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Community awareness and use of anti-Müllerian hormone testing in Australia: a population survey of women

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ABSTRACT

STUDY QUESTION: What is the anti-Mullerian hormone (AMH) test usage, awareness, and perceived reasons for testing in a representative community sample of women in Australia?

SUMMARY ANSWER: : Among women aged 18–55 years, 13% had heard about AMH testing and 7% had had an AMH test, with the top three reasons for testing including due to infertility investigations (51%), considering pregnancy and wanting to understand their chances (19%) or to find out if a medical condition had affected fertility (11%).

WHAT IS KNOWN ALREADY: The growing availability of direct-to-consumer AMH testing has raised concerns about overuse, however as most AMH tests are paid for privately by consumers, data on test usage is not publicly available.

STUDY DESIGN, SIZE, DURATION: National cross-sectional survey of 1773 women, conducted in January 2022.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Females aged 18–55 years were recruited from the representative 'Life in Australia' probability-based population panel and completed the survey online or by telephone. Main outcome measures included if and how participants had heard about AMH testing, whether they had ever had an AMH test, main reason for testing and test access.

MAIN RESULTS AND THE ROLE OF CHANCE: Of the 2423 women who were invited 1773 responded (73% response rate). Of these, 229 (13%) had heard about AMH testing and 124 (7%) had had an AMH test. Testing rates were highest among those currently aged 35–39 years (14%) and associated with educational attainment. Almost all accessed the test through their general practitioner or fertility specialist. Reasons for testing were: part of an infertility investigation (51%), considering pregnancy and wanting to understand chances of conceiving (19%), finding out if a medical condition had affected fertility (11%), curiosity (9%), considering egg freezing (5%), and considering delaying pregnancy (2%).

LIMITATIONS, REASONS FOR CAUTION: Although the sample was large and mostly representative, it was over-represented by people holding a university degree and under-represented by people aged 18–24, however, we used weighted data where possible to account for this. All data were self-reported so there is a risk of recall bias. The number of survey items was also restricted, so the type of counselling women received prior to testing, reasons for declining an AMH test or test timing were not measured.

WIDER IMPLICATIONS OF THE FINDINGS: Whilst most women reported having an AMH test for appropriate reasons, about one third had it for reasons not supported by evidence. Public and clinician education about the lack of utility of AMH testing for women not undergoing infertility treatment is needed.

STUDY FUNDING/COMPETING INTEREST(S): This project was supported by a National Health and Medical Research Council (NHMRC) Centre for Research Excellence grant (1104136) and Program grant (1113532). T.C. is supported by an NHMRC Emerging Leader Research Fellowship (2009419). B.W.M. reports research funding, consultancy and travel support from Merck. D.L. is the Medical Director of City Fertility NSW and reports consultancy for Organon, Ferring, Besins and Merck. The authors have no other competing interests.

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Introduction

Anti-Mullerian hormone (AMH) is produced by granulosa cells in small follicles, and its concentration reflects the functional ovarian follicle pool (Dewailly and Laven, 2019). AMH levels can be measured by a blood test and are inversely related to age, giving an indication of ovarian reserve, or the number of eggs remaining in the ovaries (Hunt and Vollenhoven, 2020). The AMH test can be helpful in assisted reproduction as AMH levels are associated with the potential number of eggs retrievable for IVF or egg freezing (Broer *et al.*, 2013). Based on the AMH-predicted response, adjustment of the gonadotrophin dose (i.e. giving a lower dose in cases of predicted high response) might reduce the risk of ovarian hyperstimulation syndrome (Lensen *et al.*, 2018). However, the AMH test cannot reliably predict the likelihood of pregnancy or time to pregnancy, particularly outside of fertility treatment settings (Steiner *et al.*, 2017; Lin *et al.*, 2021; Harris *et al.*, 2022). For example, a cohort study of women aged 30–44 years without a history of infertility found that, compared to women with normal AMH levels (n = 579), women with low AMH levels (n = 84) did not have a significantly different predicted probability of conceiving after 6 (62% versus 65%) or 12 cycles (75% versus 84%, respectively) (Steiner *et al.*, 2017). Additionally, whilst studies have found AMH can broadly predict onset of menopause at a population level, predictions have wide intervals, making their clinical application for individual women largely uninformative (Depmann *et al.*, 2018; De Kat *et al.*, 2021). Consequently, the big question of whether a woman will experience premature menopause cannot be answered by the AMH test (Depmann *et al.*, 2018; De Kat *et al.*, 2021). Given this, college recommendations in the USA discourage AMH testing for women without an indication of infertility (Practice Committee of the American Society for Reproductive Medicine, 2015; ACOG committee opinion, 2019), however no equivalent guidance has been produced by the relevant professional colleges in Australia.

