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Pregnant women's knowledge, attitude, and practice toward food preservatives: a cross-sectional study

Shuai Yuan[1†], Weimei Liu[2†], Zhixin Shen[3†], Meitian Ren[4] and Shuangying Hao[5*]

Abstract

Background Sodium benzoate, a common food preservative, may harm fetuses, which could increase the safety concern for pregnant women, but the knowledge, attitude, and practice (KAP) of food preservatives' impact on health among pregnant women is limited. This study explored the KAP of pregnant women regarding food preservatives.

Methods This cross-sectional study was conducted in Henan Province between March and April 2023 among pregnant women. An investigated-designed questionnaire was administered to collect the demographic characteristics and KAP scores. Scores of < 60%, 60-79%, and ≥ 80% were considered poor, moderate, and good, respectively.

Results The study collected 515 valid questionnaires [303 (58.83%) < 30-years-old participants] for analysis. The knowledge, attitude, and practice scores were 10.21 ± 2.90 (/17; 60.06%), 29.59 ± 2.73 (/40; 73.98%), and 22.86 ± 3.56 (/30; 76.20%), respectively. The structural equation model (SEM) showed that the knowledge of food preservatives directly affected attitudes (β = 0.168, *P* = 0.005) and practice (β = 0.250, *P* = 0.021) and indirectly affected practice (β = 0.047, *P* = 0.004). The attitudes toward food preservatives directly affected practice (β = 0.280, *P* = 0.021).

Conclusion Pregnant women in Henan Province have moderate knowledge, attitudes, and practices toward food preservatives. Education interventions are needed to improve the knowledge gaps identified in this study, which could also be encountered in other regions.

Trial registration Not applicable.

Keywords Knowledge, attitude and practice, Pregnant women, Food preservatives, Education interventions, Cross-sectional study

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Background

Food preservatives are substances present in food as a result of processing, storage, or packaging [1]. Food preservatives contribute to the food's shelf life and are used in precise amounts to respect daily consumption limits, but they may have toxic effects [2]. Sodium benzoate is one of the most extensively used preservatives in food, medicines, and cosmetics but can induce fetal deformity in pregnant mice [3]. Sodium benzoates and their derivatives interfere with genes involved in blood clotting, induce oxidative stress, interfere with neural tube development, and affect nucleic acids [3–6]. Potassium benzoates can cause ocular malformations [7] and fetal DNA damage [8]. Moreover, in pregnant female rats, sodium benzoate at 0.5, 1, and 1.5 mg/mL had had little effect on maternal weight gain, but perinatal mortality was significantly increased in the 1 and 1.5 mg/mL groups, without increases in fetal malformations [9]. In another study, sodium benzoate (9.3 and 18.6 mmol/kg b.w.) decreased fetal weight of rats and increased mortality [10]. Another study found fetal deformities after treatment of pregnant females with benzoate (280 and 560 mg/kg b.w.), including skin hemorrhages, craniofacial deformities, limb defects, spine defects, and neural tube defects [11]. Developmental defects, including eye defects, in mouse fetuses, were reported in a study of potassium benzoate (280 and 560 mg/kg b.w.) [12]. Another study also confirms its harmful effects on the mouse fetus (280 and 560 mg/kg b.w.) [13]. The teratogenicity of benzoate was observed in chickens (5-200 mg/kg b.w.) [14]. Sodium benzoate is added to carbonated drinks, sauces, mayonnaises, margarines, tomato paste, and fruit preserves. In turn, in its natural form, it is present in, among other things, cinnamon, mushrooms, cranberries, blueberries, and cloves [3]. Benzoate can be decarboxylated into benzene, especially in combination with vitamin C, and then exert toxic effects [15]. Still, the toxicity was tested in animals, as above, at relatively high doses, and the toxic exposure in humans is poorly known, but the dose allowed by the FDA is 0–5 mg/kg b.w. and has a "generally regarded as safe" status with the FDA [16]. Besides benzoates, β-cyclodextrin causes growth retardation in rodents [17]. Even though preservatives are added to foods to prevent or delay the development of harmful bacteria and molds and maintain the foods' good appearance, some substances could be teratogenic and present risks for the fetus [4]. Besides direct fetal toxicity [4], other substances like paraben, bisphenol A, and phthalates are endocrine-disrupting chemicals with weak estrogenic effects that can affect glucose metabolism and increase the risk of gestational diabetes [18–20]. In pregnancy, any substance that affects specific aspects of metabolism can harm the fetus or the mother [21], but it remains unknown whether food preservatives are harmful to pregnant women and their fetuses.

