Research Article

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Pharmacogenomics

Primary care providers' use of pharmacist support for delivery of pharmacogenetic testing

Aim. To investigate provider utilization of pharmacist support in the delivery of pharmacogenetic testing in a primary care setting. **Methods.** Two primary care clinics within Duke University Health System participated in the study between December 2012 and July 2013. One clinic was provided with an in-house pharmacist and the second clinic had an on-call pharmacist. **Results:** Providers in the in-house pharmacist arm consulted with the pharmacist for 13 of 15 cases, or about one of every four patients tested compared with one of every 7.5 patients in the on-call pharmacist arm. A total of 63 tests were ordered, 48 by providers in the pharmacist-in-house arm. **Conclusion:** These findings suggest that the availability of an in-house pharmacist increases the likelihood of pharmacogenetic test utilization.

Susanne B Haga*[1], Rachel Mills[1], Jivan Moaddeb[1], Nancy Allen LaPointe[2], Alex Cho[3] & Geoffrey S Ginsburg[1]

[1]Duke Center for Applied Genomics & Precision Medicine, Duke University, Durham, NC, USA

[2]Duke Clinical Research Institute, Duke University, Durham, NC, USA

[3]Department of Medicine, Duke University, Durham, NC, USA

*Author for correspondence: susanne.haga@duke.edu

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The delivery of pharmacogenetic (PGx) testing, or testing to identify genetic variants associated with adverse drug response or efficacy, will likely require some type of clinical decision support (CDS), at least during this early phase of test utilization. The number of drugs and associated tests, the interpretation of test results and application to treatment decisions contribute to the complexity of these tests and, along with limited provider knowledge [1,2], necessitate broad educational programs as well as point-of-care support.

About 80% of primary care visits include a drug prescription [3,4] and, therefore, PGx testing may provide greater benefit in this setting than in other clinical settings. However, primary care providers may not have the knowledge and comfort level with PGx testing to routinely offer it to their patients [5,6]. Some strategies to improve provider's readiness to utilize PGx testing have focused on electronic medical record (EMR)-based CDS in the form of alerts and notices [7] or pharmacist-assisted interpretation of PGx results [8–10]. As pharmacists have played a leading role in many of the clinical settings that have implemented PGx testing [11], clinical support from a pharmacist may also improve PGx test utilization. With increasing calls for patient-centered medical homes [12,13], especially as a component of accountable care organizations, pharmacists are becoming a valued team member in many practices and have established successful collaborations and practices with physicians [14–16].

Different types of CDS have been developed and evaluated to provide clinicians with information about current guidelines, appropriate test use and/or interpretation, drug–drug interactions [17–19]. In personalized and precision medicine, provider knowledge and decision support have been identified as key issues to the integration of new genetic and genomic applications [20]. While some groups are developing EMR-based PGx CDS alerts [21,22], in-person professional support may also provide valuable assistance. For instance, the Cleveland Clinic established a

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PGx consultation service staffed by a pharmacist and a physician geneticist [23]. Previous studies have demonstrated that pharmacists are well suited to provide support, able to create effective relationships with providers and achieve high provider acceptance of pharmacist recommendations [24,25]. Furthermore, pharmacists have successful providers in patient-centered medical homes [26] and have provided care with demonstrated improved patient outcomes [27–29].

With the success of pharmacists' roles in numerous PGx programs across the country, we sought to assess the feasibility of adopting a pharmacist-supported delivery model for PGx testing in a primary care setting. Pharmacists based on primary care practices currently assist with medication therapy management, polypharmacy and poor medication adherence [30–33]. Specifically, we assessed the utilization of pharmacist support and its impact on the use of PGx testing during and after the study. In this paper, we describe findings associated with a pharmacist-based CDS and its impact on PGx test utilization.

