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Impact of Artificial Intelligence (AI) on Antenatal Care Services' (ANCS) Adherence Among Multiparous

Alaa Ali Yousef Bsoul[1], Duaa AL Maghaireh[2], Khitam Alsaqer[3] & Niven Basyouni[2,4,*]

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Abstract: An increasing number of pregnant women are utilizing AI-based tools for health-related purposes as these technologies become more accessible. This study aims to explore the relationship between the use of digital platforms for health purposes and maternal adherence to prenatal healthcare services. A mixed-method design was employed, including a quantitative component with 320 pregnant multiparous women recruited through convenience sampling, and a qualitative component with 25 pregnant women selected through purposive sampling until data saturation. Data collection involved the Pregnancy Demographic Data Questionnaire and the Antenatal Care Scale (ANCS). The Results showed that 93.7% of participants had smartphones with internet access, and 84% used AI tools for 2-5 hours daily. Google was the most frequently used platform (57.9%), followed by mobile applications and YouTube (42.1%), while ChatGPT was used by 5.3%. AI tool usage was significantly associated with participants' ANCS scores (p=0.001). However, 62.2% of participants demonstrated poor attitudes and intentions toward antenatal care adherence. The study identified multiple barriers to antenatal care adherence, including issues related to the healthcare system, users, and social support systems. In conclusion, the findings suggest that integrating respectful maternity care information into AI tools may encourage pregnant women to seek prenatal care. Future research should consider the diverse socioeconomic backgrounds of expectant mothers to better understand their attitudes and challenges in accessing prenatal services.

Keywords: Artificial intelligence (AI), Digital Tools, Antenatal Care Services (ANCS), Social Media.

Introduction

A women's pregnancy can have an influence on both their somatic, emotional and psychosocial welfare. This can create a demanding and meaningful time in her life. On one hand, accommodating to the momentous physiological and anatomical modifications provoked by antenatal period could be interesting. On the other hand, an ultimate need of her physical health, including psychosocial state, is her must to safeguard both her herself as well as fetus.1 Antenatal visits are an excellent occasion to impact the health and welfare of expectant mothers, developing fetuses, and coming newborns. It helps to identify women who are at high risk in order to enable prompt care during pregnancy and childbirth.2

Deaths resulting from complications during pregnancy or childbirth are referred to as maternal mortality. Across twenty years from the beginning of the year two thousand to two thousand and twenty, the universal maternal mortality ratio (MMR) dropped by approximately one third –from three hundred and thirty-nine to two hundred and twenty-three maternal deaths per hundred thousand live births, according to UN estimates between agencies. This corresponds to a 2.1 percent average annual rate of decline. Although significant, this is only approximately 33% of the 6.4% annual rate required by 2030 to meet the Sustainable Development Goal (SDG) of 70 maternal deaths per 100,000 live births. While there has been substantial progress in global (MMR) rates from 2000 to 2015, the rates have been motionless on average from 2016 to 2022In most regions, there was a halt in the rate of decline, and in western Europe and north America, as well as Latin America and Caribbean, MMR prevalence increased in the period 2016-2022. There's hope, but it won't happen overnight. A handful of countries have

1 RN, MSN, Nursing Department, Zarqa College, Al Balqa-Applied University, Salt, Jordan ORCID, 0009-0001-1579-1322
2 Nursing Department, Faculty of Nursing, Irbid National University, Irbid, Jordan
3 Nursing Department, Faculty of Nursing, Zarqa University, Zarqa, Jordan.
4 Obstetrics and Gynecologic Nursing Department, Alexandria University, Alexandria, Egypt and Nursing Department, Faculty of Nursing, Irbid National University, Irbid, Jordan, ORCID 0000-0002-7116-5625.
* Corresponding author: dr.niven@hotmail.com

reduced emissions by 15% or more each year over the past two decades, bringing them close to or above their reduction targets to meet global aims.3 In Jordan accurate estimation of maternal morbidity and mortality is still underestimated.

