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ORIGINAL RESEARCH

Distribution and Related Influencing Factors of AMH Level in Family-Planning Women of Childbearing Age: A Cross-Sectional Study from Beijing, China

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Purpose: This study aimed to analyze the distribution and factors influencing anti-Müllerian hormone (AMH) levels among family-planning women of childbearing age in Beijing, China.

Patients and Methods: We collected the data of 3,236 family-planning women of childbearing age who underwent pre-pregnancy examinations at Xicheng District Maternal and Child Health Hospital in Beijing between October 2021 and July 2024. Collected data included age, education level, ethnicity, height, weight, and systolic and diastolic blood pressure. We calculated the body mass index (BMI) of each participant. The collected blood test results included AMH, fasting blood glucose (FBG), thyroid-stimulating hormone (TSH), creatinine (Cr), and alanine aminotransferase, and hemoglobin levels and platelet count. A structured questionnaire was used to document the subjects' dietary and lifestyle habits, environmental factors, and emotional and mental stress statuses. The patients were divided into age groups (≥36 years versus ≤35 years) and factors compared between them. Two different factors influencing AMH level were analyzed using a logistics model.

Results: The AMH level decreased with age, with a median AMH of <2.0 ng/mL for subjects aged ≥36 years. Significant intergroup differences were noted in ethnicity, education level, FBG, creatinine level, BMI, diastolic blood pressure, hemoglobin level, smoking rate, and life-related stress level. A logistic regression analysis suggested that age was a negative factor affecting AMH level in both groups (P=0.000 and 0.002, respectively). Hemoglobin and educational levels were also important influential factors of AMH in patients aged ≤ 35 years but not in those aged ≥ 36 years.

Conclusion: AMH levels gradually decreased with age. Although nutritional status and educational level significantly impacted AMH levels among women ≤ 35 years of age, their effects decreased thereafter. Thus, 35 years of age is considered an important reproductive boundary for women of childbearing age.

Keywords: AMH, women of childbearing age, cross-sectional study

Introduction

The decline in fertility rates is a global issue; by 2021, over half of all countries and regions had a rate below the replacement level.[1] Over the past few decades, the number of women giving birth at age 30–40 years has significantly increased in developed countries.[2] This phenomenon is particularly common among Asian women, with the average age at first childbirth reaching 28 years in China and Malaysia versus 31 years in South Korea.[3]

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The age at childbearing is not always a conscious process, and its delay depends on many factors, including personal, family, social, and social policy.[4] Although the ovarian functional reserve of women of childbearing age significantly impacts fertility rates, fertility intent may be a more important factor. Thus, investigating the ovarian reserve function of women with fertility intent in a real-world environment can help improve fertility rates.

Anti-Müllerian hormone (AMH), a member of the transforming factor beta family, is expressed in granulosa cells that grow within the follicles.[5] AMH level, which indirectly reflects the number of functional follicles and is considered a biomarker of functional ovarian reserve, is used in pre-pregnancy examinations for women with pregnancy plans. Low AMH levels may indicate a short reproductive window.[6] Recent studies reported that AMH is closely associated with oocyte quality and in vitro fertilization results.[7] Thus, testing AMH levels in women of childbearing age can aid the evaluation of ovarian reserve function and selection of subsequent pregnancy strategies.[8]

AMH levels gradually decrease with increasing reproductive age.[9] However, there is currently no precise boundary for AMH to distinguish ovarian function,[10] and the cutoff values for AMH and pregnancy-related tests vary in the literature among regions and ethnic groups.[2,11,12]

This study investigated the distribution of AMH levels among women planning to conceive within 3–6 months among the permanent population in a certain area of Beijing, China, as well as the factors affecting its reduction to clarify the real-world reproductive status of women of childbearing age and aimed to provide information that could improve fertility rates.