Methods

Study design

Details of the study design are described by Haga *et al.* [34]. In summary, this study assessed clinical support provided by a pharmacist at two primary care practices. Eight and nine full-time Doctor of Medicine faculties in internal medicine provide care for more than 20,000 patients annually at each practice. In one practice, the pharmacist was in the clinic daily; in this practice, the pharmacist identified recently seen patients prescribed an eligible medication and notified providers of these eligible patients for the study (pharmacist-in-house). In the second practice, pharmacist on-call support (email or phone) was available (pharmacist-on-call) regarding testing procedures, results' interpretation and/or guidelines regarding treatment decisions based on results of PGx testing. In the second practice, the pharmacist did not notify providers of eligible patients for testing. Providers in both clinics were required to attend a 1-h seminar on PGx prior to initiation of the research study. Continuing medical education (CME) credits were provided. They were also given educational materials including patient brochures and a 'pocket guide' to assist in discussions about PGx testing with patients and aid in clinical decision making, respectively. Decisions to order PGx testing were the sole discretion of the provider. One pharmacist (J Moaddeb) was assigned to both study arms. Physicians completed surveys at two time points, and chart reviews were conducted at three time points. Findings from the patient perspective are reviewed in a separate manuscript [35]. The study was approved by the Duke University Health System's Institutional Review Board (Pro#00031122).

Physician surveys

Providers were surveyed prior to participation in the PGx CME (baseline) and at the conclusion of the intervention period (follow-up). The baseline survey assessed provider attitudes, and knowledge and experiences with genetic and PGx testing. A nine-item, multiple-choice questionnaire was developed by the research team to assess PGx knowledge. The survey also included questions about factors potentially impacting use of PGx testing in the primary care setting and preferences for clinical support and education about PGx testing. At the conclusion of the study, a follow-up survey re-assessed providers' knowledge of PGx testing and assessed perceived value of the CME, interactions with the pharmacist, educational resources provided for the patient, perceived patient value of the test and likelihood of continued use of PGx testing. In addition, the follow-up survey included the questions regarding providers' perceptions and comfort with using PGx testing in order to assess changes in confidence or attitudes that were in the baseline survey.

Chart reviews

Chart reviews were performed for all patients seen at the two clinics during three periods of the study: preintervention (June 2012–December 2012); study intervention (December 2012–June 2013) and post-intervention period (June 2013–December 2013). The preintervention and post-intervention reviews documented new and recent (within 1 month) prescriptions for eligible drugs (see the 'PGx testing' section) and the number of PGx tests ordered, specifically, information about which physician and clinic (using a unique identifier code) ordered PGx testing and for which drugs were recorded. Patients who underwent testing in the study intervention period were also tracked in the 6-month follow-up period for prescription changes and adverse side effects.

During the intervention period, the pharmacist also recorded several variables, including the number of eligible drugs prescribed, the number of PGx tests ordered for each drug, which physician/clinic ordered the PGx tests, whether the pharmacist was consulted pretesting or post-testing, and how the results were applied to treatment.

PGx testing

PGx testing was performed by the Mayo Medical Laboratory (Rochester, MN, USA), a Clinical Laboratory Improvement Amendments (CLIA)-certified reference laboratory. All testing was performed on a buccal swab

sample. Six tests were offered for the following single genes or gene pair: *CYP2D6* (atomoxetine, codeine, fluoxetine, nortriptyline, imipramine and metoprolol), *CYP2C19* (esomeprazole), *CYP2C9* (carbamazepine, celecoxib, clopidogrel, warfarin), *VKORC1* (warfarin), *HLA-B*1502* (carbamazepine) and *SLCO1B1* (simvastatin).

Data analysis

Summary statistics were completed for each survey question and chart review data. Mann–Whitney tests were performed to assess the relationship between provider characteristics and PGx knowledge scores. χ^2 analysis was conducted to ascertain the difference in test ordering between the two clinics. However, due to the small number of data values for pharmacist utilization (<5 for discrete variables), no further analyses were possible.

