Impressions of pharmacogenomic testing among Certified Registered Nurse Anesthetists: a mixed-method study

Aim: Pharmacogenomic testing is useful in helping to predict and explain patient responsiveness to medication. In clinical practice, the use of pharmacogenomic testing has been shown to help reduce adverse drug events and increase patient satisfaction with their healthcare. Prior to a test being useful, it must have clinical utility. There is a gap in the literature about the perceived clinical utility of pharmacogenomic testing among anesthesia providers. **Methods:** This qualitative–quantitative sequential mixed–method study used focused interviews to formulate probes for a quantitative survey aimed at quantifying the perceptions of anesthesia providers about pharmacogenomic testing. **Results:** The results indicate anesthesia providers do not have enough knowledge about pharmacogenomic testing for it to be considered clinically useful in anesthesia practice. **Conclusion:** Although outcomes data indicate pharmacogenomic testing can help predict outcomes, anesthesia providers do not have enough knowledge and have concerns about the ethical implications of pharmacogenomic testing.

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Pharmacogenomic testing is becoming more widely used to assist healthcare providers make personalized healthcare decisions; however, a stark gap exists in the literature about the perceived clinical utility of pharmacogenomic testing in supporting prescriptive decision-making among practicing anesthesia providers. Pharmacogenomic testing is one tool that can be useful to categorize how an individual's variation in DNA will control drug metabolism by programming how the CYP450 system for drug metabolism functions [1]. With pharmacogenomic testing of an individual's CYP450 system, the results can support an anesthesia provider's prescriptive decision-making, specifically related to analgesic medications and help minimize assuming which drug and dose is best for the patient [2]. In the rapidly developing field

of personalized medicine, in which pharmacogenomics play an integral part, this technology could likely be a key component of helping an anesthesia provider determine which medications will work best for their patient.

Despite the advancement in pharmacogenomic testing technology and the supporting interpretative software translating its results, the clinical assimilation has been slow [1,3]. Although clinical outcomes studies demonstrate superior patient outcomes across multiple disciplines when pharmacologic decisions are made based on genetic information, few studies explore the perceived clinical utility of pharmacogenomic technology in supporting prescriptive decision-making [2,4,5]. Attitudes of anesthesia providers toward pharmacogenomic testing and

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their perceptions of clinical utility of the technology in supporting clinical decisions are currently unknown.

In the USA, there are multiple corporate entities that produce, market and promote pharmacogenomic testing technology and the supporting software for interpretation of the results. The myriad of differences in the complexity of the testing platforms, the availability of the technology in real-world clinical practice settings and the ability of the patient and the anesthesia provider to interpret and apply the results in real-world clinical practice is also unknown.

As the clinical utility of the pharmacogenomic testing among anesthesia providers is currently unknown, this study aims at describing how anesthesia providers in clinical practice perceive the usefulness and support the uptake of pharmacogenomic testing as well as quantify these perceptions. Additionally, results of previous work demonstrate that both qualitative and quantitative measurement of provider perceptions of clinical utility is necessary before advancement of technology into routine clinical practice can be successful [6]. Similar work has been conducted in the field of hepatology, nutrition and primary care with feasibility of a mixed-method approach to establishing clinical utility having been established in these previous works [6–8]. The purpose of this study is to develop a survey based on qualitative perceptions of anesthesia providers to better understand the perceived clinical utility of pharmacogenomic testing related to clinical prescriptive decision-making.

Theoretical framework

The guiding framework for this study is the Centers for Disease Control and Prevention's (CDC) analytic validity, clinical validity, clinical utility, ethical, legal and social implications (ACCE) Model of Public Health Genomics [9]. The model's dimensions include analytic validity, clinical validity, clinical utility and ethical, legal and social implications of a genetic test. The clinical utility portion, or outer ring, of the model was used to ground this mixed-method study (Figure 1). Anesthesia providers were questioned about knowledge, education, perceived barriers and perceptions of how the technology could impact patient care.

Research design & methodology

This study was a sequential qualitative–quantitative mixed-method design that explored the perceptions of anesthesia providers regarding the clinical utility of pharmacogenomic testing.

Qualitative phase

Participants were any licensed practicing anesthesia provider with unrestricted privileges to provide direct

patient care. Ten individuals were recruited to participate in the qualitative phase of this study. Initially, qualitative semistructured interviews were conducted with ten practicing anesthesia providers. Following thematic analysis of the qualitative data, probes were developed based on the themes that emerged from the qualitative interviews. These probes were then formulated into a quantitative survey designed to quantify the perceptions of anesthesia providers about clinical utility of pharmacogenomic testing.

