurers relevant to genomic tests and test interpretation for patients and populations.
2. Needs for policy (WGS/WES)
3. Cost of diagnostic odyssey vs WGS
4. Implications for IDFS/vertical vs others
Data warehouses, enterprise infrastructure for testing, data storage, and return of results
1. Describe the rationale for a having a genomics data strategy (e.g. from CCM report)
2. Describe best practices proper documentation of test results in patient heath record.

a. Describe the institutional policies that govern what results it is permissible or obligatory to place in the EHR.
b. Explain the implications, including benefits and downsides, of results being placed in the health record, particularly EHRs.
3. Identify challenges associated with the integration of genomic data in the EHR.
a. Privacy/security, size/amount/organization of data
4. Describe the benefits of integrated clinical decision support in the EHR.
5. Summarize the need for reclassification of genetic test results based on updated knowledge.
Ethical, legal, and societal implications
1. Explain ethical reasons to protect privacy of genetic data.
2. Examine core concepts in ethics surrounding WGS including the discuss duty to inform, legal protections against discrimination based on genetic test results (e.g., the Genetic Information Nondiscrimination Act of 2008, state laws), and genetic testing under the age of 18.
3. Recognize the increased liability that accompanies access to detailed genomic patient information and maintaining confidentiality and security.

3.4 Discussion

Analysis of previous genetics programs on the Test2Learn platform immediately showed how important it is to encourage or incentivize participants to complete both pre- and post-course evaluation and to have a reliable linkage system for participants. Having a larger population of respondents adds power to the data analysis and linkage adds the ability to pair the pre- and post-course data. Linkage allows for more robust statistical analysis and the ability to track individual improvement with the nuance of the demographic questions. Examples include being able to analyze if knowledge or comfort improvements were correlated with participant age or ethnicity, especially in the field of genetics where patient ethnicity can impact the informed consent process for testing. Linkage also allows for comparison of knowledge increases in participants that chose to undergo PGT as part of the course and those that chose to utilize random deidentified data to

further analyze the impacts of participatory education on learner knowledge. This combination of participatory and non-participatory program participants is expected with the MWGS program so comparison of these two groups also impacts curriculum and evaluation development.

Curriculum development started with intensive literature reviews that identified 592 abstracts related to the MWGS program that were reduced to 63 abstracts reviewed to find articles relevant to the program for in-depth review. The absence of any educational programs for KOLs emphasized the education gap this program could help fill, as most insurance approvals for genetic testing do not occur in a vacuum. KOL education is just as important as provider education to help get genetic care covered and made accessible to the general population and not just an affluent subset that has the means to pursue testing without the aid of insurance. Additional education gaps were found in current educational programs for providers concerning infrastructure needs of WGS and the processes surrounding clinical genomic testing. These identified gaps influenced the learning objectives associated with WGS result needs, genomic testing processes, and ELSI issues associated with WGS. Based on the competencies identified by AAFP in genomic medicine, prior genetic educational experiences of multidisciplinary teams' members, and identified gaps in current education, eight topic areas were identified for providers and six topic areas were identified for KOLs. Within each audience and topic area, 52 unique learning objectives were drafted for the educational program. The creation of certain learning objectives was influenced by the data analysis from previous programs.

The demographics of provider participants were fairly consistent with a recent publication of the demographics of Primary Care Physicians by the Robert Graham Center that reported a different ratio of male to female providers in primary care [58]. This report showed the vast majority of PCPs are MDs (not a fellow or resident) over the age of 35 while the provider

participants of these programs were primarily reported to be younger than the age of 35 and also physician residents. This discrepancy is due to the targeting of the resident population for the FMR education program and would also be why the majority of provider participants reported completing their advanced degree after 2011. This report also showed a slight majority of males to females (55% to 45%) while respondents of the FMR and ACCOUNT programs showed a slight majority of females to males (64% to 36%) which may also be due to the younger population included in this analysis. Even with differences in the reported average demographics of the PCP population and demographics of participants included in this analysis, the information gathered from this analysis is likely to be applicable to the population expected to enroll in the MWGS educational program. Despite the younger, more recently graduated population included in this analysis, the majority of providers indicated the highest level of genetics education they had received was a biology course. This confirmed previously cited reports that medical students, even those that have recently graduated, have not had specific course on genetics and therefore not receiving the robust education needed to integrate genetics into clinical care, further reinforcing the need for education on the integration of genetic testing results into clinical care. Later in the survey, a vast majority of participants also indicated they would benefit from additional education/training in genomic medicine, presumably seeing the clinical applications of genetics in their clinical practice as well as the gap in their education. Provider participants were additionally surveyed on their preferred mode of learning. While the highest number of participants indicated a preference for in-person CME learning, this kind of learning mode is not always widely accessible, especially in the era of COVID-19 precautions and travel restrictions. The second most preferred mode of learning was online CME learning, which supports the creation of a web-based educational program about genomic medicine, both due to provider preference and also the ability

of online education to be more accessible, regardless of location, for those interested in further genomic medicine education.

Additionally, this analysis identified gaps in areas to gather demographics on participants to further evaluate the MWGS educational program. Areas include participant ethnicity, previous genetic education, and years of experience in current position indicated for all participants. Ethnicity was previously only included for community participants and previous genetic education was only included for provider participants. Years of experience in current position indicated would help distinguish amount of experience in current position for all participants regardless of current position.

Knowledge was evaluated both with participants reporting perceived knowledge of specific subjects on a 5-point Likert scale and a true/false genetics knowledge quiz. Not all of the subjects included for each program were relevant to the MWGS program and not all of the subjects were the same for each of the participant groups, so they were not analyzed for this project. The topic areas of basic genetic principles and genetics of complex disease were not included in the ACCOUNT community surveys because increase in knowledge in these areas was not a goal for the community members. Due to this, analysis was focused on provider participant perceived knowledge of basic genetic concepts and genetics of complex disease, and all participant perceived knowledge of pharmacogenomics and precision medicine. These topic areas overlapped significantly with the topic areas chosen to focus on for the MWGS. Pharmacogenomics is a topic area that greatly relates to WGS data since PGx results are commonly included in WGS data so education on the clinical applications of these results will be included in the curriculum. Participant perceived knowledge was shown to increase for both pharmacogenomics and precision medicine for all participants, and provider perceived knowledge of genetics of complex disease. Provider

perceived knowledge of basic genetic concepts was not found to be significantly increased but this was because providers indicated they had a moderate to above average knowledge of basic genetic concepts both before and after completing the educational programs.

Due to this finding, the multidisciplinary team could plan to spend less time focusing on basic genetics concepts and have a more focused curriculum since this population has been shown to have adequate perceived knowledge of this topic area. Time spent focusing on a topic that a participant feels they already have a high level of knowledge in must be balanced to help build participant confidence and also challenge them appropriately. Another adaptation discussed was to intersperse the basic genetics concepts throughout the curriculum in topic areas that will utilize the concept in an application, a higher level of learning to further challenge participants and start topic explanation from areas of previous understanding.

The general ability of the FMR and ACCOUNT programs to significantly increase participant knowledge was seen for all three participant groups. Quiz questions for each participant group was specific to the information being assessed by the research team. The exact questions asked of each group can be referenced in **Appendix B** but were all drawn from the same pool of questions that had been systematically validated to evaluate learner knowledge of genetics. The questions used for the knowledge evaluation will be adapted for the MWGS education program because, while systematically validated, these questions do not show targeted evaluation of participant knowledge of the topic areas covered by this program. Also, as previously described in the literature, it is important to ask a minimum number of complex questions to test participant knowledge. Due to this, the knowledge questions will be updated to evaluate key takeaways for the specific topic areas selected by the multidisciplinary team.

The attitudes of participants on different topics were also assessed with a 4 point Likert scale. One question analyzed was aimed at identifying providers attitudes about the clinical utility of DTC, cancer carrier, prenatal carrier, and pharmacogenomic testing. Analysis showed that the course had no impact on provider attitudes about the utility of specific genetic tests, with the majority of participants finding the different testing options to be moderately useful before and after the educational program. This finding aligns with the programs goal to educate on effective clinical applications of genetics in medicine, not to promote the use of genetic testing regardless of patient presentation. Additionally, none of the participants indicated that the different genetic testing options were not useful at all to them clinically. This could potentially be because participants had been educated on potential clinical applications of the genetic testing options surveyed and believed that all of the testing options have some clinical use. This finding could also be due to post-course response bias. This further emphasizes the importance of linking data for the MWGS educational program from the pre- and post-course surveys and to continue to provide unbiased education on the use of WGS in clinical care.

Additionally, the perceptions of participants on different topics were also assessed with a 5-point Likert scale. Perceptions of provider participants on general provider preparedness to help individuals interpret their results and help patients understand the risks and benefits of the same testing options were analyzed. The results of this analysis showed similar, unaffected pre- and post-course results as previously mentioned with the majority of participants disagreeing that providers are adequately prepared. This shows that the course did not endorse provider preparedness being either adequate or inadequate. To assess participant perceived comfort levels speaking with patients about genetics, statistical analysis was completed and showed significant increase in participant comfort after completing the course. This supports that genomic education

can increase provider comfort in discussing genetics in general with patients and when paired with the significant increase in participant genetics knowledge, can help endorse accurate discourse with patients about genetic applications in their clinical care. This supports that participant comfort levels discussing genetics can be impacted by education and should be a focused topic area for the MWGS program curriculum. A main goal of this program is to educate on the clinical applications of WGS results in clinical care which has been emphasized in the curriculum, which can include results that impact medical management in many ways that should be discussed with patients.

It is also important to evaluate if provider participants have had patients bring genetics testing results into them and what types of genetic technologies they had ordered or used personally in their clinical practice. About 20-30% of FMR participants and approximately 16% of ACCOUNT providers indicated that a patient had brought in genetic results in their clinical practice, but the specific type of result brought in was not surveyed. Due to this, this analysis did not influence what types of genetic results are reviewed with provider participants but did influence the creation of learning objectives related to benefits and limitations of genetic results brought in by patients. The MWGS research team also identified the importance of reviewing the similarities and differences between different genetic testing technologies and the benefits and limitations of the results. Currently, WGS is almost exclusively utilized in research so very few provider participants were expected to have experience with ordering or using these results, which is what the survey found. The survey also confirmed that many participants did not indicate having utilized genetic technologies in their clinical practice, potentially due to their acknowledgment in their knowledge gap in genomic medicine or the inability to recognize clinical applications of different testing options. This survey also identified that karyotyping was the most commonly utilized technology, with single gene tests as the second most common and multi-gene tests and

microarrays both indicated as the third most common genetic tests utilized. This finding reinforces the need to review the similarities and differences between the test they are more familiar with than WGS. ACCOUNT community members were surveyed on testing technologies they have had been offered in their clinical care. Responses showed no clear genetic technology was used significantly more than the others, showing no inclination towards one testing type which may represent an "as indicated" clinical approach for all of their care and not provider preference and/or comfort with one type of test results regardless of patient presentation.

In the post-course FMR program survey, participants were asked about which specific aspects of the program they found to be valuable in their learning experience. This section utilized an entire page of the survey and was included at the end so the overwhelming "neutral" responses for every aspect surveyed may have been heavily influenced by survey fatigue.

3.4.1 Limitations

Analysis of the survey data collected from the ACCOUNT and FMR programs was limited by the small number of participants, inability to pair the data, and uneven amount of pre- and post-course surveys completed. Analysis of pre- and post-course surveys was also limited because the anonymous identifier created by participants was not successfully collected for all pre- and post-course responses, resulting in the inability to track individual progress. Due to this, evaluation of knowledge gain after the program intervention was focused on overall score change. This evaluation was further limited by the discordant number of pre- and post-course surveys completed.

3.5 Conclusions

Few WGS training programs exist for clinicians, and none exist for KOLs. The MWGS educational program is necessary to fill educational gaps and prepare clinicians for the integration of clinical genomic sequencing results into clinical care. Current educational programs that attempt to address clinical genomic sequencing used variable educational engagement methods. Although participatory education has perceived value as a method for genomics education, it is underutilized. With collaboration amongst a multidisciplinary team, we plan to expand the Test2Learn program using the new topics and learning objectives to develop web-based, participatory education program on WGS and its clinical applications. Analysis of previous genetic education programs that utilized the Test2Learn platform and current literature is necessary to create an informative, accurate, and novel curriculum on genomic data usage in clinical care. Lessons learned from previous programs are vital in shaping the evolving curriculum for the MWGS educational program. Multidisciplinary input is also necessary to create a robust curriculum that maximizes participant benefit and minimizes participant harm, especially in the context of a participatory program.

The efficacy and significance of the MWGS educational program will not be assessed until the program is launched in September 2021. Effective evaluation of this program is imperative to identify areas of strength and opportunities for improvement. Evaluation of the novel educational program with a participatory aspect is also imperative as this educational method is used more. Evaluation tool formation for the MWGS is also heavily influenced by analysis of previous survey materials and should be done with multidisciplinary input.

4.0 Relevance to Genetic Counseling and Public Health Genetics

Clinical genetic testing continues to become more advanced and complicated as testing techniques improve. It also continues to become more accessible as testing becomes more cost effective. During the Human Genome Project, sequencing the human genome using Sanger sequencing took over 10 years and cost almost $3 billion [59]. NGS has revolutionized the diagnostic process as a reliable, quick, and relatively cheap sequencing technique with the cost of sequencing a human genome dropping below $1,000 as of 2020 [60, 61]. With advancing technology and increasing access, education for health care providers is essential.

