Perceptions of pharmacogenetic exceptionalism and the implications for clinical management within an electronic health record

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Abstract

Genetic exceptionalism refers to a concept that genetic information is distinct from other health data and therefore should have additional safety guards in place. The objective of this study was to establish perceptions of pharmacogenetic (PGx) exceptionalism and genetic information privacy and management within the electronic health record (EHR) from individuals who attended a PGx-focused conference. A 47-question survey was distributed to 370 attendees at a PGx conference in September 2020. The survey assessed demographics, professional characteristics, perceptions of PGx exceptionalism, knowledge of genetic laws and regulations, and EHR management of PGx information. Of the 370 participants invited to take the survey, 30% ($n = 110$) responded. Most respondents were pharmacists with postgraduate training (76.2%, $n = 48$). When asked whether PGx information was exceptional, 44% of respondents agreed while 32% disagreed. Agreement with PGx exceptionalism was associated most with respondents' lack of familiarity or knowledge with PGx. Over two-thirds (67%) felt that all members of the healthcare team should be able to access their patients' PGx information without restriction in the EHR. This study identified a lack of unanimity in the perception of PGx exceptionalism and the management of PGx information within the EHR across attendees of a PGx conference. Describing the perception of accessibility of PGx information within the EHR is important to ascertain for designing privacy-related technology, institutional management policies, and legal regulations as this area in genetics is increasingly being implemented into clinical care and clinical standards of care need to be established.

Study Highlights

WHAT IS THE CURRENT KNOWLEDGE ON THE TOPIC?
Genetic exceptionalism and the management of clinical genetic information in the electronic health record (EHR) has been controversial.

WHAT QUESTION DID THIS STUDY ADDRESS?
This study assessed the perspective of pharmacogenetic (PGx) information exceptionalism and subsequent EHR management from pharmacist attendees at a PGx conference.

WHAT DOES THIS STUDY ADD TO OUR KNOWLEDGE?
This study adds the perspective of PGx information exceptionalism and management within the EHR to our current body of knowledge. We found a lack of solidarity in the perception of PGx exceptionalism and the subsequent management of PGx information in the EHR. This survey also acts as a call to action for the standardization of protections set within the EHR for PGx information and for education around the protections afforded to genetic information.

HOW MIGHT THIS CHANGE CLINICAL PHARMACOLOGY OR TRANSLATIONAL SCIENCE?
Setting a standard of practice around PGx information privacy and protections will increase implementation efficiency on an individual health system level.

INTRODUCTION

The Human Genome Project (HGP) (1990–2003), a landmark in medical research, has resulted in significant changes in genetic research and genetic information being incorporated into clinical care. The culture and perception of genetic information management is related to its reputation in ancestry and health, and spurs concerns around the management of genetic information.[1] Patient concerns around handling of genetic information center around the immutability and the identifying nature of the information, the historical mishandling of genetic information, and potential discrimination based on the information.[2,3] From a healthcare provider's perspective, concern of liability for accountability of all genetic test results are high.[4,5] Even prior to the publication of the HGP in 2003, taskforces worked on predicting and mitigating ethical, legal, and social issues such as handling and privacy for a patient's genetic information.[2]

In 1997, Murray coined the term "genetic exceptionalism," meaning a patient's genetic information is distinct from other clinical, health-related data and should be treated as special or distinct from other health-related data.[2,6–8] In the early 2000's, handling genetic information as exceptional, including legal or regulatory protections, garnered strong support. Furthermore, McGuire et al. argued that genomic information may need special policy and practice protections within the context of electronic health records (EHRs).[2] In 2008, the Genetic Information Nondiscrimination Act (GINA) was enacted to protect patients from health insurance companies discriminating against an individual based on genetic information.[9,10]

Now 18 years post-HGP, it is argued that genetic exceptionalism is past its expiration date as we move into a blended genomic/big data era of medicine, yet exceptionalism practices continue to permeate clinical healthcare today.[3,8] Garrison et al. recently relayed a call to action to update verbiage from genetic exceptionalism to genomic contextualism in that we recognize a fundamental duality of genetic information.[1] This allows room in the argument for different types of genetic information to be handled differently while acknowledging that genomic information is similar and yet distinct from other health-related information.[1] Genomic contextualism would allow for a case-by-case analysis of the technology and the context of its use (e.g., clinical practice, research, secondary findings).