Despite its limitations, promotion of the AMH test as a way for women to determine their current and future fertility seems more widespread than ever before. Indeed, our recent content analysis of Australian and New Zealand fertility clinic websites found many websites made claims about the utility of the test that are not evidence-based, such as claims that the test is predictive of a woman's chances of conceiving or that it can identify a woman at risk of early menopause (Copp *et al.*, 2021). Academic research can also perpetuate the notion that AMH testing is a useful tool in reproductive life planning (Evans *et al.*, 2018).

Efforts to promote and support the quality use of medical tests in Australia (e.g. judicious use of testing, testing only with consumers' fully informed consent) are reliant on comprehensive information on test usage. However, because the AMH test is not subsidized by Australia's universal health scheme (Medicare), most AMH tests ordered by doctors in Australia are paid for privately by consumers and data on current usage are therefore not publicly available. In addition, direct-to-consumer AMH testing is now widely available in the USA (Kyweluk, 2020), Australia and the UK, conflicting with guideline recommendations and exacerbating the problem of unknown patterns of use. We therefore sought to conduct the first investigation into AMH test usage in Australia and examine test awareness among consumers, testing prevalence, and consumer perspectives related to test uptake.

Materials and methods

Study population

Data were collected via an online or telephone survey of the Life in Australia™ probability-based population panel in January 2022 (Kaczmirek *et al.*, 2019). The panel was established by the Australian National University Social Research Centre in 2016, using random probability-based sampling methods and covering both online and offline populations and is the most methodologically rigorous and representative panel in Australia. Life in Australia panel members consist of Australian residents aged 18 years or older who were randomly recruited via their landline or mobile phone using dual-frame random digit dialling and provided their contact details to take part in surveys on a regular basis (Kaczmirek *et al.*, 2019). Panel members receive a small financial incentive for joining the panel and another incentive for each survey they complete. All active female panel members aged 18–55 years were invited to participate in the current study.

Ethics approval

This study was approved by the University of Sydney Human Research Ethics Committee (2021/893).

Procedure

The current study questions were included in the January 2022 survey wave administered by the Social Research Centre. Participants were informed the survey included questions added on behalf of the University of Sydney. Data collection was conducted from 17 to 31 January 2022 using both online and telephone surveys to enable people without internet access to participate. All female panel members aged 18–55 years were initially invited to complete the survey via email or text message. Non-responders were sent up to three email reminders, followed by reminder calls (maximum of six call attempts for landline, four for mobile) in the second week of fieldwork (25–30 January).

Measures

Survey questions about the AMH test included whether participants had ever had an AMH test, the main reason for AMH testing, how the test was accessed and how participants first heard about AMH testing (see Table 1 for question wording and response options). These items consisted of three newly developed and two adapted (Vakkas *et al.*, 2023) measures that were revised through discussions with the multidisciplinary study team and then pilot tested for comprehension and length with three women fitting eligibility criteria who had had an AMH test. Demographic data collected included state, region (capital city, rest of state), Socio-Economic Indexes for Areas (SEIFA; index of relative socio-economic disadvantage), gender, age group, country of birth, language other than English spoken at home, Indigenous status, and highest level of education.

Statistical analyses

To ensure the sample was representative of the Australian population, initial results examining demographic characteristics by AMH testing status were weighted to population benchmarks using propensity scores. Data were analysed using SPSS Version 28 (IBM Corp, 2021). Associations between demographic characteristics and testing status were examined using chi-square tests. Reasons for testing were grouped into medical or elective. Testing as part of infertility investigations, to assess ovarian reserve due to a medical condition and egg donation were deemed medical. Testing related to being curious about fertility, considering getting pregnant soon and wanting to understand their chances of conceiving or due to considering delaying pregnancy were deemed elective reasons. We also classified considering egg freezing as an elective reason as although an AMH test can help set expectations and give an indication of how many egg retrieval cycles may be needed and therefore

Table 1. Study questions about the Anti-Müllerian Hormone (AMH) test.