Education is imperative to the development of policies and the foundation of clinical practice. Education is also encompassed in many of the ten essential public health services such as effective communication, assuring a competent workforce, and linking to/providing care. In order to provide appropriate care and meet the growing need for genetics services, non-genetics clinicians will need to be educated on genetic testing and how to interpret genetic information. These clinicians also need to understand that genetic testing is not always the appropriate next step in medical management and must be able to identify when genetic testing may actually be indicated. Previous studies have exposed the potential harm that undereducated providers ordering genetic testing can cause, showing the need for an effective educational program on clinical utility of genetics and genomics for non-genetics providers. (cite)

In support of the critical need for genetic education, the NSGC states its commitment to "advance the various roles of genetic counselors in health care by fostering education, research, and public policy to ensure the availability of quality genetics services". Five different Medical Schools in the US have created and implemented participatory medical and graduate medical

genetic education courses: Temple University, Stanford University, Tufts University, Mt. Sinai, and University of Pittsburgh, as well as the University of Pittsburgh's School of Pharmacy [12, 62]. Genetic counselors are often involved in these courses; three of the five universities - Stanford University, Mt. Sinai, and University of Pittsburgh - have an accredited genetic counseling program where students and/or faculty have involvement with the course [12, 44, 50]. This relationship shows that when formulating the curriculum of a genetics educational program, genetic counselors and public health professionals are important stakeholders of the project as content experts as well as patient and public advocates.

As WGS becomes more common, more clinicians will encounter genetics results and applications in clinical care and need genetic education to help them understand how to integrate genetics into their practice. While the use of WGS in patient care is exceedingly rare currently due to limited insurance coverage, limited number of labs that perform WGS, and limited understanding of the clinical utility of WGS, it is anticipated that its use will grow. By utilizing WGS in a participatory course, clinicians can be educated on the most advanced technology available as it begins to be used more often in clinical care. By creating educational programs around ethical and informed genetic data use and application, programs like the MWGS program will become a bridge between genetics professionals and non-genetics clinicians.

An important component of participatory education courses is the process of and education about informed consent. Previous attempts to include a participatory aspect in genetic education exposed the potential for harm to participants who have testing without proper informed consent. This process further helps to emphasize participant understanding of the consent process and its nuances by undergoing a similar process themselves. While not every person may be interested in submitting a personal sample as part of the course, the course can still be helpful even if an

individual elects to use an anonymized sample. Thus, informed consent for participants is crucial so each individual can make an informed choice about undergoing analysis as part of the course, especially with the complexity of genetic testing results. By involving a multidisciplinary team including ethicists and genetics professionals, this potential harm to participants can be minimized while emphasizing participant educational benefit.

Genetic testing results have many different impacts and have implications throughout healthcare and the stages of life. For clinicians, participatory education programs can help them understand different types of testing and the different types of results they can receive that will impact patient care. As the application of genetics continues to transition from purely research to clinical offerings, it is important to emphasize to non-genetics providers the potential benefits and harms of genetic testing.

An essential aspect of public health is the continued effort to provide equitable care, regardless of age, gender, race, or background, and this requires educating providers on how those differences may impact genetic results. Educational programs that are widely available can help educate more clinicians on genetics and increase availability of providers equipped to handle genetics. The MWGS program includes educational aspects on the way that patient background can impact results as well as subsequent care such as: 1) the integration of genetics and genomics in healthcare regardless of a patient's background, 2) an emphasis throughout the curriculum on educating all participants on the effect that social determinants of health can have on patient populations and, 3) a section for providers on cultural informed care in genetics is imperative to continue advancing equitable care. These different applications and impacts of genetic test results are also important to emphasize to KOLs in the insurance provider industry.

As evidence to support clinical utility of WGS expands, insurance coverage and labs completing WGS will respond, potentially increasing coverage and availability of WGS [63]. Educating KOLs on the benefits and limitations can help encourage coverage and responsible adoption of WGS in clinical care. For KOLs, this can help emphasize the benefits and limitations of different genetic testing technologies and the positive impact of insurance coverage for different technologies. Insurance coverage can be a key deciding factor for most families when making healthcare decisions and can have a massive impact on patient outcomes.

The need to assure the public of a competent workforce is another essential service of public health that this educational program can help fulfill through evaluation of previous programs. Further, evaluation is an important aspect of public health, as is learning from previous experiences in history. Analysis of previous course data helps identify opportunities to improve the MWGS program and build on previous successes. For example, the FMR and ACCOUNT programs showed many areas of improvement as well as success off which the MWGS could build. While the two populations being targeted for the MWGS program will receive education specific to their areas of impact, evaluation is a key component to assess the program's ability to educate on the overlapping key topic areas.

5.0 Public Health Essay: Creation of Evaluation Tools for a Wed-Based, Participatory Education Program on Clinical Applications of Whole Genome Sequencing Utilizing Lessons Learned from Previous Participatory Genomics Courses

5.1 Project Background

The Mellon Whole Genome Sequencing Project (MWGS) is a web-based, participatory genomics course that will be created administered to both clinicians and key opinion leaders (KOLs) based on the curriculum previously described in this document. Current funding allows for 140 clinicians and KOLs who are ideally positioned to rapidly advance WGS use in clinical practice to take this course as a participatory participant. Participants will have the option of undergoing whole genome sequencing (WGS) and using their genetic data throughout the course. WGS data will be generated from participant samples that are submitted to the Institute of Precision Medicine. This data will be made available to participants on the Test2Learn platform for the participatory aspect of the course, and course material will be administered over Canvas. The recruitment for the pilot launch of this program is expected to be in September 2021 at the Precision Medicine World Conference (PMWC). The logic model for this program is included below in **Figure 6** and outlines the anticipated inputs, outputs, and outcomes of the MWGS project. The goal of the evaluation survey outlined in this paper is to evaluate the short term outcomes of this project, and additional surveys will be developed in the future to evaluate the medium and long term outcomes of this project.

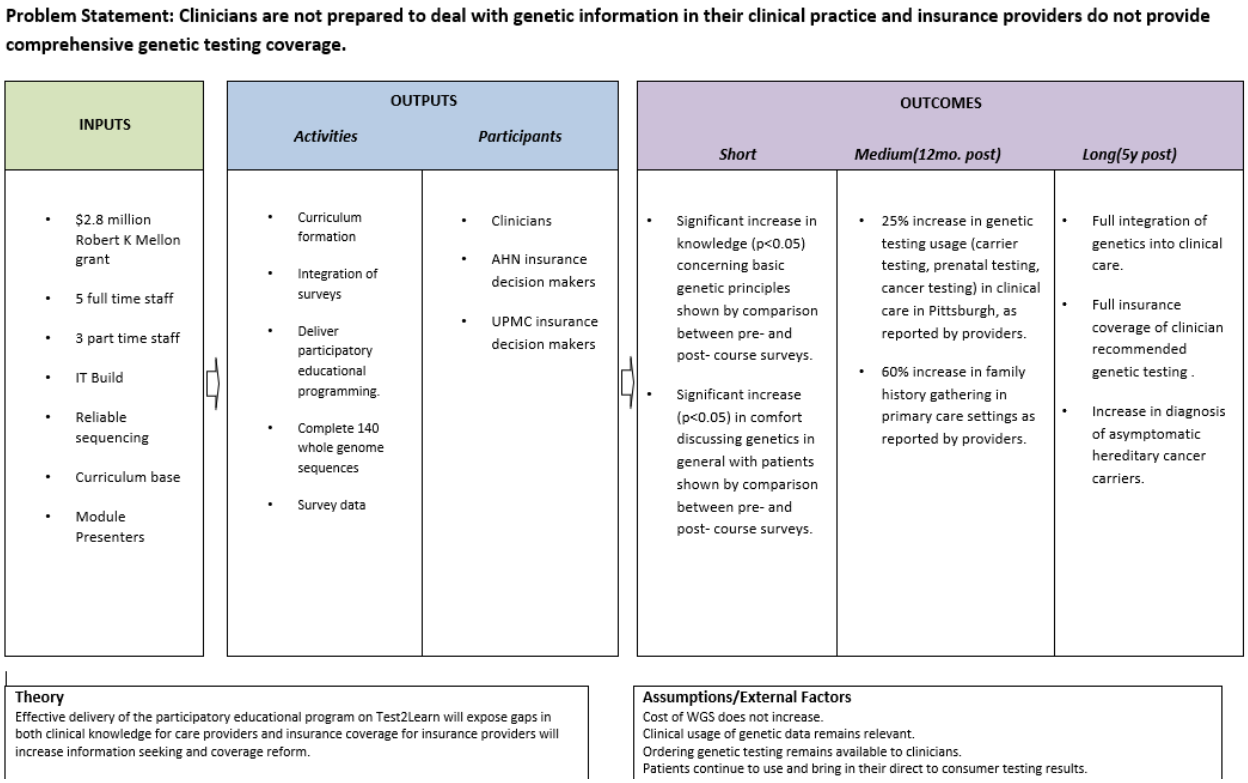

Figure 10: Logic model for the MWGS project

5.1.1 Project Aim: Survey Development

Pre- and post-program surveys will be created to evaluate the effectiveness of the course as well as the participants' attitudes and perceptions of precision medicine and medical genetics.

5.2 Development of Survey Design, Methods, and Topics

5.2.1 Survey Design

The evaluation surveys for the MWGS program were developed in Microsoft Word. While similar, separate surveys were developed for the clinician and KOL participants. The clinician surveys included sections on demographics, knowledge of genetics and precision medicine, and attitudes and perceptions regarding the use of WGS and precision medicine in clinical care (**Appendix C.1**). The KOL's surveys included sections on demographics, knowledge of genetics and pharmacogenomics, and attitudes and perceptions regarding the use of WGS and precision medicine in clinical care (**Appendix C.2**). Responses will not be required for any individual questions, and respondents will be able to exit the survey at any time. The pre-course survey will be delivered with the course and the post-course survey will be collected once the course is completed. Demographics questions will be administered at the initial participant sign on and only asked once. Knowledge and attitudes/perceptions questions will be administered immediately before and after the course. This change was made from previous courses where all pre-course and post-course questions were completed in one large survey in hopes of breaking up the survey to decrease survey fatigue.

5.2.2 Survey Development Methodology

The survey question pool was developed using previously validated questions from the FMR and ACCOUNT programs and adapting them for this course using lessons learned from previous analysis, information gathered during the literature review, and input from the research

team. The FMR survey used as the base for the clinician survey was 136 questions, and the ACCOUNT community survey used as the base for the KOLs survey was 108 questions. A copy of the clinician survey question pool is included in **Appendix C.1** and is 91 questions in total. A copy of the KOLs survey question pool is included in **Appendix C.2** and is 83 questions in total.

5.2.2.1 Demographics

As the survey for the MWGS program was created, demographics were kept uniform between populations and only included in the pre-course survey. This section included 15 questions for both KOLs and clinician participants that were not expected to change during the duration of the course. This included demographics such as the participant's gender, age, and position. Major changes from the survey of the previous programs include surveying all participants' ethnicity, years of experience in their current position, and questions about whether participants submitted a DNA sample. Some questions were also moved from the attitudes and perceptions section into the demographics section, such as the question surveying if participants planned to undergo genetic testing as part of the course since the answers to these questions were not expected to change before and after taking the course. The full survey for both participant populations can be found and further reviewed in **Appendix C**.

5.2.2.2 Evaluation of Participants Knowledge of Precision Medicine and Medical Genetics

Evaluation of participants' knowledge of precision medicine and medical genetics has been attempted before, both in the literature and in the previous Test2Learn programs. A literature review of current knowledge evaluation strategies was conducted and integrated into the knowledge-based questions from the FMR and ACCOUNT programs for the creation of the

knowledge evaluation questions for clinicians and KOLs who will participate in the MWGS program.

Clinician Knowledge Question Development

Previous medical education program evaluation approaches have been mostly quantitative, focusing on the pre- and post-course knowledge surveys as a barometer for program effectivity. While qualitative data provides deeper insight into participants' perceptions and experiences, quantitative data is the most commonly utilized [64]. This is due to the limited time availability of medical students, medical providers, and KOLs. Evaluation of educational programs on their ability to significantly increase knowledge in a subject matter is essential to proving the utility of the program and for highlighting areas of the program that could be improved. Evaluation of efficacy of genetic educational programs has centered on the ability of participants to answer knowledge questions in both pre- and post-course surveys to compare genetic knowledge of participants before and after completing the educational program.

Unfortunately, while working with graduate medical education and continuing medical education, case example questions have not been shown to be feasible, as many respondents will not take the time to read through and respond. Previous programs have also utilized true/false knowledge questions and still experienced minimal responses even with short questions. Low response rates on previous program post-course surveys has further prompted survey analysis for this program to try and maximize responses.

The Bonham and Sellers Genetic Variation Knowledge Assessment Index (GKAI) was developed to understand physician knowledge of genomics concepts and was created as part of a cross-sectional study [65]. This scale was created and measured as a count of correct answers during a cross-sectional study surveying 787 general internists in the United States but was never

tested for use in a longitudinal study [65].This scale was used by Haga et. al. while surveying primary care physicians knowledge of personal genetic testing as a part of a longitudinal study [7]. Despite the reported increase in comfort discussing genetics, no significant change in knowledge was observed between pre- and post- testing, with the majority of participants answering five out of six questions correctly both pre and post-test, indicating the need for improvement of knowledge survey question efficacy [7].

Many precision medicine research projects took a similar approach, creating multiple choice knowledge questions that are specific to the information presented in the program. For example, the MedSeq project mentions the use of a 6-item multiple choice survey created by their study team to analyze participant knowledge longitudinally [6]. This allows researchers to perform targeted evaluation on the knowledge they are hoping to impart on participants, focusing on analysis on key-takeaways that can be more succinct rather than in-depth application questions.

