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RAPID ACUTE CARE GENOMICS: CHALLENGES AND OPPORTUNITIES FOR GENETIC COUNSELORS

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ABSTRACT

Genomic medicine in pediatric acute care is showing great promise, with rapid results from exome and genome sequencing returned within days providing critically important information for treatment and management of seriously ill children. Many have suggested that rapid acute care genomics presents novel genetic counseling issues. This is due to the need for rapid response to referrals, the immense emotional distress that parents are likely to experience when their child is in acute care, and the unfamiliar environment of the acute care setting. To explore the practice of genetic counselors in this setting, we conducted qualitative interviews with 16 genetic counselors (GCs), representing a large proportion of GCs at the frontline of providing genetic counseling in acute care settings in Australia. Interviews revealed themes describing genetic counseling in acute care, including practical challenges of counseling within a rapid turnaround time, similarities with other contexts such as prenatal counseling, and the need for education of other health professionals. Interestingly, GCs did not raise concerns in the interviews for parents' ability to provide informed consent for rapid genomic sequencing. GCs also encountered practical and organizational challenges with counseling in this setting where 24 hour care is provided, at odds with traditional '9 to 5' Genetics service delivery. Working closely in a multidisciplinary team was common and participants believed that GCs are well-positioned to take a leading role in the education of other health professionals as rapid acute care genomics becomes routine clinical practice. Despite views that genetic counseling practice in rapid acute care genomics is unique, these exploratory data suggest that GCs are flexible, adaptable and sufficiently skilled to deliver patient-centered counseling in this setting. Our work indicates GCs are ready and willing to contribute at an early stage of adoption of genomic investigations in acute care.

KEYWORDS

Genetic Counseling; Pediatrics; Qualitative; Genomics; Genetics Services; Acute Care

INTRODUCTION

Genetic conditions and congenital abnormalities are said to be the leading cause of neonatal deaths (Clark et al., 2018; Farnaes et al., 2018; Petrikin et al., 2018; Petrikin, Willig, Smith, &

Kingsmore, 2015; Stark et al., 2018; Willig et al., 2015). This may be because, for many monogenic conditions, symptoms present within the first month of life (Saunders et al., 2012). Additionally, the neonatal phenotypic presentation may be atypical or incomplete (Stark et al., 2016), making a diagnosis of a specific genetic condition in this population difficult (Saunders et al., 2012; van Diemen et al., 2017). As a result, rapid exome or genome sequencing (termed collectively rapid genomic sequencing, rGS) in neonatal or pediatric intensive care units (NICUs or PICUs) may be genomic medicine's 'critical' or 'breakthrough' application (Friedman et al., 2018; Gyngell, Newson, Wilkinson, Stark, & Savulescu, 2019; Kingsmore, Petrikin, Willig, & Guest, 2015). New technologies are typically adopted quickly and enthusiastically in pediatric acute care, making this an ideal setting for the routine application of genomic medicine, which may have a large effect on clinical practice (Mestek-Boukhibar et al., 2018; Saunders et al., 2012; Smith, Willig, & Kingsmore, 2015). This change in practice will need to involve many health professionals, including intensivists, nurses, clinical geneticists, laboratory scientists and genetic counselors (GCs) (Gyngell et al., 2019).

Standard clinical genomic sequencing (exome or genome sequencing) has a turnaround time of between six weeks and six months (Kingsmore et al., 2015); to date, turnaround times reported for rGS vary between 2.1 (Soden et al., 2014) and 23.0 days (Farnaes et al., 2018). Rapid turnaround times and a diagnostic utility of around 42% (Clark et al., 2018) contribute to the impressive clinical utility of rGS in pediatric acute care settings (Petrikin et al., 2018; Stark, Schofield, et al., 2019). Rapid genomic sequencing informs clinical decision-making in pediatric acute care (Sanford et al., 2019; van Diemen et al., 2017); diagnoses have been shown to effect medical management in up to 52% of cases (Meng et al., 2017; Soden et al., 2014; Stark et al., 2016). Furthermore, unnecessary clinical investigations can be avoided if a rapid diagnosis reveals prognostic information which can "spare parents diagnostic odysseys that instill inappropriate hope" (Saunders et al., 2012, p. 3). This is true even for negative or uncertain findings, which can change or rule out certain differential diagnoses (Niguidula et al., 2018). Despite best efforts, mortality rates in pediatric acute care settings are high (Petrikin et al., 2015). Of those who receive a genetic diagnosis from rGS, mortality rates can be as high as 57% at 120 days of life (Willig et al., 2015). One major outcome of a diagnosis in this cohort of patients is therefore facilitating discussions around the withdrawal of treatment and initiation of palliative care (Farnaes et al., 2018; Gyngell et al., 2019).