Item	Responses and reference (if applicable)
1)	**Have you ever had an Anti-Müllerian Hormone (AMH) blood test, sometimes called the "egg timer" or "ovarian reserve" test?** a) Yes b) No c) Don't know d) Prefer not to say
2)	(*If yes to 1*) **What was the main reason for AMH testing? (please select the option that fits best)** (Vakkas *et al.*, 2023) a) I was considering freezing my eggs b) I was curious about my fertility c) I was considering getting pregnant soon and wanted to understand my chances of conceiving d) I was considering delaying pregnancy and wanted to know if this was a good idea or not e) To find out if a medical condition had affected my fertility (e.g. chemotherapy or radiotherapy, PCOS, endometriosis, thyroid issues, surgery, family history of premature menopause, other) f) It was part of infertility investigations (I had already been having trouble conceiving) g) Other (please specify) h) Don't know i) Prefer not to say
3)	(*if yes to 1*) **How did you access the test?** a) Through my GP b) Through a fertility clinic c) Through an online website d) Other (please specify) e) Don't know f) Prefer not to say
4)	(*if haven't had an AMH test*) **Have you ever heard of Anti-Mullerian Hormone (AMH) testing?** a) Yes b) No c) Don't know d) Prefer not to say
5)	(*if yes to 1 or 4*) **How did you first hear about AMH testing?** (Vakkas *et al.*, 2023) a) Friends or family b) Recommended by my GP c) Recommended by my fertility specialist d) Internet advertisement/Google e) Through social media f) TV/radio/podcast g) Other (please specify) h) Don't know i) Prefer not to say

the cost when a person has decided to freeze their eggs, AMH testing is not useful for those in the pre-contemplation or contemplation phase of the egg freezing decision-making process. For example, egg freezing should not be recommended on the basis of a low AMH level as this is not in accordance with evidence about the test's predictive value. *P*-values <0.05 were considered to indicate statistical significance.

Results

Participants

Of the 2423 active and eligible Life in Australia panel members invited to take part, 1773 completed the survey (73.2% response rate). Reasons for non-participation included declined to take part (2.3%) or being non-contactable/unable to complete the survey during the fieldwork period (24.5%). Unadjusted demographic characteristics of the sample roughly matched the general population in terms of key demographic characteristics; however, the sample was more highly educated (55% versus 35% of general population holding a university degree (Australian Bureau of Statistics, 2021)) and there was underrepresentation of people aged 18–25. Table 2 shows the weighted demographic characteristics of the sample.

Community awareness and usage of the AMH test

Of all participants, 228 (13%) had heard about AMH testing and 124 (7%) reported having had an AMH test (54% of those who had heard of the test). Testing rates were highest amongst those aged 35–39 years (14% aged 35–39 years reported having had an AMH test; see Figure 1 for testing rates by age). Having had the test was associated with current age and higher educational attainment ($P < 0.05$), but no other socio-demographic characteristics (Table 2).

Of the 228 participants who had heard about AMH testing, the most common information sources were fertility specialists (29%), followed by friends or family (23%) (Table 3). The distribution of information sources differed by testing status ($\chi^2 = 121.59$, $P = <0.001$), with those having had an AMH test mostly first hearing about it from their GP or fertility specialist, whereas those who have not had an AMH test mostly first hearing about the test through friends/family or through seeing it on TV/radio/podcast/advertised online/social media (Table 3).

Reasons for testing

Of the 124 participants who reported having had an AMH test, 63 (51%) indicated it was part of infertility investigations, 24 (19%) because they were considering getting pregnant soon and wanted to understand their chances, 14 (11%) to find out if a medical condition had affected their fertility, 11 (9%) because they were curious about their fertility, 6 (5%) because they were considering egg freezing, and 3 (2%) because they were considering delaying pregnancy and wanted to know if this was a good idea or not. Only one participant (1%) specified 'other', explaining it was because she had donated her eggs, and two participants indicated 'don't

Table 2. Weighted* demographic characteristics of sample (%) by testing status.