In the last 5 years, it was argued that genetic information is indeed distinct from other health-related information but not to the extent of requiring legal/regulatory protections, similar to other sensitive health-related data such as HIV status.[7] Additionally, Evans et al. argue that the EHR has sufficient privacy standards to hold other sensitive information such as social security numbers and that the fundamental nature of an EHR is to house highly personal information.[3] Similarly, a systematic review reported that the public had concern over privacy of genetic information, with 60% agreeing that maintaining privacy was not possible; however, 96% agreed that a direct-to-consumer testing company had protected their privacy, with 74% saying their information would be similarly or better protected in an EHR.[11] With increasing technological capabilities in EHRs, it is possible to mask or hide genetic data from subsets of providers and there is not consensus on how, when, or from whom genetic information should be masked.[2,12] Rigorous protection and masking of genetic information is argued to impede further scientific progress and clinical translation into routine clinical practices.[13]

Clinical pharmacogenetics (PGx) is the application of genetics to predict risk of pharmacokinetic changes,

adverse reactions, and medication response on an individual patient level. Clinical PGx is being implemented in clinical practice through single gene tests, exome/genome sequencing, and more commonly as genetic panels and is rapidly expanding outside of pioneering academic medical centers. One of the biggest challenges with PGx implementation is the integration of the genetic information into the EHR as discrete, visible, manageable elements. Now that EHRs are becoming more accommodating for the documentation of genetic information should additional safeguards be set around PGx information within the EHR? It is currently unknown how the PGx community views PGx exceptionalism or how the PGx community is setting, or not setting, additional safeguards around the access of PGx information within the EHR. The objective of this survey was to determine if the controversy of genetic exceptionalism extends into the PGx community and subsequently assess perception of EHR management of PGx information.

METHODS

Survey development

This was a cross-sectional, survey study approved by the local institutional review board (University of Minnesota, STUDY00010753). Survey questions were developed by the study team with the goal of characterizing the participants' perceptions of PGx exceptionalism and PGx privacy in the EHR. The survey questions underwent an iterative review process by the study team prior to collecting responses. The survey included a brief background on genetic exceptionalism and definitions for PGx information, genetic information, genetic test, and genetic exceptionalism. Questions were categorized into six sections that included self-reported demographics, professional characteristics, PGx exceptionalism, exceptionalism perceptions, laws and regulations, PGx information management, and an open response (Appendix S1). Questions within the sections of PGx exceptionalism, exceptionalism perceptions, and PGx information management were scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The laws and regulations section was rated as "yes", "no," or "unsure" and if participants answered yes, branching logic was developed to then ask the level of understanding specific to PGx on a five-point Likert scale.

Survey distribution

The survey was distributed to 370 participants at the conclusion of the University of Minnesota Biennial PGx Conference

held in September 2020. The conference was open globally for anyone interested in PGx. It was a 2-day, live-virtual conference that encompassed the theme of "Implementation of Pharmacogenomics into Clinical Care." Topics delivered across five sessions were "Implementation Science and Examples of Pharmacogenomics Implementations," "Pharmacogenomics to Improve Drug Therapy and Safety and an Update From CPIC," "Pharmacogenomics Complexities: Case Discussions," "Primary Care Pharmacogenomics," and "Important Considerations in Pharmacogenomics Implementation: Avoiding the Pitfalls." The virtual conference platform was used to email the participants with the survey link for participation through REDCap (Research Electronic Data Capture). Participants were given 2 weeks to complete the survey and a reminder email was sent at the 1-week midpoint. Completion of the survey was anonymous, voluntary, without compensation, and participants were allowed to skip questions.

Statistical analysis

Data were extracted from REDCap and imported into JMP Pro Version 15 for analysis. Descriptive statistics were generated. Proportions assessed were based on the total number of respondents for each question separately. Categorical data were compared between groups using Chi-square or Fisher's exact tests as appropriate. For further analysis, Likert data were collapsed into three categories (agree, disagree, and neutral) and analysis was focused to only pharmacists that practiced within the United States. Frequencies were stratified by gender, age, profession, practice area, years in practice, population served, postgraduate training, time spent in patient care, confidence in PGx knowledge, and personal PGx test. Further analysis was performed on data from pharmacists confident in their PGx knowledge and are included as Table S1. A p value of <0.05 was used to denote statistical significance.

RESULTS

Demographics

Of the 370 conference participants invited to take the survey, 110 (30%) completed the survey. A summary of respondent demographics and professional characteristics is provided in Table 1. The respondents included 66 (66%) pharmacists, 13 (13%) current students, as well as MDs, PhDs, and nurses. The majority of the pharmacists were 18–49 years of age (68.8%). Years spent in practice were evenly distributed from <5 years to more than 20 years.

