



# Prenatal testing technologies in Australia: Unintended clinical and emotional complexities in underprepared systems

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## ABSTRACT

The past decade has seen technological advances in prenatal screening technologies rapidly integrated into clinical practice. These technologies have revolutionised healthcare and raised complex socio-ethical issues such as equitable access, medical commercialisation, and new eugenics. However, the important issue of the impact of these technologies on healthcare professionals is receiving less attention. Exploring this issue in the Australian context, we conducted a survey from August to November 2022, targeting health and allied health professionals who work with parents in the perinatal period who have received a fetal diagnosis. We received 75 substantive responses from a diversity of professionals, including sonographers, midwives, genetic counsellors and medical providers.

In this article, we consider the unintended impacts of prenatal screening technologies on healthcare workers, drawing from Ziebland et al., 's 2021 unintended consequences framework. Our reflexive thematic analysis produced three key themes: "Unintended Clinical Complexities", "Adapting Work Practices to Keep Up in Systems that Lack", and "Unintended Intensification of Emotional Labour". Prenatal testing technologies have intentionally increased early testing and fetal information, offering veiled promises of increased certainty in pregnancy. However, our analysis highlights that these advancing technologies also generate more ambiguous results, creating unintended clinical and emotional complexities for healthcare providers. Workers must manage increased clinical uncertainty and constant change, creating intensified emotional labour in under-prepared systems. We conclude by identifying the need to recognise the impacts of advancing prenatal screening technologies on healthcare workers and for targeted professional training to prepare healthcare professionals for the complexities introduced by these new technologies.

## 1. Introduction

The last decade has seen rapid and ongoing technological advances in prenatal tests to screen or diagnose developmental, health or genetic variation in a fetus. Advances in obstetric ultrasound technologies allow earlier identification of anomalies in fetal structures (Weissbach et al., 2023). Next-generation sequencing following invasive testing can now diagnose previously undetectable genetic variants (Chandler et al., 2022). Next-generation sequencing of cell-free DNA in maternal blood, commonly called non-invasive prenatal testing (NIPT), has also advanced to detect possible genome-wide variants (Hui et al., 2023). The introduction of advancing prenatal testing technologies has intentionally changed the clinical work of health and allied health

professionals. Technologies have increased earlier testing, and, as envisaged, the rate of prenatal diagnosis (MacArthur et al., 2023). Complicating these rapid technological shifts, however, is their market-driven development and promotion, which has narrowed concerns to the profitable aspects of testing. The pace and nature of these advances and their introduction into clinical practice have attracted a breadth of scholarly inquiry. Social and bioethical questions include concerns about testing marketisation and corporate agendas (Agarwal et al., 2013), equitable access (McKinn et al., 2022), and whether embedded ableist assumptions are creating new forms of eugenics (Nakou, 2021). The experiences of workers navigating these technological advances in prenatal technologies have attracted less focus.

This paper illuminates unintended consequences of rapidly evolving

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prenatal screening and testing technologies on Australian health and allied health professionals. We describe unintended clinical complexities, the adapting practices of workers to keep up with technological advancements in systems that lack, and the subsequent unintended intensification of emotional labour for workers. These unintended consequences surfaced through a secondary analysis, whereby we re-examined existing data from our 2022 survey research which documented the experiences of Australian-based health and allied health professionals who work with parents who have received a prenatal diagnosis. Unintended impacts of technological advancements emerged from the initial study, warranting re-examination of qualitative data.

While advancing prenatal technologies likely impacts workers globally, Australia presents a case study of theoretical interest. There is global recognition that advanced prenatal technologies are operating within systems that lack resources to support informed parental choices, such as trained professionals, psycho-social counselling and balanced informational materials (Ravitsky et al., 2021). As health and legal systems create unique contexts for prenatal screening regimes, detailed examination of individual countries is fitting. Australia also provides a national case study type where advanced prenatal screening and diagnostic technologies have been introduced without a formal screening program, whereby introduction of technologies has been ad hoc (Ravitsky et al., 2021).

Unlike Australia, availability of psychosocial counselling into systems of practice appear better funded and organised in countries with public consultation and nation-wide implementation of NIPT (Ravitsky et al., 2021). Australian pregnancy care guidelines recommend informing pregnant people of options for prenatal screening (Living Evidence for Australian Pregnancy and Postnatal Care, 2024), yet offer limited guidance on delivery of care beyond results. Attempts to bridge gaps in systems, training, and guidance has seen one state-level development of consensus-based guidelines (Queensland Health, 2024) and materials developed by professional bodies, such as parent-centred communication in obstetric ultrasound (Australasian Society for Ultrasound in Medicine [ASUM], 2022). A paucity of Australian-based guidance remains for working with parents beyond the initial high-chance finding (Shakes et al., 2023). Unlike the UK, where research now explores the efficacy of training methods, including communication coaching (Johnson et al., 2023), such training options remain limited in Australia. Gaps have also been identified in Australian health professional education related to undertaking work with parents who receive unexpected fetal news (Browning and Henry, 2023; Thomas et al., 2020).

We aim to illuminate the unintended consequences of advancing prenatal technologies in Australia, identifying contextually dependent knowledge of use to improve health professional wellbeing in Australia. Our findings will resonate with other countries with similar complexities in training, access, and ad hoc implementation of prenatal technologies. This study contributes to the call for greater knowledge by discussing the findings with consideration of Ziebland et al., 's 2021 unintended consequences framework. Thus, we surface unintended consequences of new prenatal testing technologies upon health and allied health workers who work with parents in various roles and any stages in the perinatal period.

