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A Qualitative Study of Healthcare Providers' Perspectives on the Implications of Genome-Wide Testing in Pediatric Clinical Practice

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Abstract

The utilization of genome-wide chromosomal microarray analysis (CMA) in pediatric clinical practice provides an opportunity to consider how genetic diagnostics is evolving, and to prepare for the clinical integration of genome-wide sequencing technologies. We conducted semi-structured interviews with 15 healthcare providers (7 genetic counselors, 4 medical geneticists, and 4 non-genetics providers) to investigate the impact of CMA on clinical practice, and implications for providers, patients and families. Interviews were analyzed qualitatively using content analysis. Most providers reported that genomic testing enhanced their professional experience and was beneficial to patients, primarily due to the improved diagnostic rate compared with earlier chromosomal studies. Other effects on practice included moving towards genotype-first diagnosis and broadening indications for chromosomal testing. Opinions varied concerning informed consent and disclosure of results. The duty to disclose incidental findings (IFs) was noted; however concerns were raised about potential psychosocial harms of disclosing pre-symptomatic findings. Tensions were revealed between the need for comprehensive informed consent for all families and the challenges of communicating time-consuming and potentially anxiety-provoking information regarding uncertain and incidental findings that may be relevant only in rare cases. Genetic counselors can play an important role in liaising with families, health professionals and testing laboratories, providing education and guidance to non-genetics providers, and enabling families to receive adequate pre- and post-test information and follow-up care.

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Disclosure of interest

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INTRODUCTION

Chromosomal microarray analysis (CMA) is recommended as a first-tier diagnostic test to evaluate conditions including developmental delay, autism spectrum disorders, and multiple congenital anomalies (Manning & Hudgins, 2010; Miller et al., 2010), and its clinical utility has been documented in pediatric practice (Ellison et al., 2012). When introduced to the field of cytogenetics, array-based testing was described as revolutionary (Beaudet & Belmont, 2008), “transformative” (Shaffer & Bejjani, 2006, p.303), and “inaugurat[ing] the third age of cytogenetics” (Friedman, 2009, p.21). Early cytogenetic techniques developed in the 1950’s permitted determination of the number of chromosomes in a cell. In the 1970’s techniques for banding of human chromosomes were developed. Karyotypes entailed low resolution genome-wide investigation, and florescent *in situ* hybridization (FISH) studies enabled targeted testing for smaller deletions and duplications based on phenotypic suspicion (Cody, 2009; Mefford & Eichler, 2009). CMA and newer efforts at whole exome sequencing (WES) and whole genome sequencing (WGS) are genome-wide and high-resolution. The increased utilization of CMA in clinical practice could potentially shift the field of medical genetics towards a genotype-first approach to diagnostics and syndrome-delineation (Hennekam & Biesecker, 2012; Ledbetter, 2008). Additionally, genome-wide testing generates large quantities of information, some of which may be uncertain, unanticipated, or both, raising ethical concerns about disclosure, especially in pediatric populations (Grody, 2003; Wade, Wilfond, & McBride, 2010; Wilfond & Ross, 2009). While the new technologies have provided improved diagnostic rates, questions have been raised about how best to integrate genomic testing into clinical practice. Unexpected and VUS findings can complicate the process, involving the evaluation of parents and other family members, and highlighting the importance of genetic counseling (Ali-Khan, Daar, Shuman, Ray, & Scherer, 2009; Boone et al., 2013; Darilek et al., 2008).

As we move towards new approaches to testing and diagnosis, genetics providers are confronting new opportunities and challenges in evaluating and conveying the capabilities of genome-wide tests and potential uncertainties of results. It is important to understand the perspectives of health providers regarding the impact of CMA testing on their clinical practice, to identify their concerns, and to document changes in their approaches to ordering, interpreting and conveying genetic test results in the course of clinical utilization of CMA. The lessons learned in the context of array-based testing can assist in preparing for the clinical integration of novel genome-wide sequencing methodologies. The present paper reports the findings of a qualitative study on the experiences of a group of healthcare providers who order CMA in the context of pediatric clinical diagnostic evaluation. We explore providers’ perspectives on the implications and impact of using CMA in their clinical practice.

METHODS

The data described in this article represent one component of an exploratory study of the impact of CMA testing on families and healthcare providers. The overall study comprised clinical observations, interviews and a survey, and included healthcare providers and families of children tested using CMA (Reiff et al., 2012; Reiff et al., 2013). This paper reports findings from in-person qualitative interviews conducted with 15 healthcare providers.

Data collection and analysis

A convenience sample (Bernard, 2012) of providers who had ordered CMA was used. Providers were identified by staff at the cytogenomics laboratory of a university-affiliated hospital, and were invited, either in person or via email, to participate in an interview. All those who were invited agreed to participate and written informed consent was obtained. The study was approved by the hospital's Institutional Review Board.

Interviews typically lasted 40–60 minutes, and were conducted by one of the authors (MR). Using a semi-structured interview guide, participants were asked a set of open-ended questions, with probes to elicit detailed descriptions of their experiences with CMA testing. This paper primarily addresses qualitative responses to questions concerning the impact of CMA on clinical practice. Providers were asked what they thought was novel about CMA, how it affected their practice, and how they dealt with uncertain and unanticipated results. Demographic questions were asked at the end of the interview.

Interviews were audio-taped, transcribed verbatim, and uploaded into NVivo, a software program for qualitative analysis (Bazeley, 2007). We used a content analysis approach to identify themes and develop a coding scheme (Bernard, 2002). Codes were generated by the author (MR) and all transcripts were independently coded by two additional coders. Through an iterative process, codes were refined and inconsistencies were resolved by discussion. The average inter-coder agreement was 97%.

Participant characteristics

This article reports data from interviews conducted with 15 healthcare providers consisting of 4 medical geneticists (MG's), 7 genetic counselors (GCs), and 4 non-genetics providers (NGPs) including a pediatrician (P), pediatric neurologist (PN), developmental pediatrician (DP), and nurse practitioner (NP). Fourteen providers had ordered CMA from the hospital cytogenomic laboratory. Of these, thirteen were hospital-based, one (PR16) was based in a satellite practice, and one (PR11) was in private practice. One genetic counselor (PR05) was employed at a different hospital, and was included because of an expressed interest in the study topic. One non-genetics provider (PR08) worked in a department with a genetic counselor. The other three non-genetics providers did not work directly with geneticists or genetic counselors, but liaised with a laboratory genetic counselor regarding test results. Providers used a variety of laboratories for CMA, based primarily on selective coverage of laboratories by health insurers. Providers reported practicing between 1 and 35 years, and utilizing CMA technology for between 1 and 5 years. Overall, providers estimated that they

had ordered or interpreted between 10 and over 100 CMAs in the past year. Only three providers (two NGPs and one GC) had ordered 50 or fewer CMAs in the past year. Demographic characteristics are summarized in Table 1.