TABLE 1 Demographics and characteristics of participants

Characteristic	*n*	%
Country of practice	102	100.0
United States	96	94.1
Other[a]	6	5.9
Profession	100	100.0
Current student	13	13.0
MD	6	6.0
Other[b]	8	8.0
PharmD	66	66.0
PhD	7	7.0
Pharmacist participant characteristics		
Gender	64	100.0
Male	24	37.5
Female	40	62.5
Age (years)	64	100.0
18–49	44	68.8
50+	19	29.7
Prefer not to answer	1	1.56
Practice area	61	100.0
Academia	26	42.6
Healthcare	33	54.1
Industry	2	3.3
Years in practice	64	100.0
<5	15	23.4
5–10	15	23.4
11–20	15	23.4
>20	18	28.1
Unknown/NA	1	1.6
Population underserved	60	100.0
Yes	24	40.0
No	36	60.0
Postgraduate training (beyond residency)	63	100.0
Yes	48	76.2
No	15	23.8
Time in patient care	60	100.0
0%–49%	45	71.4
50%+	15	23.8
Pharmacogenetic knowledge?	63	100.0
Confident	36	57.1
Somewhat confident	17	27
Not confident	10	15.9
Personal PGx test?	63	100.0
Yes	40	63.5
No	23	36.5

Abbreviations: NA, not available; PGx, pharmacogenetic.

[a]Includes: Canada, Egypt, Puerto Rico, Switzerland, and Thailand.

[b]Includes: Chief Medical Officer, Industry, Certified Nurse Practitioner (CNP)/Advanced Practice Registered Nurse (APRN), and Sales.

Of all the respondents, 48 (76.2%) had postgraduate training including fellowships, Master's degrees, certificate programs, and/or board certifications beyond residency training. Most pharmacists were in academia (26, 42.6%) or healthcare (33, 54.1%), with a small number in industry (2, 3.3%). Over half (57.1%) felt confident in providing PGx-guided care and most (63.5%) had undergone a personal PGx test.
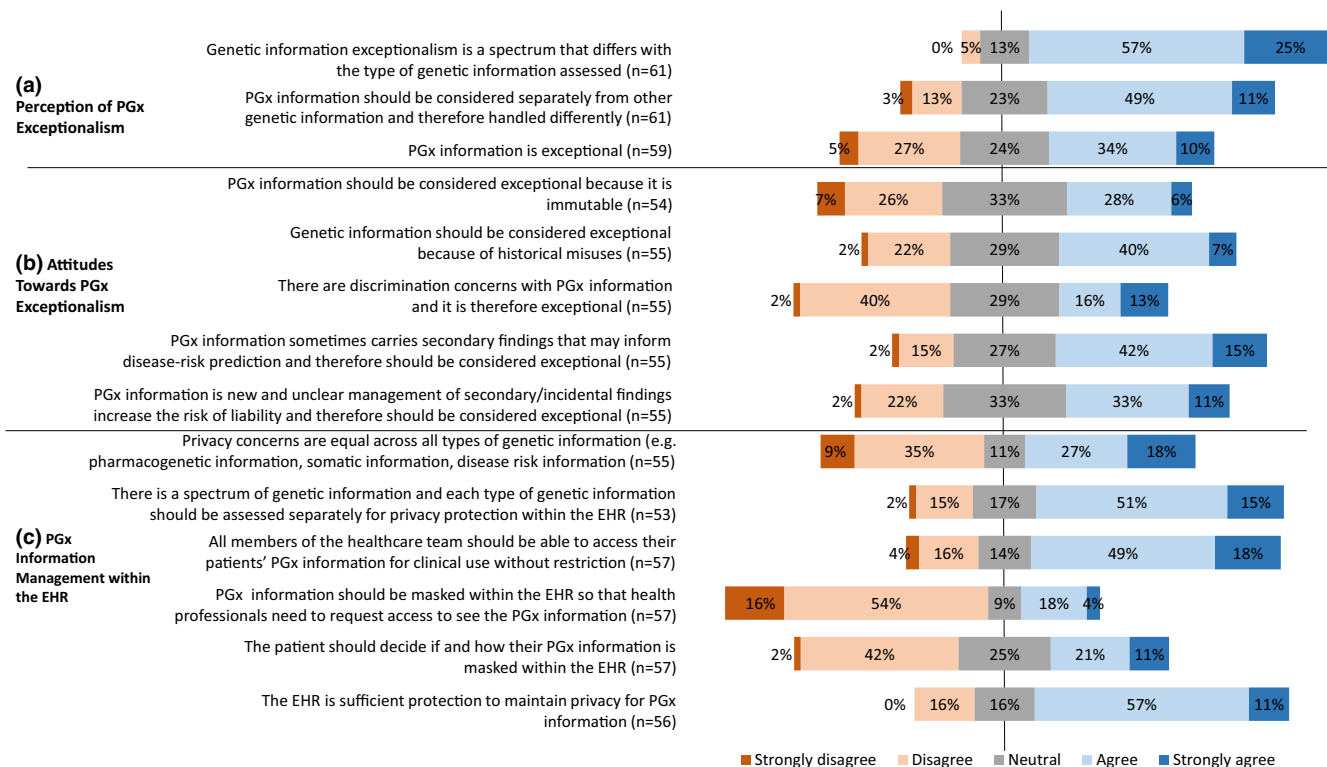
Perception of PGx exceptionalism