The qualitative portion of the study utilized case-study methodology as originally proposed by Yin [10]. Using purposive sampling of ten practicing anesthesia providers after informed consent was obtained, semistructured interviews were conducted. These anesthesia providers consisted of one practicing anesthesiologist and nine Certified Registered Nurse Anesthetists in north Texas, USA. They ranged in years of experience from 3–24 years and represented practice in community hospitals, outpatient surgical centers and in academic medical centers. Ten providers were chosen based on data saturation was obtained in qualitative analysis.

Questions for the qualitative interview were developed using the CDC ACCE Model of Public Health Genomics; clinical utility [9]. [Supplementary Material 1](#) is the focused interview guide. Interviews were conducted in the anesthesia provider's place of business, usually in a private office or private consultation room. The primary investigator conducted all interviews, which were audio recorded and transcribed using a professional transcription service.

Quantitative phase

Following data analysis and thematic development of the qualitative data, probes for a quantitative survey were developed from the qualitative data set results ([Supplementary Material 2](#)). Survey development was based on the Office of Behavioral and Social Sciences and Research guidance on development of surveys in the field of human subjects research [11]. This survey was initially tested with the original ten participants from the qualitative portion of the study. This allowed for triangulation of the data and revision of the initial survey instrument [11]. Cognitive pretesting and subsequent item revision were conducted. The final survey that was administered is attached as [Supplementary Material 2](#). The survey was constructed and administered using the REDCap™ system (Vanderbilt University, TN, USA). The sample population for the quantitative survey was obtained from the American Association of Nurse Anesthetists (AANA) and consisted of a random sample of 6000 practicing Certified Registered Nurse Anesthetists

Figure 1. Centers for Disease Control and Prevention's analytic validity, clinical validity, clinical utility, ethical, legal and social implications model of public health genomics.

(CRNAs; out of approximately 44,000) in the USA and military installations worldwide [12]. The survey was distributed electronically, in a blinded fashion, and the respondents could answer on a computer, smartphone or tablet device.

Qualitative data analysis

Qualitative data analysis was conducted using case-study methodology as proposed by Yin and colleagues [10]. Following professional transcription, the individual interview transcripts were validated for quality by the primary investigator. Using multiple-embedded case-study methodology, each provider was assumed to represent an individual case. Each anesthesia provider represents an individual case because they each care for a cadre of patients; their individual practice represents the sum of the care provided for the cadre of individuals receiving an intervention [10,13]. Yin indicates that for case-study methodology exploring new concepts, only a minimum number of subjects are necessary to achieve data saturation.

Using NVivo® qualitative data analysis software, data were first deductively coded, framed by the CDC ACCE Model of Clinical Utility [9]. Using cross-case

synthesis methods, each anesthesia provider was treated as a separate case and embedded cases were established after the first case was coded. Following deductive coding, inductive coding using constant comparison was used to develop key themes in the entire data set [14]. The process used to establish rigor of the findings was based on a systematic process of coding and interpretation [15]. In this process, the primary investigator initially reviewed and coded the data based on the ACCE Model. Next, a second, expert qualitative researcher coded the data using the same method. Systematic comparison was made between the primary investigator and the expert methodologist to compare findings, negotiate consensus and ensure rigor of the coding and analysis process [15].

Quantitative data analysis

Following qualitative data analysis, the themes that emerged were used to formulate survey items aimed at quantifying provider perceptions of clinical utility. Initially, questions were constructed based upon each theme that emerged and those questions underwent cognitive pretesting with the group of ten original participants. Refinement of the questions was then

conducted. Each question consisted of a unidirectional, Likert-scale type question that aimed to measure only one distinct concept. Two items were constructed per theme for a total of 14 items on the final survey.