RESULTS

The results are organized according to the main themes in our analysis: What differentiates CMA testing?; uncertainties in CMA testing; incidental findings, the informed consent process; and non-genetics providers using CMA. Statements illustrating each theme and sub-theme are presented in Table 2.

Evolutions, revolutions and continuities in genetic testing: What differentiates CMA testing?

When asked what differentiates CMA testing from previous forms of genetic testing, providers spoke about the increased resolution, specificity, and diagnostic yield of the CMA test. The specificity of the CMA and its ability to define the exact chromosomal region involved was also described by providers as novel. Providers articulated that the unbiased nature of the information, and the ability to scan the genome for multiple chromosomal disorders at once distinguished CMA from previous forms of chromosomal testing, for example:

It's dramatically different in that you're getting just a lot more information. You're getting unbiased information. (PR07;MG. Table 2 #1).

When discussing the effects of CMA testing on diagnostic practice, several providers noted that while precise description of physical features remained essential for consideration of single gene disorders, recognition of clinical features of chromosomal conditions was not as imperative as in the past when only targeted testing was available. Nearly half of the providers described examples of or movement towards a genotype-first approach to diagnostics. One provider described how the delineation of a specific syndrome was made possible by CMA testing, which prompted the comparison of clinical features between patients with a similar deletion:

This is a clinical picture that's defined itself because of the array. So we found that this series of patients had the same difference on the array. ... When you put the patients together they do have a similar constellation of findings. So we think this is a newly defined entity. (PR12;GC. Table 2 #2)

Some concern was expressed about the potential shift towards a genotype-first diagnosis, for example:

I wonder if we sometimes rely a little too much on them [arrays]. Before it was more of a clinical diagnosis and clinical judgment, and now it's – let's sit back and wait for this test to show us what we should do next. (PR06;GC. Table 2 #2)

Several providers noted that the ability to detect much smaller chromosomal aberrations that were often associated with milder phenotypes was altering the image and expectations for individuals with chromosomal differences and broadening the indication for chromosomal testing. One provider explained that whereas “*in the old days of karyotyping, chromosomal*

abnormality always meant pretty significant and bad outcomes” with microarray findings “there is more room for variability and for good outcomes...” (PR04;GC). Additionally, a couple of providers described diagnoses of atypical cases of known syndromes where clinical features of the disorder were lacking despite the cytogenomic abnormality detected by array (Table 2; #3 and #4).

Approximately one third of respondents articulated that the relatively high proportion of VUS results differentiated CMA from previous types of genetic testing (Table 2 #5). One provider felt that microarray testing altered his practice inasmuch as *“I probably think a little bit more about sending it, whether to send it or not [compared to previous forms of chromosomal testing]...because of this question of unexplainable variants” (PR03;MG). CMA was perceived by some providers as a precursor to WGS and WES, in bringing an increase in the volume of information and the demand for genetics services. Providers noted the increased time necessary to interpret and communicate CMA studies, and expressed concerns that there would be insufficient personnel to manage the quantity of information, for example:*

I think that the technology is getting a little bit ahead of the number of boots on the ground that can deal with it, and I worry about what’s going to happen as sequence variation comes out... I think we need to get more geneticists out there because this is the way it’s going and there’s not enough people to really give this information out [PR15;MG.]

In addition to the novel aspects of CMA, providers articulated ways in which CMA was *not* a major departure from prior practice. Two providers expressed the view that the ambiguity associated with variant findings had always been present in genetics and medicine more generally. As one genetic counselor explained, *“the volume of small variants and unknown things is a lot higher than when you send other testing ... but the major issues of ambiguous results... have always kind of been there” in genetics (PR12;GC). Similarly, a senior medical geneticist explained that the CMA test has “been added to things that we have available [and] increases the chances of getting a specific diagnosis. But I don’t think it’s changed the way I practice” (PR10;MG). One provider noted that while CMA increases the chances of a finding, “the idea of identifying a genetic cause that might have been transmitted from one of the parents is always threatening. The idea of identifying a genetic cause that has arisen de novo but that can’t be fixed no matter how much therapy their child gets is also threatening, although from a slightly different quarter. I don’t think the SNP is appreciably different in its threat dimension to parents than the earlier test” (PR11;NGP-DP).*

Uncertainties of CMA testing

Providers identified several sources of uncertainty in the context of CMA testing, in addition to the uncertainty associated with variant results (described above). These ranged from uncertainty surrounding the child’s illness and clinical presentation, to uncertainties of CMA interpretation, to the uncertainty associated with abnormal results for which prognostic information is limited. A prominent theme expressed by six of fifteen providers was the importance of communicating the possibility of an uncertain result in the course of pre-test

counseling. Several providers explained that after gaining experience with VUS results, their counseling style had evolved to include more discussion of ambiguous findings before the test was run (Table 2 #6). One provider illustrated the importance of such conversations, with an example of a child evaluated for mild features whose array revealed a VUS result. Interpretation of this variant was complicated by the fact that the child's biological father had been a sperm donor for whom no phenotypic information was available. As the provider explained,

... the family actually spent quite a bit of time talking about the impact of this test on them. And they said they would have much preferred to have been given a lot more information before ordering the test about what it could have shown.
(PR05;GC)

This provider went on to question the value of the information in this case:

I think it's just created more anxiety for them than it was worth because ... we don't know, but it's probably not going to cause any future problems for him. But the family is walking around wondering whether it is or not. So I think for them it was probably worse to do the test. (PR05;GC)

In addition to preparing patients for potential variant findings, several providers expressed the importance of conveying the uncertain nature of such findings to families during results disclosure. While many providers emphasized uncertainties associated with CMA testing and especially variant results (Table 2 #7), a couple of providers tended to define variants as "non-significant" rather than "uncertain" (Table 2 #8).

Most providers emphasized downplaying the significance of variants until parental testing was completed, and transparency in the face of variant findings where pathogenicity remained ultimately unknown (Table 2 #9). Providers also spoke about uncertainties associated with determining causality, and acknowledged the limitations of current genomic databases and array technology that may miss small but clinically important deletions and duplications (Table 2 #10).