Results

Preintervention provider experience, attitudes and knowledge

Provider characteristics

Seventeen primary care providers from two internal medicine clinics affiliated with Duke University Health System were eligible to participate in the study. Thirteen providers agreed to participate in the study and completed the required CME course prior to the study; six were part of the pharmacist-in-house clinic, and seven were part of the pharmacist-on-call clinic. Twelve physicians completed the baseline survey (Table 1). Limited demographic data were collected to protect the identity of this small group. In summary, most of the providers graduated from medical school between 1991 and 2000 and had an average of 14.9 years of clinical practice experience.

Provider experience with genetic testing

Seven providers (n = 7; 58%) reported ordering genetic testing for disease diagnosis one-time or two-times per year and two providers ordered three or more tests per year (Table 1). Four providers reported ordering PGx testing at least once a year. Based on the chart review, no PGx testing was performed during the 6-month preintervention period for any of the 175 new prescriptions of the 12 eligible medications (Table 2).

All 12 providers indicated that they did not feel well informed about genetic testing in general (one somewhat and 11 strongly) nor about PGx testing specifically (four somewhat and eight strongly). Half of the providers reported being familiar with PGx testing prior to this study. Two providers agreed, or somewhat agreed, that they would feel comfortable discussing PGx testing with a patient prior to ordering the test. Three providers (25%) somewhat agreed that they would feel comfortable discussing the results of PGx testing with a patient, and three providers would feel comfortable using PGx testing to inform treatment decisions.

Awareness of PGx testing was gained from professional meetings (n = 1), drug or laboratory representative (n = 2), publications (n = 3), CME learning (n = 2), grand rounds (n = 3) or point-of-care notification (n = 1). One provider reported familiarity with PGx due to participation in a different clinical trial. When asked how providers would prefer to learn about PGx, nine (75%) indicated grand rounds or other in-house seminars.

Providers' perspectives on the delivery of PGx testing

We were also interested in assessing primary care providers' perspectives on the delivery of PGx testing and desired clinical support prior to the study. Eleven providers (92%) indicated that having some assistance in interpretation (analogous to a radiologist) would increase their likelihood to order a PGx test. Ten providers (83%) believed that pharmacists would have some or a large role in delivering PGx; nine providers (75%) believed that geneticists/genetic counselors would have some or a large role in delivering PGx testing. Five providers (42%) believed that the physician who ordered a PGx test should communicate test results to the patient, and five believed that either the ordering physician, a genetic counselor or a pharmacist could communicate PGx results (one indicated only a genetic counselor should communicate results and another indicated only a pharmacist should communicate results).

Provider knowledge of PGx

The average number of correct responses to the knowledge-based questions was 5.08 out of nine questions (observed range: 2–7) at baseline. All but one provider incorrectly answered the question regarding which group(s) was prohibited from using genetic information based on the federal genetic nondiscrimination law. When year of graduation is considered, the average number of correct responses was 5.6 for those who graduated in or after 1991 compared with 4.4 for those that graduated in 1990 or earlier ($p \leq 0.05$). However, those who indicated that they were familiar with PGx testing at baseline scored lower (4.8) than those who indicated that they were not familiar with PGx testing (5.3; $p \leq 0.05$).

Intervention

Pharmacist consultation

Based on records kept by the consulting pharmacist, eight of the 13 participating providers (two providers

Table 1. Provider year of graduation and experience with pharmacogenetic testing (n = 12).

Characteristic	Providers, n (%)
Year graduated from medical school	
Before 1980	1 (8%)
1981–1990	4 (33%)
1991–2000	5 (42%)
After 2000	2 (17%)
Provider experience ordering genetic testing	
Never order	3 (25%)
1–2-times per year	7 (58%)
≥3-times per year	2 (17%)
Provider referral to genetics services	
Never refer	3 (25%)
1–2-times per year	6 (50%)
≥3-times per year	3 (25%)
Provider familiarity with PGx	
Familiar with PGx	6(50%)
Not familiar	6 (50%)
Provider experience ordering PGx testing	
Never order	8 (67%)
1–2-times per year	2 (17%)
≥3-times per year	2 (17%)