Factor analysis using the maximum likelihood extraction was used to analyze the data [16]. This method allows for inferences to be made on the population as a whole based on the extracted factors from the sample, which is appropriate for this quantitative data [17,18]. Because the factor analysis is exploratory and descriptive, an assumption of the maximum likelihood method that each item have a normal distribution was relaxed. To determine the strength of relationship among items as a measure of sampling adequacy the Kaiser–Meyer–Olkin test (KMO) was used to evaluate whether the numbers of significant correlations were sufficient for factor analysis [17]. Criteria for extraction included visual examination of the Scree plot and as a secondary measure, Kaiser’s criteria recommending retention of factors with eigenvalues greater than 1 [17]. To facilitate factor interpretation, factors were rotated using the Direct Oblimin technique, which is useful when factors are thought to be related. Following maximum likelihood extraction, Horn’s parallel analysis was carried out to confirm the number of factors extracted sufficiently loaded and that minimal residual remained. Data were analyzed using IBM SPSS version 22 for Mac (IBM Corp, NY, USA).

Following analysis of the qualitative data, seven themes emerged as concerns anesthesia providers had regarding pharmacogenomic testing. To accomplish factor analysis of the proposed instrument, two items were constructed per construct to be measured. The primary investigator developed the 14-item survey and cognitive pretesting of the survey was accomplished with all ten of the qualitative participants. These qualitative participants practiced in community hospitals, rural hospitals, outpatient settings and academic medical centers. Their years of experience ranged from 6–27 and all were actively practicing anesthesia providers. Following refinement of the survey instrument, it was formatted into the REDCap survey management system. Survey items consisted of 14 items on a 0–10 Likert scale with 0 meaning completely disagree and 10 meaning completely agree. All items were written with unidirectionality.

A random sample of 6000 practicing CRNAs in the USA and military installations worldwide were invited to participate in the electronic survey. Through the AANA research division, a random list of potential participants was formulated. This list was generated from the database of CRNAs and filters were applied to only sample actively practicing CRNAs. An invitation letter was electronically distributed to participants explaining

the purpose of the survey and inviting participation. An electronic link was included in the letter directing potential participants to the electronic survey system.

Qualitative results

Deductive coding was conducted first. Framed by the CDC ACCE Model of Public Health Genomics, five themes emerged from the analyzed data set. These themes were: a lack of understanding and knowledge about the technology, a lack of facilities to conduct and interpret the testing, limited access to the technology, economic concerns about genetic testing and finally legal and ethical implications of ordering genetic testing.

The first theme that emerged from the data centered on understanding and knowledge about pharmacogenomic testing and the interpretation of the results related to clinical decisions. Providers indicated they did not have enough education as it relates to pharmacogenomic testing to see it as useful in their anesthesia practice:

- “Well, I’m not really sure how it would impact the patients because I don’t yet know the value of it, I don’t know enough about it”;
- “We’re gaining knowledge that may have utility once we understand it better.”

Further, providers indicated that they lacked facilities to conduct and interpret the findings of pharmacogenomic testing. Most providers indicated that they did not have access to ordering the pharmacogenomic test in their facility of practice. In answering the question regarding impactfulness of the technology, providers indicated that they were limited at times in their access to the technology:

- “I guess coming from a rural-type facility and practice, we’re limited a lot of times in things that are available to us. We may not have a big variety of medications to choose from. We tend to be pretty limited to what we have and so, in some ways, it may not influence what we do.”

Providers also indicated that they had limited access to the technology. This was primarily seen with providers practicing in smaller, nonacademic medical centers and those facilities in a more rural setting. Providers felt that the technology was something that was not easily accessible:

- “Currently I’m in a small facility and in a rural facility and it seems like, with medicine, that technology is usually centered around the big

facilities where they've got the money and they've got the ability to study those technologies."

Anesthesia providers universally were concerned about the economic implications of pharmacogenomic testing. Concerns related to the actual cost to the patient, cost to the healthcare system as a whole and costs to the provider if the third-party payers do not cover the testing expense were all prominent in the data. Additionally, providers thought that there is probably not a good cost-benefit ratio that is currently available to support the use of pharmacogenomic testing in their practice:

- "Did I really need to do an expensive test to figure that out? Or, can I just write a prescription and if they responded really well to it, okay, break in half-take a half one, instead. Or, Wow, that isn't strong enough for you? Okay, well, you have to take two instead of one. I didn't need a multi-thousand dollar test to figure that out";
- "I think actual barriers may be to some degree the expense of it as it's being developed. I think any new technology is usually pretty expensive, until it has been in use for a longer period of time. I think that that's the main problem, is going to be money";
- "I think instituting the technology is going to be somewhat slow. I think people are really resistant to changing things in the first place. It's expensive, I'm sure, to develop this technology, and I think that those kinds of things can make an adoption of a technology like that somewhat difficult";
- "If the technology advances, it will have to come to a point where it became affordable which takes time and then it may have an impact on rural facilities."