The physician and theologian Paracelsus, one of the fathers of modern toxicology, enounced in 1538 that "The dose makes the poison" [22]. Food preservatives may probably affect anyone if consumed in large amounts [3–8, 17, 23–26]. Many pregnant women are cautious about consuming foods containing preservatives [27, 28]. Food preservatives are found in almost all foods and are invisible, odorless, and tasteless. Therefore, it is easy to overlook their effects [29]. A study from Bangladesh showed that pregnant women had poor knowledge, attitudes, and practices (KAP) toward food safety, including food preservatives [30]. An early study in Pakistan showed that most women were unaware of the harmful substances found in food [31]. There are no KAP of Chinese pregnant women regarding food preservatives. Only a few studies report the habits of Chinese individuals toward reading the food labels [32] or avoiding pickled foods during pregnancy [33, 34]. KAP studies are important to determine the knowledge gaps, misconceptions, and misunderstandings that can hinder the proper performance of an action or behavior [35, 36].

Therefore, this study aimed to examine the KAP toward food preservatives among pregnant women and explore the factors associated with the KAP scores.

Methods

Study design and subjects

This cross-sectional study enrolled pregnant women in Henan Province between March 8 and April 4, 2023. Pregnant women ≥ 18 years old who were able to understand the study and voluntarily agreed to participate were included in the study. The study was approved by the Ethics Committee of the School of Medicine of Henan Polytechnic University (Approval No. HPU2022-002). Written informed consent was obtained from all participants before they completed the survey.

Questionnaire introduction

The questionnaire was designed based on the literature [4, 21, 29] and according to recognized methods for KAP studies [37]. Two rounds of consultation with specialists were conducted. In the first round, one obstetrician and gynecologist were invited, and several questions were adjusted. In the second round, one obstetrician, one gynecologist, and one questionnaire survey expert were invited, and the content of the questions was adjusted again. The feedback from the experts included correctness, clarity, comprehensibility, and the number of total questions. This step was taken to ensure content validity. The questionnaire was pre-tested by 52 pregnant women, showing a Cronbach's α coefficient of 0.770, indicating acceptable internal consistency. The pilot participants

were requested to indicate any unclear questions to ensure face validity.

The final version of the questionnaire contained four dimensions: demographic characteristics (e.g., age, education, occupation, monthly household income, gestational weeks, times of pregnancy, and times of childbirth), knowledge dimension, attitude dimension, and practice dimension. The knowledge dimension consisted of 17 items, with 1 point for a correct answer and 0 points for a wrong or unclear answer, with a possible score range of 0–17 points. The attitude dimension consisted of eight items scored using a 5-point Likert scale, with positive attitude questions being forward-assigned scores of 5 – 1 from strongly agree to strongly disagree and the negative attitude item (A5) being reverse-assigned, with a possible score range of 8–40 points. The practice dimension consisted of seven items, with items P1-P6 scored using a 5-point Likert scale, ranging from always (5) to never (1), with a possible score range of 6–30 points. Item P7 provided a descriptive analysis of which preservatives were specifically known by the pregnant women. Each KAP dimension score was graded according to Bloom's cut-offs [38]: scores of < 60% were considered poor, scores of 60-79% were considered moderate, and scores of ≥ 80% were considered good (i.e., adequate knowledge, positive attitudes, and proactive practice).