Some have argued that genomic medicine will result in significant changes to genetic counseling practice (Ormond, 2013), whereas others suggest that GCs already possess the skills required to practice when this new technology is applied (Brett et al., 2018). Either way, GCs are likely to play a vital role in managing the expectations of both health professionals and patients with regard to genomic sequencing (Brett et al., 2018; Hooker, Ormond, Sweet, & Biesecker, 2014). With any new technology, hopes can exceed reality; this is particularly true for genomic technologies in pediatric acute care (Fenn & Raskino, 2008). The acute care setting presents a unique clinical scenario compared to other inpatient settings, with unique outcomes and opportunities (Meng et al., 2017); the constant involvement of a variety of health professionals, the unpredictable environment of acute care, and the other competing clinical priorities for the patient all contribute to the difficulty of pre-test genetic counseling in this setting (Diamonstein, 2019). Because of this, concerns have been expressed about the ability to adequately provide genetic counseling in the acute care setting, particularly with respect to informed consent (Clowes Candadai, Sikes, Thies, Freed, & Bennett, 2019; Diamonstein, 2019; Gyngell, Newson, Wilkinson, Stark, & Savulescu, 2019).

The preparedness of health professionals to deliver genomic medicine in the acute care setting has also been questioned (Char, Lee, Magnus, & Cho, 2018). Knapp and colleagues (2019) examined the attitudes of neonatologists towards the use of rGS in the acute care setting, revealing clinician concerns about the consent process: in particular, they were concerned about parents' ability to provide fully informed consent, and also questioned whether this type of consent is necessary in this setting, as it is not often required for other tests and procedures they would routinely order or perform in acute care.

Recent reflections from GCs working at one hospital in Melbourne, Australia provide anecdotal evidence of how this emerging application of genomics can impact genetic counseling practice (Ayres, Gallacher, Stark, & Brett, 2019), but there remains a need to rigorously investigate the genetic counseling issues arising in the context of rGS in pediatric acute care. This national, multi-center study addresses this gap, exploring models of care, genetic counseling issues and practice in interviews with GCs participating in a clinical study of rapid acute care genomics. This study therefore provides key perspectives on the changing practice of GCs in the era of genomic medicine.

METHODS

Context

Implementation of rGS in the Australian pediatric acute care setting has been evaluated in a multi-site study by the Australia Genomics Health Alliance, which is conducting a program of research investigating the integration of genomic testing in healthcare across Australia (Stark, Boughtwood, et al., 2019). The Acute Care Genomics study involved 12 Australian hospitals and two clinical laboratories aimed at delivering rapid trio exome sequencing in <5 days for critically ill neonatal and pediatric patients with suspected monogenic conditions. The clinical protocol and outcomes are described elsewhere (Australian Genomics Health Alliance Acute Care Flagship, 2020).

Briefly, patients were eligible for inclusion in the Acute Care Genomics study if they were admitted to a participating NICU or PICU, had a suspected monogenic condition, and were referred to Genetics for assessment. Other hospital patients were considered if a rapid result was likely to alter management. Potential participants were nominated following clinical geneticist assessment, and were approved electronically by an expert panel. Two laboratories accredited by the National Association of Testing Authorities performed the clinical exome sequencing tests. One laboratory received tests from three states, while tests from the fourth state were sent to the second laboratory based in that state. Results returned to patients related to phenotype and included pathogenic and likely pathogenic variants, and a limited number of variants of uncertain significance, which were deemed to be of potentially high clinical significance. Tests and genetic counselors were funded by the Acute Care Genomics study.

The intended workflow involved either a GC or clinical geneticist (or both) conducting pre-test counseling with parents to facilitate decision-making regarding testing (acceptance rates are documented elsewhere (Australian Genomics Health Alliance Acute Care Flagship, 2020)). Similarly, a genetics health professional (GC or clinical geneticist) disclosed the result; in circumstances where a genetics health professional was not available, such as on a weekend, another health professional involved in the care of the patient (e.g. the intensivist) disclosed the result.