Materials and Methods

Patients

This study enrolled 3,236 women of childbearing age who had a clear pregnancy plan and underwent pre-pregnancy examinations at the Xicheng District Maternal and Child Health Hospital in Beijing between October 2021 and July 2024.

The inclusion criteria were as follows: 1. age 20–45 years; 2. planning to conceive in the next 3–6 months; 3. not taking contraceptive pills or other sex hormone drugs within the previous 3–6 months; and 4. willingness to participate.

The exclusion criteria were as follows: 1. history of ovarian surgery; 2. discovery of malignant tumors during the pre-pregnancy examination; 3. systemic autoimmune diseases or other psychiatric disorders and clear factors making pregnancy unfavorable; and 4. congenital structural abnormalities of the reproductive tract or tumors of the reproductive system or pituitary gland.

We calculated the median and mean AMH values of the subjects of different ages. To prevent the influence of special values in the group data, we grouped the participants into groups based on median values (<2.0 or ≥2.0 ng/mL) and analyzed the impact of differences in general condition, lifestyle, and blood indicators between them on AMH levels.

The study was conducted in accordance with the ethical standards of the Declaration of Helsinki and approved by the Ethics Committee of Beijing Xicheng District Maternal and Child Health Care Hospital (no. 2023-KY-006-02).

Observed Parameters

We collected data including age, education level, and ethnicity through the medical record system and collected the subjects' height, weight, and systolic and diastolic blood pressure through physical examinations. We then calculated the body mass index (BMI) of each subject based on their height and weight.

We also collected data on factors related to the participants' lives and work. Each participant filled out a questionnaire asking items such as if they eat meat or eggs, vegetables, or raw meat and if they smoke. The possible answers for most items were "yes" and "no." The options for questions about whether they smoke passively or drink alcohol included "no", "occasionally", and "frequently." The options for questions about life and work pressure, tense relationships with relatives, friends, and et.al, and economic pressure included "none", "very little", "a little", "relatively high", and "very high." All participants answered all questions clearly and independently.

We also collected the blood test results including hemoglobin content, platelet count, and fasting blood glucose (FBG), thyroid-stimulating hormone (TSH), alanine aminotransferase (ALT), and creatinine (Cr) levels to evaluate their nutritional status and thyroid, liver, and kidney function.

AMH Measurement

To perform the AMH measurements, we extracted 3 mL of venous blood from each fasted participant, allowed the sample to stand at room temperature for 30 min, centrifuged the sample at 3000 rpm for 10 min, and collected the serum. We then measured the AMH levels using a fully automated electrochemiluminescence immunoassay analyzer (cobas e801; Roche,Swiss).

Statistics

All statistical analyses were performed using SPSS (v. 26.0), SigmaStat (v. 3.5), and Excel (v.16.0.18227.20082). We used the "ggplot2" package in R (4.4.1) to plot the data. We analyzed the level data using analysis of variance and compared the data between groups using one-way analysis of variance. If an option had 0 participants in a group, the entire option was omitted from the analysis. We calculated the relevant factors influencing AMH in subjects of the different groups using a binary logistic regression analysis. Statistical significance was set at $P < 0.05$.

Results

An analysis of the relationship between the AMH values of the 3,236 subjects with their age revealed that the subjects reached the maximum AMH value at age 27–29 years. Subsequently, the AMH levels gradually decreased with age (Figure 1). As the median AMH of subjects aged ≥ 36 years was <2.0 ng/mL (Table 1), we divided the subjects into groups of women ≤35 years and those ≥36 years (younger and older groups, respectively) for further study.

An intergroup comparison (Table 2) showed significant differences in educational level (P<0.001) and ethnicity (P=0.038). The mean education level was significantly higher in the younger versus older group, mainly due to the significant increase in the number of participants with a graduate-level or higher education.

In terms of blood test results, the mean AMH was significantly higher in the younger versus older group (P<0.001). The FBG (P<0.001), Cr (P=0.005), BMI (P=0.019), and diastolic blood pressure (P=0.017) were significantly lower among the younger versus older groups. Moreover, the mean hemoglobin level was significantly higher among the younger versus older subjects (P=0.024).