The knowledge evaluation questions in the FMR and ACCOUNT programs focused on the understanding of general genetics concepts rather than the educational takeaways specific to those programs. As an educational class on genetics for physician residents, providers, and community members, general evaluation of genetic concept literacy was appropriate for course evaluation. However, because the MWGS is an educational program focused on clinical care and integration of genetic results into care, it is important to evaluate participant understanding of the information presented to them in the course. The 18 clinician knowledge questions developed using the lessons learned from the literature review and previous programs are included below in **Table 13**. The questions were organized by topic areas selected by the research team with one question representing each topic area and paired with the 5-point Likert scale knowledge self-assessment included in the survey. For each topic area, the curriculum related to the topic area was pulled into

the table and used by the research team to create consensus key-takeaways. For clinicians, this resulted in the creation of nine multiple choice questions meant to assess clinician participant knowledge on the topic area. The correct answer for each question is bolded.

Table 13: Knowledge questions for clinicians paired with the topic area the question is evaluating, including topic key-takeaway and related curriculum

a) Precision medicine	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	1. Precision medicine takes into account individual variability in the genome to personalize medical management. Common clinical applications of precision medicine include all of the following EXCEPT: ☐ Use of pharmacogenomic (PGx) test results to target medication prescribing. ☐ **Use of polygenic risk scores (PRS) to assess a patient's risk for common diseases.** ☐ Use of panel genetic testing to assess a patient's risk for common cancers. ☐ Use of carrier genetic testing to assess a patient's risk of being a carrier for a rare disease. ☐ Use of expansive genetic sequencing to assess a patient's risk of having a genetic condition.
Key takeaway	Examples in current clinical care, as well as benefits and limitations of genetics and the promise of enabling individualized care with superior outcomes.
Related curriculum	Describe innovations in genetic technologies that have advanced scientific knowledge towards precision medicine. Recognize logistical, ethical, legal, and societal issues that impact genetic testing and data use in the healthcare setting.
b) Whole genome sequencing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	2. Whole genome sequencing cannot detect: ☐ Single nucleotide variants (SNVs) ☐ Large structural variants ☐ **Changes in methylation** ☐ Copy number variations ☐ Mitochondrial DNA variants

Key takeaway	Understand risks vs benefits and limitations, including technology differences between WGS and other genetic testing.
Related curriculum	Differentiate between different genetic testing technologies. Evaluate the value of WGS testing in a treatment plan for an individual patient.
c) Basic genetic concepts	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	3. Mutations are changes in an individual's DNA and results in a different version of the gene. Which of the options below is an example of a mutation that, if considered independently, would not impact medical management? ☐ A patient with one pathogenic mutation in CYP2C19. ☐ A patient with Trisomy 21. ☐ A patient with one pathogenic mutation in BRCA1. ☐ **A patient with one pathogenic mutation in CFTR.**
Key Takeaways	Understand types of genetic variation and their nomenclature (Ex. SNP, PRS, etc).
Related curriculum	Define foundational genetics concepts and nomenclature. Describe mechanisms of genetic variation that can lead to disease and differences in treatment response. Differentiate between the clinical diagnosis of disease informed by genetics and the identification of genetic predisposition to disease. Identify the relevance of genetics in the manifestation and treatment of disease. Recognize the combined impact of behavioral, social, environmental, and genetic factors in the manifestation, prevention, and treatment of disease.
d) Advanced genetic concepts	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	4. Genetic mutations are classified on a scale from benign to uncertain to pathogenic per ACMG-AMP guidelines. A patient has genetic results that report a variant of uncertain significance. Which of the following is not a possibility that should be discussed with the patient?: ☐ As the lab gets more data, they reclassify the variant as benign.

	☐ As the lab gets more data, they reclassify the variant as pathogenic. ☐ **In hopes of getting more data, the lab offers testing only for family members that are similarly affected to help reclassify the variant.** ☐ In hopes of getting more data, the lab requests more phenotypic data to help reclassify the variant.
Key Takeaways	Integration of higher end genetics concepts (Ex. results name change with new testing or reinterpretation).
Related curriculum	Compare preemptive versus reactive testing. Explain challenge the uncertainly and evolving knowledge associated with interpretation of certain results. (e.g. VUS, reclassification) Defend the opportunity to make decisions regarding the return of results as opposed to mandatory return
e) Applications of whole genome sequencing in clinical practice	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	5. Whole genome sequencing technology cannot clinically be used at this time to: ☐ Diagnose an individual with a predisposition to develop cancer. ☐ **Diagnose an individual with a predisposition to develop complex disease.** ☐ Identify an individual as a carrier for a condition. ☐ Diagnose an individual with a monogenic genetic syndrome.
Key Takeaways	The broadening practice areas where WGS may and may not be useful in clinical practice (they should be able to name them).
Related curriculum	Identify when genetics is relevant to your practice. Determine which genetic testing technology is most appropriate.
f) Ordering whole genome sequencing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	6. When consenting a patient to receive genetic testing, which of the following results should be discussed as a potential result of genome sequencing: ☐ Pathogenic mutations ☐ Uncertain mutations ☐ Secondary mutations ☐ **Benign mutations** ☐ Mosaic mutations

Key Takeaways	How to order WGS, including understanding of insurance coverage, result types, etc.
Related curriculum	Identify considerations for selecting a genetic testing laboratory from which to order a test. Develop procedures for appropriate consenting for WGS. Discuss the potential impact of secondary findings in genetic testing. Develop a process to estimate the cost of WGS services in the current reimbursement landscape
g) Returning genetic testing results	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	7. A pathogenic result found on whole genome sequencing should prompt a provider to do all of the following except: ☐ Refer the patient to a genetics provider for further follow-up. ☐ Identify appropriate resources for the patient. ☐ **Test family members for the pathogenic finding.** ☐ Interrogate the result using online resources such as ClinVar and OMIM.
Key Takeaways	Key principles of communicating patient results to them including post-test counseling interventions.
Related curriculum	Review core concepts in the interpretation WGS results. Assess the source of existing test results (e.g., CAP/CLIA, clinical, vs. direct-to-consumer, research results) and recommend new testing if appropriate. Explain the differences between an informative/noninformative results and issues surrounding evolving knowledge. Identify reliable online resources of genetic information for providers, patients, and those whom patients choose to share information. Use a culturally sensitive approach to patient counseling regarding test results. Identify when and how to refer a patient to a genetic specialist.
h) Clinical integration of WGS	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	8. A patient's whole genome sequencing results: ☐ Can be routinely integrated into current common EHR systems.

	☐ Should not be expressly used in patient medical management. ☐ Should not be reanalyzed because they already reflect all pathogenic variants. ☐ **Should be stored as a diagnostic report and not as raw data in the EHR.**
Key Takeaways	Understanding impact of result location. (Ex. cds, annotation options, discoverability).
Related curriculum	Describe best practices proper documentation of test results in patient heath record. Identify challenges associated with the integration of genomic data in the EHR. Describe the benefits of integrated clinical decision support in the EHR. Summarize the need for re-classification of genetic test results based on updated knowledge.
i) Ethical, legal, and societal implications of genetic testing.	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	9. Which statement concerning the ethical, legal, and social implications of whole genome sequencing testing true: ☐ The Genetic Information Non-Discrimination Act protects patients from being discriminated against based on their genetic testing results when purchasing disability insurance. ☐ All pathogenic findings, including secondary findings should always be reported to patients. ☐ Genetic testing for adult onset conditions in minors should always be conducted if there is a known pathogenic mutation in a family member. ☐ **Genetic testing results are protected under HIPAA.**
Key Takeaways	Limitations of GINA and genetic data provided by patients.
Related curriculum	Explain ethical reasons to protect privacy of genetic data. Discuss duty to inform. Describe the ethical considerations regarding genetic testing under the age of 18. Recognize the legal protections against discrimination based on genetic test results (e.g., the Genetic Information Nondiscrimination Act of 2008).

KOL Knowledge Question Development

During the literature review done in preparation for the survey creation, no participatory genetics education programs for the general population, such as KOLs in insurance, have been created. Therefore, there are no previously published surveys available for this population. However, a survey for a similar population of college educated individuals that did not have a biology background was available for analysis. Efforts were made in 2007 to create systematically validated genetics literacy assessment instruments for undergraduates. This tool was created after the statement released in 2002 from the American Society of Human Genetics that included a list of benchmarks of genetics concepts for non-science majors, presumably pursuing a bachelor's degree. These benchmarks were then used to narrow down which concepts are necessary for genetics literacy. Thirty-one questions based on these concepts were created and validated to evaluate genetic literacy in non-biology major undergraduate students[66]. This tool was used as an example of how to validate questions about general genetics literacy but is not tailored to specific educational programs and focuses more general genetics concepts.

The knowledge evaluation questions in the ACCOUNT program for KOLs also focused on general genetics concepts rather than specific educational takeaways of the program. However, knowledge questions developed for the MWGS course for KOLs focused on evaluating participant understanding of the information presented to them in the course. The 14 KOL knowledge questions developed using the lessons learned from the literature review and previous programs are included below in **Table 14**. The questions were organized by the topic areas selected by the research team with one question representing each topic area and paired with the 5-point Likert scale knowledge self-assessment included in the survey. For each topic area, the curriculum related to the topic area was pulled into the table and used by the research team to create consensus key-

takeaways. For KOLs, this resulted in the creation of seven multiple choice questions meant to assess participant knowledge on the topic areas. The correct answer for each question is bolded.

Table 14: Knowledge questions for KOLs paired with the topic area the question is evaluating, including topic key-takeaway and related curriculum

a) Precision medicine	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	1. Precision medicine takes into account individual variability in the genome to personalize medical management. Common clinical applications of precision medicine include all of the following EXCEPT: ☐ Use of pharmacogenomic (PGx) test results to target medication prescribing. ☐ **Use of polygenic risk scores (PRS) to assess a patient's risk for common diseases.** ☐ Use of panel genetic testing to assess a patient's risk for common cancers. ☐ Use of carrier genetic testing to assess a patient's risk of being a carrier for a rare disease. ☐ Use of expansive genetic sequencing to assess a patient's risk of having a genetic condition.
Key Takeaways	Reason for excitement for this precision medicine technology in clinical medicine.
Related curriculum	Describe innovations in genetic technologies that have advanced scientific knowledge towards precision medicine. Explain the value of testing as a screening and prevention strategy to improve clinical outcomes at decreased cost. Recognize logistical, ethical, legal, and societal issues that impact genetic testing and data use in the healthcare setting.
b) Key genetic concepts	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
	2. Mutations are changes in an individual's DNA and results in a different version of the gene. Which of the options below is an example of a mutation that, if considered independently, would not impact medical management?

	☐ A patient with one harmful mutation associated with a dominant change in medicine metabolism, such as Clopidogrel. ☐ A patient with a different number of chromosomes than expected, like Down Syndrome. ☐ A patient with one harmful mutation for in a common cancer risk gene, like BRCA1. ☐ **A patient with one harmful mutation associated with a recessive condition, like Cystic Fibrosis.**
Key Takeaways	An individual's genetic information is variable, and some variations can lead to disease risk.
Related curriculum	Define foundational genetics concepts and nomenclature. Describe mechanisms of genetic variation that can lead to disease and differences in treatment response. Differentiate between the clinical diagnosis of disease informed by genetics and the identification of genetic predisposition to disease. Identify the relevance of genetics in the manifestation and treatment of disease. Recognize the combined impact of behavioral, social, environmental, and genetic factors in the manifestation, prevention, and treatment of disease.
c) Whole genome sequencing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	3. Whole genome sequencing cannot detect: ☐ Single nucleotide variants (SNVs) ☐ Large structural variants ☐ **Changes in methylation** ☐ Copy number variations ☐ Mitochondrial DNA variants
Key Takeaways	Understand risks vs benefits and limitations, including technology differences between WGS and other genetic testing.
Related curriculum	Differentiate between different genetic testing technologies.
d) Applications of whole genome sequencing in clinical practice	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	4. Whole genome sequencing technology cannot clinically be used at this time to:

	☐ Diagnose an individual with a predisposition to develop cancer. ☐ **Diagnose an individual with a predisposition to develop complex disease.** ☐ Diagnose an individual as a carrier for a condition. ☐ Diagnose an individual with a genetic syndrome.
Key Takeaways	Broad understanding of multiple application areas, including situations where WGS may not be the best option.
Related curriculum	Describe leading scenarios where whole genome sequencing is having a profound impact on healthcare. Distinguish up and coming applications for the use of WGS data.
e) Economics surrounding genetic testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	5. Studies have shown that the use of whole genome sequencing: ☐ Increases overall cost of healthcare. ☐ Decreases testing turnaround time. ☐ **Has a diagnostic yield higher than other first line genetic testing options, such as SNP microarray.** ☐ Is routinely covered by insurance.
Key Takeaways	There is great need for better coverage of testing and regulation of that coverage based on clinical utility data being generated (know what is already being reimbursed vs what is not).
Related curriculum	Explain the cost, cost–effectiveness and reimbursement by insurers relevant to genomic tests and test interpretation for patients and populations. Needs for policy (WGS/WES) Cost of diagnostic odyssey vs WGS Implications for IDFS/vertical vs others
f) Integration of genetic testing results into patient health record	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	6. A patient's whole genome sequencing results: ☐ Can be routinely integrated into current common EHR systems. ☐ Should not be expressly used in patient medical management. ☐ Should not be reanalyzed because they already reflect all pathogenic variants.

