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NIPT for adult-onset conditions: Australian NIPT users' views

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Abstract

Noninvasive prenatal testing (NIPT) has become widely available in recent years. While initially used to screen for trisomies 21, 18, and 13, the test has expanded to include a range of other conditions and will likely expand further. This paper addresses the ethical issues that arise from one particularly controversial potential use of NIPT: screening for adult-onset conditions (AOCs). We report data from our quantitative survey of Australian NIPT users' views on the ethical issues raised by NIPT for AOCs. The survey ascertained support for NIPT for several traits and conditions including AOCs. Participants were then asked about their level of concern around implications of screening for AOCs for the future child and parent(s). Descriptive and comparative data analyses were conducted. In total, 109 respondents were included in data analysis. The majority of respondents expressed support for NIPT screening for preventable (70.9%) and nonpreventable AOCs (80.8%). Most respondents indicated concern around potential harmful impacts associated with NIPT for AOCs, including the psychological impact on the future child and on the parent (s). Despite this, the majority of participants thought that continuation of a pregnancy known to be predisposed to an AOC is ethically acceptable. The implications of these data are critically discussed and used to inform the normative claim that prospective parents should be given access to NIPT for AOCs. The study contributes to a body of research debating the ethical acceptability and regulation of various applications of NIPT as screening panels expand.

KEYWORDS

adult-onset conditions, bioethics, ethics, NIPT, prenatal screening

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1 | INTRODUCTION

Over the past decade, noninvasive prenatal testing (NIPT) has been widely adopted into obstetric care. It is now available in over 60 countries worldwide.[1] Generally performed from 10 weeks' gestation, NIPT involves the analysis of foetal cell-free DNA circulating in maternal plasma.[2] Frequently, NIPT screening panels cover trisomies 21, 18, and 13, sex chromosome aneuploidies, and foetal sex determination, but the future scope of NIPT will likely expand to include a more detailed analysis of the foetal genome,[3] significantly enhancing the extent of foetal genetic information potentially available to prospective parents.

One possible use of NIPT that is being widely discussed is screening for adult-onset conditions (AOCs), that is, conditions which most commonly manifest in adulthood.[4] This potential use of NIPT raises specific ethical concerns that do not necessarily arise for other applications of NIPT or at least not to the same extent. For example, there is controversy around the ethical acceptability of terminating a pregnancy based on an AOC, with some considering termination as depriving the future person of a 'healthy' life up until disease onset in adulthood.[5] In the case NIPT might detect a predisposition to an AOC but the pregnancy is continued, there are ethical concerns around the burden of genetic knowledge, for example psychosocial sequelae for the parent(s) and future child, genetic discrimination against the future child, and a possible violation of the future child's rights by revealing their genetic information.[6]

While ethicists have expressed concern around the implications of NIPT screening for AOCs, a full understanding of this problem is not possible without an awareness of the views of important stakeholders. For the purpose of this paper, we have focussed on NIPT users. This does not imply that the views of parents or NIPT users on this topic should be considered in isolation. It is important to consider the views and experiences of a wide range of other stakeholders. NIPT users do, however, have important experiences in pregnancy and parenthood which are likely to be valuable contributions to this morally challenging discourse.

There is currently limited research on the degree to which NIPT users are concerned about the ethical issues raised by NIPT for AOCs, or how these issues may affect actual use and uptake of NIPT. Existing empirical research has primarily assessed parents' overarching views on whether NIPT for AOCs should be made available to parents, without delving into the relevant ethical concerns. Several quantitative studies have shown a range of 29%–49% support among parents for finding out whether a child is predisposed to AOCs, with the level of support depending on the features of the AOCs in question.[7] To our knowledge, however, there are no existing quantitative studies directly addressing NIPT users' views on ethical issues which may underlie support for or rejection of the availability of this screening, such as the impacts of testing on the future child, parent(s), and parent–child relationship(s). An awareness of the concerns individuals may have will help identify the right questions to address in both theoretical ethical debate and public discourse. Furthermore, understanding the weight that users of NIPT give to particular ethical considerations can inform the development of publicly legitimate policy and practice guidelines.[8]

We undertook a survey of Australian NIPT users to ascertain their views on ethical concerns associated with screening for AOCs. In Section 1, we provide background on the existing ethical debate regarding NIPT for AOCs. In Section 2, we present and discuss our empirical data. Our survey results indicate that a majority of Australian NIPT users view that NIPT should be available to screen for AOCs, yet most also hold significant concerns over potential harms to the future child. We integrate these survey findings with our ethical discussion from Section 1 to defend the claim that NIPT for AOCs should be available to parents. Our analysis considers possible effects of using this technology for the (prospective) parents and the (future) child. We do note the use of NIPT for AOCs also has an effect on other people (e.g., siblings), and broader society, but we will not focus on these wider effects in this paper.

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2 | SECTION 1: BACKGROUND ON ETHICAL ISSUES

Ethical concerns regarding NIPT for AOCs include controversy around termination of pregnancy (TOP) to avoid having a child with an AOC,[9] as well as concerns around the sequelae were a pregnancy known to be predisposed to an AOC continued. Concerns raised include possible psychological sequelae for the future child, genetic discrimination against them, and possible violation of the future child's rights.