Questionnaire distribution and quality control

The questionnaires were distributed to the participants in the form of electronic questionnaires through the official WeChat and QQ groups of pregnant women, and QR codes were found on exhibition boards and posters. The electronic questionnaire was created using the Wenjuanxing e-questionnaire platform (Wenjuanxing Tech Co., Ltd., Changsha, China). A QR code was generated to access the electronic questionnaire. The participants logged in by scanning the QR code sent via WeChat. The first page of the questionnaire explained the study's aim, what was required from the participant, and the statement about data security and anonymity. The first page also contained the consent form. Signing the consent form was mandatory to gain access to the questionnaire. A one-submission-per-IP address restriction was enforced, and all questionnaire items were mandatory to maintain data quality and ensure comprehensive responses. At the beginning of the e-questionnaire, the participants had to click the option "I agree to participate in this study" before they could answer the questions. All data were collected anonymously. The researchers' team members checked all questionnaires for completeness, internal coherence, and reasonableness. Questionnaires with logical errors, responses times longer than the number of questions multiplied by 4 s, an IP address from outside China, and those who failed to pass the attention detection questions randomly inserted by the electronic questionnaire system were considered invalid.

Statistical analysis

SPSS 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. The continuous variables with normal distribution were presented as means ± standard deviation (SD) and analyzed using Student's t-test or one-way ANOVA. The categorical data were presented as n (%) and analyzed using the chi-squared test. Pearson's analysis was used to test the correlation between KAP dimensions. Structural equation model (SEM) analysis was performed to determine how the KAP dimensions influenced each other. It was hypothesized that knowledge directly influenced attitudes and practice and that attitudes directly influenced practice. Two-sided P-values < 0.05 were considered statistically significant.

Results

Baseline characteristics

The questionnaire was distributed to 529 pregnant women, but eight questionnaires were submitted using the same IP address, and six were filled out with the same option selected for all KAP items. Hence, 515 valid questionnaires were included in the analysis, with an effective response rate of 97.35%. Most participants were < 30 years (58.83%), with junior college/undergraduate education (92.23%), urban residence (93.40%), employed (90.10%), with a monthly income of < 10,000 CNY (38.83%), in mid-pregnancy (45.05%), at their first pregnancy (72.04%), and without previous childbirths (68.35%) (Table 1).

Knowledge, attitude, and practice

The knowledge score was 10.21 ± 2.90 (possible range: 0–17; 60.06%), indicating moderate knowledge. Low knowledge scores were observed for items K6 (50.49%; "Chemically synthesized preservatives include acid-based preservatives, ester-based preservatives, and inorganic salt preservatives"), K8 (45.24%; "Preservatives have no effect on pregnant women and their offspring if they are used in accordance with national regulations and limitations and not be overconsumed"), K10 (26.41%; "Foods which do not contain food preservatives are safer"), K11 (29.90%; "Food preservatives cannot be metabolized and excreted by the human body, which can affect the development of future generations"), K15 (29.90%; "Potassium sorbate has a better preservative effect than sodium benzoate"), K16 (31.65%; "Potassium sorbate has less toxicity than sodium benzoate"), and K17 (54.56%; "Potassium sorbate can be used in a wider range of foods than sodium benzoate for food preservation") (Table S1). The attitude score was 29.59 ± 2.73 (possible range: 8–40; 73.98%), indicating moderate attitudes. The distribution