Six providers discussed the issue of uncertainty associated with diagnoses that do not have clear prognoses due to the rarity of novel chromosome differences and their variable expressivity. Several described telling parents that the child would "be the guide" and teach them about the chromosomal result. Parents may anticipate that diagnosis will lead to prognosis, and may expect positive test results to translate to better medical interventions, which often remain elusive despite a defined cause. Several providers explained that having an explanation "*doesn't give us the crystal ball*" (PR12;GC), which some families found frustrating (Table 2 #11). A related theme was the involvement of patients and families in the process of discovery as the science evolves over time, affecting the interpretation of specific results. The following quote demonstrates the importance of follow-up appointments, in order to keep families updated and inform them of new developments and discoveries:

I don't have a problem saying to the family that their child is actually going to teach us about what this means. ..I will tell them that I will keep looking [in the

literature]...and part of what forces me to keep looking is following up. It may not happen without the follow-up [appointment] to force me to do it. (PR03;MG. Table 2 #12).

One provider mentioned that involving families in research provides them not only with a route to the most current information, but also a way to make a valuable contribution to the advancement of science, which can help some parents to cope with the uncertainties of having a child with a rare condition:

[Some parents] feel very good about knowing that their child could help towards advancements in science. .. I think we're changing a lot in that respect. It's opening up an avenue of identification of things we never would have known before and some parents get a lot of support from that, and they're enthusiastic as we are. They really want to help be a part of the discovery of genetics and if their child could help in that, then there's some good that came out of the differences their child has. (PR01;GC. Table 2 #12).

Incidental findings

The majority of providers had received or were aware of cases of incidental findings (IFs); only one provider had not considered the possibility of incidental findings before the interview. Nine of 15 providers shared experiences of incidental findings found by array ranging from non-paternity to pre-symptomatic Duchenne muscular dystrophy.

In discussing the disclosure of incidental findings, providers often described severity of the condition or risk and available medical management options in framing the scenarios where incidental findings arose. One provider described the incidental discovery detected in a child and a parent of hereditary neuropathy with liability to pressure palsies associated with alterations in PMP22. The provider team deliberated whether or not to disclose the finding, and decided to disclose the information because it was medically relevant. In sharing the result it was revealed that the mother was in fact symptomatic and the information proved to be helpful in providing an explanation for her symptoms:

... she knows now she has to avoid [certain activities]. That's really all she has to do. There are much worse kinds of things that you could find out to tell people.

And that was part of the reason we decided to tell them. (PR03;MG)

Providers reported varying experiences and opinions about the risks and benefits of identifying IFs in microarray testing of children (Table 2 #13). For example, a retinoblastoma gene deletion found in a newborn before clinical presentation of cancer was clearly beneficial: the baby was promptly evaluated and multiple tumors were identified and treated, enabling the child's vision to be saved and the cancer to be cured. The benefits of other IFs were more controversial with different providers describing the same diagnoses (e.g., adult-onset cancer or late childhood onset conditions) as beneficial or harmful to the child or family in question. Some providers focused on the benefits of early detection and screening for conditions revealed incidentally (such as Duchenne muscular dystrophy and some types of cancer). Several providers also described the psychological distress associated

with incidental findings, stress that families would have avoided for years in the absence of the pre-symptomatic diagnostic CMA results, for example:

So I mean there's that huge risk of finding these things we're not expecting... if we didn't have this [array] and they weren't tested for this, then the families would go however many years or whatever without knowing this, and from the medical perspective it's great for these families to know.... But I don't necessarily think that it's great for the families that they're identified young because that's so much emotional distress on a family that would not have had to deal with that emotional distress for years. (PR08;NGP-NP. Table 2 #14)

Providers articulated a sense of duty to share all information revealed by CMA (Table 2 #15). While microarray testing introduces the possibility of finding a wide, albeit rare, range of incidental findings, several providers contextualized this chance, noting that unanticipated results are not unique to microarray testing (Table 2 #16).

Informed consent process

Most providers spoke of a consent process whereby the test was explained and potential findings, such as VUS, were discussed. Two providers noted that while outpatients were consented, inpatients underwent testing based on the blanket consent signed upon admission. Several providers noted the absence of a consent form for CMA testing at their institution. One explained that

...consents came from [the] pre-symptomatic testing arena with a prototype being Huntington's. Chromosome analysis has always been done on symptomatic individuals. So therefore I think historically there was never a consent. Nowadays with the arrays, of course you can find things that...you were not looking for. (PR04;GC. Table 2 #17)

Lack of explicit consent or counseling that addressed the potential for IFs was noted by several providers, and many reported that they tend not to discuss the potential for incidental findings with families prior to testing, unless parents raise the issue (Table 2 # 18). One provider noted that "in an ideal situation" the possibility of IFs might be discussed pre-test, but pointed out that this could arouse unnecessary anxiety for many families for the benefit of a rare few. Additionally, one provider reported that most people don't take much notice when informed of potential IFs because it is rare and unlikely to happen to them (Table 2 #19). Time limitations in clinic were described as a barrier to comprehensive consenting. However, it was considered important to give families the option to decline disclosure of IFs in the event that they were detected (Table 2 #20). Several providers acknowledged that despite accepted professional standards against pre-symptomatic testing of children, CMA could detect conditions pre-symptomatically in children in the course of evaluation for an unrelated indication.

A couple of providers mentioned that either a consent form or educational literature for families could facilitate informed consent to CMA testing. Such documentation was seen as an opportunity to discuss the significant potential for VUS results, the small chance of incidental findings, as well as the limitations of current genetic testing. One provider

suggested that printed information provided before testing would be an appropriate place to note the possibility of incidental findings, given the time constraints in clinical settings:

I think a lot of it's just kind of the limitations of being in clinic and trying to get everything done. And trying to see the patients, that it's hard to go into that in sufficient detail with everyone and then open a whole can of worms. But I think in that case, if there was going to be some kind of literature or something provided to them beforehand, then I think that would be a good way to just put it out there as a general caveat. (PR12;GC. Table 2 #21).

Roles and needs of non-genetics providers using CMA

Several providers, both geneticists and non-geneticists, mentioned the need for genetics expertise in interpreting and conveying CMA results to families. It was noted by several genetics providers that providers with insufficient knowledge of genetics might order the test inappropriately or cause confusion for families through their inability to interpret the results or provide guidance, for example:

I think [non-geneticists] need to be prepared before they send a high resolution test off to know that they're going to have to handle uncertainties. And many of them are not equipped to handle that... (PR15; MG. Table 2 #22)

While concerns were expressed surrounding the inappropriate interpretation of CMA by non-genetics providers, the non-genetics providers and several genetics providers reported feeling comfortable with non-genetics providers ordering CMA, with the caveat that they understand the implications of negative results, and appropriately refer to geneticists. Reasons cited for non-genetics providers having a role in ordering CMA included the practical difficulties for families of obtaining and attending a genetics consultation, and the nation-wide lack of genetics professionals (Table 2;#23).