But the majority of these maternal deaths are avoidable. In order to reduce the global health burden of maternal and infant mortality, tools of Artificial Intelligence (AI) such as YouTube videos, Facebook, google web Sites, Mobile Applications and digital announcements, can be integrated into the current interventions to help raise awareness. Other strategies include sending reminders for healthcare arrangements and schedules, promoting ANCS, and stepping up health promotion.4 For illustration, increasing the availability of parental facts and information on AI tools can boost the usage of ANC and increase the adherence to antenatal visits.5 An improvement in prenatal care attendance was seen in a study carried out in Zanzibar, Tanzania, that created a mobile phone ANC intervention utilizing short messaging services to enable two-way communication between healthcare providers and pregnant women.6 It's interesting to note that providing ANCS via digital technologies is still in its early years and is not done often enough, which prevents developing technologies from being fully utilized.7 Apparently, the majority of pregnant women attended ANCS at least four times, but in Malawi, as an example of one of the developing countries, approximately only one-third of women had their first ANC visit in the first trimester.8 Policymakers can create low-cost mobile initiatives for pregnant women by identifying AI technologies that are practicable and can be used to promote ANC services adherence.9 Besides, these mobile AI tools can be used for appointment scheduling, reminders, monitoring ANC visit adherence, and two-way contact between expectant mothers and healthcare providers .10

Over the last decades, computer based intelligence ,Artificial Intelligence (AI), has been creating a noteworthy awareness in an extraordinary number of fields and ventures, including medical and health maintenance and care.11 In the context of using AI in health research, it implies prediction, generally refers to, which is the probability that a certain condition is present but has not yet been detected. Among numerous others, prediction research papers can also be recognized into quite a lot of categories. One of them is explanatory studies, in which the aim to identify which indicators contribute to the outcome.12

In the peculiar setting of pregnancy and antenatal care, numerous simulated intelligence calculations and strategies have been applied for the expectation or anticipation of problems. AI tools are widely used by many women to ask, check and understand many of their symptoms and complains related to the state of pregnancy.13 Formatting feasible AI tools that can be employed to enhance Antenatal Care Services can assist legislators to develop affordable mobile interventions for antenatal women. Alike these mobile wellbeing interventions can be used to launch conjoint communication between mothers and maternity nurses, make arrangements, send memorials and keep an eye on Antenatal Care visits compliance among them.5 Therefore, this study explores and explains the impact of artificial intelligence (AI) usage on multiparous adherence to antenatal visits. Since use of AI tools became popular, an increasing number of mothers have used it for purposes connected to their health. The purpose of this paper is to provide an overview of the association between different digital platforms use for health-related reasons and maternal adherence to antenatal care schedule of visits, in order to reflect on the alleged beneficial and potentially harmful effects of AI use by pregnant mothers.

Methods

Design

An Explanatory mixed methods design was used to conduct this study. This explanatory study consists of two phases: quantitative design, followed by qualitative design. The quantitative research design used a descriptive, cross-sectional survey design. A quantitative approach was chosen because it allows the researcher to describe and examine the relationship among the variables.

Participant /Quantitative design

Convenience sampling technique was used to recruit the pregnant women chosen for quantitative design. The inclusion criteria include: Jordanian pregnant mothers, aged 18- 40; married, who speak Arabic language, consent to participate in the study; normal pregnancy; no infertility history; no abortion history; multiple pregnancy, who lived in the region, and beginning of their second trimester of pregnancy. The sample size (n 320) was considered to be adequate as it was equal to 10 times the number of items in the scale (26) and add 20% response rate. The number of participants should be, at least, three times the number of items in the scale.14

Participant / Qualitative design

A non-probabilistic, purposive sampling method was used to recruit 25 pregnant women. The qualitative sample size is determined until the data reached a saturation point.

Setting

This study was conducted in Teaching Community health centers in the north of Jordan. It was selected because it was the biggest teaching center in the north of Jordan. The center is located in Irbid, with a nearly 80-120 women visit the antenatal clinic daily.

Instruments:

Pregnancy Demographic Data Questionnaire

Demographic data Questionnaire was developed by the researcher based on literature review.15-18

Antenatal Care Scale (ANCS)

Antenatal Care Scale developed by Emel Tas-c-ı-Duran et al. (2013). The ANCS were categorized into six subgroups based upon the TPB: intention (three items); subjective norm (three items); normative beliefs (eight items); attitude towards the behavior (six items); behavioral beliefs (four items); and perceived behavioral control (two items). The instrument was intended to be a seven-point Likert scale, with seven indicating complete agreement and one indicating complete

disagreement. Some items on the scale were seven-point Likert type but did not range from 'totally disagree' to 'totally agree', and instead varied according to the attitude that was described for that specific item. The possible range of the ANCS was 26–182, with higher scores indicating a stronger intention to receive antenatal care. The scale is valid and reliable with 0.73 to 0.93. at Jordan.19

Ethical Consideration

Approval for this study was granted by the Committee on Human Research, Publications and Ethics at Irbid National University at Jordan to conduct this study. Written consent was also obtained from pregnant women before enrolling them as study participants. Participants were assured of the confidentiality of the study and can withdraw at any time.