Anesthesia providers did seem to think that pharmacogenomic testing might be advantageous which speaks to the effective benefit of the ACCE Model. Participants expressed the results of pharmacogenomic testing could be useful to plan their anesthetic care. They expressed pharmacogenomic testing would result in less pain, faster recovery times and provide a better, more patient-centered way of delivering anesthesia care. Providers indicated that they think the technology would help to focus care, inform decisions and have positive impacts on patient outcomes.

- "I think the advantages to the technology is being able to narrow down with our patients what is the best drug to be used for them – the amounts of the

Table 1. Participant characteristics.

Variables	Values
Age (years); mean $\pm$ SD	48 $\pm$ 11
Gender (male); %	44
Practice location (%):	
– Community hospital	54
– Academic medical center	25
– Outpatient facility	15
Practice type (%):	
– Not specialized	78
– Pediatrics	5
– OB	4
– Neuro	1
Degree (%):	
– Certificate	6
– Bachelor's	12
– Master's	72
– Doctorate	8
OB: Obstetrics; SD: Standard deviation.	

drug. So, that we can target our patient population to tailor the best anesthetic for them";

- "If you could really tailor your anesthetic to that patient then obviously you're going to wake up faster, you're going to wake up crisper, you're going to wake up the patient more alert, less pain and all the side effects that go along with what we do in the OR so that they would have a better experience with that."

The final theme that emerged from the deductive analysis of the data focused on the ethical, legal and social implications of using pharmacogenomic testing to help inform clinical decisions. Providers generally expressed that there was perhaps an increased liability or exposure to risk if they ordered and used a genetic test in practice:

- "I think if I do the test and it shows, on one side, they might be have a very high addictive potential and I decide to prescribe anyway, that might increase my liability. Because, I knew ahead of time this was going to be a problem. On the other side, if it shows that they were a high metabolizer and they would require high doses of opioid, and so, I used that to drive my prescribing practices, in that I would write higher doses for them right off the bat. And, they either had an adverse event based on the higher dose that I gave them, and/or they were diverting and I just thought, Oh well, I misinter-

puted that information as they are high metabolizers, so, I'm just going to have to keep on giving them more and more medications. I think that might be misleading or a false sense of security."

Following the deductive coding, inductive coding was undertaken using constant comparison methods. The first theme that emerged from the inductive coding was the complexity of the technology. Providers general thought that the pharmacogenomic testing was extremely complex and difficult to understand. They indicated not only was the technology complex in interpretation, but understanding when it was indicated an how to go about ordering a test, as well as developing their personal comfort in using the test in clinical practice was all very confusing:

- "All of the details of that are very confusing to me. It's not something I am comfortable with and it's almost to the extent that I perceive the interpretation of the test as something that would be so burdensome that I wouldn't want to do it";
- "I think, from my perception, is that we have a test that may or may not be a really powerful tool. And, the deal is that they've got a billing code for it, but there is not a lot of research out there to show us if you do this test in this scenario it can improve your outcomes in this fashion."

The final theme was the providers' feelings that using the pharmacogenomic testing to support decision-making would help them avoid complications in the care of their patients. Providers felt that they could use the technology to narrow and focus their care and make decisions about the very best care possible; not just the status quo. Additionally, they felt that knowledge was power and the more information you know ahead of the proposed anesthetic the better the care delivered:

- "My initial inclination would be that if you've got insight into the genetics of a person that that would dictate decisions that you make for them, along the lines of malignant hyperthermia or something like that. The more you know about the makeup of the person, the better able you are to choose appropriate medications";
- "I think the advantages to the technology is being able to narrow down with our patients what is the best drug to be used for them – the amounts of the drug. So, that we can target our patient population to tailor the best anesthetic for them";
- "Less post-operative nausea, and vomiting, among others. Those kinds of things. Less post-operative pain. I really think that that has a whole lot of promise for patients."

Table 2. Total variance explained.							
Factor	Initial Eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings [†]
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)	Total
1	4.844	34.597	34.597	4.341	31.009	31.009	3.597
2	2.057	14.696	49.292	1.586	11.331	42.340	2.940
3	1.228	8.773	58.065	0.716	5.115	47.455	3.035
4	0.990	7.069	65.134	–	–	–	–
5	0.810	5.786	70.921	–	–	–	–
6	0.780	5.575	76.496	–	–	–	–
7	0.565	4.037	80.532	–	–	–	–
8	0.527	3.767	84.300	–	–	–	–
9	0.491	3.509	87.809	–	–	–	–
10	0.408	2.913	90.722	–	–	–	–
11	0.383	2.738	93.460	–	–	–	–
12	0.353	2.523	95.983	–	–	–	–
13	0.297	2.124	98.107	–	–	–	–
14	0.265	1.893	100.000	–	–	–	–
Extraction method: maximum likelihood.							
[†] When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.							