Several non-genetics providers acknowledged their limitations regarding interpretation of CMA results. Almost all providers expressed a need for guidance and education for non-genetics providers and for close collaboration with geneticists. Some suggestions for collaborative models included educational sessions provided at staff meetings, referral to genetics professionals and guidance provided by those with genetics expertise (Table 2; #24).

DISCUSSION

The purpose of this study was to elicit perspectives of providers regarding the impact of CMA technology and to describe the main issues arising with respect to the uncertainties involved with CMA in pediatric clinical practice. In general, the providers interviewed expressed positive reactions to CMA, felt that it enhanced their professional experience and was beneficial to patients and families, primarily due to the improved diagnostic rate compared with earlier chromosomal studies. Common themes were the increased diagnostic yield, a move towards genotype-first diagnosis, expanding the phenotypic spectrum of known disorders, broadening indication for chromosomal testing, and the challenges presented by uncertain results and IFs. A prominent theme concerned the need for

communication with families about uncertainty both pre- and post-test. Providers identified multiple sources of uncertainty, including VUS results and prognostic uncertainty surrounding novel and rare pathogenic results. Experience with IFs was commonly reported, but opinions about the benefits and harms of disclosing IFs varied among providers. In our study there was a tendency to discuss IFs only in the rare cases where they actually occurred. Providers articulated a duty to disclose IFs, however concerns were raised about the potential psychosocial harms of disclosing pre-symptomatic findings. Respondents noted the challenges of providing detailed explanations about possible IFs, given the large quantity of information and time constraints in clinic. Some participants thought the process could be improved by providing all families with informational materials prior to testing which could explain the potential for VUS results and IFs, and clarify the limitations of the test.

The changes occurring as a result of genome-wide testing have been compared with transformations following previous cytogenetic advances such as banding technology which revealed the chromosomal basis of known syndromes and led to the identification of new syndromes (Friedman, 2009; Jackson & Pyeritz, 2011; Ledbetter, 2009). Many differences of opinion expressed by providers in our study reflect debates in the field regarding genotype-first vs. phenotype-first approaches (Cody, 2009; Lacassie, 2009; Saul & Moeschler, 2009). The benefits of a genotype-first approach include early diagnosis, allowing earlier intervention and recurrence risk counseling for the family. It can also clarify the clinical diagnosis for cases that present atypically, lead to a diagnosis through a single test in a patient with nonspecific findings, and may be more readily ordered by primary care providers, thus expediting diagnosis (Mefford, 2009). Disadvantages of genotype-first diagnosis can include unnecessary and inappropriate testing which can decrease the sensitivity of the test and drive up health care costs (Lacassie, 2009).

Uncertain findings

Most providers emphasized the importance of communicating with families about results of uncertain clinical significance both pre- and post-test. For some, experience demonstrated that when families were prepared for the possibility of VUS findings, they tended to have better understanding and coping with the result. This finding is consistent with literature recommending pre-test counseling about the potential for variant findings (Darilek et al., 2008; Kearney, Thorland, Brown, Quintero-Rivera, & South, 2011; Reiff et al., 2012).

Individual differences were evident in the extent to which providers defined specific results as “uncertain.” The variation in providers’ attitudes about defining and conveying uncertainty suggests that patients may receive different interpretations of VUS findings depending on their provider’s views and feelings about uncertainty. Studies have found that variations in physicians’ practice patterns may be explained by variation in tolerance for ambiguity, suggesting that physicians with low tolerance for ambiguity may have decreased ability to acknowledge uncertainty (Geller, Tambor, Chase, & Holtzman, 1993; Gerrity, DeVellis, & Earp, 1990; Gerrity, White, DeVellis, & Dittus, 1995). Additionally, providers tend to calibrate their explanations to match the patient or family in front of them in terms of the level of education, understanding of genetics, tolerance for ambiguity and other relevant factors that vary individually (Portnoy, Han, Ferrer, Klein, & Clauser, 2011). Time

constraints are another factor that may affect the extent to which a provider would elaborate on a finding of uncertain significance, and the amount of information conveyed. These potential influences on providers' patterns of communication of genetic information deserve further investigation.

Knowledge of the significance of a VUS often evolves over time as more data become available, and it can be challenging for providers to keep abreast of new information. For example, there is some evidence that the variability in phenotype may be explained by secondary variants that contribute to clinical outcome and severity (Girirajan et al., 2012). Using information technology infrastructure, new systems are being developed to help laboratories to inform ordering physicians when new information emerges (Aronson et al., 2012). It will be more challenging to re-contact patients to update them on new information (Pyeritz, 2011). Our data suggest that follow-up visits are an important tool in keeping both providers and families up to date with new information. Parents may incorrectly assume that they will be informed of relevant new discoveries. It must be clearly communicated if families are expected to re-contact their providers to be informed of new developments and discoveries regarding a given result. Families should be counseled regarding when to re-contact providers and what to expect in terms of evolving information on genetic variants.

In addition to discussing the possibility of variant findings, pre-counseling for CMA testing should convey the potentially limited impact of genetic diagnosis on treatment options or prognostication. In some regards, the boundaries between clinical care and clinical research are blurred within genetics, necessitating thoughtful communication about the benefits and limitations of genetic studies. If novel or rare findings may make the "child the guide" for understanding the meaning of a genetic test result, parents will likely remain motivated to uptake testing given the possibility of an informative finding, but should be informed of the potential limitations in interpreting extremely rare or novel findings before testing is ordered.

Incidental findings

Clinical guidelines recommend that patients and families should be informed of the potential for IFs before genomic testing (Green et al., 2013; Kearney et al., 2011; Manning & Hudgins, 2010). Despite the guidelines, the results of the present study are consistent with findings from our previously published research in which many physicians reported that, in a hypothetical scenario, they did not consider it pertinent to discuss the potential for IFs before testing (Reiff et al., 2013). The qualitative data in the present study provide further insight into providers' reasons for not discussing IFs, which include the rarity and the wide range of potential findings, and the perception that it is impractical to take the time to discuss potential IFs with all patients given their infrequent occurrence. Additionally, for some families, discussion of potential IFs could be overwhelming and provoke unnecessary anxiety. Our findings are consistent with other research reporting similar opinions among genetics providers regarding preferences not to have detailed pre-test discussion of IFs (Downing, Williams, Daack-Hirsch, Driessnack, & Simon, 2013).

Providers' opinions varied regarding the benefits and harms of disclosing IFs. While there was consensus that an incidental finding leading to the early diagnosis of a treatable or

preventable condition is beneficial, consensus decreased in relation to conditions with onset in adulthood or later childhood, and those for which there are no known medical treatments or interventions. Our findings reflect trends indicating some discordance among geneticists regarding which IFs to report, and the importance of factors affecting the decision to disclose IFs, e.g., whether the result pertained to an adult or a child, and the established pathogenicity of the variant (Green et al., 2012).