Attitudes and perceptions of PGx exceptionalism of respondents were assessed and are shown in Figure 1a. The majority of respondents ($n = 50$, 82%) felt that genetic information exceptionalism is a spectrum that differs with the type of genetic information and most ($n = 37$, 60.7%) agreed that PGx information should be considered separately from other genetic information. Overall, approximately one-third ($n = 19$, 32.2%) of respondents disagreed that PGx information is exceptional. Of those confident in their PGx knowledge, 15 disagreed that PGx information was exceptional versus none of those not confident in their PGx knowledge ($p = 0.039$, Table 2). When only assessing pharmacists confident in their PGx knowledge, 43% ($n = 15$) disagreed that PGx information was exceptional and 40% ($n = 14$) agreed it was exceptional (Figure S1).

Attitudes towards PGx exceptionalism

A set of five statements with rationale supporting exceptionalism assessed the attitudes towards PGx exceptionalism (Figure 1b). Overall, responses were similar across the five statements with most participants agreeing with the statements. However, most pharmacists disagreed ($n = 23$, 41.8%) with the statement "there are discrimination concerns with PGx information and it is therefore exceptional." When stratified, respondents were statistically less likely to agree that PGx information was exceptional due to discrimination concerns when they were confident in their PGx knowledge ($p = 0.018$, Table 2).

Knowledge and understanding of genetic laws and regulations

Knowledge of three types of regulations – Health Insurance Portability and Privacy Accountability Act (HIPAA), Genetic Information Nondiscrimination Act

FIGURE 1 Views of pharmacogenetic (PGx) exceptionalism and the impact on perception of electronic health record (EHR) management of PGx information. PGx conference attendees' perception (a), attitudes (b), and perception of PGx management within the EHR (c). Participants' responses were ranked on a five-point Likert scale; questions were not mandatory therefore the number of respondents is listed for each statement.

(GINA), and state laws – pertaining to genetic information were assessed separately. If the respondent affirmed knowledge of the regulation in the question, they were then assessed for understanding of how it pertained to PGx information. All respondents ($n = 57$, 100%) had heard of HIPAA (Figure 2). Some 28% ($n = 16$) of respondents had not heard of or were unsure if they had heard of GINA, and of those that did, 85% ($n = 35$) understood how it pertained to PGx information. Respondents were statistically more likely to have heard of the GINA if they were in academia or a healthcare practice setting, had postgraduate training ($p = 0.0045$), less time spent in patient care (0%–49% vs. 50 + %; $p = 0.0014$), were confident in their PGx knowledge ($p = 0.0001$), and if they had a personal PGx test done ($p = 0.031$, Table 2). Moreover, 40.4% ($n = 23$) of respondents were aware of their state laws that pertained to genetic information (Figure 2).

PGx information management within the EHR

Respondents' perception and attitudes towards PGx information privacy and management within the EHR was

assessed with six questions (Figure 1c). More than half ($n = 38$, 66.7%) of respondents agreed that all members of the healthcare team should be able to access their patients' PGx information for clinical use without restriction. However, 21.1% ($n = 12$) agreed that PGx information should be masked within the EHR so that health professionals need to request access to see the PGx information. When stratified, respondents confident in PGx knowledge were more likely to disagree that PGx information should be masked within the EHR ($p = <0.0001$) as well as if the respondents had had a personal PGx test ($p = 0.0005$, Table 2). Some 44% ($n = 24$) disagreed that privacy concerns were equal across all types of genetic information and most (67.9%, $n = 36$) agreed each type of genetic information should be assessed separately for privacy protection within the EHR. Most respondents ($n = 38$, 67.9%) agreed that the EHR is sufficient protection to maintain privacy for PGx information (Figure 1c).