## 2. Background

### 2.1. Unintended consequences of advancing prenatal screening and diagnostic technologies

New digital health technologies are expected to generate improvements in areas including diagnosis and care (Agreli et al., 2021). Broader expectations are that technologies will improve access and resource allocation and generate efficiencies. Yet, much literature concurs that “many of these promises have so far failed to materialize” (Carboni et al., 2022, p. 1). Medical literature acknowledges that new digital

technologies can fail to deliver their promised benefits (Carboni et al., 2022) and can be more demanding of practitioners, diminishing the quality of care they can deliver to patients (Bergey et al., 2019). Literature in science, technology and society finds technologies can create multifold and contradictory impacts (Carboni et al., 2022). While steering change in particular directions, impacts of technologies are difficult to predict. This perspective recognises “distributed agency” across human and non-human agents so that constant dynamic conditions enact between technology and work practices, rather than producing a final state. To strategically respond to the impacts of new technologies, the valued recognition of health workers is understood to be crucial (Agreli et al., 2021).

The introduction of digital technologies in primary health can generate a complex of unintended consequences, potentially impacting “people, relationships ... and ways of working” (Ziebland et al., 2021, p. 1). In their conceptual literature review, Ziebland et al. (2021) identified three domains of impact from unintended consequences: (i) power disruptions that reconfigure relationships between health professions or with patients; (ii) outcomes paradoxical to the primary intentions of a technology, sometimes delivered “in parallel” (p. 4); and, (iii) a culture of pessimism towards new digital technologies generated from negative emotional responses. Simplistic “techno-utopian” perspectives on new technologies (Lupton, 2014) narrowly claim they provide “cheaper, safer care” (Ziebland et al., 2021, p. 2), overlooking situated complexity (Ziebland et al., 2021, p. 2) and not considering the agency of technology to shape human behaviour and relationships, as proposed by posthuman feminism (Braidotti, 2022). Digital health technologies can also “pose new issues of accountability” (Ziebland et al., 2021, p. 4), creating ethical imperatives to undertake systematic assessment of potential harms. While Ziebland et al. (2021) focus on online technology systems that support clinical work, such as telehealth, their framework usefully informs understanding of the human impacts of advances in clinical technologies in prenatal testing.

From a socio-material perspective, new technologies can reshape practices and interactions in complex and integrated ways (Bergey et al., 2019). Changes to role configuration is widely identified as a major impact of new digital technologies (Agreli et al., 2021). Reconfigurations include role enlargement and changing tasks (Bergey et al., 2019), such as new responsibilities and altered professional scope and task boundaries (Pettrakaki and Kornelakis, 2016). Changes to “technology-in-practice” includes altered “scripts” of work which may be “difficult to control in their unfolding” (Carboni et al., 2022, p. 8). (Nicolini, 2006, p. 2757) captures the integrated and ongoing impacts between new digital technologies and daily practice as a “negotiation between the innovation and the work activity”. This negotiation determines how the technology is engaged “in practice”, which may differ from intended use.

Invisible knowledge and tasks can emerge with the introduction of new digital health technologies. Role expansion or task redistribution requires the invisible work of professions to be made explicit for technology to be successfully integrated into practice (Agreli et al., 2021). Changed role expectations can generate new and unprepared-for invisible work. This may be the relational work undertaken by professionals with patients to “accommodate technologies into their daily practices” such as workers explaining technology to patients (Carboni et al., 2022, p. 6). Maslen (2017) describes this as the “sensory work” of new technology, highlighting how, alongside altering communication between patients and professionals, technologies disrupt established connections between health professionals and patients. The “extra lengths” that professionals must go to “to make the new connections work” suggests a new emotional load on professionals. While the introduction of new digital technologies can differ according to profession and organisational position (Pettrakaki and Kornelakis, 2016), organisations with good collaboration practices and supportive leadership fare better with the introduction of new technologies (Bergey et al., 2019).

## 2.2. Ambiguity of advancing prenatal technologies and clinical decision making

Healthcare professionals in Australia value advanced prenatal genomic technologies for their potential to provide expectant parents with information (Drysdale et al., 2024). Yet, concerns have arisen about the pace of technological advancements and the paradoxical effect of more information generating less certainty (Drysdale et al., 2024). While unknowns have always been present in pregnancy, advancing prenatal technologies, driven by commercial imperatives, use a promissory discourse to give veiled suggestions that engaging in these testing regimes will produce knowability in pregnancy. However, earlier detection of a structural anomaly may not lead to any additional certainty about the prognosis and meaning of the anomaly for the fetus or future child. While genomic diagnoses may be confirmed through prenatal microarray or exome sequencing, this confirmation can generate further uncertainties about the meaning of results and the accuracy of information (Harding et al., 2020).

Ambiguity arising from advanced prenatal testing has required new workflows for clinical decision-making, such as whether to report variants of uncertain significance (VUS). Guidelines vary and can be unclear about the management of VUS, but recommendations suggest parents should be notified of the potential to identify VUS and have the option to opt-out (Klapwijk et al., 2021). While opt-out options suggest autonomous parent decisions, recent research identified that VUS were significantly less frequently reported when the workflow included an opt-in from parents rather than opt-out (Haddad-Halloun et al., 2024). This finding indicates how systems and structures designed to navigate the ambiguity of prenatal technologies can directly influence clinical decisions, reporting and outcomes.