Such concerns, which can be broadly divided into rights-based and harm-based concerns about the future child, are complicated by the fact that the results of NIPT may, in the event of TOP, lead to there being no future child. Even so, the reliance on the future child's rights and interests has given purchase against the extension of uses of NIPT. For example, Delatycki advocates for restricting access to NIPT for AOCs by directly contrasting the rights of the future child against those of theparents: 'the decision about whether to provide a prenatal test in this scenario…must be based on who is deemed to have the greater right. Is the future individual's right to decide about testing … paramount, or is the right of the parents to have prenatal diagnosis … more important?'.[10(p. 1067)] Such objections based on consideration of the future child can broadly be separated into rights-based objections and harm-based objections.

Those arguing for restricting the use of NIPT for AOCs often use a rights-based approach, for example, arguing that the use of this screening threatens the future person's 'right not to know', as it makes it impossible for them to choose ignorance about their genetic information.[11] It is, so it has been argued, important to protect this right as individuals may prefer not to know their genetic information to avoid emotional burden associated with genetic knowledge; for instance this knowledge might create new difficult decisions which demand attention or even influence future decisions about reproductive choices.[12]

A related but distinct right is the 'right to an open future',[13] initially introduced by Joel Feinberg in 1980. This essentially describes the child's right to have their future opportunities kept intact until they can autonomously make decisions for themselves. Feinberg gives the drastic example of cutting off an infant's legs, which would violate this right by preventing the future adult from walking freely.[14] In theory, the choice to irreversibly screen an unborn foetus for AOCs could similarly violate the autonomy of the future person. This right forms a large basis on which international guidelines recommend against testing *minors* for AOCs that are untreatable or do not offer immediate benefit.[15] While initially intended to apply to the child, the open future principle has been extended to the foetus in the context of considering NIPT for AOCs.[16] This is because, as outlined by De Jong et al., testing a foetus 'de facto' amounts to testing the future child (where the pregnancy is continued to term),[17] and so this right can still meaningfully apply to foetuses that will be born.[18]

The decision to undergo NIPT for AOCs is also postulated to cause harm to the future child independently of rights-based violations. A common concern relates to psychological harm: the future child could experience reduced psychological well-being due to awareness of their predisposition to an AOC.[19] This could include poor self-esteem, harm to the parent–child relationship, and stigma directed at the child.[20] Despite these concerns, existing systematic reviews have found there is little evidence to suggest that receiving predictive genetic screening information actually confers decreased psychosocial well-being in children.[21] Other related concerns regard the possibility that individuals with a predisposition to an AOC may be denied employment or insurance, or even experience familial and community stigmatisation.[22]

Some related issues when considering the rights and interests of the future child depend on the characteristics of the AOCs in question. For example, an important point of discussion revolves around the penetrance of target genes, that is, the proportion of carriers who actually express the relevant trait or disease.[23] In cases of incomplete penetrance, such as the *BRCA1* gene mutation, the test might identify genes which might never affect the future individual. Therefore, it could be argued that AOCs with incomplete penetrance could present a stronger risk to the future child's well-being than those with a more certain outcome, as greater uncertainty about whether an AOC will eventually affect the individual might lead to greater psychological distress.

Conversely, those with a permissive approach to the application of NIPT for AOCs tend to rely on claims about the reproductive interests of

[9]de Die-Smulders, C. et al., op. cit. note 5, pp. 304–315; Bennett, op. cit. note 5, pp. 198–207.
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[15]American Academy of Pediatrics Committee on Bioethics, op. cit. note 4, pp. 1451–1455; Canadian Pediatric Society. (2003). Guidelines for genetic testing of healthy children. *Paediatric & Child Health*, *8*(1), 42–45; European Society of Human Genetics. (2009). Genetic testing in asymptomatic minors: Recommendations of the European Society of Human Genetics. *European Journal of Human Genetics*, *17*(6), 720–721.
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[18]Claesen, Z. et al., op. cit. note 16, pp. 41–49.
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[21]Wade, C. H., Wilfond, B. S., & McBride, C. S. (2010). Effects of genetic risk information on children's psychosocial wellbeing: A systematic review of the literature. *Genetics in Medicine*, *12*(6), 317–326; Wakefield, C. E., Hanlon, L. V., Tucker, K. M., Patenaude, A. F., Signorelli, C., McLoone, J. K., & Cohn, R. J. (2016). The psychological impact of genetic information on children: A systematic review. *Genetics in Medicine*, *18*(8), 755–62.
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prospective parents. While there are a range of conceptions of reproductive autonomy, evolving consensus dictates that respect for parental reproductive autonomy can be understood as allowing parents to make informed decisions within the reproductive realm which are based on meaningful reflection on their own values and preferences.[24] Different prospective parents may have different motivations in seeking out foetal genetic information, ranging from the possibility that it will inform decisions about TOP, to simply seeking information to prepare for parenthood,[25] and respect for reproductive autonomy requires that parents should be able to act on these motivations.

Some parents may undergo foetal screening for AOCs so that they can make an informed decision about whether or not to continue their pregnancy.[26] In particular, prospective parents affected by family history of a given AOC may wish to avoid passing on the condition in order to prevent further familial hardship or suffering in their offspring.