	Total sample (unweighted N = 1764#, weighted N = 1763.5) %	Have had an AMH test (unweighted n = 124, weighted n = 101.7) %	Have not had an AMH test (unweighted n = 1640, weighted n = 1661.8) %	Statistical test values** χ^2	P
Age group				**35.925**	**<0.001**
18–24 years	16.5	2.4	17.4		
25–34 years	28.8	28.9	28.8		
35–44 years	27.1	49.3	25.7		
45–54 years	25.2	18.5	25.6		
55 years	2.5	0.8	2.6		
Education				**17.662**	**0.017**
<Year 12	7.3	4.1	7.5		
Year 12	24.2	10.8	25.0		
Certificate/diploma	33.5	33.8	33.5		
University degree^	35.1	51.3	34.1		
State				7.501	0.424
New South Wales	31.5	29.6	31.6		
Victoria	26.5	21.6	26.8		
Queensland	20.2	23.9	20.0		
South Australia	6.6	6.0	6.6		
Western Australia	10.4	15.9	10.1		
Tasmania	1.9	0	2.0		
Northern Territory	1.1	0.5	1.1		
Australian Capital Territory	1.8	2.4	1.8		
Region				1.302	0.298
Capital city	70.1	75.1	69.8		
Rest of state	29.9	24.9	30.2		
SEIFA				4.261	0.668
Quintile 1 (most disadvantaged)	18.4	12.0	18.8		
Quintile 2	17.5	15.3	17.6		
Quintile 3	20.0	22.1	19.9		
Quintile 4	20.4	23.5	20.2		
Quintile 5 (least disadvantaged)	23.5	27.2	23.3		
Country of birth				0.984	0.819
Australia	66.2	62.6	66.4		
Non-English-speaking country	24.8	26.8	24.6		
English-speaking country	8.9	10.6	8.8		
Language other than English spoken at home				0.056	0.967
Yes	29.8	30.3	29.8		
No	70.1	69.7	70.2		
Indigenous status				0.194	0.967
Aboriginal	2.0	1.8	2.0		
Torres Strait Islander	0	0	0		
Both	0.1	0	0.2		
No	97.8	98.2	97.8		

* Weighted to population benchmarks using propensity scores.
\# 8 participants indicated 'don't know' to whether they have had an AMH test, and 1 participant did not answer this question, so have been excluded from analyses.
** Comparison between those who have and have not had an AMH test.
^ 9 participants' highest education level was unavailable, so they were merged with the most common category (university degree).

know'. See Supplementary Table S1 for reasons for testing by how participants first heard of AMH testing.

Reasons for testing were grouped into medical (n = 78, 63%) or elective (n = 44, 35%). No statistically significant associations between medical or elective reasons and sociodemographic characteristics were observed (all $P > 0.05$, data available upon request).

How women accessed the test

Of the 124 participants who had had an AMH test, 78 (63%) indicated they had accessed the test through a fertility clinic, 38 (31%) through their GP, 1 (1%) through an online website, and 6 (5%) through another medical practitioner (e.g. gynaecologist). When dichotomizing into 'medical' or 'elective' reasons, there was statistical evidence of an association between reason for testing and how women accessed the test ($P = 0.016$). Tests for medical reasons were mostly accessed through a fertility clinic (73% versus 24% through GP), whilst tests for elective reasons were more equally accessed across GP (43%) and fertility clinic (48%, Table 4, see Supplementary Table S2 for non-dichotomized reasons for testing by access).

Discussion

This population-based study found that among women aged 18–55 years, 13% had heard about AMH testing and 7% had had an AMH test. Testing uptake was highest amongst those currently aged 35–39 years (14%) and associated with higher educational attainment. Whilst the top three information sources for first hearing about AMH testing included friends/family or online through social media/radio/TV, the majority (77%) of those who had an AMH test first heard about it from their GP or fertility specialist, suggesting doctors are currently the main drivers of test uptake. Although the majority had the test for medically indicated reasons, about one third of respondents had the test to