Advancements in the sophistication of prenatal testing technologies have altered the clinical contexts in which testing is offered by increasing routinisation (Drysdale et al., 2024). Many health professionals frame a delineation between their role of giving information enabled from prenatal technologies, with women and families tasked with the decisions that follow (Stephenson et al., 2017). However, challenges arise with ambiguous findings, between the medico-legal safety of sharing all grey findings and the attempt to protect expectant parents from the psychosocial consequences of ambiguous fetal news (Stephenson et al., 2017). Healthcare in Australia is not currently structured to facilitate decision-making when fetal results are ambiguous or unexpected (Drysdale et al., 2024). The challenges of advancing prenatal testing in clinical decision making are further indicated in the lack of guidelines and policies and the lack of consensus about “what’s okay and not okay”, with differences in practices among health and allied health professionals who care for parents who receive fetal news (Stephenson et al., 2017, p. 86).

## 2.3. Emotional labour as an unintended consequence of advancing technologies

Hochschild’s (1983) concept of “emotional labour” theorises the emotion demands of a work role that are considered necessary to perform the role. Initially focused on service work, emotional labour has been applied to healthcare work, with literature reviewed by Riley and Weiss (2016). They identified four themes: gendered dimensions and professionalisation of emotion; the intrapersonal dimension of healthcare workers managing their emotions at work; organisational causes of emotion work; and, support and training requirements for emotional labour. They emphasise that the emotional labour of healthcare workers needs to be recognised and valued, and its management systematically supported.

Health and allied health professionals regularly perform emotional labour due to the sensitivity of their work and their encounters with difficult patient circumstances, which can become exhausting (Carminati, 2021). In nursing, with its higher pro-social motivation, the

drive to “enhance the well-being of others” is related to higher burnout risk (Dill et al., 2016, p. 99). “Moral distress” in health professions captures work arrangements that restrict workers from undertaking their work in a way that meets their sense of moral responsibility. It is caused by constrained conditions of work – for instance, being under-resourced for the required work, a known situation for sonographers working in prenatal screening (Thomas et al., 2020). The emotional response to moral distress can include guilt and helplessness, whereby systemic lack is individualised as a personal failing of the worker (Molinario et al., 2023). Genetic counsellors who work in prenatal settings are found to be the most likely of all genetic counsellors to experience moral distress (Wadman et al., 2022). The reasons for this moral distress included concerns about the poor practice of other providers and creating boundaries with distressed patients.

Considerations of emotions and new health technologies have largely focused on fearful responses to change, such as generalized technology-anxiety (Agreli et al., 2021). However, Carboni et al. (2022) challenge the notion that fear is the key emotion issue for health workers and innovation, arguing that the stress of healthcare work can be worsened by technologies (Carboni et al., 2022). The emotional labour of communicating unexpected fetal news in prenatal screening work is indicated in UK guidelines for obstetric ultrasound (Johnson et al., 2020). These points come under the principle “Kindness” and include to “understand the nature of shock”, “expressing regret” and “reaffirm emotions”. “Self care” is also included in the guidelines, which implicitly acknowledges the emotional demands of this area of health practice.

Analysing the unintended impacts of new technologies in healthcare settings is important and gives indications of the type of changes that may be identified in prenatal testing domains. Sociological analysis of impacts (Carboni et al., 2022) encourages positioning new health technologies as agentic actors within a “micropolitics of sociotechnical change” (p. 7). This approach usefully opens the scope of analysis to consider the broad impacts of introducing new digital technologies and the experiences of health and allied health workers working with parents in new prenatal testing domains.

## 3. Research Methodology

This paper presents findings from secondary analysis of qualitative data, undertaken for in-depth consideration of an important dimension from the primary study. The primary study comprised an online, self-administered survey that explored health and allied health workers’ experiences, practices and perspectives on training needs for work with parents who receive a prenatal diagnosis. The continued advancement of technologies for prenatal screening, diagnosis and prognostication and the consequences for working with parents weaved through the findings of the primary analysis and is the focus of the secondary analysis.

### 3.1. Research participants

Our recruitment strategy included all professionals who work with parents in the perinatal period, not limited to professions involved with diagnosis or prognosis; see Table 1 – Survey Respondent Demographics for a detailed breakdown. A prenatal diagnosis can impact parent psychosocial health and well-being beyond the screening and testing period (Oftedal et al., 2022) and different health and allied health specialties hold differing views of prenatal testing technologies (Drysdale et al., 2024). Therefore, it was pertinent to include perspectives of those working with parents at any stage, including the perinatal period, grief or subsequent pregnancies. Through wide eligibility criteria (Supplementary File 1), professionals could self-identify their work with parents. This openness created potential to capture the perspectives of workers otherwise excluded from studies on prenatal diagnosis, which typically focus solely on the screening and diagnostic period.