Other parents may wish to screen for AOCs to increase their knowledge of their foetus' genetic information without an intention to terminate the pregnancy.[27] Parents may hope to seek reassurance or 'peace of mind' from a low-probability result (no indication of an AOC).[28] Furthermore, a high-probability result (indication of an AOC) may be used to increase preparedness for rearing a child with a predisposition.[29] For example, NIPT for preventable AOCs such as the *BRCA* mutation could allow parents to prepare financially for cancer surveillance measures, or even the cost of a mastectomy. While NIPT for nonpreventable AOCs such as Huntington's disease cannot prepare parents to enact preventative measures, it may nevertheless be important in allowing them to prepare emotionally, by adjusting expectations to accommodate the likelihood of their offspring being affected by an AOC. It has also been suggested that parents who know that their child has a higher chance of a nonpreventable or untreatable AOC may be empowered to pursue advocacy, seek experimental treatments, or urge the research community to search for new treatment options,[30] which could possibly hasten innovation in the development of therapies.

Ultimately, there are compelling arguments that screening foetuses for AOCs could bring about psychosocial harm or rights-based violations to the future child, yet also many possibly valid reasons why parents may wish to pursue this screening. Having considered the existing debate, we will next examine the views of NIPT users before attempting to use their views to inform bioethical analysis on the subject.

[24]Johnston, J. & Zacharias, R. L. (2017) The future of reproductive autonomy. *Hastings Centre Report, 47*(S3), S6–11.
[25]Deans, Z., et al. op. cit. note 6, pp. 19–25.
[26]Bowman-Smart, H., et al. op. cit. note 7, pp. 231–238.
[27]Deans, Z., et al., op. cit. note 6, pp. 19–25.
[28]Bennett, J., op. cit. note 5, pp. 198–207; Bowman-Smart, H., Savulescu, J., Mand, C., Gyngell, C., Pertile, M.D., Lewis, S., & Delatycki, M. B. (2019). "Small cost to pay for peace of mind": Women's experiences with non-invasive prenatal testing. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 59*(5), 649–655.
[29]Haidar, H., Le Clerc-Blain, J., Vanstone, M., Laberge, A. M., Bibeau, G., Ghulmiyyah, L., & Ravitsky, V. (2021). A qualitative study of women and partners from Lebanon and Quebec regarding an expanded scope of noninvasive prenatal testing. *BMC Pregnancy Childbirth, 21*(1), 1–54.
[30]Laurie, G. (1996). The most personal information of all: An appraisal of genetic privacy in the shadow of the human genome project. *International Journal of Law, Policy and the Family, 10*(1), 74–101.

3 | SECTION 2: EMPIRICAL SURVEY

There is limited research on the degree to which NIPT users are concerned about the various ethical issues raised by NIPT for AOCs. Existing empirical research has primarily assessed the views of parents and healthcare practitioners (HCPs) on whether NIPT for AOCs should be accessible, without examining their views on the underlying ethical considerations such as psychosocial impacts, the future child's rights, and the possible benefits for parents.[31] A literature search did not identify any quantitative studies directly addressing participants' views on the impacts of this screening in these domains. We sought to remedy this research gap through a study that quantitatively assessed the magnitude of concern that NIPT users' may have around specific ethical issues raised in relation to NIPT for AOCs. Incorporating these data, we aimed to develop an account of how the ethical views of NIPT users can inform bioethical debates around NIPT screening for AOCs.

3.1 | Methods

Ethics approval was granted by the Monash University Human Research Ethics Committee on the 16th July 2021 (project Number 29350).

3.1.1 | Participants and recruitment

We surveyed Australian individuals or partners of individuals who had previously undergone NIPT, as they are direct stakeholders in this area with experience of pregnancy and parenthood. They also have pre-existing familiarity with NIPT, which could aid their understanding of and engagement with survey content.

Participants were recruited through advertisements posted on online fertility, pregnancy, and parenting forums and websites directed towards Australian users, namely: BubHub, EveryBump, BabyCenter, Melbourne Mums Groups, and North Sydney Mums Group. Participants under 18 years and those who had never used NIPT were excluded. Before providing consent, participants were directed to an explanatory statement containing study information, inclusion and exclusion criteria, possible risks and benefits of participating, participant anonymity, and data management and storage information.

3.1.2 | Data collection

The survey commenced by ascertaining information about participants' past experiences with NIPT, including test results. The next

[31]Bowman-Smart, H., et al., op. cit. note 7, pp. 231–238; Millo T., et al. op. cit. note 7, pp. 376–383; Borry, P., et al. op. cit. note 7, pp. 35-43; van Schendel, R. V., et al. op. cit. note 7, pp. 598–604.

survey component comprised 40 questions with 5-point Likert scales (*definitely not*, *probably not*, *unsure*, *probably*, and *definitely*). Participants were presented with a number of traits and conditions which are current frequent uses of NIPT (foetal sex, Down syndrome, trisomies 21, 13, and 18), as well as preventable AOCs and nonpreventable AOCs. AOCs were described to participants as 'genetic conditions [which] only start affecting you when you are an adult'. Furthermore, preventable AOCs were defined as those AOCs where 'something can be done to stop the disease happening', and the example of hereditary bowel cancer was used. Nonpreventable AOCs were defined as those where 'nothing can be done to stop the disease', and the example of Huntington's disease was provided. Questions ascertained support for availability of NIPT for each trait/condition listed, as well as personal interest in screening for that trait/condition. Participants were then asked to indicate their level of agreement with relevant ethical issues around NIPT for AOCs, including their views on the ethical acceptability of continuing pregnancies diagnosed with AOCs. Lastly, sociodemographic data were collected, which included age, gender, education level, household income, marital status, and child-bearing status. Administered on Qualtrics, the survey contained 79 questions and was estimated to take 15 min to complete.