PGx: Pharmacogenetic.

from the pharmacist-on-call arm and all six from the pharmacist-in-house arm) consulted the pharmacist regarding 15 cases. Providers in the pharmacist-in-house arm consulted with the pharmacist for 13 of the 15 cases, a rate of about one of every four patients tested compared with one of every 7.5 patients tested in the pharmacist on-call arm. Consultations occurred across the 6-month intervention period. Eight of the 15 consultations were for testing for treatment with simvastatin, two each for fluoxetine and warfarin, and one each for clopidogrel, metoprolol and esomeprazole. The pharmacist was consulted on four cases prior to testing regarding the appropriateness of testing and re-contacting a patient for testing; providers ordered PGx testing for three of those four following consultation. Eleven of the 15 pharmacist consultations occurred after PGx testing were ordered regarding interpretation of results, medication interactions and use of alternative medications. On average, consultations lasted 5.7 min, with post-testing consultations lasting 6.2 min and pretesting consultations lasting 4.5 min.

Of the eight providers that completed the follow-up survey, five (63%) reported consulting with the pharmacist. In the follow-up survey, providers who did not consult the pharmacist indicated that they did not do so because they did not feel they needed pharmacist's input or they did not have time. All respondents strongly or somewhat agreed that having a pharmacist available is helpful. To improve pharmacists' involvement, two providers would have liked the pharmacist to meet with the patients; two would have liked more learning opportunities about PGx with the pharmacist; and three would have liked the pharmacist to mail the patients a written summary of the test results. One of the providers in the pharmacist-on-call group who did not order any PGx testing during the course of the study also noted that having a pharmacist available to help choose patients for testing could have been useful, as was done in the other clinic.

PGx test utilization

During the study intervention period, when PGx testing was made available with the assistance of a pharmacist, chart review identified 258 new prescriptions of the eligible medications (Table 2). A total of 63 PGx tests were ordered: 33 tests were ordered for patients newly prescribed for one of the targeted drugs (52%); 15 tests were ordered for drugs' patients who had been taking prior to their visit; and 15 were ordered for patients with a clinical indication for treatment. Thus, 20.7% of patients prescribed or potentially in need of one of the eligible medications underwent testing. The PGx test ordered most often was *SLCO1B1* (n = 45; 71% of tests ordered) for simvastatin use.

Of the 63 tests ordered, 48 were ordered by the six providers in the pharmacist-in-house arm (of 100 eligible patients) and 15 in the pharmacist-on-call arm (of 158 eligible patients; $p < 0.00001$). Overall, 11 of the 13 participating providers (87%) ordered at least one PGx test during the intervention period. One of the providers from the pharmacist-in-house arm accounted for 34.9% (n = 22) of tests ordered.

Eighteen of the 63 patients who underwent testing had an abnormal PGx test result that indicated a medication or dosing change from the standard of care as recommended in the package inserts and/or by CPIC dosing guidelines (see Supplementary Table 1 for phenotype frequencies). We confirmed that a medication change was made for three of the 18 patients with an abnormal result via chart review. All three were in the pharmacist-in-house arm. One patient who had been taking clopidogrel at the time of testing was switched to prasugrel based on a *CYP2C19* intermediate metabolizer result. The simvastatin dose of a patient found to be a *SLCO1B1*5* carrier who reported leg pain was reduced by half. A third patient who was taking fluoxetine was switched to bupropion (Well-

butrin XL™,) after being identified as a *CYP2D6* poor metabolizer. Based on the chart review, we were able to identify the reason why a recommended change was not implemented for three of the remaining 15 cases with an abnormal PGx test result; the patient stopped taking the medication on their own, preferred to continue with the current medication and reported no manifestation of adverse effects. Chart review did not reveal any discernable reasons regarding treatment decisions in the other 12 cases. In addition, a normal result informed the decisions to prescribe simvastatin in three cases. Providers consulted the pharmacist on five of the six patients where the test results impacted treatment decisions.