**Table 1**  
– Survey Respondent demographics.

Attribute	n	%
<b>Area of practice<sup>a</sup></b>		
Antenatal/pregnancy care	23	19.5%
Obstetric ultrasound	23	19.5%
Fetal medicine	21	17.8%
Other	17	14.4%
Research	9	7.6%
Perinatal mental health	8	6.8%
NICU or alike in-patient service	5	4.2%
General maternity and birth services	4	3.4%
Primary care	3	2.5%
General mental health	2	1.7%
Maternal and child health	2	1.7%
Early childhood development	1	0.8%
Total	118	100.0%
<b>Profession<sup>a</sup></b>		
Sonographer/radiographer	17	24.3%
Genetic counsellor	12	17.1%
Midwife	9	12.9%
Other	7	10.0%
Medical provider - perinatal specialty	4	5.7%
Nurse	4	5.7%
Peer worker	4	5.7%
Psychologist	3	4.3%
Counsellor	3	4.3%
Researcher	3	4.3%
Social worker	2	2.9%
Medical provider - non-perinatal specialty	1	1.4%
Medical provider - non-patient facing	1	1.4%
Occupational therapist	0	0.0%
Total	70	100.0%
<b>Years of practice: Median (Q1, Q3)</b>		
10 years (3.75, 20.5)	70	
<b>Geographical area of practice<sup>a</sup></b>		
Metropolitan (large capital city)	44	62.0%
Inner regional (large centre with a population more than 50,000)	7	9.9%
Outer regional (centre with a population between 5000–49,000)	11	15.5%
Rural (centre with a population less than 5000)	7	9.9%
Remote (100kms from nearest town)	2	2.8%
Total	71	100.0%
<b>Frequency of work with parents who receive/received news of a possible or confirmed fetal anomaly</b>		
Daily	22	31.0%
Weekly	28	39.4%
Monthly	12	16.9%
Quarterly	5	7.0%
Less than quarterly	4	5.6%
Total	71	100.0%

<sup>a</sup> Respondents encouraged to select all that apply.

### 3.2. Survey design

Online qualitative surveys are appropriate for studies of large and diverse populations to access a range of voices and sense-making (Braun et al., 2020). While assumptions may be that depth of data is lost in qualitative surveys compared to interviews, Braun et al. (2020) challenged this assumption through their exploration of studies engaging this underutilised method. For this study, qualitative surveys offered advantages, including affordable access to diverse participants around Australia, the potential to include perspectives of professionals who would otherwise abstain from face-to-face interviews, increased anonymity which can facilitate disclosure in sensitive research, and to circumvent a dominant demographic or background of participant (Braun et al., 2020).

The survey was designed as cross-sectional, with a qualitative component and a series of simple rating scales. All questions were optional. The combination of quantitative questions with qualitative open-ended questions enabled the collection of both numerical data and detailed personal insights from health and allied health professionals

about their experiences. Open questions asked respondents to reflect upon experiences of feeling professionally equipped or ill-equipped and to consider challenges and changes over time in their work with parents. Closed questions were followed with prompts for further information to elicit focused qualitative responses (Braun et al., 2020). Demographic questions and a further open field for additional comments were included in the survey. The survey tool was reviewed by an antenatal care provider, a statistics expert, and people with lived experience of receiving prenatal diagnosis. University Human Research Ethics Committee approval was obtained.

### 3.3. Data collection

The survey was open from 10 August to 28 November 2022. Distribution was via email, social media, professional networks and webforms to perinatal clinical or peer support organisations and health and allied health professional organisations (n = 34). This approach was chosen to generate the largest number of responses but does not allow for a clear delineation of population and so a response rate is not possible.

As the primary study explored workers' experiences, practices and perspectives on training needs for work with parents who receive a prenatal diagnosis, organisations were not limited to those involved with prenatal screening and diagnostic technologies. Organisations (Supplementary File 2) were selected due to their potential to access health and allied health professionals who work with parents at any stage in the perinatal period who receive or have received a prenatal diagnosis. The survey was reviewed while in progress and closed when responses reached a mid-range sample size for a qualitative survey sufficient to achieve the dataset richness to address the research questions (Braun et al., 2020).

### 3.4. Analysis

Qualitative data were analysed using reflexive thematic analysis, as developed by Braun and Clarke (2020) and grounded in social constructionist foundations. Our inductive approach was to interpret rather than describe data and to understand meaning as drawn from across the dataset rather than attached to individual questions, as recommended for qualitative surveys (Braun et al., 2020). Two researchers (BJ & PS) undertook separate readings to develop initial codes and themes, using organic and recursive coding and mind-mapping on paper and in NVivo (Version 12). We then refined codes through collaborative analysis. We questioned individual interpretations from our different professional and scholarly backgrounds (social work/sociology and mental health nurse/health sciences) to reflexively nuance our collective analysis. Collaborative discussion and drafting with the third researcher added further nuance to the analysis.

The findings of the parent study encapsulated complexities of knowing and learning in work with parents who receive or have received a prenatal diagnosis. The continued advancement of technologies for prenatal screening was a significant element that weaved through those findings. Our secondary analysis was informed by Ziebland et al.'s (2021) unintended consequences framework for understanding the complexities of working conditions that arise from technological advances. Secondary analysis involved two researchers' (BJ & PS) further immersion in the data to identify, code and discuss data relevant to Ziebland et al.'s (2021) concepts of power, paradoxes and pessimism. Further collaborative workshops and writing with a third researcher completed the secondary analysis. To enrich our findings narrative, we include substantial quotes from respondents, referenced with their survey response number and identified profession. Quotes serve as key examples to illuminate dimensions of identified themes, offering a nuanced understanding of the complex issues at hand.