Table 1 Characteristics of the participants and KAP scores

Variables	*n* (%)	Knowledge score		Attitude score		Practice score	
		Mean ± SD	*P*	Mean ± D	*P*	Mean ± SD	*P*
Total	515	10.21 ± 2.90		29.59 ± 2.73		22.86 ± 3.56	
Age (years)			0.968		0.225		0.786
< 30	303 (58.83)	10.22 ± 3.05		29.72 ± 2.76		22.83 ± 3.63	
≥ 30	212 (41.17)	10.21 ± 2.67		29.42 ± 2.68		22.92 ± 3.47	
Education			0.392		0.645		0.004
High school and below	9 (1.75)	9.33 ± 3.50		29.11 ± 2.85		19.33 ± 3.32	
Junior college/undergraduate	475 (92.23)	10.20 ± 2.90		29.58 ± 2.69		22.87 ± 3.56	
Postgraduate and above	31 (6.02)	10.74 ± 2.71		29.97 ± 3.23		23.84 ± 3.16	
Residence			0.795		0.405		0.130
Rural	34 (6.60)	10.09 ± 2.95		29.97 ± 2.66		21.97 ± 3.33	
Town	481 (93.40)	10.22 ± 2.90		29.57 ± 2.73		22.93 ± 3.57	
Occupation			0.266		0.072		0.068
Employed	464 (90.10)	10.26 ± 2.89		29.67 ± 2.72		22.96 ± 3.39	
Unemployed	51 (9.90)	9.78 ± 2.99		28.94 ± 2.77		22.00 ± 4.79	
Monthly household income			0.692		0.902		0.194
< 10,000	200 (38.83)	10.14 ± 2.92		29.55 ± 2.87		22.84 ± 3.84	
10,000–20,000	196 (38.06)	10.17 ± 2.92		29.66 ± 2.43		22.60 ± 3.23	
20,000	119 (23.11)	10.41 ± 2.86		29.56 ± 2.95		23.34 ± 3.57	
Gestational weeks			0.623		0.383		0.928
Early pregnancy (1–12 weeks)	177 (34.37)	10.34 ± 2.93		29.47 ± 2.77		22.91 ± 3.74	
Mid pregnancy (13–25 weeks)	232 (45.05)	10.08 ± 2.79		29.54 ± 2.78		22.80 ± 3.51	
Late pregnancy (26–40 weeks)	106 (20.58)	10.29 ± 3.11		29.92 ± 2.53		22.93 ± 3.39	
Number of pregnancies			0.654		0.707		0.838
1	371 (72.04)	10.18 ± 2.94		29.57 ± 2.65		22.88 ± 3.48	
≥ 2	144 (27.96)	10.31 ± 2.80		29.67 ± 2.92		22.81 ± 3.78	
Number of childbirths			0.325		0.725		0.598
0	352 (68.35)	10.13 ± 2.90		29.57 ± 2.63		22.92 ± 3.45	
≥ 1	163 (31.65)	10.40 ± 2.89		29.66 ± 2.94		22.74 ± 3.80	

of the responses to the attitude items is presented in Table S2. The mean practice score was 22.86 ± 3.56 (maximum of 30; 76.20%), indicating moderate practice. The distribution of the answers to the practice items is presented in Table S3.

Correlation analysis

The knowledge scores were correlated with the attitude ($r = 0.179$, $P < 0.001$) and practice ($r = 0.242$, $P < 0.001$) scores. The attitude scores were correlated to the practice scores ($r = 0.251$, $P < 0.001$) (Table S4).

SEM analysis

Apart from the comparative fit index (CFI), which was slightly < 0.80, all fit indices fulfilled the acceptable values. Both the goodness of fit index (GFI) and adjusted goodness of fit index (AGFI) were estimated at 0.839 and 0.815 and indicated a good fit. The root mean square error of approximation (RMSEA) was < 0.10 and was considered acceptable. Thus, the SEM for food preservatives KAP had a good fit and was acceptable (Table S5). The knowledge of food preservatives directly affected attitudes ($\beta = 0.168$, $P = 0.005$) and practice ($\beta = 0.250$, $P = 0.021$) and indirectly affected practice ($\beta = 0.047$, $P = 0.004$). The attitudes directly affected practice ($\beta = 0.280$, $P = 0.021$) (Fig. 1**and** Table 2).