The scope of the survey did not address all possible factors informing views on screening for AOCs. It was limited to questions about features of AOCs such as preventability, because, due to the long time between detection of foetal genetic information and possible onset of disease in adulthood, much of the individual and collective focus would likely revolve around whether disease onset can be prevented in predisposed individuals during that time, rather than the treatability after disease onset in adulthood. Likewise, the survey did not address the varying penetrance of AOCs in question in order to retain focus on the ethical issues associated with NIPT screening for AOCs in general, rather than moving the focus to the particular characteristics of AOCs which make them more or less favourable as individual screening targets.

Likewise, the issue of cost of NIPT was not addressed to reduce confounding of participants' ethical views by considerations of distributive justice and resource allocation. Therefore, when discussing whether NIPT for AOCs should be accessible by parents, the term 'available' was used broadly without specification into whether this meant available within the public healthcare system or at a cost.

3.1.3 | Data analysis

SPSS version 27 was used to analyse the collected data, imported as an SPSS file from Qualtrics. Nine respondents were excluded due to significantly incomplete surveys (defined as less than 25% survey completed). For analyses, 5-point Likert scales were collapsed to 3-point scales (*positive*, *unsure*, and *negative*). Data were summarised using descriptive statistics (frequencies and percentages). The actual number of responses was used as the denominator (actual *n*) for the calculation of frequencies where there were missing responses. Chi-square tests were conducted to explore associations between demographic characteristics and support for NIPT for AOCs. The Bonferroni-corrected *p*-value was 0.004 based on the number of tests performed.

3.2 | Results

A total of 118 responses were received between July and September 2021, with 109 eligible respondents after exclusion criteria were applied. Demographic characteristics are shown in Table 1.

3.2.1 | Views on NIPT for adult-onset conditions and resulting terminations

Participants expressed strong support for NIPT screening for AOCs. Overall, 70.9% ($n = 73/103$) thought that NIPT should be available to find out about preventable AOCs, such as increased probability of bowel cancer, and 73.5% ($n = 75/102$) were personally interested in using NIPT for this purpose. Similarly, 80.8% ($n = 80/99$) of respondents thought that NIPT should be available for non-preventable AOCs, such as Huntington's disease, with 74.7% ($n = 74/99$) of them personally interested in this testing. No significant correlations were found between any demographic characteristics and support for NIPT for AOCs.

There was little support for the ethical permissibility of TOP based on AOCs. Most participants (81.6%) thought that it was ethically unacceptable to terminate based on preventable AOCs ($n = 84/103$). Support was lower in regard to TOP based on nonpreventable AOCs: 39.4% ($n = 39/99$) thought that it was ethically acceptable to terminate these pregnancies, with 28.3% ($n = 28/99$) finding this ethically unacceptable and 32.3% ($n = 32/99$) unsure. Similarly, 91.3% ($n = 94/103$) expressed that they would not personally consider a TOP based on a preventable AOC, while there was less consensus whether participants would personally consider a TOP based on a nonpreventable AOC: 33.3% ($n = 33/99$) would consider it, 31.3% ($n = 31/99$) would not consider it, and 35.4% ($n = 35/99$) were unsure.

3.2.2 | Views on potential impacts of NIPT for adult-onset conditions

As displayed in Figure 1, most participants indicated concern around the possibility of harmful impacts associated with NIPT for AOCs, both preventable and nonpreventable. Specifically, the majority agreed that the future child and parent(s) would likely feel distressed or anxious knowing about the child's predisposition to an AOC, with more participants concerned for non-preventable AOCs over preventable AOCs. There were variable responses when asked whether parents knowing their child is predisposed to an AOC

TABLE 1 Demographic characteristics of study cohort.

Participant characteristic	Participants (*n*)	Percentage (%)
Age (years), *n* = 109		
18–25	2	1.8
26–30	15	13.8
31–35	50	45.9
36–40	29	26.6
41+	13	11.9
Gender, *n* = 96		
Male	1	1.0
Female	95	99.0
Nonbinary or other	0	0.0
Highest completed level of education, *n* = 96		
Secondary school (year 10 or below)	1	1.0
Secondary school (VCE or equivalent)	1	1.0
Technical or trade certificate	10	10.4
Bachelor's degree	40	41.7
Postgraduate qualification (e.g. Masters, PhD)	44	45.8
Combined household income after tax, *n* = 96		
Less than $25,000	0	0.0
$25,000–$49,999	0	0.0
$50,000–$99,999	9	9.4
$100,000–$149,999	19	19.8
$150,000–$199,999	25	26.0
$200,000–$299,999	27	28.1
More than $300,000	12	12.5
Prefer not to say	4	4.2
Marital status, *n* = 96		
Single	1	1.0
Partnered	18	18.8
Married	77	80.2
Current number of children, *n* = 96		
0	9	9.4
1	51	53.1
2	30	31.3
3	5	5.2
4	1	1.0
Pregnancy status, *n* = 96		
Not pregnant	67	69.8
Pregnant	27	28.1
Unsure	2	2.1
Intends on having more children, *n* = 96		
No	31	32.3
Yes	45	46.9
Unsure	20	20.8
Personal history of any conditions mentioned in the survey, *n* = 96		
No	92	95.8
Yes	4	4.2
Family history of any conditions mentioned in the survey, *n* = 96		
No	82	85.4
Yes	14	14.6

would affect the parent–child relationship. Participants mainly agreed that NIPT for AOCs would assist parents to prepare better for the future, especially for preventable AOCs.