	☐ **Should be stored as a diagnostic report and not as raw data.**
Key Takeaways	There will be challenges and need for a broad genomics data strategy, including what results to store and how to store them in the EHR.
Related curriculum	Describe the rationale for having a genomics data strategy. Describe best practices proper documentation of test results in patient heath record. Describe the institutional policies that govern what results it is permissible or obligatory to place in the EHR. Explain the implications, including benefits and downsides, of results being placed in the health record, particularly EHRs. Identify challenges associated with the integration of genomic data in the EHR (Ex. privacy/security, size/amount/organization of data). Describe the benefits of integrated clinical decision support in the EHR. Summarize the need for reclassification of genetic test results based on updated knowledge.
g) Ethical, legal, and societal implications of genetic testing.	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
	7. Which statement concerning the ethical, legal, and social implications of whole genome sequencing testing true: ☐ The Genetic Information Non-Discrimination Act protects patients from being discriminated against based on their genetic testing results when purchasing disability insurance. ☐ All pathogenic findings, including secondary findings, should always be reported to patients. ☐ Genetic testing for adult onset conditions in minors should always be conducted if there is a known pathogenic mutation in a family member. ☐ **Genetic testing results are protected under HIPAA.**
Key Takeaways	The coverage limitations of GINA and the complex ELSI implications should be thoroughly thought through before implementation of this technology.
Related curriculum	Explain ethical reasons to protect privacy of genetic data. Examine core concepts in ethics surrounding WGS including the discuss duty to inform, legal protections against discrimination based

	on genetic test results (e.g., the Genetic Information Nondiscrimination Act of 2008, state laws), and genetic testing under the age of 18. Recognize the increased liability that accompanies access to detailed genomic patient information and maintaining confidentiality and security.

For the two participant groups, there was a fair amount of overlap between the overarching curriculum and evaluation questions. For example, both groups will need an introduction to precision medicine and WGS, but they will also require different content to accomplish their individual learning objectives. The information that the KOLs need to understand the impacts of WGS in clinical care will be more focused on economics and outcomes, while the clinicians will require a more in-depth introduction and education on the clinical applications. This difference is exemplified in the knowledge question content, with more background information being included in the questions for KOLs and more clinical terminology for the clinicians. For example, the phrase "harmful change" was used for KOLs, and "pathogenic variant" was used for clinicians since clinicians will experience the terminology "pathogenic variant" frequently in clinical genetics but KOLs may not need to know this distinct phrase, only that the change in the genetic information is harmful.

5.2.3 Evaluation of Participants Attitudes and Perceptions Regarding the Use of Precision Medicine and Medical Genetics in Primary Care

Evaluation of participants' attitudes and perceptions regarding the use of precision medicine and medical genetics has been attempted before, both in the literature and in the previous Test2Learn programs. A literature review of current attitudes and perceptions evaluation strategies

was conducted and integrated into the attitudes and perceptions questions from the FMR and ACCOUNT programs for the creation of the questions for clinicians and KOLs who will participate in the MWGS program.

While whole genome sequencing (WGS) has applications in all forms of healthcare, it has not yet been widely utilized in primary care, though physicians are reporting its eventual use as inevitable [1, 67]. The major concerns shown to influence the decision to utilize genetic testing are clinical utility of results, data security and privacy of results, impact of results on health insurance eligibility, impact of results on life insurance eligibility, impact of results on employment discrimination, and fear of learning their results [6, 9, 10, 13, 25, 62, 68]. Evaluation of these factors for clinicians has been conducted by PMRPs, MEPs, GMEPs, and CMEPs, so there is more data, both longitudinally and overall, for these factors for providers. Evaluation of these factors for patients and the general population has been more limited, being conducted in some PMRPs and community education projects. Due to this limited sampling, participants included in these projects may not be representative of the general population.

In evaluating the perceived clinical utility of genetic sequencing data, which can influence the decision to undergo testing, clinicians and the public are both identifying benefits of WGS that are not typically considered, such as family planning and testing, intrinsic value of information, and the ability to prepare for the future [24]. For example, patient participants of the BabySeq project seemed to have a more favorable benefit/risk ratio of WGS than the clinician participants surveyed for this project, which may be indicative of the general population or may be limited to the patient population surveyed by this project [24]. Healthy individuals included in the PeopleSeq Consortium were enthusiastic about their experience of undergoing pre-dispositional sequencing and not distressed by their results, reporting value in their health related results and agreeing that

genetic testing results should be available in the medical record for clinical use [13]. Participants included in focus groups conducted by the Geisinger MyCode Community Health Initiative also agree that genomic results should be returned as part of the precision medicine project despite possible anxiety or lack of clinical actionability, indicating that these factors would not deter them from pursuing genetic sequencing [17].

As part of the PMRPs that were initially focused purely on genetics research and not return of patient results, participants were heavily surveyed on their attitudes and perceptions around genetic results. Projects utilized the hospital depression and anxiety scale to survey patient participants mental health concerning the decision to be part of the research project and did not find that participating increased participant depression or anxiety for the majority of participants [16, 69].

As part of the initial MEPs, GMEPs, and CMEPs programs that initially utilized participatory educational interventions, participant comfort was heavily surveyed. Participant decision regret to utilize or not utilize their own genetic information as part of the educational program was evaluated using the validated decision-regret scale [70]. Participant anxiety about the decision to utilize or not utilize their own genetic information as part of the educational program was evaluated using the validated shortened version of the intolerance of uncertainty scale [71]. Participant depression related to their decision to utilize or not utilize their own genetic information as part of the educational program was evaluated using the validated two-item patient health questionnaire [72].

As the survey for the MWGS program was created, major changes to the attitudes and perceptions questions focused on more targeted analysis and potential scholarship from findings. In the analysis of the ACCOUNT program iterations, it was found that many of the questions may

not have been useful. This finding combined with the low-response rate and indication of survey fatigue encouraged the research team to be more targeted in the questions asked in this final section of the survey. Due to the consistent findings presented in the literature and findings of the previous program iterations, questions regarding participant depression and decision-regret were not included in this program. Participant perceptions and attitudes evaluation attempted to have a similar analysis compared to previous program surveys but was more targeted to WGS and its clinical uses and consolidated to 20 questions. The full survey for both participant populations can be found and further reviewed in **Appendix C**.

5.3 Discussion

Overall, analysis of the ACCOUNT and FMR programs was limited due to the low response rate for the post-course survey and overall small population, but there were still many lessons to be learned to help guide the creation of the MWGS program surveys. Analysis of the previous program survey data showed both areas of success and opportunities for improvement for the survey scaffolding adapted for the MWGS program survey.

A key area for improvement was to cut down on the overall number of questions asked to increase participant responses and decrease survey fatigue. This goal was accomplished with an overall decrease in clinician survey length by 33% and a decrease in KOLs survey length by 24%. Additional interventions will be made during the launch of the program to try to increase survey completion, such as breaking up the survey sections instead of administering all questions at once.

A major limitation of the creation of this survey is that the timeline for this project did not allow for the survey to be tested on any population before completion of this essay. While the

survey was able to utilize lessons learned from previous programs, final changes before widespread dissemination are not documented here as they have not yet occurred. After much discussion, the research team believes that the initial administration of the course during the Precision Medicine World Conference (PMWC) that is planned to be hosted in person in Pittsburgh in September 2021 will be the true pilot of the MWGS program. At that time, 140 participants are expected to be enrolled in the program. The technical aspects will be piloted before this launch, but the entirety of the program will be piloted with this event. This cohort will be the pilot, especially since a participant group of 140 is still fairly small, and anyone that the research team would include in pilot testing of the program will most likely also be present and recruited at the PMWC. This leaves the opportunity for future changes before the final launch of the course and the pre- and post-course surveys after the piloting phase is complete. Final launch of the program will be when the program is made widely available on the web-based platform for clinicians and KOLs in different locations to receive this novel education program.

Final surveys that are launched with the program are expected to be much the same and allow for continued cross sectioned studies of the program and its efficacy over time. Changes made after pilot survey analysis will allow for fine tuning of the survey. Hopefully, this survey will also be able to be the base from which further, longitudinal research can be conducted with updated versions to be administered at more long-term timepoints.

Appendix A Data Analysis

Appendix A.1 FMR Educational Program Institutional Review Board Approval

University of Pittsburgh
Institutional Review Board

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
(412) 383-1508 (fax)
http://www.irb.pitt.edu

Memorandum

To: Mylynda Massart
From: IRB Office
Date: 3/8/2018
IRB#: PRO17040285
Subject: Primary Care Genomics Education

The above-referenced project has been reviewed by the Institutional Review Board. Based on the information provided, this project meets all the necessary criteria for an exemption, and is hereby designated as "exempt" under section

45 CFR 46.101(b)(1)

Please note the following information:

- Investigators should consult with the IRB whenever questions arise about whether planned changes to an exempt study might alter the exempt status. Use the "**Send Comments to IRB Staff**" link displayed on study workspace to request a review to ensure it continues to meet the exempt category.
- It is important to close your study when finished by using the "**Study Completed**" link displayed on the study workspace.
- Exempt studies will be archived after 3 years unless you choose to extend the study. If your study is archived, you can continue conducting research activities as the IRB has made the determination that your project met one of the required exempt categories. The only caveat is that no changes can be made to the application. If a change is needed, you will need to submit a NEW Exempt application.

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.

Appendix A.2 ACCOUNT Educational Program Institutional Review Board Approval

Approval Notice
Continuing Review

May 7, 2019

Robert Winn, MD
Cancer Center
Phone: (312) 355-4113 / Fax: (312) 355-1085

RE: **Protocol # 2018-0449**
(sIRB) Educating FQHC Providers to Advance Pharmacogenomics and Research Participation in Diverse Settings

Dear Dr. Winn:

Your application was reviewed and approved by the Expedited review process on May 7, 2019. You may now continue your research. You may now continue your research.

Please note the following information about your approved research protocol:

Please note that as per the revised Federal Regulations (2018 Common Rule) and OPRS policies your research no longer requires a Continuing Review; therefore, the approved documents are stamped only with an approval date. Although your research no longer requires a Continuing Review, you will receive annual reminder notices regarding your investigator responsibilities (i.e., submission of amendments, final reports, and prompt reports), and will be asked to complete an Institutional Status Report which will be sent to you via email every 3 years. If you fail to submit an Institutional Status Report, your research study will be administratively closed by the IRB. For more information regarding Continuing Review and Administrative Closure of Research visit: http://research.uic.edu/node/735.

Protocol Approval Date: May 7, 2019
Approved Subject Enrollment #: 60 (30 subjects enrolled)
Performance Sites: University of Pittsburgh, East Liberty Family Health Care Center, UIC
Sponsor: National Institutes of Health, University of Pittsburgh
Institutional Proposal (IP) #: Not available, 00413102
Grant/Contract No: Not available, Not available
Grant/Contract Title: Not available, Educating FQHC Providers to Advance Pharmacogenomics & Research Participation in Diverse Settings
Research Protocol(s):

a) Educating FQHC Providers to Advance Pharmacogenomics and Research Participating in Diverse Settings; Version 3.0; 12/01/2018

Documents that require an approval stamp or separate signature can be accessed via OPRS Live. The documents will be located in the specific protocol workspace. You must access and use only the approved documents to recruit and enroll subjects into this research project.

Recruitment Material(s):

a) Recruitment flyer—Community Leader, ELFHCC; Version 1, 12/01/2018
b) Recruitment flyer—Healthcare member, ELFHCC; Version 1, 12/01/2018

Informed Consent(s):

a) Informed Consent - Healthcare member; Version 3; 12/01/2018
b) Informed Consent - Community Leader; Version 3; 12/01/2018

Additional Determinations for Research Involving Minors:
These determinations have not been made for this study since it has not been approved for enrollment of minors.

Your research continues to meet the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific categories:

Protocol reviewed under expedited review procedures [45 CFR 46.110 and/or 21 CFR 56.110] Category: 7

Please remember to:

→ Use your **research protocol number** (2018-0449) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with the policies of the UIC Human Subjects Protection Program (HSPP) and the guidance ***Investigator Responsibilities.***

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further conditions, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact the OPRS office at (312) 996-1711 or me at (312) 996-0548. Please send any correspondence about this protocol to OPRS via OPRS Live.

Sincerely,

Brandi L. Drumgole, B.S.
Assistant Director
Office for the Protection of Research Subjects

cc: Robert Winn, Cancer Center, M/C 973
OVCR Administration, M/C 672

Appendix B Survey Materials

Appendix B.1 ACCOUNT Educational Program Surveys

Appendix B.1.1 Healthcare Provider Pre-Course Survey

Demographics (Providers/Staff):

What is your current age?

- ☐ 18 to 24 years
- ☐ 25 to 34 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 64 years
- ☐ Age 65 or older

Please select your gender?

- ☐ (0) Male
- ☐ (1) Female
- ☐ (2) Transgender Female
- ☐ (3) Transgender Male
- ☐ (4) Gender Variant/Non-conforming
- ☐ (5) Not listed
- ☐ (6) Prefer Not to Answer

What best describes your current position (select one only):

- ☐ (0) Physician Resident
- ☐ (1) Pharmacy Resident
- ☐ (2) Graduate Program (master's or Ph.D.)
- ☐ (3) Fellowship
- ☐ (4) M.D./D.O.
- ☐ (5) NP/PA
- ☐ (6) PharmD/RPh
- ☐ (7) RN/MA
- ☐ (8) Staff
- ☐ (9) other: _____

In what year did you complete your advanced degree program (MD, PharmD)?
(1) Before 1990
(2) 1991-1995
(3) 1996-2000
(4) 2001-2005
(5) 2006-2010
(6) 2011+
(7) (N/A)

What is your current or anticipated future career direction in primary care?
☐ (0) Clinical – inpatient
☐ (1) Clinical – community
☐ (2) Long term care
☐ (3) Consultant
☐ (4) Academia
☐ (5) Industry
☐ (6) not sure
☐ (7) n/a

Please select what best describes your previous education regarding genetics
☐ (1) None
☐ (2) Biology course
☐ (3) Specific course on genetics
☐ (4) Specific course/training in pharmacogenomics

Knowledge of Genetics and Pharmacogenomics (Providers/Staff):

Rate your level of understanding on a scale of 1 to 5 on the following subjects
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding),

please rate your knowledge of the following:

Pharmacogenomics	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Genetics of complex disease	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Carrier Status Testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Basic genetic principles	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Precision medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The risks of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The benefits of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Gene-environment interactions	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How to interpret pharmacogenomic test results	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How pharmacogenomic test results are used in clinical practice	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

	The impact of African American ancestry on health care decision making	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
	Therapeutic decision-making about cardiovascular medications in patients with African American ancestry	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
	History of African Americans in research in America	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

(TRUE/FALSE)
Humans are over 99% identical at the DNA level.
- ☐ True (0)
- ☐ False (1)

Most cells in the body contain 47 chromosomes.
- ☐ True (0)
- ☐ False (1)

Some genetic conditions, such as sickle cell anemia, are caused by a mutation in a single gene.
- ☐ True (0)
- ☐ False (1)

A person's genotype is not expected to change over a person's lifetime.
- ☐ True (0)
- ☐ False (1)

There are ethnic contributions to variations in drug metabolism of cardiac medications.
- ☐ True (0)
- ☐ False (1)

Diseases, such as diabetes and heart disease, are caused by a change in a single gene.
- ☐ True (0)
- ☐ False (1)

Prevalence of many Mendelian diseases differs by ethnic groups.