Pre-test counseling and results return were typically delivered in person in the hospital within approximately three to five days of each other. Comparison between standard and rapid genomic sequencing in the Australian context is summarized in Figure 1.

Participants and procedures

In this sub-study, semi-structured qualitative interviews were conducted with GCs, either in-person or by telephone (see Supplementary Material 1: Semi-structured Interview Guide) to investigate their perspectives of the acute care setting and rapid testing. GCs were eligible to be included in the study if they were involved in the national Acute Care Genomics study (Australian Genomics Health Alliance Acute Care Flagship, 2020). Some had already counseled patients in this context, and some were about to begin. Those GCs with no experience in acute care genomics were included because they were about to commence providing genetic counseling or had accepted roles at sites where acute care rGS was going to be available. At the time of the interview, while they had not yet commenced their clinical role in the acute care setting, they had been involved in discussions to establish the acute care genomics service at their site.

Participants were sampled using a sequential sampling strategy consistent with a qualitative approach (Liamputtong, 2013). First, participants were sampled from a population of 16 GCs who had previously completed a survey about their involvement in acute care genomics, and had provided their contact details for further research participation (Stark, Nisselle, et al., 2019), representing 48% (16/33) of GCs working in acute care in early 2018. Snowball sampling was then employed in mid-2018 by asking participants to recommend any other GCs working in this area who had not completed the initial survey or had since commenced involvement in the clinical study. Interviews were audio-recorded, transcribed verbatim and coded for experiences with genomics and preferences for education and training.

Data analysis

Interviews were analyzed concurrently with data collection using thematic analysis (Liamputtong, 2013). Iterative data analysis was managed using NVivo 12 qualitative data analysis software (QSR International Pty Ltd., 2018). All transcripts were coded by the researcher FL, with a subset of transcripts also coded by researchers BM and AN, and

differences resolved through discussion of themes. Recruitment continued until all eligible GCs were contacted.

In quotes presented in this paper, an ellipsis (…) reflects where a significant part of speech has been removed, and square brackets represent where a word has been replaced for clarity or to protect participant anonymity.

This study was reviewed and approved by the Human Research Ethics Committee of The University of Melbourne (HREC ID 1646785.9).

RESULTS

Participant demographics

Of the 20 GCs approached, 16 were interviewed. Twelve participants were recruited via recontact from the survey, and a further four from snowball sampling. The remaining four were lost to follow-up. The sample demographics are shown in Table 1.

Preferences for models of service delivery of rapid acute care genomics

Interviewees were united in the view that practice should be patient-centered and flexible to cater for the diverse needs of families.

> *"We're at quite an early stage…but probably flexibility at the moment is the way to go." [GC 11, 10+ years' clinical experience, Pediatrics, Acute care experience]*

> *"A single model isn't going to be patient-centered for everyone…the nature of being patient-centered is unfortunately being flexible and not having a one-size-fits-all." [GC 10, 5-9 years' clinical experience, General, No acute care experience]*

However, varied views regarding models of service delivery for rapid acute care genomics were evident. Most GCs recognized that a collaborative model was best for service delivery; working together with the acute care team to identify suitable patients, order an appropriate genomic investigation and interpret the result for patient care was seen as most beneficial.

> *"I think working with the consultants in [acute care], that's kind of the model that has been followed so far, and I feel at this stage of genomics being implemented into practice I think that's probably the best way to go." [GC 3, <5 years' clinical experience, Pediatrics, Acute care experience]*

Not all GCs supported a shared approach to care. Some GCs held strong views that a Genetics-led model was best, whereby the Genetics team are responsible for deciding whether the test is appropriate for the patient, counseling parents about the test, and delivering the results.

> *"[Rapid exome sequencing] is a very specialized genetic test…Genetics certainly wouldn't be going off ordering any cardiac reviews or anything like that. You always refer to a specialist in their field, and genomics is no different. You're always going to refer to the specialists, who are the Genetics team." [GC 15, 10+ years' clinical experience, Prenatal, Acute care experience]*

> *"When left to their own devices, non-genetics specialists often apply these tests for patients that perhaps were not the best candidates for that test…having a clinical geneticist who's trained in that area [who] will come in and help guide that can be very useful to make sure that we apply the test to the right candidates." [GC 2, <5 years' clinical experience, Pediatrics, Acute care experience]*

The genetic counselor role in a multidisciplinary team

Despite feeling that the model should be led by Genetics, GCs recognized the importance of multidisciplinary teamwork in this setting, with particular reference to the existing relationship that nurses, social workers, and other health professionals had with families.

