Commentary

Pharmacogenomics

Educating patients and providers through comprehensive pharmacogenetic test reports

"...facilitating comprehension and appropriate utilization of results will be essential to optimizing the benefits of pharmacogenomics testing..."

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With the expanding number of clinically available pharmacogenetic (PGx) tests, more and more health providers, the majority of whom will likely have limited training or knowledge of genetics[1], will be using these tests. Development of educational efforts in this field have not kept pace with test development [2]. Traditional genetic test reports often include genetics jargon and abbreviations, and therefore, may not be understandable to general practitioners. Likewise, with increasing patient access to online medical records, including clinical laboratory reports, the content may be particularly challenging for patients to understand, especially for those with low-health literacy. Thus, these barriers may limit providers' and pateints' understanding of PGx reports and the appropriate use of the results. Educational efforts may be particularly helpful at the point-of-care to help providers with appropriate test utilization and interpretation. PGx testing laboratories are taking steps to increase comprehension and appropriate application of results via their test reports. In this short paper, the literature on data visualization and risk communication strategies is briefly reviewed, followed by an analysis of how some of these approaches have been applied by clinical PGx laboratories to improve comprehension.

Given the wide range of different types of genetic tests and the expanding use of testing by nongeneticists, some efforts have focused on improving the format of test reports for both providers [3] and patients [4]. Several features of current genetic test reports may be difficult to understand by providers and patients alike, due to ambiguous terminology, complexity of the result, unclear interpretation of result and lack of follow-up recommendations [5].

For patients, information in test reports should be presented "in ways that enable the individual to understand and to act on the information contained in the record" [6]. A handful of studies have explored patient preferences for reporting genetic risk information. Familiar formats such as pie charts are preferred for communicating personal genomic risk as well as approaches that tend to 'humanize' the data such as a person-based isotype array or pictograph [7]. Another study reported that a third of patients who had PGx testing did not clearly understand the results and suggested use of nonmedical language [8]. Knowledge about genetics in the general population varies substantially [9], and therefore, many may be unfamiliar with the complexities of genetic testing and associated terminology. Even highly educated individuals face challenges in interpreting sequencing data presented in tabular format and text-laden reports [10].

Several strategies for data visualization, particularly risk communication, can be utilized to create more user-friendly lab reports for patients and providers alike [11]. Reported patient difficulty with risk comprehension due

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to low numeracy, ratio bias and denominator neglect may be reduced by presenting data graphically in addition to text-based descriptions and numbers [12]. In particular, infographics have increasingly been used to display complex information in health and nonhealth settings [13]. Icon arrays (or isotype arrays) can display risk information (e.g., shaded figures indicating the proportion of affected individuals out of an appropriate total, such as 10 or 100) [14]. Use of risk labels (e.g., very common) may also help patients understand the genotype and clinical significance, presented in a tabular [15] or graphical format. Display of data in multiple formats is also desirable (text, numerical, graphical) [16]; however, for multiple test results in one report (e.g., multigene panel), this approach may yield a lengthy report. Summarizing data in a table format may help condense the data as well as highlight particular categories of health concern. This approach can also help overcome low literacy, numeracy and language barriers. While interactive graphics are being developed to improve research data analysis and visualization, the data are equivocal regarding the benefit of such tools to improve patient comprehension of medical information [10,17].

> "In particular, infographics have increasingly been used to display complex information in health and nonhealth settings."

In addition to considering display formats for lab reports, the language of the report should minimize the use of medical jargon, which poses substantial challenges to patient comprehension [18]. The disparity between the language used in health-related documents and the readability level of the user is known as a 'readability gap'. As avoiding medical jargon may not always be possible, provision of interactive learning tools or aides such as pop-up glossaries, video or audio-recorded summaries, and hyperlinks to accurate resources about a particular condition or disease could promote understanding of unfamiliar terminology [19]. Clinical laboratories that offer direct patient access to reports via a patient portal may have more flexibility with including these types of interactive tools in their reports.