## 4. Findings

The survey was opened by 93 respondents from which there were 75 substantive responses (beyond Question Two). Participants were sonographers, midwives, genetic counsellors, peer workers, nurses, medical specialists, psychologists, counsellors, researchers and social workers (Table 1). We found that health and allied health professionals are navigating unintended clinical complexities as a consequence of advanced prenatal screening and diagnostic technologies. While navigating uncertainties and new unknowns, work practices are adapting as an accommodation for the lack of support training and support for both parents and professionals. This landscape of clinical complexity and adapting work practices has consequently intensified the emotional labour required in the work with parents who have received unexpected fetal news.

### 4.1. Unintended clinical complexities

While advancing prenatal testing technologies have led to intended increases in the range of anomalies screened, tested and identified, technological advances have consequently surfaced unintended clinical complexities. Respondents attributed the transition to the use of NIPT in place of the cFTS to an increase in later diagnoses of severe structural anomalies such as anencephaly “because patients have NIPT without early anatomy ultrasound and structural anomalies go undetected until a mid-trimester anatomy scan” [36: medical provider – non-perinatal]. Furthermore, the interpretation and reporting of results and subsequent counselling have become more complicated and often more uncertain. “Many testing options available with the potential to test for many more conditions, [with consequent] increases in information and uncertainty of results” [1: genetic counsellor].

Diagnostic certainty afforded by advanced genomic testing was considered “often helpful for couples” [68: genetic counsellor]. However, a definitive genetic diagnosis is not the antidote to uncertainty. “There is often a high level of uncertainty, even when a definite genetic diagnosis is made due to the high level of variability in conditions. The counselling can be challenging when there is little available literature” [59: genetic counsellor]. Genetic variants of uncertain significance, with variable penetrance, mosaic conditions and subchromosomal anomalies were described as difficult due to “so many unknowns” [51: medical provider – perinatal specialty]. The uncertainties and exposed unknowns transfer into more complex engagements with parents and creates the challenge of “explaining uncertainty” [51: GP obstetrician]. Similarly, with ultrasound technology providing more detailed images of the developing fetus, the line between typical and atypical becomes increasingly complex creating unintended complexities, “a possible anomaly or indeterminate finding is incredibly difficult to explain ... it is very stressful for everybody” [36: medical provider, non-perinatal].

With technologies enabling more testing and producing more information, professionals must manage the increased complexity of uncertain clinical results or results with uncertain implications for a future child. This uncertainty needs to be managed in communicating fetal news to parents and in supporting parents in decision-making about the pregnancy. “[O]ften the clinical implications of a prenatal result are uncertain and assisting some couples with decision-making is really hard” [77: genetic counsellor/researcher].

### 4.2. Adapting work practices to keep up in systems that lack

Prenatal testing technologies have previously been credited for changes in parent expectations when attending prenatal ultrasounds, as technology personified the fetus which shaped expectations and hopes of parents attending scans. Respondent sonographers described how their work practices had “changed dramatically” as their role progressed to include the communication of unexpected findings to adapt to the new expectations.

“Previously we (sonographers) were directed to inform the parents of as little as possible, with the information preferred to come from a doctor. Now we are encouraged to disclose as much as we are able within our knowledge to the parents at the time of scanning.” [18: sonographer]

This shift in work role requires new skillsets for sonographers. In this new task of communicating anomalies to parents, the expected immediacy of communication allows little time to prepare how to communicate news. The variations in parent presentation and reactions make these situations difficult and require nuanced approaches by workers. “Every encounter is different. Some patients respond well others not. Have to manage each situation as it presents” [22: sonographer]. Sonographers identified gaps in their training related to this new skill set and worked hard to adapt. “As a clinical sonographer, the formal training is severely lacking, but I have supplemented this with hundreds of hours of self directed learning and research” [16: specialist clinical sonographer].

The need for work practices to adapt was also identified for other professional groups. Advancing genetic screening was attributed to the intended reduction in false positives, yet coupled with “increased testing” [42: sonographer] consequently means professionals may be delivering a higher proportion of confirmed diagnoses in their work with families. With the increased clinical complexity previously noted and the increased proportion of positive rather than negative results, it is likely that preparation or consultation demands more time, although it is unclear how these work changes are accommodated in systems that were commonly described as “lacking”.

“Lacking” conceptually connected resources, interdisciplinarity, and care into an assemblage of systematic inadequacy: “The lack of information, collaboration, consultation both pre-termination and post-termination. Lack of additional care around the trauma component of the impact of the news and the possible consequence/choices” [43: social worker/counsellor]. Respondents noted a lack of appropriate physical spaces in service settings “for [parents] to absorb news” and a lack of “appropriate follow up as short staffed” [38: sonographer]. Respondents also noted a “lack of parent friendly, easy to read and understand information sheets” [69: profession not stated] and a “[l]ack of immediate and longer term mental health support” [58: midwife].