> *"I really do think it's about working together and I do like the co-counseling because it gives the opportunity for families to have a question answered in the moment that they ask it, rather than it hanging on in their mind and preventing them from listening to the next sentence." [GC 2, <5 years' clinical experience, Pediatrics, Acute care experience]*

> *"What I think is beneficial is the nurses or the doctors who have started seeing the patients and have been around for a while, so you would presume that the family's able to build up a level of trust so that there is a role for nurses in ICU and the doctors there to be involved in this process because they've already got an existing relationship." [GC 1, 5-9 years' clinical experience, Pediatrics, Acute care experience]*

"There's a real, kind of, collaborative, multidisciplinary approach happening, and I think that's really exciting." [GC 7, 5-9 years' clinical experience, General, Acute care experience]

Although GCs commented on the utility of co-counseling in this setting, they also noted challenges.

"There's often zero conversation between the genetic counselor and that specialist before the session begins because you've been called up there and the family's already in the room, or the specialist walks in with you. There's not an opportunity usually to say, 'Okay, how do you want this to go?'…You just have to work it out as you go along." [GC 2, <5 years' clinical experience, Pediatrics, Acute care experience]

Participants commented on their experience of working with other health professionals in the acute care setting. GCs mostly felt welcome in acute care, although participants recognized that the other health professionals in acute care they interacted with did not fully understand their role, often failing to distinguish them from clinical geneticists.

"I actually haven't had anybody give off any kind of negative vibes like, 'Oh, Genetics, what do they think they're doing up here?' or anything like that. Everyone's been very friendly and welcoming." [GC 15, 10+ years' clinical experience, Prenatal, Acute care experience]

"[Acute care health professionals] don't draw a lot of distinctions – we're just Genetics. They don't draw a lot of distinction between who's the genetic counselor and who's the registrar. They just know that the Genetics person is there." [GC 16, 10+ years' clinical experience, Pediatrics, Acute care experience]

Additionally, GCs observed that there was a tension of priorities in this setting, and felt that acute care health professionals were more focused on other tests, interventions and treatments than rGS.

"We have had situations where the exome sequencing or microarray testing has been bumped down in being collected because the nursing staff sort of say, 'Well, I need to do these other tests for observation purposes. I'm not quite sure where this test fits in with the rest of their care.'" [GC 3, <5 years' clinical experience, Pediatrics, Acute care experience]

"[Acute care health professionals] think [Genetics] are – not a hindrance – but that what we're doing is not number one priority because there is a very unwell baby and often their clinical status is unstable and is absolutely more important than whether you've got a signature on a piece of paper or whether you discussed everything you needed to discuss. Or even how important it is that mum gets bled as soon as possible because actually that's not ideal for them and what they're doing…My sense has been that it's not a priority for ward staff." [GC 13, 5-9 years' clinical experience, Pediatrics, Acute care experience]

Genetic counselors agreed that acute care health professionals needed upskilling in genomics, not necessarily to be able to deliver genomic medicine in isolation but to be aware of the indications, challenges and limitations of the technology. In particular, GCs highlighted that it was important that acute care nurses receive this type of education and training.

"It would be great for the nursing staff to be upskilled in their knowledge of genomics as well because the genetic counselor will come in, they'll do their consent, and [the genetic counselor will] always be there for the family to talk to, but they're not readily available. So for nursing staff to have some knowledge of what the genomic testing is, and to be able to answer some of their questions, I think would be really good." [GC 6, 5-9 years' clinical experience, General, No acute care experience]

"We need to upskill the medical workforce as a whole to have realistic expectations of what genomics is and how it can be implemented." [GC 6, 5-9 years' clinical experience, General, No acute care experience]

"For non-genetics specialists to upskill in terms of how to identify appropriate patients, to be collaborating on determining the gene lists and being involved in the [multidisciplinary team meeting], variant review meetings, that kind of thing, I think is very important because it heightens their awareness of which patients that this test is relevant for, and not." [GC 2, <5 years' clinical experience, Pediatrics, Acute care experience]

Genetic counseling in rapid acute care genomics

Many GCs highlighted the timing issues in rapid acute care genomics. Particularly, GCs commented on the fast-paced nature of practice in this setting, and the impact that this had on their counseling.