Data Collection

Data collection was conducted in two phases: quantitative phase, and qualitative data phase.

In qualitative phase; The researchers visited the clinic before day from data collection to Identify those who met the inclusion criteria. The home address and phone number of pregnant women were recorded. Self-reported questionnaire was distributed. In the second phase, qualitative semi-structured in-depth interviews were used to identify the themes. The researcher prepared two questions which were reviewed by three nursing professionals (A, B, C). Professional A is an Associate professor in nursing college at Jaresh Private University; Professional B is Assistant Professor in the Department of Nursing Sciences at Jordan University of Science and Technology and Professional C is a professor in the Faculty of Nursing at Irbid National University. The pregnant mothers were interviewed in a closed room in the clinic to avoid interruptions and ensure privacy during the interview. Subsequently, the researcher acquired informed consent from the participants, ensuring them of the confidentiality of all data and providing them with the option to withdraw at any point. In order to encourage participants to clarify their thoughts and emotions, the researcher asked them two open-ended questions during the interview. After obtaining participants written consent, the researcher used a smartphone to record the interview. The interview was taped by the researcher because taking thorough notes during the interview would have caused him or her to lose a lot of crucial information and led them to make less eye contact and listen during the interview. Following the interview, the researcher used a USB connector to connect the smartphone to a computer and uploaded all of the audio recording data. To avoid data loss, the researcher created numerous copies of the audio recordings and kept them on a variety of data storage devices (such as a computer, USB drive, Google Drive, and external hard drive).

Results

Most of participants are less than 30 years (57.9%) with postgraduate level 70% of the participants, and most of them are working (86.4%). The majority have access to health services (84%). All participants were pleasure of pregnancy and they have a smartphone with internet availability (93.7). 84% of participants were use the AI tools mostly about 2-5 hours a day. Table (1)

Table (1): Baseline characteristics of the survey respondents.

Characteristic	Categories	n	%
Age	>=30 years	135	42.1
	<30 years	185	57.9
Occupation	Yes	219	68.4
	no	101	31.6
Living place	City	152	47.5
	Village	168	52.5
Access to health services	Yes	269	84
	no	51	16
Pleasure of pregnancy	Yes	320	100
	no	0	0
Do you have smart phone?	Yes	320	100
	no	0	0
Availability of internet	Yes	303	93.7
	No	0	0
Intermittent		17	6.3
AI tools using	Yes	269	84
	No	51	16
Time of using the AI tools	>2 hr	76	23.75
	2-5 hr	192	60
	>5 hr	52	16.25
Education level	Undergraduate	96	30
	Postgraduate	224	70

The most AI tools used was the google (57.9%) then mobile application and YouTube (42.1%), chat GPT was used by 5.3%, 15.8% use different tools. Figure (1)

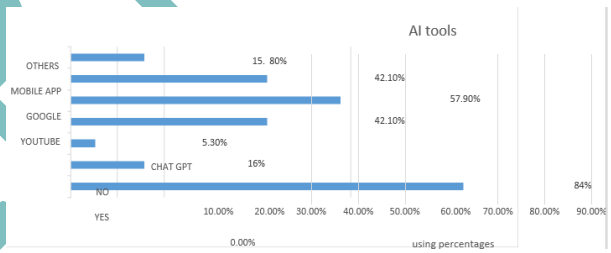

Figure (1): Have you use any of the following tools to get health information about your pregnancy?

With mean of 3.46 participants reported that they intend to attend antenatal check-ups at least once a month. However, mean of 4.84 participants reported that their doctor/nurse/midwives think that I must attend antenatal check-ups at least once a month. With mean of 4.61 they want to do what my doctor/nurse/midwives think that I should do about antenatal check-ups and It is good for their health to attend antenatal check-ups at least once a month. Mean of 4.69 attending antenatal check-ups at least once a month under your control. Low mean was observed among female who reported that they intend to attend antenatal check-ups at least once a month (3.46), same among those people who are important to the participants think that they must attend antenatal check-ups at least once a month. Also with low mean (3.46) participants want to do what their family think that they should do about antenatal check-ups. Table (2)

Table (2): The attitudes and intentions of women towards receiving antenatal care (ANCS).