The “lack of ‘gold standard’ of follow-up care (both with parents deciding to continue the pregnancy and with couples deciding to end the pregnancy)” [77: genetic counsellor] also echoed the lack of training opportunities specifically related to the psychosocial aspects of prenatal diagnosis, and surfaced that prenatal testing technologies have advanced beyond other aspects of holistic care. The unintended consequence is a system shaped to identify and deliver fetal diagnoses rather than support parents through and beyond the experience of prenatal diagnosis, leading to “problems with the system and the trauma it causes parents” [39: sonographer].

It is also unclear how sonographers and other health and allied health workers are being professionally supported in their changed work roles. Respondents described developing strategies on their own through “increased experience” [20: medical provider, perinatal]. Some reported having excellent workplace-based support, “I work in a well supported unit. Our doctors are amazing and will often look at our images and hear our concerns regarding the baby” [61: sonographer/researcher]. Other professionals described working arrangements that hindered their professional ability to work within the adapting roles and systems that lack, “the geneticist I was working with was not prepared to support me or explain the situation to me properly. I felt professionally unsupported and felt that the couple were not being appropriately informed” [65: genetic counsellor]. Without systematised recognition and support for the increasingly complex and adapting work practices undertaken by professionals in the current prenatal testing regime, a wide variety of practices and experiences are occurring.

#### 4.3. Unintended intensification of emotional labour

A further significant unintended consequence emerges within this landscape of increased clinical complexity and adapting work practices in systems that lack, the intensified emotional labour of work with parents who receive fetal news. Working with parents who receive fetal news could be expected to be emotionally demanding, “it can be hard to remain unaffected by the experience” [79: sonographer]. Respondents indicated that when they felt well-equipped, or there was a level of certainty about the diagnosis, prognosis, or parent understanding and decisions, professionals experienced satisfaction and meaning in their work with parents: “Where I was able to feel that my words were of assistance - where the woman needed my kindness I guess” [54: midwife].

“I was able to break the news kindly and gently, arranged a family member to join us so she wasn’t alone, printed photos of her baby to take home, organised care via ED at our hospital so she didn’t need to return home (5 hours away) to arrange the next steps in her care pathway. We had a hug and a cry together and she thanked me for my care.” [18: sonographer]

Adapting work practices and the clinical complexities that represent unintended consequences of advancing prenatal testing technologies harbour the potential to destabilise this balance between emotional demands and feeling equipped, through consequent intensified emotional labour. This potential was well demonstrated through the surfacing of the accumulative “emotional distress (me and them!)” [68: genetic counsellor] from regularly communicating fetal news and supporting families through “an extremely emotional time” [59: genetic counsellor]. “[A challenge in the work is ...] My own wellbeing at times when giving repeated distressing news to families when high volume of patients with diagnostic complexity” [53: nurse]. With a higher proportion of confirmed diagnoses and clinical complexity, advances in prenatal testing technology present the unintended consequence of intensifying the emotional labour in working with parents who received a prenatal diagnosis.

A particular challenge is managing parent expectations and responses when faced with new unknowns and clinical complexity, “often the clinical implications of a prenatal result are uncertain and assisting some couples with decision-making is really hard” [77: genetic counsellor]. Respondents expressed the challenges of parents’ “emotional responses and how to handle them” [80: nurse]. A wide range of parental reactions was captured in the data, from denial – “won’t discuss it and refuse to acknowledge there is a problem” [81: midwife/nurse] – through to “seeming acceptance to ladies and spouses who ... [are] sobbing messes” [39: sonographer]. Strong parental psycho-emotional responses were widely identified by respondents – “raw emotions expressed by patients” [8: genetic counsellor] – and these vary widely, from “sadness”, “grief”, “anxiety”, “devastated”, “complete shock”, “guilt and shame”, “angry and hostile”, “aggressive and intolerant”, to having “suicidal thinking”. Sometimes, professionals need to manage family situations where members are experiencing quite different emotional reactions at the same time. “The husband got up and stormed out of the room. The woman was crying hysterically, and there were two small children in the room with her very confused” [61: sonographer].

Respondents expressed helplessness and worry about their work with parents when they felt ill-equipped: “Worrying I have not dealt with the situation well” [32: sonographer]. The constant need to adapt work practices in systems that lacked and with gaps in training leave some professionals feeling “inadequate and out of my depth due to my own lack of knowledge and training on this topic ... My biggest concerns are unintentionally saying something hurtful, naive, ignorant or dismissive that creates further pain and trauma” [24: infertility counsellor].

Some respondents shared understandably emotional responses to distressing parental situations, which they identify as a risk to their wellbeing and also identify themselves as at risk of becoming emotionally

burnt out from the cumulative effects of these encounters. “It’s incredibly stressful trying to remain compassionate for subsequent patients each year when I now drag into the room with me the memories of every patient that came before that had a similar situation” [36: medical provider, non-perinatal]. While this work with parents could be expected to be emotionally taxing, advancing prenatal testing technologies have introduced unintended clinical complexities and created the need for work roles to adapt in systems that lack. These consequences subsequently intensify the emotional labour within the work with parents who receive a prenatal diagnosis.

## 5. Discussion

Our analysis of qualitative data gained from health and allied health professionals who work in Australia with parents who have received a prenatal diagnosis found that advances in prenatal screening and diagnostic technologies have led to unintended consequences of clinical complexity and the intensification of emotional labour. In response, health professionals must adapt their work practices in systems that lack.