If families are not asked before testing whether they would like to know the information revealed by IFs, it is difficult for providers to know how to proceed when they occur. The study participants reported a variety of strategies to determine how best to manage the disclosure of IFs on a case by case basis including collaboration among providers and laboratory scientists, and consideration of the specific clinical and family situation. As CMA and other types of genomic testing are utilized more frequently, it will become too time-consuming to manage them in this way. IFs may be categorized into those that are clinically actionable and should always be reported, and those that are not directly actionable where disclosure is based on patient preference (Berg, Khoury, & Evans, 2011). This implies that an informed consent process would be advisable to determine patients' preferences regarding disclosure of IFs. While time constraints do not allow for discussion of all potential findings (Berg et al., 2011), a 'generic consent' option has been suggested, which could provide information about general categories and include preferences for disclosure of findings based on considerations such as treatability, age of onset and severity (Dondorp, Sikkema-Raddatz, de Die-Smulders, & de Wert, 2012; Netzer, Klein, Kohlhasse, & Kubisch, 2009).

A predominant theme in our study was a reluctance to disclose risk information before a child develops symptoms, and the sense that the psychological burden may be harmful to the family. Research studies and ethical reflections have attempted to weigh the psychosocial harms of anticipating behaviors and over-vigilance against the benefits of psychological preparedness and early prevention (Kohane, Masys, & Altman, 2006; Lerman, Croyle, Tercyak, & Hamann, 2002; Nelson et al., 2001). Most reports agree that IFs that are clinically important and actionable should be disclosed, however, caution is recommended out of respect for the patient's right not to know, and due to implications for family members, especially when testing involves children (Christenhusz, Devriendt, & Dierickx, 2013). It is important to recognize the distinction between providing IFs to minors and to adults. Guidelines developed for use in pediatric genomic research recommend that parents provide informed consent for disclosure of IFs based on specific criteria, for example urgent clinical significance, and potential benefit outweighs risk of psychosocial harms (Abdul-Karim et al., 2013). The American College of Medical Genetics and Genomics recommendations for reporting of IFs in clinical exome and genome sequencing note that although predictive genetic testing for adult-onset diseases is generally not recommended for minors, IFs from genomic testing of a child that are relevant to some adult diseases have clinical implications for parents or other family members, and should, therefore, always be reported (Green et al., 2013). More research is needed on how information about IFs from genomic testing will affect patients and families in the long term. Meanwhile, parents are likely to be making decisions about whether or not to be informed about IFs, and in order to make informed decisions, parents will need adequate education and counseling about the

potential benefits and limitations of genomic information, and healthcare providers will need to develop ways to convey the ambiguities and uncertainties of the information (Wilfond & Ross, 2009). Given the variety of potential IFs that may be discovered (Boone et al., 2013), it is worth considering efficient ways to communicate this information prior to testing. Suggestions reported by providers in our study included providing written information to families pre-test, and facilitating timely post-test counseling and appropriate follow-up care.

Practice implications and recommendations

As genomic testing becomes more routine, genetic information is playing an increasingly important role in clinical diagnosis (Hennekam & Biesecker, 2012; Ledbetter, 2008). Additionally, new syndromes and under-characterized genomic anomalies are more commonly identified (Deak, Horn, & Rehder, 2011; Navon, 2012). There is an increasing need to integrate the clinical and the genetic information. However, most healthcare providers have inadequate understanding of genetics (Feero & Green, 2011; Greendale & Pyeritz, 2001; Kemper et al., 2010; Trinidad et al., 2008) and most laboratory scientists have little exposure to clinical phenomena (Wain et al., 2012). Genetic counselors can play a crucial role due to their familiarity with the genetic disease phenotypes and their expertise in interpreting genetic test results. Genetic counselors are ideally situated to liaise with families, non-genetics healthcare providers and laboratories, and to integrate the different types of information into a coherent picture. Genetic counselors have a role in correlating genetic and phenotypic findings, and documenting the variability of clinical presentation in affected individuals, and have been called upon to contribute detailed and accurate phenotypic information to databases that aid in the interpretation of CMA results (Wain et al., 2012). In these ways, genetic counselors can help to bridge the gap between phenotypic and genotypic information, and to increase diagnostic and prognostic accuracy.

While genetic disorders have always been associated with variable expressivity, recent discoveries have “broadened the phenotypic range associated with a given variant to include entirely distinct diseases” (Girirajan et al., 2012, p. 1322). Additionally, a genotype-first approach will result in the diagnosis of more mildly affected people with variable phenotypic features, and earlier genetic diagnoses in pediatric patient populations. It can be challenging for providers to communicate the uncertainty surrounding results, especially in regard to diagnoses with developmental implications (Ali-Khan et al., 2009; Navon, 2012). It is important to avoid setting artificial limits on a child’s potential development. Genetic counselors can help by considering the potential impact of increasingly early genetic diagnoses on parental expectations and child identity formation, and communicating to parents the potential clinical and prognostic variability among pediatric populations. Genetic counselors can also play a role in conveying the potential for higher or normal functioning given the uncertainty surrounding diagnoses, and in helping families to develop positive frameworks for understanding novel genetic syndromes (Navon, 2012).

Hennekam and Biesecker (2012) suggest that next generation sequencing (NGS) will bring about a transformation in the approach to diagnosis, whereby initial genomic testing could be ordered by a primary care physician, with follow-up by a medical geneticist or other appropriate specialist using their clinical diagnostic skills in conjunction with the genetic

information. This view is consistent with the practical considerations for the current insufficiency of genetics providers to meet demand for their services (Greendale & Pyeritz, 2001), and the expectation that non-genetics providers will play an increasing role in genomic medicine (Feero & Green, 2011). Since guidelines were issued recommending CMA as a first-tier test for the evaluation of pediatric disorders including developmental delay (Manning & Hudgins, 2010; Miller et al., 2010), CMA has been increasingly ordered by non-genetics providers including pediatric neurologists, developmental pediatricians and pediatricians (Cohen, Hoon, & Wilms Floet, 2013). In our study, genetics professionals tended towards the view that providers ordering the test should be competent to provide families adequate information and resources to understand and cope with the results. Non-genetics providers in our sample tended to feel comfortable ordering CMA only with the knowledge that they could seek guidance from and refer cases to genetics professionals. In our related study involving parents of children tested with CMA (Reiff et al., 2012) several parents who received results from non-genetics providers reported experiencing misunderstandings, exacerbated by long waits for genetics consultations and misleading Internet searches, that were later resolved through discussion with genetics professionals. Our findings are consistent with the view that providers ordering CMA are responsible for providing adequate counseling and education regarding the nature and scope of the test and the benefits, risks, limitations, costs and potential results (Cohen et al., 2013). The evident need for genetics services highlights the potential value of genetic counselors in non-genetics healthcare settings, especially in specialties where genetic testing is common such as pediatric neurology and developmental pediatrics.