Items	Mean ± SD
I intend to attend antenatal check-ups at least once a month	3.46 ± 1.79
I want to attend antenatal check-ups at least once a month	4.38 ± 2.05
I hope to attend antenatal check-ups at least once a month	4.53 ± 2.11
People who are important to me think that I must attend antenatal check-ups at least once a month	3.46 ± 1.91
People who are important to me approve that I attend antenatal check-ups at least once a month	4.07 ± 1.92
People who are important to me want me to attend antenatal check-ups at least once a month	3.76 ± 1.95
My friends think that I must attend antenatal check-ups at least once a month	4.00 ± 1.79
I want to do what my friends think that I should do about antenatal check-ups	3.84 ± 1.81
My husband/non-marital partner thinks that I must attend antenatal check-ups at least once a month	3.61 ± 2.06
I want to do what my husband/non-marital partner thinks that I should do about antenatal check-ups	3.76 ± 2.11
My family (e.g. mother, father) thinks that I must attend antenatal check-ups at least once a month	3.76 ± 2.06
I want to do what my family (e.g. mother, father) think that I should do about antenatal check-ups	3.46 ± 1.60
My doctor/nurse/midwives think that I must attend antenatal check-ups at least once a month	4.84 ± 1.60
I want to do what my doctor/nurse/midwives think that I should do about antenatal check-ups	4.61 ± 2.05
Attending antenatal check-ups at least once a month for me is	4.00 ± 1.47
Attending antenatal check-ups at least once a month for me is	3.61 ± 1.69
Attending antenatal check-ups at least once a month for me is	3.53 ± 1.61
Attending antenatal check-ups at least once a month for me is	4.00 ± 1.67
It is good for my health to attend antenatal check-ups at least once a month	4.61 ± 1.88
Attending antenatal check-ups at least once a month is	3.76 ± 1.44
Attending antenatal check-ups at least once a month helps to protect my baby's health	4.53 ± 1.59
Attending antenatal check-ups at least once a month is	4.23 ± 1.36
Attending antenatal check-ups at least once a month helps to protect my health	4.38 ± 1.53
Attending antenatal check-ups at least once a month takes my time… does not takes my time	3.53 ± 1.35
Attending antenatal check-ups at least once a month totally depends on my desire	4.53 ± 1.99
How much is attending antenatal check-ups at least once a month under your control?	4.69 ± 1.93
Total mean	**4.041 ± 1.87**

The possible range of the ANCS was 26–182, with higher scores indicating a stronger intention to receive antenatal care.

The possible range of the ANCS was 26–182, with higher scores indicating a stronger intention to receive antenatal care. The mean of Participant's attitudes and intentions toward ANCS was 105.78 ranged between 26 and 182 with a significant p value (<0.05) from the assumed mean (104). Table (3)

Table (3): Attitudes and intentions toward ANCS One sample t-test

One sample t-test

Attitudes and intentions toward ANCS	min	max	Real Mean	Std. Deviation	Assumed Mean	t-value	Sig.
	26	182	105.78	21.15	104	13.632	0.000

The participated women show strong attitudes and intentions toward ANCS (37.8%) while most of participated women were poor attitudes and intentions toward ANCS (62.2%). Table (4)

Table (4): Attitudes and intentions OF Women toward ANCS (Strong and Poor).

Level of Perception	Frequency	percentage
Strong (≤ 104)	121	37.8
Poor (> 104)	199	62.2
Total	320	100.0

The attitudes and intentions toward ANCS was associated with Age, occupation, access to health services, education level, and having a smart phone (p<0.05). Using the AI tools was associated with the participant ANCS score (p=0.001). Table (5)

Table 5: Association between the attitudes and intentions toward ANCS and AI tools using and their Demographic characteristics.