While new digital technologies may intend to improve diagnosis and care (Agreli et al., 2021), our findings affirm that technologies can create new demands of healthcare professionals which diminishes quality of care (Bergey et al., 2019). It is not the complexity of a technological system or its usage that creates these contradictory impacts in prenatal testing domains. Our study extends the understanding of contradictory impacts (Carboni et al., 2022) to include the complexities in new types of information that can be generated by new technologies. In prenatal testing, it is the management of this new and often ambiguous information that has led to the known dynamic, that new technologies reshape healthcare practices and interactions (Bergey et al., 2019). New types of invisible, relational work can be required with patients, needing altered “scripts” which may be “difficult to control in their unfolding” (Carboni et al., 2022, p. 8). This notion captures the new requirement for sonographers and other healthcare professionals to communicate the uncertainty of prenatal testing information, which for some professionals has left them feeling that they have no scripts to call on.

Our study raises questions about how health and allied health professionals are managing the ambiguity produced by new prenatal testing technologies. Work within fetal medicine and with parents who receive news about the development, health or genetics of their unborn baby was already known to be challenging and emotionally impactful (Menezes et al., 2013). Increased clinical complexities, higher numbers of confirmed diagnoses and adapting practices in underprepared systems present a risk to professionals’ wellbeing. Our study demonstrates that advancing prenatal technologies not only increase clinical uncertainties but also amplify the emotional labour required from healthcare providers. Affirming Drysdale et al.’s (2024) study, healthcare professionals recognise that the increased complexity of prenatal testing and findings means that some parents will not have the capacity to make informed decisions without significant support. The feelings of worry and helplessness reported by professionals in our study are known indicators of moral distress in healthcare work (Molinari et al., 2023). With professionals under-resourced to manage new technology-driven complexities, burnout becomes a risk. This risk has been reported in the UK in relation to the adapting role of sonographers to communicate unexpected fetal findings (Johnson et al., 2020), and is a situation of concern that may arise in other national contexts.

Ziebland et al.’s (2021) three domains framework grounds our discussion of the unintended consequences of new prenatal testing, screening and diagnostic technologies. The most significant domain for our research was Ziebland et al.’s (2021) second domain, which addresses outcomes paradoxical to the primary intentions of a technology. This dynamic is central to understanding the unintended impacts of advancing prenatal technologies. The healthcare system holds a deeply ingrained assumption that more information is inherently beneficial.

This privileging of information can overshadow the challenges of emotional and ethical complexities of healthcare. The paradox of prenatal testing technologies lies in their illusion of providing greater choice and certainty for parents through the generation of more information. However, this increased information often creates more uncertainties and new types of unknowns. This paradox creates clinical complexities for professionals who must communicate this increased complexity to parents.

The first domain in Ziebland et al.'s (2021) framework addresses power disruptions that reconfigure relationships between health professions or with patients. Power disruptions were prevalent in the experiences of healthcare workers working with advancing prenatal testing technologies. New technologies have posed a threat to professional autonomy: the authority of healthcare workers may be undermined as they appear ill-equipped to manage new clinical complexities in systems that lack. In this circumstance, power is shifting to the technology rather than between professional groups or to patients, reflecting posthuman analysis of the agency of non-human things to impact upon human experience (Braidotti, 2022).

The final domain in Ziebland et al.'s (2021) framework captures the cultures of pessimism towards new digital technologies that can be generated by health workers. Our study affirms the importance of emotional dimensions as unintended consequences of new health technologies. However, professional groups do not indicate a culture of pessimism towards prenatal testing technologies. From our analysis, an updated framework could expand this domain to broader emotional responses to introduced health technologies, including collective responses of ambivalence or pessimism, and also emotional labour. Sociologically, a further domain to usefully extend Ziebland et al.'s (2021) framework is understanding the socio-ethical contexts driving the introduction of new health technologies. For our study, medical commercialisation of healthcare technologies underpins the unintended consequences, as a significant driver to introduce new technologies into underprepared systems.

Prompted by Ziebland et al.'s (2021) third domain, we consider why the challenges caused by these new technologies are not leading to cultures of pessimism among health and allied health workers. In Australia, prenatal screening and diagnostic results were valued by healthcare professionals for the management of pregnancy, with the "strong implication that the pregnancy would be terminated" if an anomaly is identified, with less value ascribed to testing to help prepare for having a baby with an anomaly or condition (Drysdale et al., 2024, p. 12). The high value of information, assumptions of termination (Drysdale et al., 2024) and perspective of workers as information providers (Stephenson et al., 2017) may underlie healthcare workforce support for these advancing technologies that focus on the identification of fetal diagnosis, rather than on parental support beyond diagnosis. This diagnosis-focus is demonstrated in the industry-led application for public funding of NIPT in Australia, where funding coverage was sought solely for the test without funding for additional counselling or support (Medical Services Advisory Committee, 2016). More recently, new publicly funded carrier screening available to expectant parents also only includes funding for the test (Australian Government, 2023).