> *"Everything is heightened because you can have issues with difficult social circumstances or language difficulties or whatever in outpatients but you have so much more time and so many more options available to you to get around those things, whereas in the acute care setting, you just don't, you just have to figure out how to make it happen fast." [GC 13, 5-9 years' clinical experience, Pediatrics, Acute care experience]*

> *"Because the testing is rushed, it has the potential to make the whole thing feel a bit rushed, and the families feel rushed, that they need to go ahead with this test." [GC 7, 5-9 years' clinical experience, General, Acute care experience]*

Genetic counselors spoke often, and graphically, about the way they practiced within the time pressures of this setting; Box 1 illustrates how eight different GCs described the urgency these cases create.

Genetic counselors also discussed their perception of time constraints with regard to usual working hours of genetics health professionals. In Australia, GCs (and other genetics health professionals) offer services during regular office hours, and this was anticipated to be a major challenge of acute care genomics. Although there are currently no expectations for genetic counselors to work outside usual business hours, these participants identified that future acute care genomics may mean challenging this paradigm in order to deliver rapid testing and results.

> *"Genetic health professionals are really used to just being at work Monday to Friday, nine to five…We all love to walk around and say that there's 'no such thing as a genetic emergency', but I think acute care is challenging that a little bit." [GC 5, <5 years' clinical experience, Pediatrics, Acute care experience]*

> *"Genetics has traditionally been very nine to five, there's no such thing as an emergency…I'm not too sure what the solution is to that, but it is something that I think is particularly difficult. The fact that across a weekend there isn't going to be a*

genetics professional around to see these families, so a lot of it might have to wait, which obviously negates the whole purpose of it being ultra-rapid if you have to wait until a Monday to see them." [GC 3, <5 years' clinical experience, Pediatrics, Acute care experience]

Genetic counselors described seeing families when they had little information about the clinical presentation of the child, social situation or family history, and with no opportunity to initiate rapport-building before the first meeting. Some less-experienced GCs found this lack of preparation time challenging.

"You might be walking in not knowing anything about the family…the condition…gender…how old they are, anyone's names, anything, because you've literally just been brought up from your desk with a wad of paper in your hand ready to get some signatures on it." [GC 2, <5 years' clinical experience, Pediatrics, Acute care experience]

"I think one of the unique things about the rapid and ultra-rapid [genomics] setting…is that you actually don't get as much information or preparation time as you would for other patients." [GC 3, <5 years' clinical experience, Pediatrics, Acute care experience]

However, GCs with more clinical experience found it less challenging to counsel effectively with limited information.

"I've generally seen the synopsis written by the registrar, but I'll be quite upfront with the family saying, 'Look, I'm not familiar with the presentation'. I ask them to tell me in their own words what's been going on and that's usually well-received. It's an opportunity to tell their whole story to someone who's engaged, who finds it important, hasn't been overwhelmed by it yet. So I'm actually comfortable going in with limited preparation." [GC 16, 10+ years' clinical experience, Pediatrics, Acute care experience]

"We know what the test is and how to explain what an exome [sequencing test] is to families, and that's really the most important part, and also the counseling around whether they actually want the information from the test. So I guess I haven't really

spent too much time prepping to go and see them, other than printing all the forms." [GC 7, 5-9 years' clinical experience, General, Acute care experience]

In discussing the process of genetic counseling in rapid acute care genomics, GCs often contrasted this with prior counseling experiences. Participants reflected that they were initially anxious about this new area of practice, and viewed it as new and different to their existing practice. Less experienced GCs felt additional skills were required to counsel families in rapid acute care genomics.

"There are some different considerations in this setting as compared to a non-urgent setting, just in terms of the counseling skills that are involved." [GC 5, <5 years' clinical experience, Pediatrics, Acute care experience]

However, most GCs recognized that exposure to counseling in acute care increased their confidence; the majority of participants identified that GCs had the required skillset that could be adapted.