In a varied response, 47.4% (*n* = 46/97) thought that the child has a right not to know whether they are predisposed to AOCs, 26.8% (*n* = 26/97) denied the child has this right, and 25.8% (*n* = 25/97) remained unsure. Despite these concerns, 68.7% (*n* = 68/99) believed parents should tell their child about their predisposition to a preventable AOC and 56.6% (*n* = 56/99) about a nonpreventable AOC.

3.2.3 | Views on continuation of pregnancies diagnosed with adult-onset conditions

Most participants (90.6%) indicated that it is ethically acceptable to continue a pregnancy where the foetus has been diagnosed with a preventable AOC, while 62.5% indicated it is acceptable to continue pregnancies with nonpreventable AOCs (Figure 2).

3.3 | Discussion of empirical findings and ethical analysis

This study sought to explore Australian NIPT users' views on NIPT for AOCs and to use these views to inform bioethical discussion. Other quantitative and qualitative studies have examined parents', HCPs', and NIPT users' general views towards testing for AOCs, but in this study, we examined more closely participants' attitudes towards the key underlying considerations present in the ethical debate.

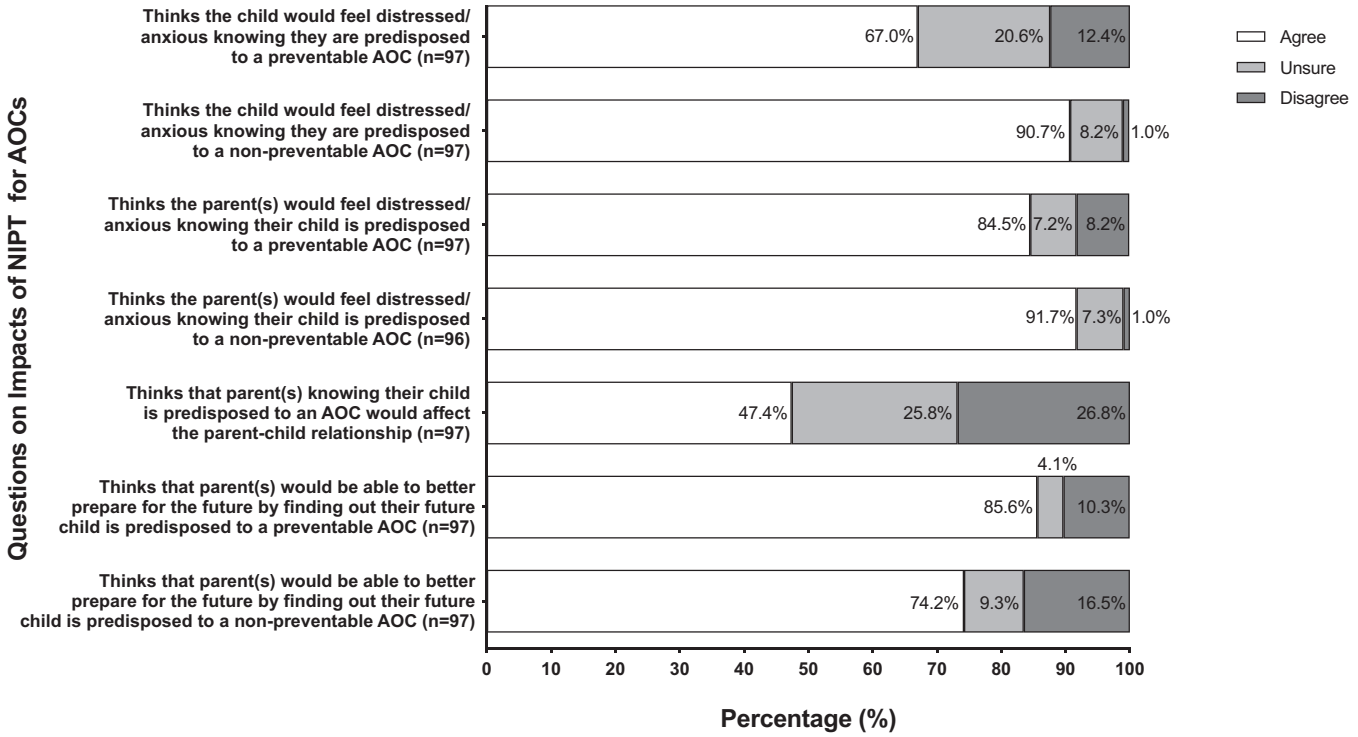

FIGURE 1 Participant views on the potential impacts of noninvasive prenatal testing (NIPT) for adult-onset conditions. Figure displays frequencies (percentages) of the sample with agree, unsure, and disagree responses to questions asking about possible beneficial and harmful implications of NIPT for adult-onset conditions (AOCs).