Our study affirms earlier suggestions that advancing prenatal testing technologies are changing the work with parents. Technological advancements in prenatal screening and diagnosis have long been understood to alter the experience of pregnancy through the effect of personifying the fetus (Edvardsson et al., 2015; Øyen and Aune, 2016). This personification and subsequent enhanced parental bonding was attributed to the changing clinical practices of sonographers in Australia (ASUM, 2022). In a study published almost a decade ago, midwives in Australia expressed concern with advancements in ultrasound technology leading to situations where greater volumes of information are produced but which is harder to interpret, thus increasing moral dilemmas for parents (Edvardsson et al., 2015). Our study confirms the enduring relevance of these concerns through the unintended clinical

complexities of advanced genomic testing, specifically related to uncertainties and exposed unknowns that extend beyond a confirmed genomic diagnosis. This advancing testing regime seems imbued with the "techno-utopian" (Lupton, 2014) promises of new technologies, resistant to concerns raised by healthcare professions, where technological advances are assumed to only generate improvements.

Prior research explored views of professionals in Australia who work in roles central to prenatal screening and diagnosis (Drysdale et al., 2024; Edvardsson et al., 2015; Stephenson et al., 2017). Our study shows that unintended consequences of advancing prenatal technologies are also experienced by health and allied health professionals who may not be directly involved with the diagnosis or prognosis. Other professionals who work with parents in the perinatal period shared challenges with unintended clinical complexities, adapting work practices and increased emotional labour in their work with parents who received a prenatal diagnosis. Research into the psychosocial outcomes of parents who receive a prenatal diagnosis has identified both acute and enduring challenges (Ofstedal et al., 2022). Therefore, wider professional groups and roles that care for parents following a prenatal diagnosis must also be considered in training and policy related to prenatal testing technologies. It is vital to consider the broader unintended consequences of advancing prenatal technologies beyond the moment of delivery of unexpected news.

Our research indicates that more system-wide support and training opportunities are required for professionals working with parents who have received unexpected fetal news in Australia. A health system that is lacking, leaves health and allied health professionals burdened with the invisible work of adapting practice. As Ziebland et al. insist (2021, p. 4), digital health technologies "pose new issues of accountability", creating ethical imperatives to undertake systematic assessment of potential harms. Strategically responding to the impacts of new technologies requires the valued recognition of health workers (Agreli et al., 2021). With recognition of the impacts of advancing prenatal screening technologies on health and allied health workers, we recommend education that addresses the overlooked psychosocial aspects of prenatal diagnosis and supports workers' ability to navigate and improve the systems they work within.

## 6. Conclusion

This study illuminates the complex and multifaceted landscape that health and allied health professionals must navigate in the era of advanced prenatal testing technologies. While these technologies promise greater choice and certainty for parents, they paradoxically introduce clinical complexities and new unknowns. Healthcare professionals find themselves at the intersection of these complexities, often without adequate support or guidance. The clinical complexities and evolving work roles within underprepared systems amplify the emotional labour required in this work.

The broader implications of this study extend to both theoretical frameworks and healthcare practice. The findings necessitate a reconsideration of the theoretical approaches used to understand the impacts of technological advancements in healthcare. The unintended consequences framework, developed by Ziebland et al. (2021), is particularly pertinent, highlighting the paradoxical outcomes and the distributed agency of technology and practice. This study contributes to this framework by providing empirical evidence of the increased emotional and clinical complexities workers face, yet illuminating the potential that workers' assumptions about health information and parental choices may underscore the limited evidence of a culture of pessimism. A further contribution is consideration of how socio-political contexts shape the implementation of technologies, with commercialisation as significant in prenatal testing.

In terms of healthcare practice, this study underscores the urgent need for targeted professional training to equip workers with the skills needed to navigate the impacts of clinical uncertainty. Training should



adopt an interdisciplinary, transformative and systems-based lens to strengthen professionals' ability to develop and improve the systems they work within. Systemic support structures must be established to provide consistent and comprehensive care, addressing both the clinical and emotional needs of healthcare workers and parents.

Future research should explore several key areas to further understand and address the challenges posed by advanced prenatal testing technologies. Longitudinal studies are needed to investigate the long-term impact of intensified emotional labour on health and allied health professionals, including potential burnout and coping strategies. Research should assess the effectiveness of targeted training programs designed to equip health and allied health professionals with the skills to manage clinical and emotional complexities introduced by new prenatal technologies. Additionally, qualitative studies should be conducted to understand how parents perceive and cope with the uncertainties and complexities of prenatal testing results, and how healthcare professionals can better support them, especially as further technological and regulatory changes occur.

Evaluating the implementation and outcomes of systemic support structures aimed at providing comprehensive care for health and allied health workers and parents is also essential, ensuring these structures meet the evolving needs brought about by technological advancements. Interdisciplinary research should be promoted to integrate perspectives from sociology, bioethics, and healthcare to develop holistic strategies for managing the impacts of technological advancements in prenatal care. Training, systemic support, and research must include health and allied health workers who support parents in other stages of the perinatal period, beyond the delivery of unexpected news, and within subsequent pregnancies, as their work with parents also harbours unintended consequences from advancing prenatal technologies.

In conclusion, advancing prenatal testing technologies have fundamentally changed the clinical and emotional landscape of perinatal care. The findings from this study call for a multi-faceted approach that addresses the ethical, emotional, and practical implications for all stakeholders involved. By recognising and addressing the unintended consequences of these technological advances, we can progress the promise of these technologies in a manner that is both ethically sound and practically feasible.

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### CRediT authorship contribution statement

**Belinda Johnson:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Pieta Shakes:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Chris Maylea:** Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Formal analysis, Conceptualization.

### Data availability

The data that has been used is confidential.

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## Appendix A. Supplementary data

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