Guidelines for clinical practice involving CMA and sequencing recommend pre-test counseling and informed consent (Green et al., 2013; Kearney et al., 2011; Manning & Hudgins, 2010; Miller et al., 2010). However, it has been argued that guidelines are not sufficiently explicit with regard to pre-test counseling (Cohen et al., 2013). Pre-test counseling for genomic testing can be challenging for providers given the time constraints in clinic, but should provide adequate guidance for families to prepare for, understand and make informed choices regarding genomic information (Cohen et al., 2013). Our study participants' suggestions for improvements in the process of CMA testing and counseling by non-genetics providers included: referral to genetics professionals at the time of testing so that families can obtain guidance soon after they receive results; liaison with genetics and laboratory personnel; educational sessions provided at staff meetings; and providing written or electronic informational materials to supplement discussions.

Post-test counseling sessions, especially for families receiving VUS or IF results, should be available soon after results are delivered and should ensure adequate comprehension of results, address any psychosocial implications for patients and family members, provide guidance regarding accessing relevant information online and connecting with other affected families. In addition, since genomic knowledge is advancing rapidly, a follow-up plan can be helpful, explicitly stating if parents are responsible for making contact so that they can be updated on any new discoveries regarding their results.

Limitations

Our goal in using a limited convenience sample was to explore in depth the experiences and underlying reasons for providers' opinions regarding CMA. However, a limitation of this study was that participants are not representative of the population of healthcare providers using CMA. All but one of the providers were affiliated with a single medical institution and were accessed through a single hospital laboratory, although several also used other laboratories for CMA. At the time of this study, the laboratories used by providers did not require that patients provide written informed consent for CMA. Other laboratories and institutions may have different procedures for consent and different criteria for identifying and reporting variant and incidental findings. Additionally, the attitudes and practices of the providers in the sample, especially the medical geneticists and genetic counselors, may have been influenced by shared knowledge presented at departmental meetings such as genetic rounds. Further research is needed to ascertain whether the findings are replicable among providers associated with a range of medical institutions and laboratories. Future studies should also include in-depth examination of the practices and attitudes of larger samples of non-genetics providers.

CONCLUSION

The availability of genome-wide testing modifies the diagnostic process, increasing the chance and scope of variant findings, ascertaining atypical cases of known disorders, diagnosing and delineating novel conditions, and identifying incidental findings. In light of the introduction of WGS and WES into clinical testing, exploration of genome-wide testing through the clinical utilization of CMA testing provides an important opportunity to consider how genetic diagnostics is evolving, bringing with it new challenges for patients and providers.

The potential psychosocial repercussions of CMA have been compared to those experienced with the introduction of karyotyping and banding technologies, when the 'first families' received diagnoses for rare syndromes about which very little was known (Fanos, 2012). Additional challenges are raised by whole-genome testing, which yields a relatively higher proportion of uncertain results and incidental findings, and can be difficult for providers to explain, and for families to understand. Providers in our study articulated some of the controversial aspects of introducing genomic testing into clinical practice, for example, the difficulties involved in communicating uncertain findings, deciding whether to disclose incidental findings, and what the consent process should be. There is a need for continued discussion and research about IFs and consent, especially in determining what information should and should not be disclosed, and the establishment of ethical guidelines. Meanwhile, it is important to maintain close collaboration between laboratories and clinicians when IFs are revealed. Our findings suggest that genetic counselors can play an important role in liaising with all parties involved in the testing process, providing accurate phenotypic information to inform testing laboratories and contribute to databases, providing adequate pre- and post-test counseling, delineating the boundaries between clinical and research investigations using genome-wide technologies, and clarifying follow-up plans for families with uncertain results and IFs.

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Table 1

Participant demographic characteristics and healthcare experience (N=15)

Demographic characteristics and healthcare experience	% (N)
<i>Gender</i>	
Female	80% (12)
Male	20% (3)
<i>Race/ethnicity</i>	
White	93% (14)
Asian	7% (1)
<i>Specialty</i>	
Genetic Counselor (GC)	47% (7)
Medical Geneticist (MG)	27% (4)
Non-Genetics Provider (NGP); Nurse practitioner (NP), Pediatric Neurologist (PN), Pediatrician (P), Developmental Pediatrician (DP)	27% (4)
<i>Years in Practice</i>	
1–5	20% (3)
6–20	60% (9)
>20	20% (3)
<i>Approx. number of CMA ordered in past year</i>	
10–50	20% (3)
>100	80% (12)

Table 2

Themes and illustrative statements pertaining to providers' perspectives of CMA testing.