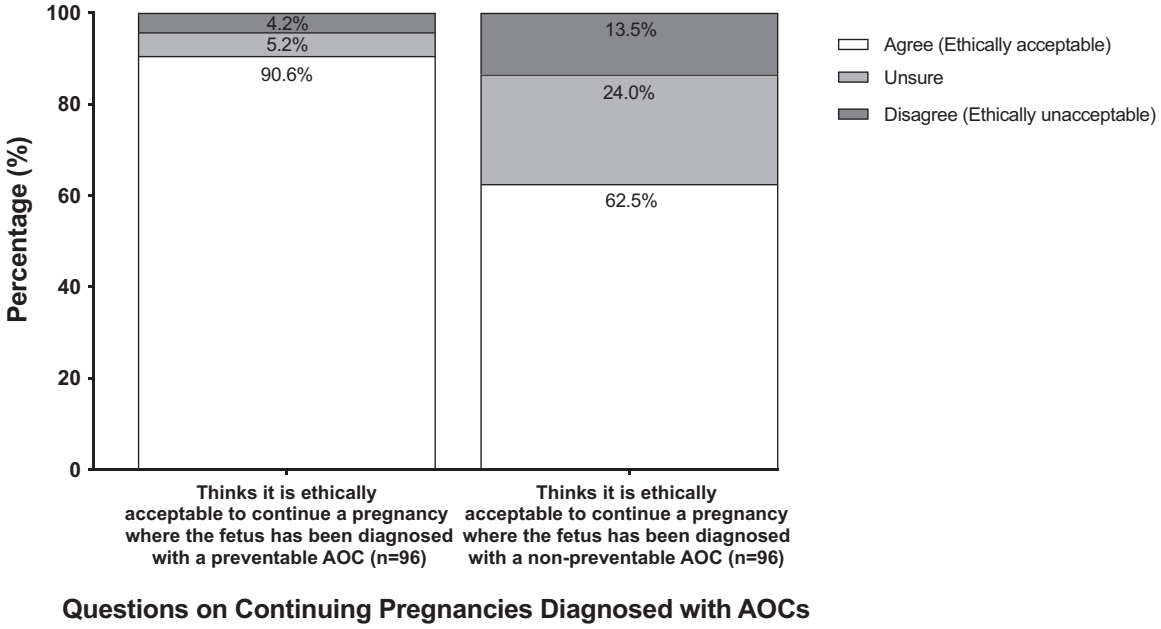

FIGURE 2 Participant views on the ethical acceptability of continuing pregnancies diagnosed with preventable and non-preventable adult-onset conditions. Figure displays frequencies (percentages) of the sample with agree, unsure, and disagree responses to questions asking about continuation of pregnancies diagnosed with preventable and unpreventable adult-onset conditions (AOCs).

A key finding was that most participants showed support for NIPT for both preventable and non-preventable AOCs. This differs from existing data, which generally shows lower parental support for NIPT for AOCs.[32] This finding might relate to several factors, including recruitment method and survey design, as well as different contexts and time periods during which data was collected. For instance, the sample here consists entirely of individuals who have previously used NIPT, which may be associated with differences in their desire to know foetal genetic information compared to other samples of parents who might not necessarily have previously undertaken NIPT.

Many respondents maintained that parents should be able to decide for themselves about whether they wish to undertake the consequences of genetic knowledge. This position is reflected in a range of arguments in the ethical literature, such as a respect for the concept of reproductive autonomy, or a view that information gathering in itself might be of value by enhancing knowledge.[33] Regardless, making the free decision to screen a foetus for AOCs impacts parents themselves but also their future child, therefore to endorse granting parents this freedom ultimately implies that parents should be the caretakers of the future child's interests in addition to advocates for their own interests.

Interestingly, a greater proportion of this sample supported NIPT for nonpreventable AOCs compared to NIPT for preventable AOCs, which differs from findings in existing literature.[34] This might suggest that support for screening is somewhat dependent on the likelihood of the screening target being actioned by TOP; support for NIPT for nonpreventable AOCs may be greater as this information is more likely to inform the decision for TOP than NIPT for preventable AOCs. This proposition is bolstered by the proportion of the sample that would personally consider TOP based on nonpreventable AOCs, which was greater than that for TOP based on preventable AOCs.

Nevertheless, TOP based on AOCs was thought of as ethically acceptable by a minority only, particularly in relation to preventable AOCs: most participants thought that TOP for preventable AOCs was ethically unacceptable, while participants were very divided on the ethical acceptability of TOP for nonpreventable AOCs. Interestingly, however, the majority of participants who opposed TOP based on AOCs still advocated for the availability of, and personal interest in, NIPT for these conditions; for example, while 84 participants thought that TOP based on preventable AOCs was ethically unacceptable, 60 of these (71.4%) still thought NIPT for preventable AOCs should be available. This could reflect that participants approve of screening for reasons other than to inform termination decisions. In particular, in the case of NIPT for preventable AOCs, genetic information could be deemed as important because it is considered actionable after birth through preventative measures. Additionally, the majority of participants agreed that discovering foetal information about AOCs would enable parents to better prepare for the future in the event that they continued the pregnancy, aligning with existing empirical findings.[35] Overall, these results ultimately affirm that NIPT users likely see value in NIPT for AOCs outside of informing TOP decisions.