In terms of the impact of daily life on the body, the proportion of smokers was significantly higher among the younger versus older subjects (2.4% vs 1.3%, respectively; P=0.000); their life- and work-related pressures were also reportedly higher (P=0.000). We detected no significant intergroup differences in dietary habits, alcohol consumption, work pressure, or economic pressure (P>0.05).

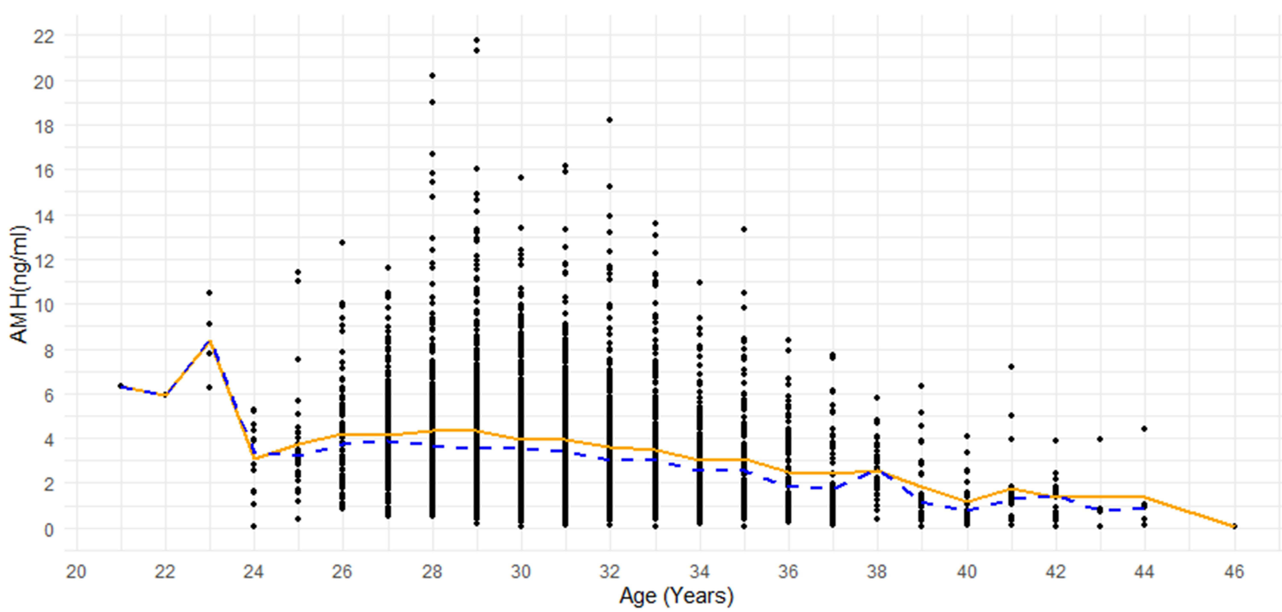

Figure 1 Scatter plot of AMH for different ages, with the lines connecting the mean and median. The Orange line represents the line connecting the mean AMH for each age, and the blue dashed line represents the line connecting the median AMH for each age.