"Some of the benefits or positives about genetic counselors is that we have a broad skillset, we're flexible, we are adaptable. So we have these core skills that are transferable amongst different settings." [GC 13, 5-9 years' clinical experience, Pediatrics, Acute care experience]

"Genomic counseling to me is not that different from genetic counseling…The basic principles of patient-centered care, active listening...it's still the same." [GC 6, 5-9 years' clinical experience, General, No acute care experience]

Finally, many GCs acknowledged that although there were some differences between counseling in the inpatient and outpatient settings, these were more practical differences rather than skills-based. For example, finding an appropriate room on the ward, and the unpredictable counseling environment of the inpatient setting, required GCs to be creative and flexible in facilitating counseling. GCs described sharing parents' attention with other acute care health professionals and constant interruptions, issues that are not often encountered in outpatient counseling sessions. Some GCs also commented they felt the acute care inpatient setting was foreign and intimidating to them.

"On the ward, there's always constantly other people floating around." [GC 5, <5 years' clinical experience, Pediatrics, Acute care experience]

"The logistics on the ward I still struggle with. I don't know who everyone is, what their roles are, who I should be talking to about different things. I always feel a little bit like an intruder on the ward because I'm not comfortable down there…I'm much more comfortable in an outpatient setting." [GC 13, 5-9 years' clinical experience, Pediatrics, Acute care experience]

"It's…a bit intimidating or daunting to go up onto a ward where the nurses and the pediatricians on the ward, it's their territory, their safe space." [GC 7, 10+ years' clinical experience, General, Acute care experience]

Parallels were drawn between genetic counseling in acute care and other settings and scenarios, for example the prenatal setting.

"When I was working in prenatal…I would get a knock on the door and [someone would] say, 'Lady across the hall, we're seeing something horrendous on ultrasound and she's coming over to see you.' So I guess it's not completely new to me to be just meeting someone when they're in a time of crisis or we're talking about really distressing information or trying to talk to patients about decision-making, about testing, at a time when they're trying to process a lot of information. I feel like those were things that I would come across quite regularly in a prenatal setting that I see a lot of parallels between when I'm going up to meet a family for the first time on the ward in acute care." [GC 5, <5 years' clinical experience, Pediatrics, Acute care experience]

"You're still dealing with the uncertainty of a diagnosis, the time pressure for us, given that we deal with pregnancy-related issues, is not unfamiliar to us. You're dealing with trauma, you're dealing with communicating information about results and about testing and about the concept of informed consent in a time of great anxiety." [GC 10, 5-9 years' clinical experience, General, No acute care experience]

Genetic counselors also recognized aspects of crisis counseling in rapid acute care genomics.

"It's crisis intervention, really, from a counseling point of view." [GC 8, 10+ years' clinical experience, Prenatal, No acute care experience]

Finally, many GCs acknowledged encountering similar challenges previously when new technologies were implemented.

"Of course we have been confronted with this stuff prior…Chromosomal microarray was able to diagnose babies early, it's just a question of when it was being done…So I don't think we're starting at the very bottom." [GC 11, 10+ years' clinical experience, Pediatrics, Acute care experience]

"We had the core skills when [chromosomal micro-] array came in, we had the core skills when predictive testing became available, we had the core skills when prenatal array came in, when panels came in." [GC 10, 5-9 years' clinical experience, General, No acute care experience]

DISCUSSION AND PRACTICE IMPLICATIONS

This study is the first to investigate the experiences of GCs in pediatric acute care at multiple centers where rGS is being offered in clinical care. With participation from a large proportion of GCs at the frontline of providing genetic counseling for rGS in acute care, this study establishes both the challenges and opportunities for genetic counseling in the context of rGS in the pediatric acute care setting. Despite previous suggestion of the novelty of genetic counseling for rapid acute care genomics, our study suggests that GCs are flexible, adaptable and sufficiently skilled to deliver patient-centered counseling in this setting.

Informed decision-making in rapid acute care genomics: not a challenge?

Genomic sequencing is known to place additional time pressure on outpatient genetic counseling consultations (Dwarte, Barlow-Stewart, O'Shea, Dinger, & Terrill, 2019). The rapidity of the processes in acute care genomics places yet further pressure, with little opportunity for GCs to prepare ahead of seeing a patient. Although all GCs in our study commented on the sense of urgency in this setting, it was those with less clinical experience who reported this as challenging.