Items	Factor 1 (benefit)	Factor 2 (knowledge)	Factor 3 (concerns)
Tailored care	0.879	–	–
Quicker wakeup and less pain	0.808	–	–
Reduce adverse drug events	0.741	–	–
Perceived benefit	0.467	–	–
Comfort with testing	–	0.803	–
Enough knowledge to use	–	0.753	–
Specific training on testing	–	0.576	–
Way to order	–	0.498	–
Easy to use	–	0.462	–
Location uses testing	–	0.439	–
Cost prohibitive	–	–	0.932
Cost is reason not used	–	–	0.629
Testing means more liability	–	–	0.496
Ethical concerns about testing	–	–	0.400

Maximum likelihood extraction pattern matrix with Oblimin rotation. Only related items with loadings greater than 0.4 are shown.

Quantitative analysis

A total of 325 surveys were returned representing a 5% response rate. Construct validity was assessed by factor analysis. A total of 262 complete surveys were used in the analysis and cases were excluded list wise if they had any missing variable responses.

Results

Participant characteristics

The age of the participants was a mean of 48 ± 11 years. There were 44% male and 52% female respondents. Participant characteristics are presented in Table 1.

Factor analysis

The KMO, an overall measure of sampling adequacy, had a value of 0.850 which indicated the patterns of correlations were relatively compact and sufficient to reveal distinct and reliable factors [17]. Factor analysis resulted in three factors. Following maximum likelihood extraction, Horn's parallel analysis was carried out to confirm the number of factors extracted. Parallel analysis confirmed that three factors sufficiently loaded and minimal residual remained. Following analyses, the pattern matrix was examined to determine the unique contribution of each item to each factor. Total variance is presented in Table 2 and items that loaded on each factor are presented in Table 3.

The pattern matrix was examined to examine the unique contributions to each factor. Items that loaded on each factor are presented in Table 3.

Factor 1 was labeled 'benefit' because items related to the perceived 'benefit' of the pharmacogenomic test

loaded on this factor. Factor 2 was labeled 'knowledge' because items related to understanding the technology and interpretation of the test results loaded on this factor. Factor 3 was labeled 'concerns' because items related to liability, cost and ethical considerations of pharmacogenomic testing loaded on this factor. The means for the scores for each item that loaded onto each factor are presented in Table 4.

Discussion & conclusion

The use of pharmacogenomic technology to support prescriptive decision-making among anesthesia providers has not been established. Qualitative data show providers expressed that they lack the knowledge necessary to use pharmacogenomic testing in clinical practice. Also, these providers expressed that cost and ethical/legal implications of pharmacogenomic testing might prohibit them from incorporating this modality in their anesthesia practice. Anesthesia providers expressed that the technology is complex and extremely difficult to understand; further, they often do not have access to the technology or the ability to order the test in the place of practice.

Anesthesia providers indicated that pharmacogenomic testing is promising and using it could result in better, more patient-centered anesthesia care. This is an interesting finding, as the anesthesia provider seems to understand the basic premise behind pharmacogenomics; however, they have stated that they lack the knowledge necessary to actually use and interpret the findings of a pharmacogenomic test. Providers generally indicated that more personalized prescrip-

Table 4. Means (standard deviation) of items loaded onto each factor.	
Item	Mean (SD)
Factor 1 (benefit)	
Pharmacogenomic testing would allow me to tailor my anesthetic to my patients	4.6 (3.3)
If I used pharmacogenomic testing, my patients would wake up quicker and in less pain	3.4 (2.9)
By using pharmacogenomic testing, I would reduce adverse drug events	4.4 (3.3)
I know how pharmacogenomic testing would benefit my patients	3.9 (3.0)
Factor 2 (knowledge)	
I am comfortable interpreting the results of a pharmacogenomic test	1.2 (2.1)
I have enough knowledge to use pharmacogenomic testing to help me make clinical decisions	1.2 (2.1)
I have received some form of training in the use of pharmacogenomic testing as it relates to making clinical decisions	1.6 (2.4)
In my primary practice location, I have access to or can order pharmacogenomic testing	0.6 (1.4)
Pharmacogenomic testing easy to use an interpret	2.1 (2.4)
My primary practice location uses pharmacogenomic testing to help providers make clinical decisions	0.7 (1.5)
Factor 3 (concerns)	
Pharmacogenomic testing is cost prohibitive	4.1 (3.1)
The reason pharmacogenomic testing is not widely used is cost	4.2 (3.4)
If I use pharmacogenomic testing in my practice, I am taking on additional liability	2.8 (2.9)
I have concerns about the ethical aspects of pharmacogenomic testing	2.8 (2.9)