Table 1 Age Groups and AMH Mean and Median Values

Age (years)	Number	AMH Mean ± Standard Deviation (ng/mL)	AMH Median (25%-75%, ng/mL)
21	1	6.30	-
22	1	5.93	-
23	4	8.40 ±1.84	8.43 (2.11–9.47)
24	13	3.09 ±1.66	3.35 (2.73–4.34)
25	31	3.73 ±2.47	3.23 (2.00–4.29)
26	80	4.18 ±2.41	3.76 (3.30–5.44)
27	12	4.16 ±2.33	3.86 (2.97–5.43)
28	295	4.36 ±2.95	3.71 (2.95–5.38)
29	430	4.35 ±3.00	3.55(3.36–5.67)
30	490	3.97 ±2.34	3.53(2.90–5.21)
31	447	3.95 ±2.45	3.42(2.77–5.06)
32	349	3.59 ±2.50	3.05(2.78–4.69)
33	278	3.46 ±2.43	2.99(2.51–4.24)
34	198	3.01 ±1.91	2.59(2.24–3.90)
35	139	3.10 ±2.34	2.58(2.81–4.20)
36	92	2.49 ±1.87	1.85(2.64–3.74)
37	57	2.40 ±1.87	1.78(2.52–3.61)
38	36	2.53 ±1.34	2.65(1.97–3.45)
39	31	1.81 ±1.58	1.21(1.95–2.71)
40	27	1.18 ±0.99	0.79(1.02–1.48)
41	18	1.80 ±1.81	1.28(0.67–1.68)
42	18	1.36 ±0.97	1.45 (1.17–1.76)
43	4	1.39 ±1.74	0.78 (1.10–1.63)
44	5	1.38 ±1.73	0.94 (0.63–1.03)
45	3	0.04±0.03	0.04

Next, we conducted a statistical analysis of the factors influencing AMH in the younger versus older age groups (Table 3). We divided younger group into those 21–25, 25–30, and 30–35 years and the older group into those 36–40 and >40 years to evaluate whether age had a significant impact on AMH in either group. Age significantly affected AMH levels in both groups (P=0.000/0.001); this relationship was negatively correlated. Other factors such as blood test results and lifestyle were not considered significantly influential in the older group. In the younger group, education level (P=0.002) and hemoglobin content (P=0.001) were considered influential factors of AMH; this relationship was positively correlated.

Discussion

The ovarian primordial follicle pool quantity and quality determine ovarian reserve function, which, to some extent, reflects female fertility potential.[13] Ovarian reserve function testing includes imaging tests such as follicle count, ovarian volume, and ovarian-related blood marker tests.[14] Serum AMH levels are considered an important indicator that is closely related to the number of follicles and represent functional ovarian reserve.[15]

The reproductive age of women significantly impacts a population's size and age structure. Over the past few decades, the mean maternal age at childbirth has significantly increased in developed countries,[16] as has the number of women delaying childbirth in Asia.[17] Delaying childbirth helps parents receive more education, which provides a safer and more stable living environment for their children.[18,19] This finding indicates that women who plan to conceive in the short term may not have the best ovarian function and may not even be 25–30 years old, the optimal reproductive age. Because of increasing maternal age, she is at a higher risk of infertility and obstetric complications.[20,21] Only when a woman desires to have children will she become pregnant and give birth. Therefore, it is necessary to test and report on their pregnancy plans.

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Table 2 General Comparison Between the Population Aged 35 and Below and Women of Childbearing Age Aged 36 and Above

	Aged 35 and Below (n=2945)	Aged 36 and Above (n=291)	P
AMH	3.34 (2.12–5.01)	1.51 (0.76–3.27))	<0.001
Education			<0.001
Unknown	7	0	
Junior middle school	2	1	
High school	22	5	
Bachelor and college	1173	164	
Master ans Doctor	1741	121	
Race			0.038
Han	2729	269	
Man	83	9	
Hui	48	10	
Mongolian	42	0	
Others	43	3	
HGB (g/L)	131 (125–137)	130 (124–136)	0.024
PLT ($\times 10^9$/L)	273 (238–313))	279 (240–314.75)	0.366
FBG (mmol/l)	5.01 (4.80–5.27)	5.14 (4.90–5.40)	<0.001
TSH (mU/L)	1.79(1.28–2.47)	1.76(1.26–2.54)	0.986
ALT (U/L)	13.00(10.00–17.00)	13.00(10.00–17.00)	0.102
Cr (μmol/L)	52.00(47.00–57.00)	54.00(48.00–59.00)	0.005
Whether they eat meat or eggs			0.767
No	34	2	
Yes	2911	289	
Whether they not prefer eating vegetables			0.794
No	2904	288	
Yes	41	3	
Whether they have a preference for consuming raw meat			0.430
No	2874	282	
Yes	71	9	
Whether they smoke			0.000
No	2914	287	
Yes	31	4	
Whether to smoke passively			0.618
No	1956	185	
Occasionally	907	97	
Frequently	82	9	
Whether to drink alcohol			0.785
No	2170	218	
Occasionally	769	72	
Frequently	6	1	
Whether feeling life and work pressure			0.000
None	836	84	
Very little	61	49	
A little	1172	127	
Relatively large	287	29	
Very large	32	2	
Whether the relationship with relatives, friends, and colleagues is tense			0.367
None	1926	183	
Very little	752	87	
A little	254	20	