Despite their focus on pre-test counseling in interviews and opportunity to comment on informed decision-making for rGS, GCs did not do so, nor did they comment on the impact of this urgency or the challenging counseling environment of the inpatient setting on informed consent. Certainly factors proposed by others as potentially compromising parents' informed decision-making (Diamonstein, 2019; Gyngell et al., 2019; Knapp et al., 2019) were evident in GCs' descriptions of their work in this study. In a discussion paper on ethics about genomics in the acute care setting, Gyngell et al. (2019) suggested that parents

436 are unlikely to have sufficient time to critically reflect and make an informed decision about
437 rGS; also that this is further compounded by the fact that parents are likely to consent to
438 such a test simply due to its potential to have a significant impact on their child's care.
439 Additionally, in reflections on three case studies, Diamonstein (2019) suggested that the
440 substantial emotional distress parents are likely to experience in this context may have a
441 significant impact on their decision-making ability. Conversely, Knapp et al. (2019) proposed
442 that the concerns of neonatologists in their study about parents' ability to provide informed
443 consent may be due, at least in part, to the extended consent process necessary for
444 research participation and therefore not representative of service delivery in a solely clinical
445 setting.

446 The absence of expressed concern about informed decision-making from GCs in our study
447 may reflect their past experience in challenging, emotionally-charged settings, as well as
448 their adaptability. Participants in this study felt that GCs were inherently flexible and
449 adaptable, and that their skills were readily transferrable to new areas of practice. They
450 drew comparisons between genetic counseling in rapid acute care genomics and crisis
451 counseling in the prenatal setting (e.g., following detection of a fetal abnormality on
452 ultrasound). Participants proposed that those who had experience in prenatal genetic
453 counseling would likely be more confident with counseling in rapid acute care genomics,
454 due to similar time pressures and parental emotional distress in the prenatal context as
455 described by Menezes and colleagues (2010). Existing prenatal counseling models and
456 practice may therefore be useful to guide counseling practice in this emerging application of
457 genomics. Participants also demonstrated the adaptability of GCs by referencing the
458 introduction of technologies in the past, such as chromosomal microarray and gene panels.

459 The involvement of a variety of health professionals in providing care, often at the same
460 time and with similar urgency, for patients has previously been suggested as a challenge for
461 informed decision-making in acute care (Diamonstein, 2019). Whilst GCs in this study raised
462 this as a challenge for genetic counseling in this setting generally, they did not see it as
463 impacting parents' informed decision-making specifically. This may again reflect GCs'
464 adaptability and familiarity with multidisciplinary teamwork, suggesting that the
465 involvement of other health professionals does not impact their counseling to the extent
466 that they are unable to continue to effectively facilitate informed decision-making.

The genetic counselor role in multidisciplinary models of service delivery

Many have observed that a multidisciplinary approach is likely to be necessary in all areas of genomics, and that GCs will be not only central to, but leaders in, in facilitating this (Facio, Lee, & O'Daniel, 2014; Hooker et al., 2014; Mills & Haga, 2014; Patch & Middleton, 2018). GCs are in high demand, particularly in specialties such as neonatal acute care (Elliott & Friedman, 2018). In Australia, intensivists are supportive of the implementation of rGS in acute care, with a Genetics-led approach being their preferred model (Stark, Nisselle, et al., 2019). As with other genomic activities (Patch & Middleton, 2018), issues with workforce capacity, mean that, with time, acute care health professionals may need to take on some or most of this work.

It may take some time to make that transition. GCs in this study felt acute care health professionals were not currently adequately prepared to provide appropriate genetic counseling for families, and that rGS was not always sufficiently prioritized in acute care. This is consistent with recent evidence that intensivists underestimate the clinical utility of rGS, and have lower confidence in delivering rGS than other genetic tests such as microarray (Stark, Nisselle, et al., 2019). One way to build both knowledge and confidence for acute care health professionals in genomics is through experiential learning (McClaren et al., 2020); multidisciplinary teamwork is likely to be the best way to facilitate this, and GCs are well positioned to play a vital role within this established relationship by educating those other health professionals.

Study limitations and further research

Our findings present the opinions and experiences of participants at an early stage of adoption of rapid acute care genomics. As a result, some GCs were in positions with responsibility for delivering genetic counseling in rapid acute care genomics but had not yet experienced providing genetic counseling for this to patients. For this reason, we considered the experience in rapid acute care genomics of GCs in our analysis. While the sample size is small, it is a national sample and includes a significant proportion of the GCs with roles in rapid acute care genomics in Australia at the time of the study. It is possible – likely even – that perceptions and opinions will evolve with further experience and as genomics becomes more embedded in pediatric acute care. Our study provides a useful foundation for studies