Discussion

The results suggest that pregnant women in Henan Province have moderate knowledge, attitudes, and practices toward food preservatives, but several knowledge items had poor scores. The study highlights the importance of targeted education interventions to help improve knowledge gaps and further promote healthier practices related to food preservatives during pregnancy.

Adequate knowledge is necessary to understand the various substances used as food preservatives and their possible impacts on maternal and fetal health. A previous study from Bangladesh showed that women had a poor KAP toward food safety, including the only question about food preservatives [30]. A study dating back to the pre-Internet era showed that Pakistani women were unaware of the noxious substances in food [31]. Still, KAP data on food preservatives during pregnancy are scarce. In the present study, pregnant women in the Henan Province had borderline moderate knowledge

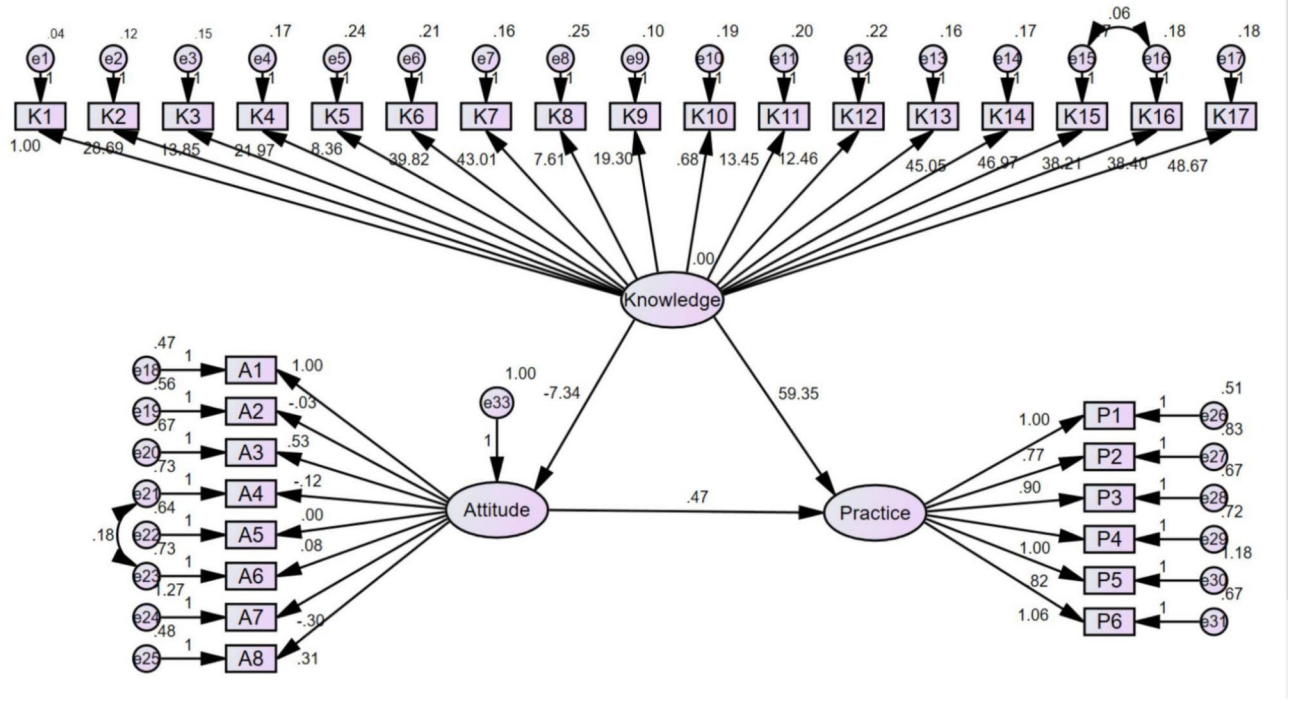

Fig. 1 Structural equation model (SEM)