Patient engagement & communication

For the study, we developed patient brochures and drug-specific handouts for providers to distribute to patients when discussing PGx testing. Six of the eight providers who completed the follow-up survey (75%) reported providing the brochure to all of their patients, and one provider (13%) gave the brochure to some patients. Three providers (38%) gave the drug-specific handouts to some of their patients; three gave the drug-specific handouts to all of their patients; and one was not aware of the handouts and did not utilize them. Five providers strongly or somewhat agreed that the brochure explained PGx testing satisfactorily.

Two providers reported that they reviewed the PGx results with all of their patients; three reviewed results with a patient only if the dose or drug choice was impacted by the result; and one reported that they did not discuss results with their patients (one declined to answer and one did not order any PGx tests). The predominant method of communicating results was by telephone (71%; n = 5); providers also indicated sharing results at a follow-up visit scheduled to discuss the prescription and test result (n = 3) or at the patient's next visit (n = 3). One provider strongly agreed with the statement "I was able to answer most questions my patients had about PGx testing and their results" and five somewhat agreed (one was neutral and one declined to answer).

Postintervention provider's attitudes & knowledge

Provider's knowledge

Eight provider participants completed both preintervention and postintervention surveys on attitudes and knowledge. The average number of correct answers at baseline was 4.88 out of 9.0 (observed range: 2–6) for providers who completed both surveys; postinter-

Table 2. Comparison of provider utilization (number of pharmacogenetic tests ordered/number of eligible prescriptions) in the pharmacist-in-house arm and the pharmacist-on-call arm.

Drug/gene (PGx test)	# of PGx tests ordered/# of new prescriptions					
	Preintervention		Intervention		Postintervention	
	Pharmacist in-house	Pharmacist on-call	Pharmacist in-house	Pharmacist on-call	Pharmacist in-house	Pharmacist on-call
Atomoxetine† (*CYP2D6*)	0/0	0/0	0/0	0/3	0/1	0/1
Carbamazepine (*CYP2C9*)	0/0	0/0	0/0	0/2	0/0	0/0
Celecoxib† (*CYP2C9*)	0/2	0/10	2/2	0/8	0/3	0/5
Clopidogrel (*CYP2C19*)	0/2	0/6	1/1	0/1	0/1	0/3
Codeine (*CYP2D6*)	0/19	0/41	1/43	0/50	0/18	0/17
Esomeprazole† (*CYP2C19*)	0/8	0/10	0/2	0/15	0/4	0/6
Fluoxetine† (*CYP2D6*)	0/7	0/8	5/11	0/20	0/4	0/10
Imipramine (*CYP2D6*)	0/0	0/1	0/0	0/0	0/0	0/0
Metoprolol† (*CYP2D6*)	0/20	0/21	5/20	0/35	0/4	0/12
Nortriptyline (*CYP2D6*)	0/3	0/3	0/0	0/3	0/1	0/0
Simvastatin‡ (*SLCO1B1*)	0/18	0/25	33/20§	12/16	0/6	0/7
Warfarin (*VKORC1*/*CYP2C9*)	0/9	0/4	1/1	3/5	0/0	0/0
Total	0/88	0/129	48/100	15/158	0/42	0/61

†Clinical Pharmacogenetics Implementation Consortium or other guidelines not available for this drug.
‡Not mentioned in US FDA approved package insert.
§*SLCO1B1* testing was ordered for 33 patients, six of whom were already taking simvastatin for at least 1 month, nine for whom statin treatment was indicated but not yet prescribed during the intervention period and 18 who were prescribed simvastatin at the time testing was ordered or after test results were available.
PGx: Pharmacogenetic.

vention, the average score decreased to 4.38 (observed range: 3–8). Overall, four providers' scores decreased, and four remained the same. Two providers correctly answered the question regarding which group(s) was prohibited from using genetic information based on the federal genetic nondiscrimination law at follow-up. Since the surveys were anonymous, we were unable to assess the relationship between PGx test utilization and changes in knowledge scores. Four of eight providers strongly agreed and two somewhat agreed that the PGx CME was informative and provided the necessary information to offer PGx testing to patients and use results appropriately.