Theme	Illustrative Statement
A. What differentiates CMA testing?	
1. Increased diagnostic yield	It has been able to get diagnoses in people that we've not been able to before. (PR10;MG) It has a higher chance of finding something. (PR11;NGP-DP) It's more precise. ... I think it's an excellent screening tool. And I think although we may not have the answer [now], we will. So knowing that, I think it helps for the future. (PR16;NGP-N)
2. Move towards a genotype-first approach to diagnostics Changing role of dysmorphology	This is a clinical picture that's defined itself because of the array. So we found that this series of patients had the same difference on the array. ... When you put the patients together they do have a similar constellation of findings. So we think this definitely is a newly defined entity. (PR12;GC) I wonder if we sometimes rely a little too much on them. Before it was more of a clinical diagnosis and clinical judgment, and now it's "Let's sit back and wait for this test to show us what we should do next..." (PR06;GC) I think that the dysmorphologists don't have to be as good at dysmorphology for these kinds of conditions, because before you'd have to, you know you'd have to say "I want FISH for Smith-Magenis syndrome" in order to diagnose it. You don't have to do that anymore. (PR05;GC)
3. Atypical diagnoses	... we never would have ordered it [FISH for Smith-Magenis]. We never would have. There've been a couple of cases of Williams syndrome that were atypical. They didn't look like Williams syndrome, they didn't act like Williams syndrome and we did an array and it diagnoses Williams syndrome. (PR05;GC)
4. Milder presentations & broader indication for testing	... I thought, you know, if a kid who looks like that cute can have a genetic disorder... [Previously] everybody with some [chromosomal] abnormality of the genome was dysmorphic and had mental retardation...I've shed that preconception now so my threshold for doing the test is basically anybody with a developmental problem. (PR11;NGP-DP)
5. New potential for identifying variants	I think that [testing] such as the BRCA 1 & 2 testing, or other kind of molecular testing, you're only looking for one thing. And even if you get a VUS, it means you may or may not develop breast or ovarian cancer. It doesn't mean you may or may not develop tons of different things. You can't even start describing all the things that you may or may not develop... I also think it's different because of these unanticipated results that we can find...It's looking at somebody's whole genome, and that's very different." (PR05;GC)
B. Uncertainties in CMA testing	
6. Preparing parents about uncertain results and parental testing	So we've kind of changed the way that we counsel patients since we started doing this based on what we found and finding all these ambiguous results... the goal is to do a lot more consenting before we order the tests, saying: "It can show something that we don't know exactly what it means at this point and we may need to do further testing and look at both of you [parents]". (PR05;GC) I've learned to give parents a little bit of anticipatory guidance that most times when we find something, it's not germane to your child's problem. So don't hit the panic button if I call you back to say we need to test both of you. ...The most likely thing we will have discovered is some previously unrecognized variation of normal .. and nine times out of ten, one of the parents has it. (PR11;NGP-DP)
7. Conveying uncertainty in results disclosure	Now though it's a much more open-ended question. ... the questions that we have about what the finding is have to be relayed to the family...So really, if we're uncertain about what the finding is you really have to try to give as much of that feeling to the family... (PR01;GC)
8. Defining VUS results as non-significant	... for me it's not at all a fuzzy ground. I think if you understand genetics and you understand how to use the genome, then to a large extent the gray area was more of a concern before we got started I think than in practice... We've had ones where there's a variant and if I see it in a parent I just say "It's a variant." To me it's not of uncertain significance. To me it's not of significance until we've proven it... (PR07;MG) A variant is simply pushed to the unknown, maybe we'll know more in the future. (PR19;NGP-N)
9. Uncertainty regarding pathogenicity	If it's a duplication I generally try to approach it with "This is not something that we necessarily need to be as concerned about" -- which isn't necessarily true. I mean, we could down the line find out that there're a lot of problems with these duplications...I mean, it could possibly become pathogenic but there's really nothing to tell them at this point. (PR02;GC).
10. Uncertainty regarding definitions of 'normal' results in databases	But you know you have to have a cutoff. I'm a little bit uncomfortable with that just because there's so little that we know, that it could be that there's something that's significant that's much smaller than that... (PR05;GC) We don't know how many 'normal' people are walking around with [a duplication/deletion] We have a screened population coming into us that we're sending testing on. ... in the database of genetic variants, there was a deletion in there which they ascribed to a normal individual. We called to find out where that sample came from and who was the normal individual, if they had been phenotyped. They'd never been phenotyped.... They just assumed it was normal because it was a parent. So the mother may be affected. It was never actually phenotyped. So there's a question as to who's really normal. ... Recently we've started to tell people who are of unusual ethnic backgrounds that they may be more prone to variations showing up because there's not a lot of ethnically matched controls that are out there that they're comparing to. (PR15;MG)
11. Non-prognostic abnormal results	...the answer diagnostically is not the answer or the road map for the child and that's the hard part, meaning that we know that there's a deletion on this chromosome and it's probably explaining the retardation in your child.

Theme	Illustrative Statement
	But we can't tell you that "Here's fifty other kids and this is the way your child's going to be." And even if there were fifty other kids that's not necessarily the way your child's going to be. (PR15;MG)
12. Follow-up and research The child "teaches" providers Participation in research	I always say down the road this uncertainty may not exist and it just may be a matter of time. Follow up is very important and a plan. I think we feel comfortable with a plan; even it's not the answer they were hoping to get. [PR01;GC] ...I don't have a problem saying to the family that their child is actually going to teach us about what this means. I think some people are hesitant to say that, but in those situations I will tell them that I will keep looking [in the literature] ...and part of what forces me to keep looking is following up. It may not happen without the follow-up [appointment] to force me to do it...Over time, we are going to be able to define a little bit better, based on literature knowledge. (PR03;MG) They [parents] feel very good about knowing that their child could help towards advancements in science. ... Many families want to help other children It's opening up an avenue of identification of things we never would know before and some parents get a lot of support from that, and they're enthusiastic as we are. They really want to help be a part of the discovery of genetics and if their child could help in that, then there's some good that came out of the differences their child has. [PR01;GC] In one case, I called the parents in and I said, "Look, you know, this is brand new. There are five cases that have just been reported by this researcher Your kid is number six. ... Here's the guys name. I've spoken to him. He's happy to see your child. This is a brand new entity. You're number six in the world. We don't know quite where this is going to lead but we think we have the smoking gun as to why your kid has his autism. So we can stop chasing other things." [PR11;NGP-DP]
C. Incidental findings	
13. IF's as risks, benefits, and a grey area	Duchenne muscular dystrophy [was] identified. So totally not what we expected, wouldn't have presented for four to six more years with weakness. He wasn't really sick, nothing really dramatic at that point. So it started the wheels turning but it does tell you the power of what we're doing. There have been other ones where I find there's a cancer gene in there and we have to start cancer screening. ... But to me that's a good thing that you're getting the information before it's a problem. ... the Duchenne muscular dystrophy might be amenable to the trials that are coming out. There are actually treatments online for the muscular dystrophy. For the cancer genes you ... would institute screening protocols, depending on the specific risk. (PR07;MG) ...that's certainly a negative. If you have a kid with developmental delays, cognitive issues, that's going to be a permanent thing. And you throw a cancer on top of that it's a very difficult situation, so, plus not necessarily a hundred percent but a predisposition factor. (PR04;GC) I think it can also be a gray area in uncovering ... adult onset conditions. That can be hard to deal with when you're working with children. (PR09;GC)
14. Psychological stress of IF's	So I mean there's that huge risk of finding these things we're not expecting... If we didn't have this [array] and they weren't tested for this, then the families would go however many years without knowing this, and from the medical perspective it's great for these families to know.... But I don't necessarily think that it's great for the families that they're identified young because that's so much emotional distress on a family that would not have had to deal with that emotional distress for years. (PR08;NGP-NP)
15. Duty to convey information	And I think the other more philosophical thing is it's their information and I think perhaps with this array technology I myself have gone a little bit away from the more paternalistic... People usually, as difficult as things may be, are able to deal with it. I think it'd be more difficult if you find something where you can do absolutely nothing about it. (PR04;GC) I feel like it's my duty [to share all the information]. I mean, they consented to the test. It's their information so they should know everything that has come out of it. (PR09;GC)
16. IF's not unique to array	I think that happens in other practices where you send a blood test looking for anemia and you get leukemia back. (PR15;MG) I think that's going to be true for a lot of things. I think if you know that a child's at risk for something you're going to screen them. So for example, if a parent has type 1 diabetes, the child's at an increased risk so you screen him more... (PR19;NGP-P)
D. Informed Consent Process	
17. Lack of an informed consent form	...consent [procedure] came from [the] pre-symptomatic testing arena with a prototype being Huntington's. Chromosome analysis has always been done on symptomatic individuals. So therefore I think historically there was never a consent. Nowadays with the arrays, of course you can find things that...you were not looking for. (PR04;GC) ...as opposed to going for cancer counseling and asking for the test yourself where you're making that decision. It's kind of being made for you so whether you're okay with that or not, that's a very personal thing. (PR02;GC)
18. No formal consent for IF's	It's just not possible to go through a hundred percent consent process. We tell them what we test. We're going to look for chromosomal rearrangements...that could explain [features]. ... No I've never said "We could find also that there is a cancer predisposition." No I don't say that ahead of time. (PR04;GC)
19. Opinions on potential impact of pre- counseling for IFs	In an ideal situation it probably should be [discussed] ... I think that would increase a lot of the anxiety while they're waiting for test results. ... It's a double-edged sword because you'd be increasing the anxiety for the ninety-five percent, ninety-nine percent of patients that that's not going to be the case for. But making it easier for the handful of people that that is going to be the case for. (PR12;GC) They may hear it. They may not take notice of it because they don't, most people, don't really think that's going to happen. (PR10;MG)