DISCUSSION

Genetic exceptionalism has long been argued but the concept of genetic contextualism, or assessing the type of genetic information for its relative exceptionalism, is

TABLE 2 Analysis of selected survey questions about perception and attitudes of pharmacogenetic exceptionalism, knowledge of genetic laws, and electronic health record management

	Pharmacogenetic information is exceptional				There are discrimination concerns with pharmacogenetic information and it is therefore exceptional			
	Disagree	Neutral	Agree	*p* Value	Disagree	Neutral	Agree	*p* Value
Gender				0.93				0.62
Male	8 (42.1)	5 (35.7)	10 (38.5)		8 (34.8)	8 (50)	6 (37.5)	
Female	11 (57.9)	9 (64.3)	16 (61.5)		15 (65.2)	8 (50)	10 (62.5)	
Age (years)				0.95				0.08
18–49	14 (73.7)	10 (71.4)	18 (69.2)		20 (87)	9 (56.3)	9 (56.3)	
50+	5 (26.3)	4 (28.6)	8 (30.8)		3 (13)	7 (43.8)	6 (37.5)	
Prefer not to answer	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	1 (6.3)	
Practice area				0.71				0.14
Academia	9 (47.4)	6 (42.9)	8 (33.3)		10 (43.5)	7 (43.8)	4 (26.7)	
Healthcare	9 (47.4)	8 (57.1)	15 (62.5)		13 (56.5)	7 (43.8)	11 (73.3)	
Industry	1 (5.3)	0 (0)	1 (4.2)		0 (0)	2 (12.5)	0 (0)	
Years in practice				0.92				0.65
<5	4 (21.1)	3 (21.4)	8 (30.8)		7 (30.4)	3 (18.8)	4 (25)	
5–10	5 (26.3)	3 (21.4)	6 (23.1)		6 (26.1)	3 (18.8)	3 (18.8)	
11–20	4 (21.1)	5 (35.7)	5 (19.2)		6 (26.1)	3 (18.8)	4 (25)	
>20	6 (31.6)	3 (21.4)	7 (26.9)		4 (17.4)	7 (43.8)	4 (25)	
Unknown/NA	0 (0)	0 (0)	0 (0)		0 (0)	0 (0)	1 (6.3)	
Underserved practice population				**0.044**				0.23
Yes	3 (17.6)	8 (57.1)	12 (48)		11 (52.4)	4 (25)	6 (37.5)	
No	14 (82.4)	6 (42.9)	13 (52)		10 (47.6)	12 (75)	10 (62.5)	
Postgraduate training				0.86				0.56
Yes	15 (78.9)	10 (71.4)	19 (73.1)		17 (73.9)	14 (87.5)	12 (75)	
No	4 (21.1)	4 (28.6)	7 (26.9)		6 (26.1)	2 (12.5)	4 (25)	
Time spent in patient care				0.85				0.14
0–49%	14 (73.7)	9 (64.3)	18 (69.2)		17 (73.9)	14 (87.5)	9 (56.3)	
50%+	5 (26.3)	5 (35.7)	8 (30.8)		6 (26.1)	2 (12.5)	7 (43.8)	
PGx knowledge				**0.039**				**0.018**
Confident	15 (78.9)	6 (42.9)	14 (53.8)		19 (82.6)	10 (62.5)	5 (31.3)	
Somewhat confident	4 (21.1)	6 (42.9)	6 (23.1)		3 (13)	5 (31.3)	8 (50)	
Not confident	0 (0)	2 (14.3)	6 (23.1)		1 (4.3)	1 (6.3)	3 (18.8)	
Personal PGx test				0.96				0.12
Yes	13 (68.4)	9 (64.3)	17 (65.4)		19 (82.6)	9 (56.3)	9 (56.3)	
No	6 (31.6)	5 (35.7)	9 (34.6)		4 (17.4)	7 (43.8)	7 (43.8)	

Abbreviations: NA, not available; PGx, pharmacogenetic.