An analysis of publicly available PGx test reports demonstrates that some laboratories are moving away from a traditional text-based lab report to incorporate new report features and displays, while still including the standard information reported in other types of genetic test reports. A review of 34 laboratories currently offering PGx testing identified eight laboratories that provide a sample test report on their website and seven other companies that include a description, template and/or snapshot of excerpts of the lab report. Two of the eight laboratories that provided sample reports are for tests of 1–2 genes, and the remainder (6) are reports for multigene panel tests. Overall, the reports range in length from 2 to 27 pages, with an average of 10 pages. If the two reports for tests of 1–2 genes are excluded, the average length of the report for gene panel tests increases to 14 pages. The reporting of the actual PGx test result is similar to most disease-related genetic testing with respect to gene name/abbreviation and genotype result, though using the standardized PGx nomenclature of the star-allele system [20]. The phenotype is described by labels such as rapid or intermediate metabolizer.

However, multigene PGx test reports differ from disease-related genetic test reports in how results are displayed and the extensive information included about the clinical significance of the test results to drug dosing and selection. All six of the multigene test reports displayed the gene/genotype/phenotype data in a tabular format. Some either included a brief text description in the table or opted to include a more detailed text-based description of the results in a subsequent section. All six of the gene panel reports use color-coding and symbols to depict level of risk for adverse responses based on the patient's genotype. A tri-color-coding system is primarily used in the results and medication tables: red (high risk), yellow/orange (moderate risk; use with caution)and green (normal; use as directed). Symbols used to convey level of urgency/risk include an exclamation point, an 'X', a flag or check marks. In contrast, the two sample reports for tests of 1–2 genes were black and white (excluding the lab logo) and text-only reports.

The increased length of the PGx reports from labs performing gene panels is primarily due to the inclusion of a table or lists of drugs that are impacted by the gene(s) tested and a recommendation regarding drug use or dosing. The medication lists extend across several pages, with the general test panels (not affiliated with a specific disease or medication class) including longer lists of medications compared with the more focused disease-based or medication class test panels (e.g., pain panel). One laboratory created a large table combining both the results and drug recommendations that extended several pages, using both symbols and colors to indicate caution or normal/standard of care.

Although graphics or icon arrays are not used in the eight sample test reports available online, one of the laboratories that showed a snapshot and description of the report uses a color-coded human icon to display the overall test outcome. Some of the laboratories employ graphics in their website or patient education resources to illustrate the range of possible test outcomes with respect to metabolizer status (e.g., a human icon drawn in a running motion to convey rapid metabolizer status) and use icon arrays to illustrate the proportion of patients who may experience adverse responses.

In summary, facilitating comprehension and appropriate utilization of results will be essential to optimizing the benefits of PGx testing across a patient's lifetime. PGx testing is still quite novel to many patients and providers, but laboratories are attempting to promote greater understanding and appropriate use of the results by transforming the traditional test report into a more comprehensive report, which may serve as a reference guide each time a new medication is prescribed. However, this lengthy report may be difficult to find the information desired to inform care or overwhelming for patients. Patients and some providers will likely still have difficulty understanding the actual results and some of the language/nomenclature, and thus, may tend to focus on labels and the warnings/recommendations.

As labs begin to design programs to enable interactive reporting whereby medication history can be added and drug–drug and drug–gene interactions can be confirmed, it is anticipated that the information in lengthy printed reports will be easier to navigate and to personalize for each patient. In the future, other test results, drug allergies and other factors relevant to predicting drug response may be added and continually updated by the provider in order to generate a truly comprehensive, personalized report. New tools or applications (apps) such as the Substitutable Medical Apps, Reusable Technologies (SMART) platform on Fast Healthcare Interoperability Resources (FHIR) can facilitate the integration of test reports into electronic health records. While efforts to redesign a lab report can be timely and costly for the laboratory, it may produce substantial benefits to patients and providers. The creativity and willingness to move 'outside the box' demonstrated by PGx testing labs may set a precedent for other clinical -omics tests.

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