This is a central finding which speaks to the way that NIPT users likely interpret the purpose of NIPT. Specifically, it suggests an underlying view that NIPT should provide an opportunity for parents to obtain information about their future child's genome that might be of value to them. This connects with the debate around personal utility in genomics and the various ways it can be understood (e.g., affective outcomes, cognitive outcomes, behavioural outcomes).[36] In contrast to this, traditional recommendations advocate for an approach involving only testing for findings that will be conventionally 'actionable', meaning able to result in some kind of preventative or treatment measure, broadly including TOP in the prenatal context.[37]

Despite this, the analysis that perhaps NIPT users in this sample might see value in NIPT for AOCs outside of informing TOP is a pertinent one which might offer an opportunity to broaden our understanding of the purpose of NIPT. For example, it is certainly perceivable that parents could derive benefit from improved planning for the birth of a child with a possible genetic condition, even if they do not wish to terminate their pregnancy. Moreover, parents and future children could benefit from knowledge of a probability profile for an AOC, allowing them to make modifiable lifestyle changes which could lower their probability. As such, as the capabilities of NIPT expand, perhaps it will no longer solely aim to inform whether a pregnancy is continued, but also may aim to assist in planning for the life of a person with a possible genetic condition.

Importantly, most participants stated they believed that information about AOCs could cause distress in the future child and parent(s). This confirms that, in spite of their support for the availability of this screening, NIPT users still indicate concern about the future child's

[32]Borry, P., et al. op. cit. note 7, pp. 35–43; Millo T., et al. op. cit. note 7, pp. 376–383; van Schendel, R. V., et al. op. cit. note 7, pp. 598–604; Bowman-Smart, H., et al., op. cit. note 7, pp. 231–238.

[33]Williams, J., Erwin, C., Juhl, A., Mills, J., Brossman, B., & Paulsen, J. S. (2010) Personal factors associated with reported benefits of Huntington disease family history or genetic testing. *Genetic Testing and Molecular Biomarkers*, *14*(5), 629–636.

[34]Bowman-Smart, H., et al., op. cit. note 7, pp. 231–238; Sullivan, H. K. B., Bayefsky, M., Wakim, P. G., Huddleston, K., Biesecker, B. B., Hull, S. C., & Berkman, B. E. J. D. (2019). Noninvasive prenatal whole genome sequencing: Pregnant women's views and preferences. *Obstetrics & Gynecology*, *133*(3), 525–532; Kalynchuk, E. J., Althouse, A., Parker, L. S., Saller, D. N., & Rajkovic, A. (2015). Prenatal whole-exome sequencing: Parental attitudes. *Prenatal Diagnostics*, *35*(10), 1030–1036.

[35]Bowman-Smart, H., et al., op. cit. note 7, pp. 231–238; Haidar, H., et al., op. cit. note 29, pp. 1–54; Sullivan, H.K.B., et al., op. cit. note 34, pp. 525–532; Bakkeren, I. M., Kater-Kuipers, A., Bunnik, E. M., Go A. T. J. I., Tibben, A., de Beaufort, I. D., & Riedijk, S. R. (2020). Implementing non-invasive prenatal testing (NIPT) in the Netherlands: An interview study exploring opinions about and experiences with societal pressure, reimbursement, and an expanding scope. *Journal of Genetic Counselling*, *29*(1), 112–121.

[36]Kohler, J. N., Turbitt, E. & Biesecker, B. B. (2017) Personal utility in genomic testing: a systematic literature review. *European Journal of Human Genetics*, *25*(6), 662–668.

[37]Horn, R. & Parker, M. (2018) Opening pandora's box?: Ethical issues in prenatal whole genoma and exome sequencing. *Prenatal Diagnosis*, *38*(1), 20–25; Jarvik, G. P., Amendola, L. M., Berg, J. S., Brothers, K., Clayton, E. W., Chung, W...Burke, W. (2014) Return of genomic results to research participants: The floor, the ceiling, and the choices in between. *The American Journal of Human Genetics*, *94*(6), 818–826.

welfare and the functioning of the family unit. Furthermore, almost half of the sample (47.9%) agreed that the future child has a right not to know their genetic information. Despite this, most participants indicated that parents should inform their future child of any predisposition to AOCs. These findings add weight to previous qualitative research whereby study participants have expressed concerns over possible psychosocial impacts.[38] Evidence that NIPT users remain concerned about these harmful impacts should encourage on-going empirical investigation into the legitimacy of the concerns.

We do acknowledge that, from a research perspective, there would likely be methodological challenges in demonstrating a causal link between screening for AOCs and any subsequent psychosocial hardship in children. This prompts the normative question of whether *hypothetical* harms to the future child should be considered morally significant enough to restrict parents' from accessing NIPT for AOCs. Within the discourse around screening *children* for AOCs, risks to the child are deemed too great to allow parents to pursue predictive genetic testing.[39] It has been argued that screening a foetus for an AOC without intention to terminate the pregnancy is morally equivalent to screening a child.[40]

However, it has also been argued that the status of the foetus as not-yet-born means that its interests and rights are to be considered differently from the rights and interests of a child.[41] A basic example of this is the widely held belief that TOP is acceptable, at least in some cases, without being morally akin to murder, yet the killing of a child is never acceptable. Additionally, in a regulatory sense, maternal lifestyle factors which may lead to harm to a future child, such as antenatal smoking, have not been subject to legal intervention.[42] These examples illustrate the notion that, while the foetus may develop into a child with distinct rights and interests, in its foetal state these rights are not yet fully realised and will crystallise upon birth.[43] As a result, the status of the foetus as unborn might mean, from a regulatory standpoint, that screening for AOCs during pregnancy is considered somewhat distinct or different from screening for AOCs during childhood.[44] As such, if harms to the future child were considered a real and significant risk, while they may become an important consideration for parents seeking to access NIPT for AOCs, such harms might not be able to justify regulatory action which restricts parents who make an informed decision to undergo NIPT for AOCs.