Bold indicates significance level at *p*-value < 0.05.

in its infancy.[1] It appears the pharmacist attendees at a PGx conference agree that each type of genetic information (e.g., somatic markers, PGx information, or disease-risk information) should be managed differently. In this survey of the PGx conference attendees, most respondents (82%) agreed that genetic information is a spectrum that differs with the type of genetic information assessed and, notably, only 5% of respondents disagreed. For health systems implementing PGx, this means that

PGx information should be addressed separately from other genetic information management, possibly with separate approval and reporting committees. The risk of treating all genetic information the same is that PGx information could be handled with the highest level of restriction and conservation afforded to the most sensitive genetic information. Additionally, 44% disagreed that privacy concerns were equal across all types of genetic information, bolstering the supposition that privacy

Pharmacogenetic information is new and unclear management of secondary/incidental findings increase the risk of liability and therefore should be considered exceptional				I have heard of the Genetic Information Nondiscrimination Act (GINA)				Pharmacogenetic information should be masked within the electronic health record so that health professionals need to request access to see the pharmacogenetic information			
Disagree	Neutral	Agree	p Value	No	Unsure	Yes	p Value	Disagree	Neutral	Agree	p Value
4 (30.8)	8 (44.4)	10 (41.7)	0.73	4 (30.8)	1 (33.3)	17 (41.5)	0.77	15 (37.5)	2 (40)	5 (41.7)	0.96
9 (69.2)	10 (55.6)	14 (58.3)		9 (69.2)	2 (66.7)	24 (58.5)		25 (62.5)	3 (60)	7 (58.3)	
10 (76.9)	10 (55.6)	18 (75)	0.38	10 (76.9)	0 (0)	30 (73.2)	0.076	32 (80)	2 (40)	6 (50)	**0.033**
3 (23.1)	8 (44.4)	5 (20.8)		3 (23.1)	3 (100)	10 (24.4)		8 (20)	3 (60)	5 (41.7)	
0 (0)	0 (0)	1 (4.2)		0 (0)	0 (0)	1 (2.4)		0 (0)	0 (0)	1 (8.3)	
9 (69.2)	5 (29.4)	7 (29.2)	0.14	2 (16.7)	0 (0)	20 (50)	**0.043**	17 (43.6)	2 (40)	3 (27.3)	0.23
4 (30.8)	11 (64.7)	16 (66.7)		10 (83.3)	3 (100)	18 (45)		21 (53.8)	2 (40)	8 (72.7)	
0 (0)	1 (5.9)	1 (4.2)		0 (0)	0 (0)	2 (5)		1 (2.6)	1 (20)	0 (0)	
3 (23.1)	7 (38.9)	4 (16.7)	0.43	2 (15.4)	0 (0)	12 (29.3)	0.056	12 (30)	0 (0)	2 (16.7)	0.15
3 (23.1)	2 (11.1)	7 (29.2)		4 (30.8)	0 (0)	10 (24.4)		12 (30)	0 (0)	2 (16.7)	
4 (30.8)	2 (11.1)	7 (29.2)		6 (46.2)	0 (0)	7 (17.1)		7 (17.5)	3 (60)	3 (25)	
3 (23.1)	7 (38.9)	5 (20.8)		1 (7.7)	3 (100)	11 (26.8)		9 (22.5)	2 (40)	4 (33.3)	
0 (0)	0 (0)	1 (4.2)		0 (0)	0 (0)	1 (2.4)		0 (0)	0 (0)	1 (8.3)	
8 (66.7)	5 (27.8)	8 (34.8)	0.086	7 (53.8)	0 (0)	14 (36.8)	0.20	17 (45.9)	0 (0)	4 (33.3)	0.13
4 (33.3)	13 (72.2)	15 (65.2)		6 (46.2)	3 (100)	24 (63.2)		20 (54.1)	5 (100)	8 (66.7)	
11 (84.6)	10 (55.6)	22 (91.7)	**0.016**	11 (84.6)	0 (0)	33 (80.5)	**0.0045**	32 (80)	3 (60)	9 (75)	0.59
2 (15.4)	8 (44.4)	2 (8.3)		2 (15.4)	3 (100)	8 (19.5)		8 (20)	2 (40)	3 (25)	
11 (84.6)	12 (66.7)	17 (70.8)	0.52	5 (38.5)	1 (33.3)	35 (85.4)	**0.0014**	29 (72.5)	4 (80)	8 (66.7)	0.85
2 (15.4)	6 (33.3)	7 (29.2)		8 (61.5)	2 (66.7)	6 (14.6)		11 (27.5)	1 (20)	4 (33.3)	
11 (84.6)	11 (61.1)	12 (50)	0.33	2 (15.4)	0 (0)	33 (80.5)	**0.0001**	32 (80)	2 (40)	1 (8.3)	**<0.0001**
2 (15.4)	5 (27.8)	9 (37.5)		8 (61.5)	2 (66.7)	6 (14.6)		6 (15)	3 (60)	7 (58.3)	
0 (0)	2 (11.1)	3 (12.5)		3 (23.1)	1 (33.3)	2 (4.9)		2 (5)	0 (0)	4 (33.3)	
11 (84.6)	10 (55.6)	16 (66.7)	0.23	8 (61.5)	0 (0)	30 (73.2)	**0.031**	33 (82.5)	1 (20)	4 (33.3)	**0.0005**
2 (15.4)	8 (44.4)	8 (33.3)		5 (38.5)	3 (100)	11 (26.8)		7 (17.5)	4 (80)	8 (66.7)	