Table 2 Estimates of hypothesis paths among food safety knowledge, attitude, and practice

Model paths	Direct effect		Indirect effect	
	β (95% CI)	*P*	β (95% CI)	*P*
A←K	0.168 (0.098, 0.244)	0.005	-	-
P←K	0.250 (0.150, 0.317)	0.021	0.047 (0.020, 0.080)	0.004
P←A	0.280 (0.146, 0.356)	0.021	-	-

of food preservatives, as well as moderate attitudes and practices. The discrepancies could be related to the healthcare systems and the nutritional counseling during pregnancy among countries. In addition, the Internet era brought easy access to health information but also access to a huge amount of misinformation about health subjects [39, 40]. The results suggest that despite moderate knowledge, the women followed the advice taken from the healthcare providers, family, friends, media, and the Internet, but without completely understanding them and without motivation. The present study identified several knowledge gaps about food preservatives that should be enforced in the education given to pregnant women (e.g., about the safety of preservatives in foods). Still, the exact causes of these gaps in knowledge was not determined in the present study. The possibilities could include, among others, deficient education about proper dietary habits at school, at work, or in society in general, improper dietary counseling at the beginning of pregnancy, a lack of interest in learning about healthy dietary habits, and inconsistent knowledge found on the Internet or among professionals. The exact causes of the knowledge gaps will have to be addressed in future studies. Nevertheless, the knowledge gaps observed in the present study included the nature and origin of the food preservatives, the potential effects on the mother's and fetus's health, the goal of using preservatives and their impact on food safety, and the general toxicity profiles of different preservatives. Indeed, sugar, sodium chloride, and vinegar are traditional food preservatives that pose minimal risks to health [41, 42]. The main concerns should lie with the chemical food preservatives, including nitrites, sodium benzoates, potassium benzoates, and β-cyclodextrin, for example [3–8, 17]. The dose is probably the key to the potential harmful effects of food preservatives in pregnant women, but data are lacking [3–8, 17, 23–26]. Still, it has been reported that many women are cautious about consuming foods with food preservatives, suggesting some positive attitudes and proactive practices in many women, as observed in the present study. Nevertheless, the results suggest that there is room for improvement in Henan Province.

The present study showed that knowledge and attitudes were positively correlated with practice. In addition, participants with higher education were more likely to exhibit higher practice scores. A higher socioeconomic status is generally associated with better health literacy [43]. It is also possible that women with a higher

education occupy a more intense job that leaves them less time to cook and care about healthy eating, and it is possible that such women consume higher amounts of prepared foods [44]. Unfortunately, a food questionnaire was not included in the present study. Future studies are needed to investigate the relationship between the KAP toward food preservatives and the actual eating habits of pregnant women. Nevertheless, the correlations among KAP dimensions indicate that improving knowledge should translate into better attitudes and practices. Indeed, according to the KAP theory, knowledge is the basis for practice, and attitude is the force driving practice [35, 36]. Therefore, women seeking pregnancy should be informed about the possible harms of food preservatives as soon as possible in the pregnancy process, ideally before conception. Such education could be given in high school, in fertility clinics, or in waiting rooms at the physician's office. The education could take the form of pamphlets, websites, or videos, for example, explaining the possible harms of food preservatives to the fetus and pregnant woman. The intervention could also propose alternatives to processed food. Public health policies and dietary guidelines for pregnant women should consider including specific guidance about processed and ultra-processed foods and food preservatives.