of this evolution; there would be benefit in further research as some of the practical challenges identified are resolved in clinical settings around the world. In particular, mixed methods and observational studies to specifically investigate the goals, interactions and content of pre-test counseling would be beneficial, as questions remain about the educational aspects of these sessions, how informed decision-making occurs in this setting, and patient expectations. Measurement of genetic counseling outcomes using established tools and frameworks (e.g. Cragun & Zierhut, 2018; Grant, Pampaka, Payne, Clarke, & McAllister, 2019; and McAllister, Wood, Dunn, Shiloh, & Todd, 2011) will also provide evidence and allow for comparisons with other settings of genetic counseling practice. Insights from comparison of the outcomes of rGS offered to parents by health professionals (such as clinical geneticists, intensive care physicians or nurses) with genetic counselors using these measures may be particularly valuable. Finally, and importantly, research is also needed to explore, in detail, the experiences of parents in this setting, particularly regarding informed decision-making.

Conclusion

Despite views that genetic counseling practice in rapid acute care genomics is unique (Stark et al., 2018), our study suggests that the extent of this novelty is somewhat overstated. Participants reported precedents for urgent or crisis genetic counseling practices that could be applied to rapid acute care genomics. Their concerns focused instead on practical challenges, including the limitations of service delivery '9 to 5'. The use of rGS as an investigative tool in neonatal and pediatric acute care is very much in its infancy. Our work indicates GCs are ready and willing to contribute at an early stage of adoption, both as part of the delivery of multidisciplinary care and also in supporting the education of other health professionals in rapid acute care genomics.

In the future, establishment of a model of service delivery will need to consider organizational changes to standard working practices for GCs to address practical barriers of genetic counseling in acute care. Irrespective of whether 24-hour, on-call genetic counseling support can be offered, GCs preparing to deliver rapid acute care genomics in the immediate future can draw on existing practice in areas of urgency, such as prenatal counseling, to inform their practice in this area. This, in addition to their existing knowledge,

skills, and flexibility, will position GCs to lead the multidisciplinary establishment of safe, effective, patient-centered approaches to delivering rapid acute care genomics.

AUTHOR CONTRIBUTIONS

Fiona Lynch contributed to the research design, recruited participants, performed and transcribed all interviews, coded all transcripts, and drafted the manuscript. Belinda McClaren and Amy Nisselle contributed to the research design, coded transcripts for concordance, and provided revisions to the manuscript. Clara Gaff contributed to the research design and provided revisions to the coding tree and manuscript.

All authors had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Questions about the study or the data should be directed to the corresponding author.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

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CONFLICT OF INTEREST

Fiona Lynch, Belinda McClaren, Amy Nisselle and Clara Gaff declare that they have no conflict of interest.

HUMAN STUDIES AND INFORMED CONSENT

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants included in the study. This study was reviewed and approved by the Human Research Ethics Committee of the University of Melbourne (HREC ID 1646785.9).

ANIMAL STUDIES

No non-human animal studies were carried out by the authors for this article.

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FIGURE LEGENDS

Figure 1. Comparison between standard and rapid genomic sequencing in the Australian Genomics context: showing specifically the process followed if trio analysis is performed in both scenarios. Adapted from Ayres et al. (2019).

Table 1. Sample demographics

		Participants n (%)
Clinical genetic counseling experience	<5 years	5 (31%)
	5-9 years	5 (31%)
	10+ years	6 (38%)
Area(s) of experience in genetic counseling practice[a]	General	9 (56%)
	Pediatrics	8 (50%)
	Prenatal	7 (44%)
	Cancer	4 (25%)
	Cardiac	2 (13%)
	Adult	2 (13%)
Experience of counseling for rapid acute care genomics	Experience	10 (63%)
	No experience	6 (38%)
State	Victoria	11 (69%)
	New South Wales	2 (13%)
	South Australia	2 (13%)
	Queensland	1 (6%)

[a]Totals >100% as some GCs had experience in more than one area of practice.

Box 1. Participants' descriptions of the urgency to provide counseling for rapid acute care genomics

"…off the cuff…"

"…on the fly."

"…a frenzied sort of process…"

"…flown by the seat of our pants…"

"…drop everything and grab the paperwork and go…"

"…flying blind…"

"…you need to rush off…"

"…on the fly…"

"…thinking on your feet…"

"…all systems go."

"…mumble through as we go."

"…flying by the seat of your pants…"

"…just wing it…"

"…all systems go…"

Figure 1