Theme	Illustrative Statement
20. Need to get consent for disclosure of IF's	I think that if it [IF] was something pretty significant that might be something you could see them not wanting to know... I mean you would probably give them the option as to how much information they wanted about whatever it was rather than just forcing that on them or just choosing not to mention it at all. (PR12;GC)
21. Need for materials/resources to inform patients	I think a lot of it's just kind of the limitations of being in clinic and trying to get everything done. And trying to see the patients, that it's hard to go into that in sufficient detail with everyone and then open a whole can of worms. But I think in that case, if there was going to be some kind of literature or something provided to them beforehand, then I think that would be a good way to kind of just put it out there as a general caveat. (PR12;GC) Ok, so I like the idea of a consent form -- that says "This is only screening for things. This doesn't look at the whole genetic code. This doesn't look for every abnormality. This is not going to tell you if you're at risk for developing breast cancer in sixty years. (PR08;NGP-NP) I think it's the provider's responsibility to give the families resources....if they're taking on the responsibility of ordering the test they need to know how to provide the family resources in interpreting the results [PR09;GC].
E. Non-genetics providers using CMA	
22. Need for genetics competence in conveying results	I think [non-geneticists] need to be prepared before they send a high resolution test off to know that they're going to have to handle uncertainties. And many of them are not equipped to handle that....They don't know necessarily how to counsel something that comes back uncertain or unknown. So I think they need to know what they're getting into before they just check off a box and send it off. ..The family is left with not quite knowing what that means. [PR15; MG] I think only providers who understand the implications of the test should be ordering it. we have [non-genetics providers] ordering the array and when it comes back abnormal, they call the family and say "Oh yeah, this is abnormal but I don't know what it means... Call genetics." And so the family calls us in a panic that there's something terrible going on when actually there isn't. Actually it's nothing and we test the parents and one of them has it and it doesn't mean anything at all. [PR05;GC] So I don't know if we're completely to the part where just any pediatrician or any general practitioner should be ordering this test. I think a lot of misinformation can be given ... It can be very distressing for a family if they're given wrong information. And then they feel very comfortable with that pediatrician, let's say. But now they come to somebody new, a geneticist, and they're given different information. Who do they trust? [PR01;GC] I think all of the [non-genetics] providers that I work with, we understand that normal does not mean that every single gene is normal ... I think that we've all got normal down. Then when it comes back as a novel mutation or some like variant of unknown significance, parental testing suggested, I think that... I would really like to think that we all can say "Alright, so the parents need to be tested." So I feel like we're all competent in that. If something new comes back that says like... "This duplication of chromosome, whatever, contains eight known genes..." and then lists this, the likelihood that we know what that means? [Our understanding is] very, very low. [P08;NGP-NP]
23. Role for non- genetics providers ordering CMA	I think that I would feel uncomfortable if they weren't seeing genetics. ... [I would refer to genetics] because then I feel like it's more of a team. ... Recently we did the parental testing and the parents were not carriers, but it turns out dad's not dad. ... Fortunately the genetic counselor's involved ...because I would not feel comfortable with that. [P08;NGP-NP] I probably will do the chromosomal SNPs and then send them to genetics if there's anything abnormal. ... They [parents] don't want to put their children through much more. They can't get off of work. It's a lot of work. It's a lot of work to get an appointment. It's a lot of work to go for an appointment. [PR19;NGP-P] There aren't enough geneticists... So if you [non-genetic provider] have a suspicion of delay or congenital anomalies or some unusual features .. you should do an array. But if you get something that you don't understand, then you should refer to the geneticist... So I think it's perfectly reasonable and ideal to educate the providers that this is the right test to do in these scenarios. But the same way if they identified a hernia, they wouldn't fix it. ... I think that the family deserves proper counseling and then also all the follow-up... So if they're ordering it and they think there's a concern, they should do a referral [to genetics] at the same time ... So by the time they get an appointment you have that test result, rather than making the process go on for half a year. [PR07;MG]
24. Collaborative team approach Education Liaising with genetics professionals	Our role at some level is to support people, like a primary care physician who might send it and get something back and not quite know what to do with it. [PR03;MG] As things, especially in genetics, are evolving, we need education. ... And you know they're always sending us stuff on email and by web. It's information overload. So it's much better to come to our staff meetings and give a twenty or thirty minute snippet of 'this is a new advance' [PR19;NGP-P] I think the technology has moved so fast. I think they've changed so fast that people have whiplash. They [non-genetics providers] don't know what's the right thing to do and they certainly don't understand the technology of the molecular biology. So I think education is really important, explaining what it can do and what it can't do. . [PR07;MG] I don't have time to talk to every lab tech. I don't have that kind of time. So I will send ... as much information as I can give to tell them what I am looking for. I may not have ordered the right test, but call me and ask me and tell me what test I need. A. I'm learning from that experience, and B. I rely on that. ... It also is helpful when you have a person's name that you can call. [PR19;NGP-P]

GC Genetic Counselor; MG Medical Geneticist; NGP Non-Genetics Provider (P-Pediatrician; PN-Pediatric Neurologist; DP-Developmental Pediatrician; NP-Nurse Practitioner)