The SEM showed that knowledge directly influenced attitude and practice and indirectly influenced practice. Therefore, improving the knowledge of preservatives and processed foods could improve attitudes and practices. Indeed, it is suggested that processed and ultra-processed foods should be avoided during pregnancy [45] since the consumption of ultra-processed foods has been associated with the development of chronic diseases in the general population and pregnant women [46, 47], including anemia [48], excessive weight gain [49], hypertension [49], and gestational diabetes [50]. Still, despite the common knowledge that processed foods have detrimental effects on health in general, a study showed that 95% of pregnant women ate ultra-processed foods [51], and two studies showed that about 33% of the calorie intake in pregnant women was from ultra-processed foods [52, 53], with negative impacts on the nutritional profile [54], suggesting poor nutritional practices during pregnancy in several populations, despite relatively better knowledge. Considering the moderate knowledge and practice, it is possible that pregnant women follow several pieces of advice without understanding them. Again, future studies should include a food questionnaire to correlate the KAP levels with the consumption of foods containing high levels of preservatives.

This study had strengths. It enrolled a large sample of pregnant women from the same province in China. The questionnaire covered several aspects of knowledge, attitudes, and practices toward food preservatives, enriching the scarce literature on the subject.

On the other hand, this study is not without limitations. The use of an e-questionnaire allows for efficient data collection, but it may have introduced response bias, particularly if participants were more comfortable completing electronic forms or if those with internet access had a different profile than those without. This was a single-center study conducted in Henan province, which enrolled pregnant women from a specific area, limiting its generalizability. Although the study included a relatively large sample, the findings may not apply to other regions, particularly those with different cultural, economic, or educational contexts. Moreover, most participants were under 30 years of age, urban dwellers, and employed. This skew toward younger, urban, and employed women may limit the applicability of the findings to older, rural, or non-working pregnant women, who may have different levels of knowledge and practice regarding food preservatives. Future studies should consider a more diverse sample from multiple regions or even rural settings to improve external validity. The questionnaire was designed by local investigators and was probably biased by local practices, guidelines, and policies. The study was cross-sectional and did not allow any causality analysis or provide data about changes in KAP over time. A SEM analysis was performed, but a SEM analysis only provides a statistical surrogate of causality and should be considered with caution [55–57]. In addition, it is a punctual measurement of time, but it could serve as a baseline for future intervention studies. Longitudinal data could add refinement to the results and their interpretation. The study did not examine the role of cultural beliefs, media exposure, access to health information, or socioeconomic factors, all of which may influence how pregnant women learn about food preservatives. The collected data revealed very limited statistically significant differences, which restricted the possibility of further analysis. It would be valuable to explore the reasons behind women's limited or poor knowledge, as this could provide insight into areas where educational interventions might be most effective. Finally, KAP studies are subject to social desirability, in which the participants can answer what they should do instead of what they really do [58, 59]. Those issues will be considered in future studies to reach more robust conclusions.

Conclusions

In conclusion, this study showed that pregnant women in Henan Province had moderate knowledge, attitudes, and practices toward food preservatives. Several knowledge areas had poor scores, especially regarding food safety, generalities about food preservatives, and the potential toxicity of food preservatives. Although the exact

harmfulness of food preservatives to pregnant women is unknown, it could do no harm to teach them to avoid processed foods when possible and to cook themselves and consume fresh products as much as possible.

Abbreviations

KAP	Knowledge, attitude and practice
SEM	Structural equation model
SD	Standard deviation
AGFI	Adjusted goodness of fit index
CFI	Comparative fit index

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12884-025-07436-z.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Supplementary Material 6

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None.

Author contributions
Shuai Yuan and Zhixin Shen carried out the studies and participated in collecting data. Shuai Yuan and Weimei Liu performed the statistical analysis and participated in its design. Shuai Yuan, Meitian Ren, and Shuangying Hao participated in the acquisition, analysis, or interpretation of data and drafted the manuscript. All authors read and approved the final manuscript.

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Data availability
All data generated or analyzed during this study are included in this article and supplementary information files.

Declarations

Ethics approval and consent to participate
This work has been carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. The study was approved by the Ethics Committee of the School of Medicine of Henan Polytechnic University (Approval No. HPU2022-002). Written informed consent was obtained from all participants before they completed the survey.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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