We interpret the fundamental moral conflict indicated by this survey to be: most participants uphold concerns about the well-being of the future child and parent(s) due to knowledge of genetic information about AOCs, and, to a lesser extent, the child's right not to know this genetic information, yet still maintain the belief that prospective parents should have the choice to use NIPT for AOCs. In other words, NIPT users think that considerations around possible harms are not compelling enough to conclude restricting screening access is necessary. This might reveal the extent to which NIPT users value and prioritise the unique nature of the foetal–maternal relationship: many NIPT users acknowledge their concerns around harms from this screening, yet maintain that parents should be able to decide about NIPT for AOCs for themselves in line with their own preferences and values. Based on a model of informed reproductive autonomy, this would ideally involve parents undertaking their own reflective process to decide whether screening for AOCs meaningfully aligns with their own values or whether possible risks might be too great.

It is important to acknowledge, however, that there are possibly social norms which might have influenced NIPT users' attitudes. Reproductive choices are undoubtedly influenced not only by personal and family values but also by social context.[45] One possible influence is the misconceived assumption that more information is always better for everyone, which neglects the complexity of many genomic test results. This misconception goes hand-in-hand with the 'technological imperative', which is a blind acceptance that technological development and application are inevitable and necessary without appropriate interrogation of the ethical, social, and legal consequences.[46]

Genetic counselling is a measure that could be utilised to account for the social context in which decisions are made, and ensure parents' decisions are as informed as possible. Allowing unrestricted access to this screening should, undoubtedly, involve enforcement of a strong responsibility for clinicians to provide thorough counselling to parents about the possible implications, both good and bad, of their decisions on the future child and the family unit. Providing personalised genetic counselling for all parents interested in this screening may be practically unfeasible given workforce shortages. Efforts could therefore be directed at alternatives, such as upskilling of midwives and obstetricians to provide appropriate counselling. Furthermore, population-based genetic counselling resources such as decision aids, online information, and videos could provide a level of fundamental education and discussion important for prospective parents to consider before examining these decisions with their pregnancy provider.

Study limitations include a relatively small sample size ($n = 109$). Notably, most recruitment took place while Victoria and New South Wales were under strict lockdown orders due to the COVID-19 pandemic, and it is unclear whether this affected recruitment success. Additionally, the uniform geographical location, high socioeconomic

[38]Haidar, H., et al., op. cit. note 28, pp. 1–54; Kalynchuk, E. J., et al., op. cit. note 34, pp. 1030–1036.
[39]American Academy of Paediatrics, op. cit. note 4, pp. 1451–1455.
[40]Deans, Z., et al., op. cit. note 6, pp. 19–25.
[41]Taylor-Sands, M. & Bowman-Smart, H. (2019) Non-invasive prenatal testing for adult-onset conditions: Reproductive choice and the welfare of the future child. *Melbourne University Law Review*, *45*(2), 730–778.
[42]Ibid.
[43]Ibid.
[44]Ibid.
[45]Price, N. & Hawkins, K. (2007) A conceptual framework for the social analysis of reproductive health. *Journal of Health, Population, and Nutrition*, *25*(1), 24–36.
[46]Kluge, E-H. W. (2011) Ethical and legal challenges for health telematics in a global world: Telehealth and the technological imperative. *International Journal of Medical Informatics*, *80*(2), e1–5.

status, and high proportion of female respondents also reduce the generalisability of the findings. The survey platform was online, which may have restricted recruitment to those with relevant technology and skills to navigate the online format. Participants were also self-selected, which could have introduced bias. The fact that all participants had previously used NIPT may have meant this sample was more engaged with advancements in genetic screening technology, and therefore more open-minded to expanding screening panels. Lastly, with regard to the survey stimulus and questions, the examples provided (i.e., bowel cancer and Huntington's disease) may have introduced bias related to particpants' level of understanding of, or personal experience with, these conditions.

This research contributes to a growing body of evidence around acceptable prenatal screening targets as technological advances enhance our ability to noninvasively uncover genetic information about the unborn foetus. In particular, it highlights that the concept of reproductive autonomy might form the basis of NIPT users' endorsement of the acceptable availability of NIPT for AOCs. Future bioethical analysis could develop greater understanding of whether, from a regulatory perspective, the moral status of the foetus is such that consideration of the *future* child's rights and interests could impact the antenatal decision-making of prospective parents. Undoubtedly future empirical research should seek to characterise the experiences of children who are made aware of their genetic information about AOCs before they can autonomously make this decision for themselves, in order to determine whether harms to the future child are, in fact, a real and significant risk.

4 | CONCLUSION

This paper used an empirical study of users' views as a basis for bioethical analysis on the topic of NIPT for AOCs. Providing scope for the perspectives of NIPT users in this discourse allows for a more balanced understanding which characterises the concerns of key stakeholders. Our sample supported the view that NIPT for AOCs should be available to prospective parents, despite strongly agreeing with the possibility of harm to the future child and the family unit from NIPT. The finding that users are concerned about those harms provides a strong reason for continued investigation into the well-being of children who are aware of their genetic predisposition to AOCs. We hope that this research can, by incorporating the voices of relevant groups, eventually culminate in feasible guidelines and policies which observe the attitudes of NIPT users.

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