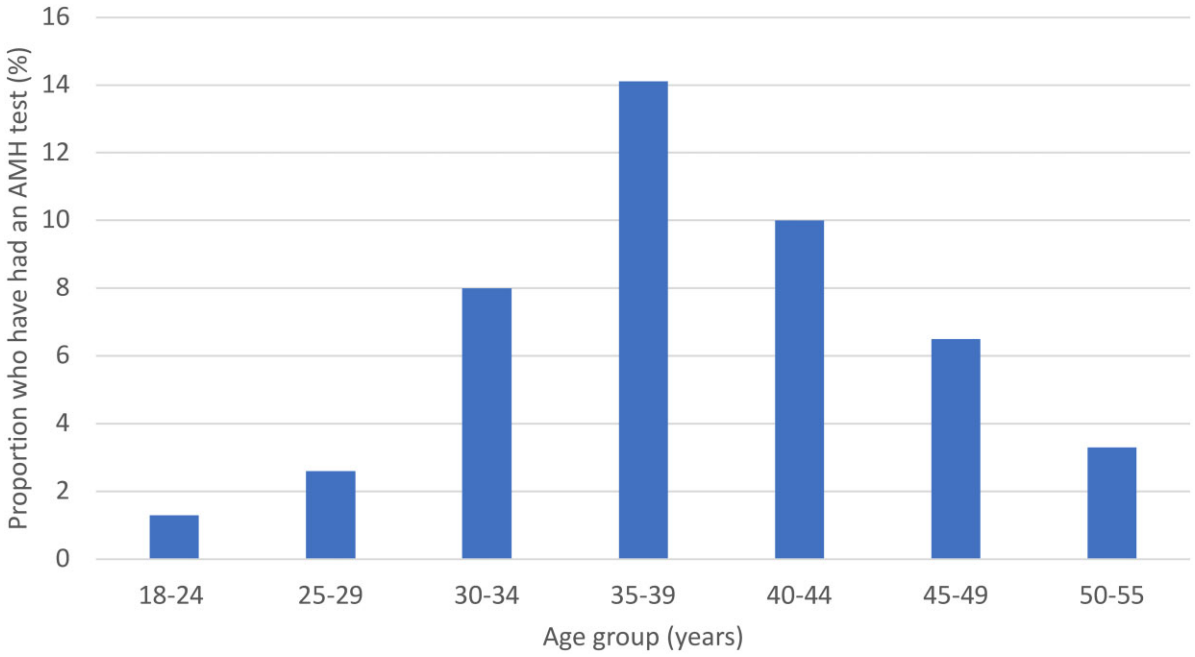

Figure 1. **Testing rates by age group at survey collection.**

Table 3. How participants first heard of anti-Müllerian hormone (AMH) testing by testing status.

	Total of those who had heard about AMH testing (n = 228)	Have had an AMH test (n = 124)	Have not had an AMH test (n = 104*)
Friends or family	51	14 (27%)	37 (73%)
Recommended by my GP	36	31 (86%)	5 (14%)
Recommended by my fertility specialist	67	65 (97%)	2 (3%)
Internet advert, social media or tv/radio/ podcast	40	6 (15%)	34 (85%)
Other#	30	6 (20%)	24 (80%)
Don't know	4	2 (50%)	2 (50%)

Examples included through university or due to studying a medical degree.
* %s of total heard about AMH testing.

Table 4. Medical and elective reasons for testing by access.

Access	Medical	Elective	Value*	P
Through GP	19 (24%)	19 (43%)	8.961	0.016
Through fertility clinic	57 (73%)	21 (48%)		
Through another medical practitioner**	2 (3%)	3 (7%)		
Declined to answer	0	1 (2%)		

* Fisher's exact test.
** Included gynaecologist (n = 4) or endocrinologist (n = 1). Two participants indicated 'don't know' for the question about reasons so have been excluded from this analysis.

gain insights into their fertility or inform their reproductive life planning. Given the AMH test cannot predict a woman's current or future fertility potential (Steiner *et al.*, 2017; Lin *et al.*, 2021) and is not sufficiently accurate or precise enough to identify a woman at risk of early menopause (Depmann *et al.*, 2018; De Kat *et al.*, 2021), this finding is concerning.

This finding that a small but substantial proportion of AMH testing appears to be undertaken for inappropriate reasons raises ethical concerns about testing causing more harm than benefit and potential lack of transparency regarding the test's limitations (Copp *et al.*, 2021) undermining autonomy and informed consent (Bayefsky *et al.*, 2020). Potential adverse implications of AMH testing outside of infertility settings include a false sense of security about delaying pregnancy for those who receive a normal or high result, or unwarranted anxiety about not being able to conceive, pressure to conceive earlier than desired or to freeze eggs for those who receive a low result (Pritchard *et al.*, 2017; Evans *et al.*, 2018; O'Brien *et al.*, 2020; Copp *et al.*, 2021). The potential for sub-optimal consent processes, test interpretation and adverse implications is likely further increased with direct-to-consumer testing, particularly given the occurrence of misleading advertising online (Copp *et al.*, 2021). Direct-to-consumer testing provides a pathway to testing without the involvement of a GP or specialist, removing the opportunity for counselling regarding the test's limitations prior to the test being ordered. Interviews with women attending a fertility clinic found that whilst AMH testing raised awareness of the impact of age on fertility and women valued the information they received, it also caused significant psychological distress and created a sense of urgency and haste towards fertility treatment (O'Brien *et al.*, 2020). These women believed that AMH testing should be reserved for those with a clinical need for testing, as it can create unnecessary distress and urgency for women who are not yet in a position to conceive (O'Brien *et al.*, 2020).