restrictions within the EHR should not be blanketed across the broad category of genetic information.

When asked specifically about whether PGx information is exceptional, the agreement/disagreement was not as strongly observed. Interestingly, the pharmacist respondents were split with 44% agreeing and 32% disagreeing. With pharmacists confident in their PGx knowledge, representing a portion of the PGx community, the number that agreed and disagreed on whether PGx information is exceptional was almost split equally. In contrast to the majority of respondents agreeing that PGx information should be managed separately from other genetic information, the point of PGx exceptionalism in the context of EHR management could be argued as arbitrary.

Notably, the PGx conference attendees surveyed mostly agreed that all members of the healthcare team should be able to access their patients' PGx information for clinical use without restriction and disagreed that PGx information

100%
of pharmacists had heard of the Health Insurance Portability and Privacy Accountability Act (n=57)

70%
of those pharmacists understood how it pertains to PGx information (n=39)

72%
of pharmacists had heard of the Genetic Information Nondiscrimination Act (n=41)

85%
of those pharmacists understood how it pertains to PGx information (n=35)

60%
of pharmacists were not aware or were unsure of their state laws pertaining to genetic information (n=34)

FIGURE 2 Knowledge of laws and regulations protecting clinical genetic information. Pharmacogenetic (PGx) conference attendees' ($n = 81$) knowledge of Health Insurance Portability and Privacy Accountability Act (HIPAA), Genetic Information Nondiscrimination Act (GINA), and state genetic laws. If a participant affirmed knowledge of the regulation, their understanding of how that regulation applied to PGx practice was also assessed.

should be masked within the EHR. Treating genetic information as exceptional by masking or protecting it within the EHR would create a barrier to translation into clinical practice as the handling and management of genetic information in an EHR gets increasingly convoluted the more "special" it needs to be treated. In clinical practice, PGx information is used across specialties, treatment settings, and across healthcare professionals. Imposing protections on PGx information by masking it to the healthcare team, as current EHRs are beginning to allow, will impede efficient medication optimization and even further hinder the implementation and use of PGx into practice in general. As implementation of PGx into clinical practice progresses to become standard of care, as a PGx community it is the community's obligation to ensure they are setting and maintaining standards around the privacy of PGx information within the EHR. Setting standards around the clinical management of PGx information and its protection now will reduce local implementation challenges as institutions struggle to make these decisions on an individual scale, create an easier transition for the transfer of PGx information across institutions, and reduce liability concerns if one perspective is represented as standard of practice.

Paralleling the privacy restrictions and standards that can be set institutionally around genetic information in the EHR are larger genetic protections afforded by HIPAA, GINA, and state regulations. The majority of protections for genetic information should be outside of clinical care and instead at the legislative level so as to not impede access to genetic results and so that all healthcare organizations apply and conform to the same standards. More than two-thirds of the pharmacist respondents to this survey had heard of GINA representing a large education gap; this gap in knowledge may be even greater outside of those interested in PGx. Notably, respondents were more likely to have heard of GINA if they spent less time in patient care. Time spent not in direct patient care could include

academia, industry, and research where knowledge about laws and regulations are heightened over knowledge of clinical practice guidelines and could hypothetically have impacted the results. Most notably, when responses were stratified, familiarity with PGx represented by confidence in PGx knowledge and if the respondents had had a personal PGx test were significantly associated with differences in agreement of PGx exceptionalism and EHR management, signifying the role that education plays in perception of exceptionalism. If PGx information is accessible by all on the healthcare team from within an EHR, it could be argued that the practicing health care community, not just PGx or genetic specialists, needs to be accountable for understanding the limitations, implications, and complexities around genetic information. Education for practicing healthcare professionals, current students, and academic partners on the risks, limitations, and current afforded legal protections around genetic information is imperative as implementation of PGx in clinical practice continues.