- ☐ True (0)
- ☐ False (1)

Differences in a person's genome can explain >30% of the overall variability on a drug's pharmacokinetics and/or pharmacodynamics.

- ☐ True (0)
- ☐ False (1)

Drugs have pharmacogenomic information in their FDA approved product labeling.

- ☐ True (0)
- ☐ False (1)

The product labeling for warfarin includes specific recommendations for dosing in patients with certain genetic variants.

- ☐ True (0)
- ☐ False (1)

The genetic variation in clopidogrel (Plavix) metabolism is due to differences of the CYP451 enzyme.

- ☐ True (0)
- ☐ False (1)

Personal genomic testing is available without a prescription.

- ☐ True (0)
- ☐ False (1)

Guidelines recommend tailoring of blood pressure medications based on pharmacogenomics.

- ☐ True (0)
- ☐ False (1)

Attitudes/Perceptions Regarding the Use of Pharmacogenomics and Precision Medicine (Providers/Staff):

Do you feel you would benefit from additional education/training in genomic medicine?

☐ Yes (0)
☐ No (1)

Please indicate your preferred mode of learning about genomic medicine:

☐ (0) Professional meetings
☐ (2) Laboratory representative
☐ (3) Peer-reviewed publications/journals
☐ (4) Online CME learning
☐ (5) In-person CME learning (e.g., grand rounds or other in-house seminars)
☐ (6) Just-in-time (point-of-care, reminder notice through electronic medical record)
☐ (7) Other (please specify) _____

Do you plan on personally undergoing genetic testing as part of this course?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if you had been told the result would be entered into your medical record?

☐ Yes (0)
☐ No (1)

Did concerns regarding any of the following affect your decision to undergo testing.

☐ Data security/privacy (0)
☐ Impact on health insurance eligibility (1)
☐ Impact on life insurance eligibility (2)
☐ Employment discrimination (3)
☐ Fear of learning results (ie., cancer risk, Alzheimer's risk) (4)

In general, how useful do you feel the following testing will be to you in the clinical setting?

Pharmacogenomic Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4
Prenatal Carrier Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4
Cancer Genetic Carrier Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4
Direct to Consumer Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4

Most primary care physicians have enough knowledge to help individuals interpret the results of the following types of tests:
(1=strongly disagree; 2= disagree; 3=neutral; 4=agree; 5=strongly agree)

Pharmacogenomic Testing	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Prenatal Carrier Testing	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Cancer Genetic Carrier Testing	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Direct to Consumer Testing	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Most primary care physicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of tests:
(1=strongly disagree; 2= disagree; 3=neutral; 4=agree; 5=strongly agree)

Pharmacogenomic Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Prenatal Carrier Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Cancer Genetic Carrier Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Direct to Consumer Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

All primary care providers should be required to have some knowledge of pharmacogenomics.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Part of a primary care physician's role should include counseling patients regarding pharmacogenomic information.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
How likely is it that knowing genetic information about yourself would lead to changes in your own behavior?	Very Unlikely ☐ 1 Unlikely ☐ 2 Somewhat Likely ☐ 3 Likely ☐ 4 Very Likely ☐ 5

Personalized genetic testing companies provide an accurate analysis and interpretation of genotype data	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Most people can accurately interpret their personalized genetic testing results.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable ordering pharmacogenomic testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable explaining the process of pharmacogenomic testing to patients	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable discussing pharmacogenomic test results with patients	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

If you were to undergo personalized genomic testing, would you share your results with your personal physician?

☐ Yes (0)
☐ No (1)

If you were to undergo personalized genomic testing, would you ask a health care provider for help in interpreting the results?

☐ Yes (0)
☐ No (1)

Would you at this time recommend personalized genomic testing for a patient?

☐ Yes (0)
☐ No (1)

Are you aware of direct-to-consumer genetics testing (e.g 23andMe, etc.)?

☐ Yes (0)
☐ No (1)

Have you personally ever had genetic testing performed?

☐ Yes (0)
☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

- ☐ Yes (0)
- ☐ No (1)

In your practice, have you had a patient bring genetic test results to you?

- ☐ Yes (0)
- ☐ No (1)

In past year, how often have you ordered or used the following genetic testing services to manage your patients?

a. Pharmacogenomics?

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (1-5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

b. Diagnostic genetic testing (e.g. Huntington's Chorea, hypertrophic cardiomyopathy)?

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (1-5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

c. Carrier Testing (e.g. CF, Tay-Sachs)

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (1-5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

d. Cancer Risk Testing (e.g. BRCA, Lynch)

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (1-5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

In the past year, which testing technologies have you ordered or used to manage your patients (check all that apply)?

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Not sure of the type

Attitudes/Perceptions Regarding the ALL of Us Precision Medicine Program (Providers/Staff):

Have you heard of the All of Us Research Program?
☐ Yes (0)
☐ No (1)

Have you heard a presentation about the All of Us Research Program?
☐ Yes (0)
☐ No (1)

Have you enrolled in the All of Us Research Program?
☐ Yes (0)
☐ No (1)

Do you know anyone who has enrolled in the All of Us Research Program?
☐ Yes (0)
☐ No (1)

How likely are you to tell a patient about the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How likely are you to encourage a patient to enroll in the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How confident do you feel in discussing the all of the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5

Do you feel you have enough education about the All of Us Research Program to promote enrollment?
☐ Yes (0)
☐ No (1)

Appendix B.1.2 Community Member Pre-Course Survey

Demographics (Advisory Board):

What is your current age?

- ☐ 18 to 24 years
- ☐ 25 to 34 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 64 years
- ☐ Age 65 or older

Please select your gender?

- ☐ (0) Male
- ☐ (1) Female
- ☐ (2) Transgender Female
- ☐ (3) Transgender Male
- ☐ (4) Gender Variant/Non-conforming
- ☐ (5) Not listed
- ☐ (6) Prefer Not to Answer

What best describes your current position (select one only):

- ☐ (0) Community Board Member
- ☐ (1) Other _____

What is the highest education level you have completed?

- ☐ (0) less than a high school diploma
- ☐ (1) high school degree or equivalent (GED)
- ☐ (2) some college, no degree
- ☐ (3) Associate degree (AA, AS)
- ☐ (4) Bachelor's degree (BA, BS)
- ☐ (5) Master's degree (MA, MS, Med)
- ☐ (6) Professional degree (MD, DDS, DVM)
- ☐ (7) Doctorate (PhD, EdD)

What is your ethnicity? (select all that apply)

- ☐ (0) Black or African American
- ☐ (1) White
- ☐ (2) Hispanic or Latino
- ☐ (3) Native American or American Indian
- ☐ (4) Asian/Pacific Islander
- ☐ (5) Middle Eastern/North African

Are you currently?

- ☐ (0) Employed full time (40 or more hours per week)
- ☐ (1) Employed part time (up to 39 hours per week)
- ☐ (2) Unemployed and currently looking for work
- ☐ (3) Unemployed and not currently looking for work
- ☐ (4) Student
- ☐ (5) Retired
- ☐ (6) Homemaker
- ☐ (7) Self-employed
- ☐ (8) unable to work

Do you currently make in one year?

- ☐ (0) Less than $20,000
- ☐ (1) $20,000 to $34,999
- ☐ (2) $35,000 to $49,999
- ☐ (3) $50,000 to $74,999
- ☐ (4) over $100,000
- ☐ (5) prefer not to answer

Knowledge of Genetics and Pharmacogenomics (Advisory Board):

Rate your knowledge on a scale of 1 to 5 on the following subjects
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding),

please rate your knowledge of the following:

Understanding of genetic contributions to your health	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Understanding of the concept of Pharmacogenomics	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Understanding of the concept of Precision Medicine	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
The impact of African American ancestry on health care decision making	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

True/False:

Humans are over 99% identical at the DNA level.
- ☐ True (0)
- ☐ False (1)

Most cells in the body contain 47 chromosomes.
- ☐ True (0)
- ☐ False (1)

Pharmacogenomic testing is currently available for most medications.
- ☐ True (0)
- ☐ False (1)

Personal genomic testing (like 23andMe) is available to consumers and can be done without a prescription.
- ☐ True (0)
- ☐ False (1)

Most common diseases, such as diabetes and heart disease, are caused by a single mutation on one gene.
- ☐ True (0)
- ☐ False (1)

A person’s genotype (genetic code) is not expected to change over a person’s lifetime.

- ☐ True (0)
- ☐ False (1)

There are ethnic contributions to variations in drug metabolism that impact multiple cardiac medications.

- ☐ True (0)
- ☐ False (1)

Attitudes/Perceptions Regarding the Use of Pharmacogenomics and Precision Medicine (Advisory Board):

Do you feel you would benefit from education in genomic medicine?

☐ Yes (0)
☐ No (1)

Do you plan on personally undergoing genetic testing as part of this course?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if you had been told the result would be entered into your medical record?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if this course also offered genetic testing to determine your predisposition to a variety of common diseases (e.g. diabetes, cardiovascular disease)?

☐ Yes (0)
☐ No (1)

In general, how important are the following tests to understanding and managing your personal health?

Pharmacogenomic Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4
Prenatal Carrier Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4
Cancer Genetic Carrier Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4
Direct to Consumer Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4

Most primary care physicians have enough knowledge to help individuals interpret the results of the following types of tests:

(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Prenatal Carrier Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Cancer Genetic Carrier Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Direct to Consumer Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5

Most primary care physicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of tests:

(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Prenatal Carrier Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Cancer Genetic Carrier Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Direct to Consumer Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5

All primary care providers should be required to have some knowledge of pharmacogenomics.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Part of a primary care physician's role should include counseling patients regarding pharmacogenomic information.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
How likely is it that knowing genetic information about yourself would	Very Unlikely Unlikely Somewhat Likely Likely Very Likely

lead to changes in your own behavior?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Personalized genomic testing companies provide an accurate analysis and interpretation of genotype data	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Most people can accurately interpret their personalized genomic testing results.	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable if my PCP orders pharmacogenomic testing	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable having my PCP explain the process of pharmacogenomic testing to me	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable discussing pharmacogenomic test results with my PCP	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable discussing genetics in general with my PCP	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

If you were to undergo personalized genomic testing, would you share your results with your personal physician?

☐ Yes (0)
☐ No (1)

If you were to undergo personalized genomic testing, would you ask a health care provider for help in interpreting the results?

☐ Yes (0)
☐ No (1)

Would you at this time recommend personalized genomic testing for a friend or family member?

☐ Yes (0)
☐ No (1)

Prior to this course were you previously aware of direct-to-consumer genetics testing (e.g 23andMe, etc)?

☐ Yes (0)

☐ No (1)

Have you personally ever had genetic testing performed?

☐ Yes (0)
☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

☐ Yes (0)
☐ No (1)

If you had personalized genomic testing done, did you share your results with your PCP?

☐ Yes (0)
☐ No (1)

As far as you are aware, have you ever had the following types of testing offered to you? (mark all that apply)

☐ Pharmacogenomics
☐ Diagnostic genetic testing (e.g. Huntington's Chorea, hypertrophic cardiomyopathy)
☐ Carrier Testing (e.g. CF, Tay-Sachs)
☐ Genetic Cancer Risk Testing (e.g. BRCA, Lynch)

Attitudes/Perceptions Regarding the ALL of Us Precision Medicine Program (Advisory Board):

Have you heard of the All of Us Research Program?

- ☐ Yes (0)
- ☐ No (1)

Have you heard a presentation about the All of Us Research Program?

- ☐ Yes (0)
- ☐ No (1)

Have you enrolled in the All of Us Research Program?

- ☐ Yes (0)
- ☐ No (1)

Do you know anyone who has enrolled in the All of Us Research Program?

- ☐ Yes (0)
- ☐ No (1)

How likely are you to tell a friend or family member about the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How likely are you to encourage a friend or family member to enroll in the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How confident do you feel in discussing the all of the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5

Do you feel you have enough education about the All of Us Research Program to promote enrollment?

- ☐ Yes (0)
- ☐ No (1)

Appendix B.1.3 Healthcare Provider Post-Course Survey

Course Expectations (Providers/Staff):

What elements of the course will you expect to be most difficult to master in your routine practice?

What suggestions do you have for overcoming these difficulties?

Do you have any other comments, questions, or feedback?