(*Continued*)

Table 2 (Continued).

	Aged 35 and Below (n=2945)	Aged 36 and Above (n=291)	P
Relatively large	11	1	
Very large	2	0	
Whether feeling economic pressure			0.346
None	1369	134	
Very little	764	66	
A little	720	80	
Relatively large	78	11	
Very large	14	0	
BMI (kg/m^2)	20.6(19.2–22.5)	21.0(19.5–22.6)	0.019
Systolic pressure (mmHg)	108(100–116.25)	110(101–109)	0.051
Diastolic pressure (mmHg)	67(62–73)	68(62–76)	0.017

Table 3 Binary Logistics Regression Analysis of AMH in Groups 35 and Under and 36 and Over

	Aged 35 and Below (n=2945)		Aged 36 and Above (n=291)	
	P	**EXP (β)**	**P**	**EXP (β)**
Age	0	0.608	0.001	0.219
Education	0.002	1.292	0.942	0.981
Race	0.608	1.037	0.376	1.218
HGB (g/L)	0.001	1.014	0.664	1.006
PLT (×10^9/L)	0.766	1	0.977	1
FBG (mmol/l)	0.542	0.945	0.646	1.148
TSH (mU/L)	0.508	1.015	0.546	1.055
ALT (U/L)	0.754	1.001	0.486	0.989
Cr (μmol/L)	0.069	1.011	0.898	1.002
Whether they eat meat or eggs	0.338	0.622	0.615	0.449
Whether they not prefer eating vegetables	0.81	0.911	0.999	0
Whether they have a preference for consuming raw meat	0.52	0.831	0.426	1.878
Whether they smoke	0.759	0.878	0.519	2.088
Whether to smoke passively	0.801	1.023	0.152	1.435
Whether to drink alcohol	0.726	1.038	0.571	1.193
Whether feeling life and work pressure	0.589	1.031	0.309	0.839
Whether the relationship with relatives, friends, and colleagues is tense	0.79	0.979	0.609	1.142
Whether feeling economic pressure	0.505	1.044	0.404	0.86
BMI (kg/m^2)	0.961	1	0.752	1.017
Systolic pressure (mmHg)	0.168	0.993	0.231	1.019
Diastolic pressure (mmHg)	0.492	1.005	0.963	1.001