SD: Standard deviation.

tive decisions could be made, especially for acute pain and nausea prevention, if pharmacogenomic testing is used in anesthesia practice. Along with providing more personalized care, anesthesia providers do indicate that pharmacogenomic testing would help to reduce adverse drug events and overall help to reduce poor outcomes in clinical practice.

Results of the factor analysis of the quantitative survey show that anesthesia providers’ use of pharmacogenomic testing can help to be explained by three phenomena: lack of knowledge, economic and ethical/legal concerns and perceived or anticipated benefit to the patient. Items from a 14-item survey can be effectively reduced to fewer items that would directly question these three phenomena.

Limitations exist in this study. First, the qualitative interviews were conducted with anesthesia providers that were geographically located in one region of North Texas. These interviews and their resulting data do not represent the anesthesia population as a whole. Although saturation was reached in the qualitative analysis, additional interviews could have shown additional themes and feelings about pharmacogenomic testing. Second, a very small response rate on the quantitative survey could have biased the results. The title of the survey might have dissuaded individuals from

responding, as pharmacogenomics is a foreign concept to many practicing anesthesia providers.

Future work should include analysis of the results of each item in the survey along with correlational analyses to help determine if there are predictive factors that might play into an individual provider’s perceptions and knowledge about pharmacogenomic testing (such as age, degree, practice location).

Importantly, from this study, it was discovered that anesthesia providers need additional education about pharmacogenomic testing. Providers are unaware of the rather minimal cost of the testing and the wide availability of testing through various commercial entities. Providers are also unaware of the specific outcome studies that demonstrate superiority in pain control and antiemetic therapy when pharmacogenomic testing is used to guide prescriptive decision-making. Additional education in the areas ethical and legal implications of pharmacogenomic testing as compared with a wider, more generalized genetic panel is needed. Interventions aimed at helping anesthesia providers understand pharmacogenomic testing, its utility, use and cost is necessary.

Forecasting several year into the future, the use of pharmacogenomic testing in anesthesia practice will become more common. Using genetic data to inform

prescriptive decisions could certainly prove useful in supporting prescriptive decision making. Having genetic information to help guide the healthcare provider to administer the right drug, at the right dose and at the right time will improve safety and decrease complications. Before this can be realized, however, further education and training for the end-user; the clinician, must be performed. Before the clinician can use a technology to inform their care, they must understand fully its indications and implications for their patients.

Financial and competing interests disclosure

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No writing assistance was utilized in the production of this manuscript.

Ethical conduct of research

This study was approved by the Institutional Review Board of the Medical University of South Carolina (IRB of record; degree granting institution for PI's PhD) and the Institutional Review Board of Texas Christian University (PI's place of employment).

Executive summary

Background

- Pharmacogenomics is known to improve outcomes related to anesthesia care.
- Pharmacogenomics is not widely utilized in anesthesia care.

Qualitative findings

- Anesthesia providers are unsure of how and when to use pharmacogenomic testing in anesthesia care.
- Anesthesia providers are concerned about the cost and practicality of pharmacogenomic testing.
- Anesthesia providers do not have sufficient knowledge to incorporate pharmacogenomic testing into their care.

Quantitative findings

- Anesthesia providers understand the benefit of pharmacogenomic testing.
- Anesthesia providers lack knowledge regarding pharmacogenomic testing.
- Anesthesia providers have concerns about the ethical and legal aspects of pharmacogenomic testing.

Conclusion

- Pharmacogenomic testing is rarely used in anesthesia practice due to lack of provider knowledge.
- Pharmacogenomic testing lacks clinical utility in anesthesia practice.
- Interventions aimed at increasing anesthesia provider knowledge are necessary to increase pharmacogenomic testing's clinical utility in anesthesia care.

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