The following have been valuable to you in your learning experience:

The online courses	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
The live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
The Test2Learn exercises in the live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
Clear learning objectives	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
Detailed course outline	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree

Knowledge of Genetics and Pharmacogenomics (Providers/Staff):

Rate your level of understanding on a scale of 1 to 5 on the following subjects
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding),

please rate your knowledge of the following:

Pharmacogenomics	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Genetics of complex disease	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Carrier Status Testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Basic genetic principles	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Precision medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The risks of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The benefits of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Gene-environment interactions	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How to interpret pharmacogenomic test results	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How pharmacogenomic test results are used in clinical practice	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The impact of African American ancestry on health care decision making	None	Minimal	Moderate	Above Average	Expert

	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Therapeutic decision-making about cardiovascular medications in patients with African American ancestry	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
History of African Americans in research in America	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

(TRUE/FALSE)

Humans are over 99% identical at the DNA level.
- ☐ True (0)
- ☐ False (1)

Most cells in the body contain 47 chromosomes.
- ☐ True (0)
- ☐ False (1)

Some genetic conditions, such as sickle cell anemia, are caused by a mutation in a single gene.
- ☐ True (0)
- ☐ False (1)

A person's genotype is not expected to change over a person's lifetime.
- ☐ True (0)
- ☐ False (1)

There are ethnic contributions to variations in drug metabolism that impact multiple cardiac medications.
- ☐ True (0)
- ☐ False (1)

Most common diseases, such as diabetes and heart disease, are caused by a change in a single gene.
- ☐ True (0)
- ☐ False (1)

Prevalence of many Mendelian diseases differs by ethnic groups.

- ☐ True (0)
- ☐ False (1)

Subtle differences in a person's genome can have a major impact (eg. explain >30% of the overall variability) on a drug's pharmacokinetics and/or pharmacodynamics.

- ☐ True (0)
- ☐ False (1)

Drugs have pharmacogenomic information in their FDA approved labeling.

- ☐ True (0)
- ☐ False (1)

The product labeling (package insert) for warfarin includes specific recommendations for dosing in patients that have specific genetic variants.

- ☐ True (0)
- ☐ False (1)

The genetic variation in clopidogrel (Plavix) metabolism is due to differences of the CYP451 enzyme.

- ☐ True (0)
- ☐ False (1)

Personal genomic testing is available to consumers and can be done without a prescription.

- ☐ True (0)
- ☐ False (1)

Guidelines recommend tailoring of blood pressure medications based on pharmacogenomics.

- ☐ True (0)
- ☐ False (1)

Attitudes/Perceptions Regarding the Use of Pharmacogenomics and Precision Medicine (Providers/Staff):

Did this course inspire you to seek additional education/training in genomic or precision medicine?

- ☐ Yes (0)
- ☐ No (1)

Please indicate your preferred mode of learning about genomic medicine:

- ☐ (0) Professional meetings
- ☐ (2) Laboratory representative
- ☐ (3) Peer-reviewed publications/journals
- ☐ (4) Online CME learning
- ☐ (5) In-person CME learning (e.g., grand rounds or other in-house seminars)
- ☐ (6) Just-in-time (point-of-care, reminder notice through electronic medical record)
- ☐ (7) Other (please specify) _____

Did you personally undergo genetic testing as part of this course?

- ☐ Yes (0)
- ☐ No (1)

  Would you have made the same decision if you had been told the result would be entered into your medical record?

  - ☐ Yes (0)
  - ☐ No (1)

  Did concerns regarding any of the following affect your decision to undergo testing.

  - ☐ Data security/privacy (0)
  - ☐ Impact on health insurance eligibility (1)
  - ☐ Impact on life insurance eligibility (2)
  - ☐ Employment discrimination (3)
  - ☐ Fear of learning results (ie., cancer risk, Alzheimer's risk) (4)

In general, how useful do you feel the following testing will be to you in the clinical setting?

Pharmacogenomic Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4
Prenatal Carrier Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4
Cancer Genetic Carrier Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4
Direct to Consumer Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4

Most primary care physicians have enough knowledge to help individuals interpret the results of the following types of tests:
(1=strongly disagree; 2= disagree; 3=neutral; 4=agree; 5=strongly agree)

Pharmacogenomic Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Prenatal Carrier Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Cancer Genetic Carrier Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Direct to Consumer Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

Most primary care physicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of tests:
(1=strongly disagree; 2= disagree; 3=neutral; 4=agree; 5=strongly agree)

Pharmacogenomic Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Prenatal Carrier Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Cancer Genetic Carrier Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Direct to Consumer Testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

All primary care providers should be required to have some knowledge of pharmacogenomics.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Part of a primary care physician's role should include counseling patients regarding pharmacogenomic information.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
How likely is it that knowing genetic information about yourself would lead to changes in your own behavior?	Very Unlikely ☐ 1 Unlikely ☐ 2 Somewhat Likely ☐ 3 Likely ☐ 4 Very Likely ☐ 5
Personalized genetic testing companies provide an accurate analysis and interpretation of genotype data	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

Most people can accurately interpret their personalized genetic testing results.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I would feel comfortable ordering pharmacogenomic testing	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I would feel comfortable explaining the process of pharmacogenomic testing to patients	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I would feel comfortable discussing pharmacogenomic test results with patients	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

If you were to undergo personalized genomic testing, would you share your results with your personal physician?

☐ Yes (0)
☐ No (1)

If you were to undergo personalized genomic testing, would you ask a health care provider for help in interpreting the results?

☐ Yes (0)
☐ No (1)

Would you at this time recommend personalized genomic testing for a patient?

☐ Yes (0)
☐ No (1)

Are you aware of direct-to-consumer genetics testing (e.g 23andMe, etc.)?

☐ Yes (0)
☐ No (1)

Have you personally ever had genetic testing performed?

☐ Yes (0)
☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

☐ Yes (0)

☐ No (1)

In your practice, have you had a patient bring genetic test results to you?

☐ Yes (0)
☐ No (1)

In the past year, how often have you ordered or used the following genetic testing services to manage your patients?
a. Pharmacogenomics?

☐ (0) Never or not familiar with the testing
☐ (1) Rarely (1-5 per year)
☐ (2) Occasionally (6-10 per year)
☐ (3) Frequently (11+ per year)

b. Diagnostic genetic testing (e.g. Huntington's Chorea, hypertrophic cardiomyopathy)?

☐ (0) Never or not familiar with the testing
☐ (1) Rarely (1-5 per year)
☐ (2) Occasionally (6-10 per year)
☐ (3) Frequently (11+ per year)

c. Carrier Testing (e.g. CF, Tay-Sachs)

☐ (0) Never or not familiar with the testing
☐ (1) Rarely (1-5 per year)
☐ (2) Occasionally (6-10 per year)
☐ (3) Frequently (11+ per year)

d. Cancer Risk Testing (e.g. BRCA, Lynch)

☐ (0) Never or not familiar with the testing
☐ (1) Rarely (1-5 per year)
☐ (2) Occasionally (6-10 per year)
☐ (3) Frequently (11+ per year)

In the past year, which testing technologies have you ordered or used to manage your patients (check all that apply)?

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Not sure of the type

Attitudes/Perceptions Regarding the ALL of Us Precision Medicine Program (Providers/Staff):

Have you heard of the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

Have you heard a presentation about the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

Have you enrolled in the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

Do you know anyone who has enrolled in the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

How likely are you to tell a patient about the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How likely are you to encourage a patient to enroll in the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How confident do you feel in discussing the all of the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5

Do you feel you have enough education about the All of Us Research Program to promote enrollment?
- ☐ Yes (0)
- ☐ No (1)

Appendix B.1.4 Community Member Post-Course Survey

Knowledge of Genetics and Pharmacogenomics (Advisory Board):

Rate your knowledge on a scale of 1 to 5 on the following subjects
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding),
please rate your knowledge of the following:

Understanding of genetic contributions to your health	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Understanding of the concept of Pharmacogenomics	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Understanding of the concept of Precision Medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The impact of African American ancestry on health care decision making	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

True/False:

Humans are over 99% identical at the DNA level.
- ☐ True (0)
- ☐ False (1)

Most cells in the body contain 47 chromosomes.
- ☐ True (0)
- ☐ False (1)

Pharmacogenomic testing is currently available for most medications.
- ☐ True (0)
- ☐ False (1)

Personal genomic testing (like 23andMe) is available to consumers and can be done without a prescription.
- ☐ True (0)
- ☐ False (1)

Most common diseases, such as diabetes and heart disease, are caused by a single mutation on one gene.

- ☐ True (0)
- ☐ False (1)

A person's genotype (genetic code) is not expected to change over a person's lifetime.

- ☐ True (0)
- ☐ False (1)

There are ethnic contributions to variations in drug metabolism that impact multiple cardiac medications.

- ☐ True (0)
- ☐ False (1)

Attitudes/Perceptions Regarding the Use of Pharmacogenomics and Precision Medicine (Advisory Board):

Do you personally undergo genetic testing as part of this course?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if you had been told the result would be entered into your medical record?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if this course also offered genetic testing to determine your predisposition to a variety of common diseases (e.g. diabetes, cardiovascular disease)?

☐ Yes (0)
☐ No (1)

In general, how important are the following tests to understanding and managing your personal health?

Pharmacogenomic Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4
Prenatal Carrier Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4
Cancer Genetic Carrier Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4
Direct to Consumer Testing	Not Useful ☐ 1	Minimally Useful ☐ 2	Moderately Useful ☐ 3	Very Useful ☐ 4

Most primary care physicians have enough knowledge to help individuals interpret the results of the following types of tests:

(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Prenatal Carrier Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Cancer Genetic Carrier Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Direct to Consumer Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Most primary care physicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of tests:

(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Prenatal Carrier Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Cancer Genetic Carrier Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Direct to Consumer Testing	None Minimal Moderate Above Average Expert ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

All primary care providers should be required to have some knowledge of pharmacogenomics.	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Part of a primary care physician's role should include counseling patients regarding pharmacogenomic information.	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

How likely is it that knowing genetic information about yourself would lead to changes in your own behavior?	Very Unlikely ☐ 1 Unlikely ☐ 2 Somewhat Likely ☐ 3 Likely ☐ 4 Very Likely ☐ 5
Personalized genomic testing companies provide an accurate analysis and interpretation of genotype data	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
Most people can accurately interpret their personalized genomic testing results.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable if my PCP orders pharmacogenomic testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable having my PCP explain the process of pharmacogenomic testing to me	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable discussing pharmacogenomic test results with my PCP	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
I would feel comfortable discussing genetics in general with my PCP	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

If you were to undergo personalized genomic testing, would you share your results with your personal physician?

☐ Yes (0)
☐ No (1)

If you were to undergo personalized genomic testing, would you ask a health care provider for help in interpreting the results?

☐ Yes (0)
☐ No (1)

Would you at this time recommend personalized genomic testing for a friend or family member?

☐ Yes (0)
☐ No (1)

Prior to this course were you previously aware of direct-to-consumer genetics testing (e.g 23andMe, etc)?

- ☐ Yes (0)
- ☐ No (1)

Have you personally ever had genetic testing performed before this course?

- ☐ Yes (0)
- ☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

- ☐ Yes (0)
- ☐ No (1)

If you had personalized genomic testing done, did you share your results with your PCP?

- ☐ Yes (0)
- ☐ No (1)

As far as you are aware, have you ever had the following types of testing offered to you? (mark all that apply)

- ☐ Pharmacogenomics
- ☐ Diagnostic genetic testing (e.g. Huntington's Chorea, hypertrophic cardiomyopathy)
- ☐ Carrier Testing (e.g. CF, Tay-Sachs)
- ☐ Genetic Cancer Risk Testing (e.g. BRCA, Lynch)

Attitudes/Perceptions Regarding the ALL of Us Precision Medicine Program (Advisory Board):

Have you heard of the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

Have you heard a presentation about the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

Have you enrolled in the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

Do you know anyone who has enrolled in the All of Us Research Program?
- ☐ Yes (0)
- ☐ No (1)

How likely are you to tell a friend or family member about the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How likely are you to encourage a friend or family member to enroll in the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5
How confident do you feel in discussing the all of the All of Us Research Program?	Very Unlikely ☐ 1	Unlikely ☐ 2	Somewhat Likely ☐ 3	Likely ☐ 4	Very Likely ☐ 5

Do you feel you have enough education about the All of Us Research Program to promote enrollment?
- ☐ Yes (0)
- ☐ No (1)

Appendix B.2 FMR Educational Program Surveys

Appendix B.2.1 Pre-Course Survey

Demographics:

What is your current age?

- ☐ 18 to 24 years
- ☐ 25 to 34 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 54 years
- ☐ Age 65 or older

Please select your gender?

- ☐ (0) Male
- ☐ (1) Female
- ☐ (2) Transgender Female
- ☐ (3) Transgender Male
- ☐ (4) Gender Variant/Non-conforming
- ☐ (5) Not listed
- ☐ (6) Prefer Not to Answer

What best describes your current position (select one only):

- ☐ (0) Physician Resident
- ☐ (1) Pharmacy Resident
- ☐ (2) Graduate Program (Masters or Ph.D.)
- ☐ (3) Fellowship
- ☐ (4) M.D./D.O.
- ☐ (5) NP/PA
- ☐ (6) RN/MA
- ☐ (7) Staff
- ☐ (9) other: _____

What is your current or anticipated future career direction in primary care?

☐ (0) Clinical – inpatient
☐ (1) Clinical – community
☐ (2) Long term care
☐ (3) Consultant
☐ (4) Academia
☐ (5) Industry
☐ (6) not sure
☐ (7) n/a

In what year did you complete you advanced degree program (MD, PharmD)?