Five providers strongly or somewhat agreed that they felt more informed about PGx testing after their participation in the intervention study (two were neutral and one strongly disagreed). Six providers strongly or somewhat agreed that they felt comfortable discussing PGx testing with patients after their participation (two strongly or somewhat disagreed). Five felt comfortable using PGx results to inform treatment decisions after participation (one was neutral and two somewhat or strongly disagreed). And six somewhat or strongly agreed that they feel comfortable discussing PGx test results with patients after their participation in the study (two somewhat or strongly disagreed).

Perceived value of PGx testing

When asked about the future of PGx testing at the conclusion of the study, 38% (n = 3) of providers strongly agreed that PGx would become standard of care in the future, 33% somewhat agreed, one individual had a neutral opinion and one somewhat disagreed. Six providers (75%) perceived that PGx testing decreased anxiety in some patients who underwent testing during the intervention period.

Four providers (50%) strongly or somewhat agreed that PGx testing should be ordered prior to prescribing a medication that has PGx information in their package insert; two providers had a neutral opinion; and two providers are somewhat or strongly disagreed. Five providers (62%) felt that PGx testing was very or somewhat useful in informing drug dosing or selection; two providers had a neutral opinion; and one felt it was not all useful.

Continued test utilization

Providers were asked if they would continue to order PGx testing after the study ended. Two providers (22%) indicated that they were very likely to continue; one provider was somewhat likely to continue; two (22%) were undecided; and three were not very or not at all likely. However, based on the chart review of the 6-month period following the conclusion of the study, none of the providers ordered PGx testing (Table 2). Providers were asked to rank factors that would increase their likelihood of ordering PGx testing. Availability of clinical guidelines was the most important factor (56%), followed by cost of the test (44%) and test turnaround time (44%). Eight providers (89%) believed that pharmacists or geneticists/genetic counselors would have a role in delivering PGx. Six of the eight providers indicated that they would be more likely to order PGx with assistance.

Providers were asked what barriers they faced in providing PGx testing during the intervention period: six of eight providers indicated that needing to have patients return to provide a saliva sample for testing was a barrier; five indicated that there was insufficient time to discuss PGx testing during an office visit; and three indicated the turnaround time to receive results was too long. Providers were asked how PGx tests should be delivered: five (63%) felt point-of-care testing would be effective, whereas two would support prospective testing. Four providers believed that if pre-emptive testing is available and reimbursable, it should be ordered the first time a medication is prescribed (regardless of age), whereas two believed young adulthood (with or without a prescribed medication) was the best time for pre-emptive testing (no providers believed that pre-emptive PGx testing should be ordered at birth or during adolescence).

Discussion

While discovery and evidence of the impact of genetic variants on drug response continues, routine use of PGx testing has been gradual [36]. The diffusion of PGx testing, like other new clinical applications, faces many barriers, including provider unfamiliarity, and uncertain clinical utility, reimbursement and patient interest [37]. This study aimed to assess the feasibility of pharmacist support to address some of these issues, particularly assisting providers with identifying patients suitable for PGx testing and assisting with test ordering, interpretation and medication changes. We find that in-person pharmacist support yielded greater test utilization compared with on-call pharmacist support in a primary care setting. However, neither clinic ordered PGx testing in the postintervention period, suggesting that ongoing pharmacist support or additional continuing education may be necessary to sustain these services.

Both prior to and following the study, the majority of participating providers believed that pharmacists would play a role in delivering PGx testing. Providers in the pharmacist-in-house arm consulted with

the pharmacist for 13 of the 15 cases, a rate of about one of every four patients tested compared with one of every 7.5 patients tested in the pharmacist-on-call arm. While the small numbers limit our ability to ascertain whether pharmacist utilization was significantly different between the study arms, the significantly higher number of PGx tests ordered in the pharmacist-in-house arm could be attributed to the convenient accessibility to and immediate availability of the pharmacist in this arm. In addition, the majority of pharmacist consultations occurred after PGx testing were ordered, suggesting that providers were comfortable in making decisions about test ordering without the assistance of the pharmacist.