This survey is limited by representing only the perspective from the pharmacists that attended a conference focusing on clinical implementation of PGx. Pharmacists are an integral part of the PGx implementation team; however, they represent only one specialty, when PGx implementation spans across the health system. This knowledge could be expanded and compared if assessed in other groups such as patients, payers, health system administrators, and other clinicians. Middleton et al. previously assessed the public's perception of genetic exceptionalism and willingness to donate genetic data.[14] About 52% of the participants held genetic exceptionalism views and were more likely to think thus if they had a familiarity in genetics, personal experience in genetics, and a tertiary-level education.[14] Lenk et al. showed that patients have a "right to know" when it comes to genetic data but did not assess the perception sharing, confidentiality, or privacy of the data.[6] In this survey, more participants were equally

split in agreement/disagreement that the patient should decide how their PGx information is masked within the EHR. The public's perception about PGx information, its exceptionalism, and its protections has not been assessed.

A second limitation of this study was not further defining PGx. Just as genetics can be viewed as a spectrum (e.g., somatic information, disease-risk information, PGx information, etc.), there is a similar spectrum within PGx itself representing pharmacodynamics, pharmacokinetics, and hypersensitivity reactions. Additionally, pharmacogenes can also be associated with disease risk, and in practice today some PGx genes are being handled separately from other PGx genes routinely tested for on PGx panels because of inherent disease implications. A prime example is the testing for *UGT1A1* that is commonly used to assess risk of toxicity with irinotecan.[15] *UGT1A1* in this context can help define dosing or avoidance of irinotecan. However, *UGT1A1* is also linked with Gilbert's syndrome, a benign syndrome associated with hyperbilirubinemia that is aside from any medication use.[15] This incidental finding can be revealed with routine PGx testing and oftentimes warrants a referral or consult outside of the current scope of a pharmacist. This example highlights that even within the PGx realm of genetics, the spectrum of disease risk associated with each pharmacogene should be considered and best practices around the management of pharmacogenes with disease risk should be further assessed.

Furthermore, this study is limited by not having undergone strict validation of the survey questions prior to distribution to participants as well as having a response rate of 30%.

CONCLUSIONS

This survey of PGx conference attendees showed that opinions on PGx exceptionalism is not one of solidarity across pharmacists confident in their PGx knowledge, let alone all the pharmacists surveyed, while revealing interesting trends in the knowledge around genetic laws and regulations with impactful implications for PGx management in the EHR. The respondents agreed that PGx information should not be categorized with all genetic information used clinically; and when considering privacy protections within the EHR, more education on the risks, limitations, and legal protections could influence perspective on implementing privacy protections.

Finding the balance between using genetic tools to improve health outcomes and protecting the privacy of genetic data is critical. Genetic information is unique from other health information used to optimize patient care but genetics are also conditional and are only a piece of the puzzle when considering a patient holistically. This survey found that amongst the PGx conference attendees there was not overwhelming solidarity on how PGx information should be treated in the context of clinical care, and setting best practices and clinical standards is imperative to further progress clinical implementation. Perception of genetic exceptionalism is important to address to have consensus for the rapidly evolving implementation of clinical PGx. Importantly, our survey showed that respondents were more likely to hold exceptionalism views the less confident they were with their PGx skills, suggesting an opportunity for education not only on using PGx clinically but also for the protections afforded to genetic information. Promotion of health and improving medication outcomes will depend on clinician accessibility of PGx information and this survey found that amongst the PGx community that included pharmacists, medical doctors, and students, the overwhelming attitude was that PGx information should be accessible to all healthcare providers within the EHR. Perceptions of PGx exceptionalism are important to ascertain to subsequently develop privacy-related technology within the EHR, institutional management policies, clinical practice standards, and legal/federal regulations as PGx is increasingly being implemented into clinical care.

AUTHOR CONTRIBUTIONS

T.B., J.B., P.J., and D.S. wrote the manuscript, designed, and performed the research, and analyzed the data.

CONFLICT OF INTEREST

The authors declared no competing interests for this work.

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SUPPORTING INFORMATION
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