(8) Before 1990
(9) 1991-1995
(10)1996-2000
(11)2001-2005
(12)2006-2010
(13)2011-2015
(14)2016+
(15)n/a

Please select what best describes your previous education regarding genetics

☐ (1) None
☐ (2) General Biology course
☐ (3) Specific course on Genetics
☐ (4) Specific course/training in Pharmacogenomics

Knowledge regarding genomics and precision medicine:

Rate your knowledge on a scale of 1 to 5 on the following subjects
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding),

please rate your knowledge of the following:

Pharmacogenomics	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Genetics of complex disease	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Carrier Status Testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Basic genetic principles	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Precision medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The risks of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The benefits of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Gene-environment interactions	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How to interpret pharmacogenomic test results	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How pharmacogenomic test results are used in clinical practice	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

How pharmacogenomic test results are used in clinical practice	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

(TRUE/FALSE)

Humans are over 99% identical at the DNA level.
(1) True
(0) False

Most cells in the body contain 47 chromosomes.
(1) True
(0) False

Some genetic conditions, such as sickle cell anemia, are caused by a mutation in a single gene.
(1) True
(0) False

A person's genotype is not expected to change over a person's lifetime.
(1) True
(0) False

Most common diseases, such as diabetes and heart disease, are caused by a single gene variant.
(1) True
(0) False

Prevalence of many Mendelian diseases differs by ethnic groups.
(1) True
(0) False

Subtle differences in a person's genome can have a major impact (eg. explain >30% of the overall variability) on a drug's pharmacokinetics and/or pharmacodynamics.
(1) True
(0) False

Drugs have pharmacogenomic information in their FDA approved labeling.
(1) True
(0) False

The product labeling (package insert) for warfarin includes specific recommendations for dosing in patients that have specific genetic variants.
(1) True
(0) False

Pharmacogenomic testing is currently available for most medications.
(1) True
(0) False

Personal genomic testing is available to consumers and can be done without a prescription.
(1) True
(0) False

Attitudes/Perceptions Regarding the Use of Genomics and Precision Medicine in Primary Care:

Do you feel you would benefit from additional education/training in genomic medicine?

☐ Yes (0)
☐ No (1)

Please indicate your preferred mode of learning about genomic medicine:

☐ (0) Professional meetings
☐ (2) Laboratory representative
☐ (3) Peer-reviewed publications/journals
☐ (4) Online CME learning
☐ (5) In-person CME learning (e.g., grand rounds or other in-house seminars)
☐ (6) Just-in-time (point-of-care, reminder notice through electronic medical record)
☐ (7) Other (please specify) _____

Do you plan on personally undergoing genetic testing as part of this course?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if you had been told the result would be entered into your medical record?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if this course also offered genetic testing to determine your predisposition to a variety of common diseases (e.g. diabetes, cardiovascular disease)?

☐ Yes (0)
☐ No (1)

In general, how useful do you feel the following testing will be to you in the clinical setting?

Pharmacogenomic Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4
Prenatal Carrier Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4
Cancer Genetic Carrier Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4
Direct To Consumer Testing	Not Useful	Minimally Useful	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4

Most primary care physicians have enough knowledge to help individuals interpret the results of the following types of tests:

(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Prenatal Carrier Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Cancer Genetic Carrier Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Direct To Consumer Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Most primary care physicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of tests:
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Prenatal Carrier Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Cancer Genetic Carrier Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Direct To Consumer Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

All primary care providers should be required to have some knowledge of pharmacogenomics.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Part of a primary care physician's role should include counseling patients regarding pharmacogenomic information.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

	How likely is it that knowing genetic information about yourself would lead to changes in your own behavior?	Very Unlikely ☐ 1 Unlikely ☐ 2 Somewhat Likely ☐ 3 Likely ☐ 4 Very Likely ☐ 5
	PGT companies provide an accurate analysis and interpretation of genotype data	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
	Most people can accurately interpret their PGT results.	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
	I would feel comfortable ordering pharmacogenomic testing	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
	I would feel comfortable explaining the process of pharmacogenomic testing to patients	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
	I would feel comfortable discussing pharmacogenomic test results with patients	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5
	I would feel comfortable discussing genetics in general with patients	Strongly Disagree ☐ 1 Disagree ☐ 2 Neutral ☐ 3 Agree ☐ 4 Strongly Agree ☐ 5

If you were to undergo PGT, would you share your results with your personal physician?

☐ Yes (0)
☐ No (1)

If you were to undergo PGT, would you ask a health care provider for help in interpreting the results?

☐ Yes (0)
☐ No (1)

Would you at this time recommend PGT for a patient?

☐ Yes (0)
☐ No (1)

Prior to this course were you previously aware of direct-to-consumer genetics testing (e.g 23andMe, etc.)?

- ☐ Yes (0)
- ☐ No (1)

Have you personally ever had genetic testing performed?

- ☐ Yes (0)
- ☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

- ☐ Yes (0)
- ☐ No (1)

In your practice, have you had a patient bring genetic test results to you?

- ☐ Yes (0)
- ☐ No (1)

In past year, how often have you ordered or used the following genetic testing services to manage your patients?

a. Pharmacogenomics?

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

b. Diagnostic genetic testing (e.g. Huntington's Chorea)?

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

c. Carrier Testing (e.g. CF, Tay-Sachs)

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

d. Cancer Risk Testing (e.g. BRCA, Lynch)

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

In the past year, which testing technologies have you ordered or used to manage your patients (check all that apply)?

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Not sure of the type

Appendix B.2.2 Post-Course Survey

Knowledge of Genetics and Pharmacogenomics:

Rate your knowledge on a scale of 1 to 5 on the following subjects
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

please rate your knowledge of the following:

Pharmacogenomics	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Genetics of complex disease	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Carrier Status Testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Basic genetic principles	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Precision medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The risks of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
The benefits of pharmacogenomic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Gene-environment interactions	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
How to interpret pharmacogenomic test results	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

How pharmacogenomic test results are used in clinical practice	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

(TRUE/FALSE)

Humans are over 99% identical at the DNA level.
- ☐ True (0)
- ☐ False (1)

Most cells in the body contain 47 chromosomes.
- ☐ True (0)
- ☐ False (1)

Some genetic conditions, such as sickle cell anemia, are caused by a mutation in a single gene.
- ☐ True (0)
- ☐ False (1)

A person's genotype is not expected to change over a person's lifetime.
- ☐ True (0)
- ☐ False (1)

Most common diseases, such as diabetes and heart disease, are caused by a change in a single gene.
- ☐ True (0)
- ☐ False (1)

Prevalence of many Mendelian diseases differs by ethnic groups.
- ☐ True (0)
- ☐ False (1)

Subtle differences in a person's genome can have a major impact (eg. explain >30% of the overall variability) on a drug's pharmacokinetics and/or pharmacodynamics.
- ☐ True (0)
- ☐ False (1)

Drugs have pharmacogenomic information in their FDA approved labeling.
- ☐ True (0)
- ☐ False (1)

The product labeling (package insert) for warfarin includes specific recommendations for dosing in patients that have specific genetic variants.
- ☐ True (0)
- ☐ False (1)

Pharmacogenomic testing is currently available for most medications.

- ☐ True (0)
- ☐ False (1)

Personal genomic testing is available to consumers and can be done without a prescription.

- ☐ True (0)
- ☐ False (1)

Attitudes/Perceptions Regarding the Use of Pharmacogenomics and Precision Medicine in Primary Care:

Do you feel you would benefit from additional education/training in genomic medicine?

☐ Yes (0)
☐ No (1)

Please indicate your preferred mode of learning about genomic medicine:

☐ (0) Professional meetings
☐ (2) Laboratory representative
☐ (3) Peer-reviewed publications/journals
☐ (4) Online CME learning
☐ (5) In-person CME learning (e.g., grand rounds or other in-house seminars)
☐ (6) Just-in-time (point-of-care, reminder notice through electronic medical record)
☐ (7) Other (please specify) _____

Did you personally undergoing genetic testing as part of this course?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if you had been told the result would be entered into your medical record?

☐ Yes (0)
☐ No (1)

Would you have made the same decision if this course also offered genetic testing to determine your predisposition to a variety of common diseases (e.g. diabetes, cardiovascular disease)?

☐ Yes (0)
☐ No (1)

In general, how useful do you feel the following testing will be to you in the clinical setting?

Pharmacogenomic Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4
Prenatal Carrier Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4
Cancer Genetic Carrier Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4
Direct To Consumer Testing	Not Useful ☐ 1 Minimally Useful ☐ 2 Moderately Useful ☐ 3 Very Useful ☐ 4

Most primary care physicians have enough knowledge to help individuals interpret the results of the following types of tests:
(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Prenatal Carrier Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Cancer Genetic Carrier Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5
Direct To Consumer Testing	None ☐ 1 Minimal ☐ 2 Moderate ☐ 3 Above Average ☐ 4 Expert ☐ 5

Most primary care physicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of tests:

(1=no knowledge; 2=minimal understanding; 3=moderate understanding; 4=above average understanding; 5=expert understanding)

Pharmacogenomic Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Prenatal Carrier Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Cancer Genetic Carrier Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Direct To Consumer Testing	None	Minimal	Moderate	Above Average	Expert
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

All primary care providers should be required to have some knowledge of pharmacogenomics.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Part of a primary care physician's role should include counseling patients regarding pharmacogenomic information.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
How likely is it that knowing genetic information about	Very Unlikely	Unlikely	Somewhat Likely	Likely	Very Likely

yourself would lead to changes in your own behavior?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
PGT companies provide an accurate analysis and interpretation of genotype data	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Most people can accurately interpret their PGT results.	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable ordering pharmacogenomic testing	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable explaining the process of pharmacogenomic testing to patients	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable discussing pharmacogenomic test results with patients	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
I would feel comfortable discussing genetics in general with patients	Strongly Disagree Disagree Neutral Agree Strongly Agree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

If you were to undergo PGT, would you share your results with your personal physician?

☐ Yes (0)
☐ No (1)

If you were to undergo PGT, would you ask a health care provider for help in interpreting the results?

☐ Yes (0)
☐ No (1)

Would you at this time recommend PGT for a patient?

☐ Yes (0)
☐ No (1)

Prior to this course were you previously aware of direct-to-consumer genetics testing (e.g 23andMe, etc.)?

☐ Yes (0)
☐ No (1)

Have you personally ever had genetic testing performed?

☐ Yes (0)
☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

☐ Yes (0)
☐ No (1)

In your practice, have you had a patient bring genetic test results to you?

☐ Yes (0)
☐ No (1)

In past year, how often have you ordered or used the following genetic testing services to manage your patients?

a. Pharmacogenomics?

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

b. Diagnostic genetic testing (e.g. Huntington's Chorea)?

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

c. Carrier Testing (e.g. CF, Tay-Sachs)

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

d. Cancer Risk Testing (e.g. BRCA, Lynch)

- ☐ (0) Never or not familiar with the testing
- ☐ (1) Rarely (<5 per year)
- ☐ (2) Occasionally (6-10 per year)
- ☐ (3) Frequently (11+ per year)

In the past year, which testing technologies have you ordered or used to manage your patients (check all that apply)?

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Not sure of the type

Course Expectations:

What elements of the course will you expect to be most difficult to master in your routine practice?

What suggestions do you have for overcoming these difficulties?

Do you have any other comments, questions, or feedback?

The following have been valuable to you in your learning experience:

1. The online courses	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
2. The live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
3. The Test2Learn exercises in the live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
4. The optional reading material	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
5. Clear learning objectives	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
6. Detailed course outline	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
7. The interactive exercises in the live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree

Appendix C MWGS Surveys

Appendix C.1 Clinician Survey Questions

Demographics:

What is your current age?

- ☐ 18 to 24 years
- ☐ 25 to 34 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 64 years
- ☐ Age 65 or older

Please select the gender you identify with:

- ☐ (0) Male
- ☐ (1) Female
- ☐ (2) Gender Variant/Non-conforming
- ☐ (3) Prefer Not to Answer

What is your ethnicity? (select all that apply)

- ☐ (0) Black or African American
- ☐ (1) White
- ☐ (2) Hispanic or Latino
- ☐ (3) Native American or American Indian
- ☐ (4) Asian/Pacific Islander
- ☐ (5) Middle Eastern/North African

What best describes your current position (select one only):

- ☐ (1) M.D./D.O.
- ☐ (2) NP/PA
- ☐ (3) PharmD/RPh
- ☐ (4) RN/MA
- ☐ (5) Staff
- ☐ (6) Insurance Affiliate
- ☐ (7) other: _____

In what year did you complete your highest achieved degree?
(16)Before 1990
(17)1991-1995
(18)1996-2000
(19)2001-2005
(20)2006-2010
(21)2011+
(22)(N/A)

Please select what best describes your previous education regarding genetics:
☐ (1) None
☐ (2) Biology course
☐ (3) Specific course on genetics
☐ (4) Specific course/training in pharmacogenomics

Please indicate your preferred mode of learning about medical genetics:
☐ (0) Professional meetings
☐ (1) Laboratory representative
☐ (2) Peer-reviewed publications/journals
☐ (3) Online CME learning
☐ (4) In-person CME learning (e.g., grand rounds or other in-house seminars)
☐ (5) Just-in-time (point-of-care, reminder notice through electronic medical record)
☐ (6) Other (please specify) _____

Do you plan on personally undergoing genetic testing as part of this course?
☐ (0) Yes
☐ (1) No

a. Would you have made the same decision if this course also offered genetic testing to determine your predisposition to a variety of common diseases (e.g. diabetes, cardiovascular disease)?
☐ (0) Yes
☐ (1) No

b. Did concerns regarding any of the following affect your decision to undergo testing.
☐ (0) Data security/privacy
☐ (1) Impact on health insurance eligibility
☐ (2) Impact on life insurance eligibility
☐ (3) Employment discrimination
☐ (4) Fear of learning results (ie., cancer risk, Alzheimer's risk)

Have you personally ever had genetic testing performed?

- ☐ Yes (0)
- ☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

- ☐ Yes (0)
- ☐ No (1)

In your practice, have you had a patient bring genetic test results to you?

- ☐ Yes (0)
- ☐ No (1)

If yes, which testing technologies have you **had a patient bring into** you? (check all that apply)

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Direct to Consumer testing
- ☐ (8) Not sure of the type

In the past year, which testing technologies **have you ordered or used** to manage your patients (check all that apply)?

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Not sure of the type

Pre-Course Assessment:

Knowledge of Genetics and Pharmacogenomics:

Rate your level of understanding on a scale of 1 to 5 for the following subjects:

Precision medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Whole genome sequencing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Basic genetic concepts	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Advanced genetic concepts	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Applications of whole genome sequencing in clinical practice	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Ordering whole genome sequencing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Returning genetic testing results	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Integration of genetic testing results into patient health record	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Ethical, legal, and societal implications of genetic testing.	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

Please select the most accurate answer.