In terms of access, almost all women accessed the test through their GP or specialist. Although pre-test counselling was not assessed in the current study, this finding is reassuring as it suggests that most women are likely receiving some level of counselling prior to testing. Given the only recent emergence of direct-to-consumer AMH testing in Australia, the use of direct-to-consumer AMH testing is likely to increase as online companies intensify their marketing of it. Concerningly, although most tests were performed for medically indicated reasons, half of those accessing the test through their GP had the test for elective, non-evidence-based reasons. A recent pilot survey of 72 GPs practicing in Australia found that 40% of respondents failed to identify that AMH is not a measure of egg quality or natural fertility (Slater *et al.*, 2022). It is vital doctors have access to high quality information and resources to support them in counselling women regarding the risks and benefits of AMH testing, including the test's limitations. Professional colleges should provide clear guidance for clinicians in jurisdictions where this does not already exist, including procedural guidance on how to counsel women about the test's utility and limitations. There is also a role for simultaneously equipping women with access to clear evidence-based information on AMH testing to enable them to make informed decisions. Delivery of this information using the same approaches and channels that are used to promote and market AMH testing to consumers (e.g. links to it online in the results of online search engines, social media campaigns) may be particularly effective.

Strengths of the study include its novelty. This is the first population-based study assessing community awareness and use of the AMH test worldwide. The study population also closely resembled the Australian general population of females aged 18–55 years, with a high response rate (73%), increasing the generalizability of the findings. The Life in Australia™ panel is the most methodologically rigorous and representative Australian panel using random probability-based sampling rather than self-selected volunteers (Kaczmirek *et al.*, 2019). This study also has limitations. Although the sample was large and mostly representative, it was over-represented by people holding a university degree (55% versus 35% of the general population) and under-represented by people aged 18–24 years (9% versus 16%). To correct for this, analyses of data collected among the entire sample (i.e. AMH test usage) used weighted data, thereby providing greater confidence in generalizing these results to the Australian population. However, as this is the first study examining test reasons and access in the subpopulation of individuals who have had an AMH test, the (sub)population distribution of relevant characteristics is not known. As such, it was not possible to assess, or correct for, the representativeness of this subsample in analyses, which may limit the generalizability of the findings. Further, as there is no available data on AMH test usage in Australia, it was not possible to conduct an informative sample size calculation, and therefore we sought to maximize the sample size by including the entire eligible Living in Australia panel cohort (n = 2423 females aged 18–55), which would be adequate to produce national-level estimates with a confidence interval no wider than 4%. All data are also self-reported and may be subject to recall bias. Furthermore, the study aims were limited in scope, with focus on assessing population prevalence. We did not assess reasons women were offered the test but decided to not have it, limiting our ability to assess predictors of having an AMH test. As the number of items we could include in the survey was restricted, we also did not ascertain what type of counselling women received prior to testing, nor what year or age AMH testing was performed, preventing interpretations about the extent of informed consent or current AMH test usage. Research currently underway is exploring the impact of AMH testing on women, including the extent to which there is informed consent and discussion of the test's limitations, and the actions women take in response to test results (Vakkas *et al.*, 2023). Data on the number of tests performed annually should also be made publicly available, and repeated surveys to gauge trends and changes in AMH testing over time are warranted.

In conclusion, the majority of women in this sample had AMH testing for medically indicated reasons, with the highest proportion getting it as part of infertility investigations in a fertility clinic setting. However, the finding that 39 of the 1773 women in the sample had an AMH test because they were curious about their fertility or considering getting pregnant soon suggests that, at a population level, a notable number of Australian women may have had the test for a reason not supported by the evidence. Public and clinician education about the lack of utility of AMH testing for women not undergoing infertility treatment is needed to prevent women undergoing testing in the belief that it can provide reliable insights into their fertility and reproductive timeline. As direct-to-consumer testing becomes more common, the need to improve women's awareness about the test's limitations is vital.

Supplementary data

Supplementary data are available at *Human Reproduction* online.

Data availability

Data are available on reasonable request.

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Authors' roles

T.C., R.T., J.D., K.H., M.P., S.L., D.L., and K.M. were involved in designing the study and developing the methods. T.C. conducted the analysis with input from E.C. T.C. drafted the manuscript. All authors critically revised the manuscript.

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Conflict of interest

B.W.M. reports research funding, consultancy and travel support from Merck. D.L. is the Medical Director of City Fertility NSW and reports consultancy for Organon, Ferring, Besins and Merck. No other relevant disclosures exist.

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