At the conclusion of the study, the majority of participating providers (62%) indicated their belief that PGx testing was very or somewhat useful in informing drug dosing or selection, and 75% felt that testing decreased anxiety in some patients, potentially improving medication adherence. About half of the providers believed that PGx testing should be ordered prior to prescribing a medication that has PGx information in the package insert. However, their perceived value of PGx testing did not appear to align with their knowledge of PGx, which was re-assessed at the conclusion of the study, nor translate into continued use of testing in the 6-month period after the study concluded, despite the continued prescription of medications to patients who could have benefited from testing and expectation of some providers to continue ordering. The brief knowledge assessment used was likely not comprehensive, and thus, providers' perceived value and understanding of PGx were not reflected in their lower knowledge scores at the end of the study. The knowledge providers gained from participating in the study may have been related to general familiarity with testing, and how to discuss, order and interpret testing in the context of the patient's additional clinical information. Several other factors may also have contributed to the lack of sustained use of PGx testing including the lack of insurance coverage, and the time and effort to order testing from an external laboratory; both were prearranged for the study. Though there is little literature exploring the effects of pharmacist support on use of PGx testing, Overby *et al.* [22] reported an increase in perceived value of an EMR-based CDS for PGx testing, but a decline in physician confidence in prescribing decisions after a period of time with the PGx CDS. A similar finding in our study about decreased provider knowledge and recall about PGx testing following the intervention period may also be attributed to physicians' reliance on the pharmacist. Development of a longer CME or a series of CME sessions might have proven more effective to promote provider's knowledge as has been demonstrated elsewhere [38], and could have potentially reduced the need for a pharmacist for an extended period of time.

Some limitations should be noted about this study. The provider and patient populations as well as the small number of patients who underwent PGx testing limit the generalization of the study's findings. In addition, some of the medications on the list were not prescribed or prescribed sparingly, potentially due to provider's preferences, use of alternative medications or characteristics of the patient population, limiting the number of eligible patients for the study. Differences in impact of PGx results on treatment decisions may vary by medication, which could not be assessed in this study.

Conclusion

In conclusion, this pilot study provided some insights into the potential impact of pharmacist support and use of PGx testing in a primary care setting. Although our findings indicate that providers are receptive to PGx testing and perceive it to be valuable, availability of some types of CDS appears to be crucial to the utilization of testing. Additionally, while CME has been reported as an effective way to introduce new knowledge to the providers [39], more effort is required to translate new knowledge into practice [40]. Lastly, the findings indicate that pharmacists may play an role in the delivery of PGx testing in some clinical settings by working with providers to interpret and/or apply results appropriately.

Supplementary data

To view the supplementary data that accompany this paper please visit the journal website at: www.futuremedicine.com/doi/full/10.2217/pgs-2016-0177

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Ethical conduct of research

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

Executive Summary

- Six of the eight providers strongly or somewhat agreed that the pharmacogenetic (PGx) continuing medical education was informative and provided the necessary information to enable delivery of PGx testing to patients and use of results appropriately.
- A significantly higher number of PGx tests were ordered by providers in the pharmacist-in-house arm than the pharmacist-on-call arm.
- Providers in the pharmacist-in-house arm consulted with the pharmacist for 13 of 15 cases, a rate of about one of every four patients tested compared with one of every 7.5 patients in the pharmacist on-call arm.
- Of 18 patients with abnormal test results, physicians only altered drug or dosing for three patients. An additional three patients were prescribed simvastatin after providers received normal test results. All six of these patients were in the pharmacist-in-house arm.
- Test utilization did not continue postintervention; further research is needed to clarify if this was due to lack of pharmacist support or other barriers such as insurance reimbursement, time or lack of in-house testing services.

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