In fact, AMH levels and cutoff values vary greatly among different studies.[22] When the cutoff value of AMH for predicting clinical pregnancy is 1.0–3.22 ng/mL, its sensitivity and specificity are 34.4–86.2% and 26–78.5%, respectively.[23] AMH level is now mainly used in examinations performed prior to assisted reproductive methods. In a meta-analysis of 28 studies, AMH had good predictive ability for adverse ovarian reactions, with an area under the curve of 0.78.[24] Moreover, AMH has significant utility in predicting ovarian hyperstimulation in response to gonadotropin stimulation. At a critical value of 3.36–5.0 ng/mL, its sensitivity and specificity were 53–90.5% and 70–94.9%, respectively,[25] indicating that assisted reproduction requires higher AMH levels than natural pregnancies. Because our subjects were women planning to conceive rather than patients diagnosed with infertility or ovarian dysfunction, we ultimately chose 2.0 ng/mL as the cutoff value for grouping patients by age. Owing to the significant individual differences in AMH within each group, we chose to group the subjects into younger and older groups based on the median AMH of each. AMH level is closely related to age, first increasing in adolescence, peaking at 25 years of age, and gradually decreasing to undetectable levels at the end of menopause.[26,27] Similar conclusions were drawn from our observational data; when patients were >40 years old, the median AMH level was even lower than 1.1 ng/mL, the level recognized in relevant guidelines in China as one manifestation of ovarian dysfunction. Interestingly, in terms of pregnancy, women > 35 years are considered elderly; this group often has high rates of perinatal mortality,[28] gestational diabetes, and other pregnancy diseases.[29] Our research suggests an urgent need for active pregnancy and childbirth for women > 35 years of age with or without the use of assisted reproduction.

The influence of race on reproductive status has been increasingly emphasized. AMH levels differ significantly among different races and ethnicities, and studies evaluating different reproductive declines in European and Asian populations reported that allelic frequencies significantly impact AMH.[30] One study comparing Chinese women to European women found that the former had higher peak serum AMH concentrations and their levels declined more rapidly with age.[31] In our study, we examined AMH results for common ethnic groups in Beijing, including the Han, Manchu, Hui, and Mongolian. We found no significant differences among ethnic groups (P=0.774). An examination of the influence of ethnicity on AMH levels by age group revealed that it was not important. Thus, in China's AMH examination and subsequent pregnancy guidance, ethnicity may not be an important reference indicator. Of course, Yang et al's research conducted in different areas of China suggested that female AMH levels differ among them, possibly due to various factors such as ambient air quality. Therefore, a single study result should not be used as a guide unless it is that of a large-scale national study.

Hemoglobin is considered an indicator of a patient's nutritional status in other diseases, especially in tumor treatment, and often associated with a poor prognosis.[32,33] Pregnant women with high hemoglobin levels at the time of their first visit are more likely to develop diabetes in the third trimester of pregnancy,[34] while the hemoglobin level in the first trimester of pregnancy is related to the end-diastolic volume of male infants at 10 years of age.[35] Our research indicates that patients < 35 years of age have higher hemoglobin levels, which are among the important influential factors of AMH level; this was not the case in the ≥36 years group. This may indicate that young people have a better nutritional status, whereas an age > 36 years has a much greater impact on AMH than other influencing factors. However, statistics are currently lacking on pregnancy status, and it cannot be determined whether hemoglobin levels are related to whether patients can conceive and carry a pregnancy to term.

It should be noted that our study included only women with pregnancy plans, which means that our research results do not represent the AMH status of all women in the same age group. The conclusions of this study should not be used as a survey conclusion for AMH in women of all age groups, as this would lead to significant bias including age, ethnicity, and social environment. A large-scale stratified study based on age is necessary to determine the true AMH values in women. For example, in the review by Kotlyar et al,[36] women aged 21–24 years had the highest AMH levels.

Conclusion

The AMH level of women of childbearing age who intend to have children decreases with age. Moreover, it is related to hemoglobin content and education level in women < 35 years of age but not in those >35 years. These findings suggest that it is necessary to advise women who desire to have children to do so sooner rather than later, preferably before 35 years of age.

Ethical Approval

The study was carried out in accordance with the ethical standards laid down in the Declaration of Helsinki, and was approved by Ethics Committee of Beijing Xicheng District Maternal and Child Health Care Hospital(No:2023-KY-006-02). We informed and obtained consent from patients after September 2023. The ethics committee of the earlier retrospective study considered that the informed consent form could be waived.

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No contributors not mentioned in the text.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

All authors have no conflicts of interest to declare in this work.

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