Precision medicine takes into account individual variability in the genome to personalize medical management. Common clinical applications of precision medicine include all of the following EXCEPT:

- ☐ Use of pharmacogenomic (PGx) test results to target medication prescribing.
- ☐ **Use of polygenic risk scores (PRS) to assess a patient's risk for common diseases.**
- ☐ Use of panel genetic testing to assess a patient's risk for common cancers.
- ☐ Use of carrier genetic testing to assess a patient's risk of being a carrier for a rare disease.
- ☐ Use of expansive genetic sequencing to assess a patient's risk of having a genetic condition.

Whole genome sequencing cannot detect:

- ☐ Single nucleotide variants (SNVs)
- ☐ Large structural variants
- ☐ **Changes in methylation**
- ☐ Copy number variations
- ☐ Mitochondrial DNA variants

Mutations are changes in an individual's DNA and results in a different version of the gene. Which of the options below is an example of a mutation that, if considered independently, would not impact medical management?

- ☐ A patient with one pathogenic mutation in CYP2C19.
- ☐ A patient with Trisomy 21.
- ☐ A patient with one pathogenic mutation in BRCA1.
- ☐ **A patient with one pathogenic mutation in CFTR.**

Genetic mutations are classified on a scale from benign to uncertain to pathogenic per ACMG-AMP guidelines. A patient has genetic results that report a variant of uncertain significance. Which of the following is not a possibility that should be discussed with the patient?:

- ☐ As the lab gets more data, they reclassify the variant as benign.
- ☐ As the lab gets more data, they reclassify the variant as pathogenic.
- ☐ **In hopes of getting more data, the lab offers testing only for family members that are similarly affected to help reclassify the variant.**
- ☐ In hopes of getting more data, the lab requests more phenotypic data to help reclassify the variant.

Whole genome sequencing technology cannot clinically be used at this time to:

- ☐ Diagnose an individual with a predisposition to develop cancer.
- ☐ **Diagnose an individual with a predisposition to develop complex disease.**
- ☐ Identify an individual as a carrier for a condition.
- ☐ Diagnose an individual with a monogenic genetic syndrome.

When consenting a patient to receive genetic testing, which of the following results should be discussed as a potential result of genome sequencing:

- ☐ Pathogenic mutations
- ☐ Uncertain mutations
- ☐ Secondary mutations
- ☐ **Benign mutations**
- ☐ Mosaic mutations

A pathogenic result found on whole genome sequencing should prompt a provider to do all of the following except:

- ☐ Refer the patient to a genetics provider for further follow-up.
- ☐ Identify appropriate resources for the patient.
- ☐ **Test family members for the pathogenic finding.**
- ☐ Interrogate the result using online resources such as ClinVar and OMIM.

A patient's whole genome sequencing results:

- ☐ Can be routinely integrated into current common EHR systems.
- ☐ Should not be expressly used in patient medical management.
- ☐ Should not be reanalyzed because they already reflect all pathogenic variants.
- ☐ **Should be stored as a diagnostic report and not as raw data in the EHR.**

Which statement concerning the ethical, legal, and social implications of whole genome sequencing testing true:

- ☐ The Genetic Information Non-Discrimination Act protects patients from being discriminated against based on their genetic testing results when purchasing disability insurance.
- ☐ All pathogenic findings, including secondary findings should always be reported to patients.
- ☐ Genetic testing for adult onset conditions in minors should always be conducted if there is a known pathogenic mutation in a family member.
- ☐ **Genetic testing results are protected under HIPAA.**

Attitudes/Perceptions Regarding the Use of Whole Genome Sequencing and Precision Medicine:

In general, how useful do you feel the following WGS testing results will be to you in the clinical setting?

Pharmacogenomic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ACMG-SF Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Genetic Factors of Complex Disease (Polygenic Risk Score Results)	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Diagnostic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

In general, I have enough knowledge to help individuals interpret the results of the following types of results:

Pharmacogenomic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ACMG-SF Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Genetic Factors of Complex Disease (Polygenic Risk Score Results)	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Diagnostic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

In general, I have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of results:
(1=strongly disagree; 2= disagree; 3=neutral; 4=agree; 5=strongly agree)

Pharmacogenomic Results	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5
ACMG-SF Results	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5
Genetic Factors of Complex Disease (Polygenic Risk Score Results)	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5
Diagnostic Results	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5

All clinicians should be required to have some knowledge of medical genetics.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
Part of a clinician's role should include counseling patients regarding genetic testing.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
I would feel comfortable ordering genetic testing.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
I would feel comfortable explaining the process of genetic testing to patients.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5

I would feel comfortable discussing genetic test results with patients.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I would feel comfortable referring a patient to a genetics provider.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Would you at this time recommend genomic testing for a patient?

☐ Yes (0)
☐ No (1)

Course Expectations (Providers/Staff):

What elements of the course will you expect to be most difficult to master in your routine practice?

What suggestions do you have for overcoming these difficulties?

Do you have any other comments, questions, or feedback?

The following have been valuable to you in your learning experience:

The online courses	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
The Test2Learn exercises in the live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
Clear learning objectives	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
Detailed course outline	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree

Appendix C.2 KOLs Survey Questions

Demographics:

What is your current age?

- ☐ 18 to 24 years
- ☐ 25 to 34 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 64 years
- ☐ Age 65 or older

Please select the gender you identify with:

- ☐ (0) Male
- ☐ (1) Female
- ☐ (2) Gender Variant/Non-conforming
- ☐ (3) Prefer Not to Answer

What is your ethnicity? (select all that apply)

- ☐ (0) Black or African American
- ☐ (1) White
- ☐ (2) Hispanic or Latino
- ☐ (3) Native American or American Indian
- ☐ (4) Asian/Pacific Islander
- ☐ (5) Middle Eastern/North African

What best describes your current position (select one only):

- ☐ (1) M.D./D.O.
- ☐ (2) NP/PA
- ☐ (3) PharmD/RPh
- ☐ (4) RN/MA
- ☐ (5) Staff
- ☐ (6) Insurance Affiliate
- ☐ (7) other: _____

In what year did you complete your highest achieved degree?

(23)Before 1990
(24)1991-1995
(25)1996-2000
(26)2001-2005
(27)2006-2010
(28)2011+
(29)(N/A)

Please select what best describes your previous education regarding genetics:

- ☐ (1) None
- ☐ (2) Biology course
- ☐ (3) Specific course on genetics
- ☐ (4) Specific course/training in pharmacogenomics

Please indicate your preferred mode of learning about medical genetics:

- ☐ (0) Professional meetings
- ☐ (1) Laboratory representative
- ☐ (2) Peer-reviewed publications/journals
- ☐ (3) Online CME learning
- ☐ (4) In-person CME learning (e.g., grand rounds or other in-house seminars)
- ☐ (5) Just-in-time (point-of-care, reminder notice through electronic medical record)
- ☐ (6) Other (please specify) _____

Do you plan on personally undergoing genetic testing as part of this course?

- ☐ (0) Yes
- ☐ (1) No

a. Would you have made the same decision if this course also offered genetic testing to determine your predisposition to a variety of common diseases (e.g. diabetes, cardiovascular disease)?

- ☐ (0) Yes
- ☐ (1) No

b. Did concerns regarding any of the following affect your decision to undergo testing.

- ☐ (0) Data security/privacy
- ☐ (1) Impact on health insurance eligibility
- ☐ (2) Impact on life insurance eligibility
- ☐ (3) Employment discrimination
- ☐ (4) Fear of learning results (ie., cancer risk, Alzheimer's risk)

Have you personally ever had genetic testing performed?

- ☐ Yes (0)
- ☐ No (1)

Has anyone close to you had genetic testing performed (e.g., parent, child, sibling, friend)?

- ☐ Yes (0)
- ☐ No (1)

In your experience, have you ever brought genetic test results to a clinician for use in your medical management?

- ☐ Yes (0)
- ☐ No (1)

If yes, which testing technologies have you brought into your clinician's office? (check all that apply)

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Direct to Consumer testing
- ☐ (8) Not sure of the type

In the past year, which testing technologies **have you had a clinician order or used** to manage your medical care (check all that apply)?

- ☐ (0) Not applicable (have not used)
- ☐ (1) Karyotyping
- ☐ (2) Single gene tests
- ☐ (3) Multiple gene panels
- ☐ (4) Microarray-based testing
- ☐ (5) Targeted sequencing
- ☐ (6) Whole genome or exome sequencing
- ☐ (7) Not sure of the type

Knowledge of Genetics and Precision Medicine:

Rate your level of understanding on a scale of 1 to 5 for the following subjects:

Precision medicine	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Whole genome sequencing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Basic genetic concepts	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Applications of whole genome sequencing in clinical practice	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Economics surrounding genetic testing	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Integration of genetic testing results into patient health record	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5
Ethical, legal, and societal implications of genetic testing.	None ☐ 1	Minimal ☐ 2	Moderate ☐ 3	Above Average ☐ 4	Expert ☐ 5

Please select the most accurate answer.

Precision medicine takes into account individual variability in the genome to personalize medical management. Common clinical applications of precision medicine include all of the following EXCEPT:

- ☐ Use of pharmacogenomic (PGx) test results to target medication prescribing.
- ☐ **Use of polygenic risk scores (PRS) to assess a patient's risk for common diseases.**
- ☐ Use of panel genetic testing to assess a patient's risk for common cancers.
- ☐ Use of carrier genetic testing to assess a patient's risk of being a carrier for a rare disease.
- ☐ Use of expansive genetic sequencing to assess a patient's risk of having a genetic condition.

Mutations are changes in an individual's DNA and results in a different version of the gene. Which of the options below is an example of a mutation that, if considered independently, would not impact medical management?

- ☐ A patient with one harmful mutation associated with a dominant change in medicine metabolism, such as Clopidogrel.
- ☐ A patient with a different number of chromosomes than expected, like Down Syndrome.
- ☐ A patient with one harmful mutation for in a common cancer risk gene, like BRCA1.
- ☐ **A patient with one harmful mutation associated with a recessive condition, like Cystic Fibrosis.**

Whole genome sequencing cannot detect:

- ☐ Single nucleotide variants (SNVs)
- ☐ Large structural variants
- ☐ **Changes in methylation**
- ☐ Copy number variations
- ☐ Mitochondrial DNA variants

Whole genome sequencing technology cannot clinically be used at this time to:

- ☐ Diagnose an individual with a predisposition to develop cancer.
- ☐ **Diagnose an individual with a predisposition to develop complex disease.**
- ☐ Diagnose an individual as a carrier for a condition.
- ☐ Diagnose an individual with a genetic syndrome.

Studies have shown that the use of whole genome sequencing:

- ☐ Increases overall cost of healthcare.
- ☐ Decreases testing turnaround time.
- ☐ **Has a diagnostic yield higher than other first line genetic testing options, such as SNP microarray.**
- ☐ Is routinely covered by insurance.

A patient's whole genome sequencing results:

- ☐ Can be routinely integrated into current common EHR systems.
- ☐ Should not be expressly used in patient medical management.
- ☐ Should not be reanalyzed because they already reflect all pathogenic variants.
- ☐ **Should be stored as a diagnostic report and not as raw data.**

Which statement concerning the ethical, legal, and social implications of whole genome sequencing testing true:

- ☐ The Genetic Information Non-Discrimination Act protects patients from being discriminated against based on their genetic testing results when purchasing disability insurance.
- ☐ All pathogenic findings, including secondary findings, should always be reported to patients.
- ☐ Genetic testing for adult onset conditions in minors should always be conducted if there is a known pathogenic mutation in a family member.
- **Genetic testing results are protected under HIPAA.**

Attitudes/Perceptions Regarding the Use of Whole Genome Sequencing and Precision Medicine:

In general, how useful do you feel the following WGS testing results will be to your medical management?

Pharmacogenomic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ACMG-SF Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Genetic Factors of Complex Disease (Polygenic Risk Score Results)	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Diagnostic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

In general, clinicians have enough knowledge to help individuals interpret the results of the following types of results:

Pharmacogenomic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ACMG-SF Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Genetic Factors of Complex Disease (Polygenic Risk Score Results)	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Diagnostic Results	Not Useful	Minimally Useful	Neither	Moderately Useful	Very Useful
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

In general, clinicians have enough knowledge to ensure patients understand the risks and benefits surrounding the following types of results:
(1=strongly disagree; 2= disagree; 3=neutral; 4=agree; 5=strongly agree)

Pharmacogenomic Results	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5
ACMG-SF Results	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5
Genetic Factors of Complex Disease (Polygenic Risk Score Results)	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5
Diagnostic Results	Not Useful ☐ 1	Minimally Useful ☐ 2	Neither ☐ 3	Moderately Useful ☐ 4	Very Useful ☐ 5

All clinicians should be required to have some knowledge of medical genetics.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
Part of a clinician's role should include counseling patients regarding genetic testing.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
In the future, pharmacogenomic testing will routinely be used to optimize drug selection and/or dosing.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
I would feel comfortable having genetic testing ordered for me.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5
I would feel comfortable discussing the process of genetic testing with a clinician.	Strongly Disagree ☐ 1	Disagree ☐ 2	Neutral ☐ 3	Agree ☐ 4	Strongly Agree ☐ 5

I would feel comfortable discussing genetic test results with clinicians.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
I would feel comfortable consulting a genetics provider.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Would you at this time recommend genomic testing insurance coverage?

☐ Yes (0)
☐ No (1)

Course Expectations:

The following have been valuable to you in your learning experience:

The online courses	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
The Test2Learn exercises in the live course	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
Clear learning objectives	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree
Detailed course outline	Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree

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