Variables		attitudes and intentions toward ANCS		X2	p-value
		Strong	Poor		
Age	>= 30 years	105	30	8.238	0.004*
	< 30 years	100	85		
Pleasure of pregnancy	Yes	170	150	2.511	0.121
	No	0	0		
Occupation	Yes	20	199	8.392	0.003*
	No	70	31		
Living place	City	68	84	.015	0.570
	Village	85	83		
Access of health services	Yes	146	123	16.717	0.001*
	No	24	27		
Education level	Undergraduate	62	34	8.114	.036*
	Postgraduate	98	126		
Do you have smart phone?	Yes	121	199	7.112	.029*
	No	0	0		
Availability of internet	Yes	85	218	.015	0.570
	Intermittent	8	9		
AI tools using	Yes	56	213	17.618	0.001*
	No	36	15		
AI tools using time	>2 hr	41	35	.015	0.570
	2-5	77	115		
	>5 hr	29	23		

Pregnant women not adhering to the antenatal clinic could be related to maternal healthcare system barriers, barriers related to maternal healthcare users and barriers related to the social support system.

First: Maternal healthcare system barriers include; quality of service delivery and human resources, along with essential equipment. Also, financial barriers, access barriers,

communication and information barriers, medical system barriers, and emotional barriers

"The private sector doctors provide a detailed scan of my baby and conduct thorough check-ups for both me and my baby"

"The cost of examination is high every month in private clinics, and I prefer the private clinic more than the government one, because there is better attention and care, and the doctor explains everything related to pregnancy".

"If I visit the maternity clinic, I usually go in the morning to see the doctor. While there, I receive many visitors and spend most of my time waiting. By the time I come back home, I am very exhausted but still eager to care for my children and educate them"

"I couldn't locate the medication in a lot of reviews, so I ended up purchasing it at my own cost from somewhere else."

Second: Antenatal care visit barriers related to maternal healthcare users include; the demands of academics, employment, and assessments such as exams and work commitments can hinder pregnant individuals from attending antenatal care visits and insufficient knowledge

"I did not attend the antenatal clinic monthly because I had very busy in my studying and exams, and the university was not always willing to suspend me until I went to review".

"Had the pressure of studying and exams, and the university was not always willing to suspend me until I went to review"

"During my pregnancy, I didn't visit the doctor and assumed that, as with previous pregnancies, folic acid and baby aspirin would be sufficient. It came as a surprise when I learned that I needed to begin taking diluted injections after the pregnancy was over".

Third: Cultural barriers related to traditional beliefs barriers & traditional practice barriers as well as traditional preferences barriers

"I did not go to the antenatal clinic until the fourth month to know the sex of the fetus, when I knew baby sex, I committed to the visits"

"The first three months of pregnancy, I did not visit the doctor. I kept taking folic acid, but when I was in the fourth, I went to the doctor to know the sex of the fetus."

Fourth: Antenatal care barriers related to Socio-economic barriers:

"I did not go to many reviews because each visit cost me more than 20 dinars, and they were not available every month".

"It is true that I am safe in government hospitals, but in the days I did not have a rental car"

Discussion And Conclusions

Although, the majority of women enrolled in the study sample were having access to health services, postgraduate and all of them are pleased with their pregnancy, the study's findings indicate that they are in general had a poor attitude and an intention to comply with antenatal care services, which is reflected in their irregular prenatal visits. Another interesting finding, almost two thirds of them use the AI tools, for 2 to 5 hours daily regardless of their occupation. The results are congruent with a research by Karácsony 2020, shows that about 11 % of study sample spend more than six hours; less than one fifth between four and six hours; one third use it from between two to four hours; less than one third between one and two hours; and minority use it for less than an hour. 20

Indeed, certain women can realize advantages from various artificial intelligence instruments. Conversely, some lack sufficient health information to distinguish between the physiological changes that are typical during pregnancy and the warning or dangerous signals that need to be reported right away to her obstetrician which may make them reluctant of seeking antenatal health care.

Supported this study findings, It has been discovered that patient use of AI, in form of social media platforms, has an impact on the relationship between the patient and the healthcare provider. This includes more equitable communication, more frequent doctor switching, and less than ideal interactions.21

This study result is incongruent with Bashir, et al 202322 who reported that most of women in his study had a positive attitude toward ANCS.22 This contradiction can be explained as the level of overall knowledge of the Bashir's respondents about ANC was average leading to healthy practice and compliance with ANCS. This may confirm the researchers' point of view that health knowledge had a significant positive correlation with women practices and adherence to antenatal visits during pregnancy. The bias that may limit AI's utility and efficacy is the relative paucity of knowledge regarding women's healthcare.

According to Norori, et al 202323 lack of knowledge is not the only bias but algorithmic bias is a significant unresolved issue that needs to be addressed.23 Artificial intelligence (AI) has great promise for transforming the healthcare industry and supporting clinical decision-making. Prior to AI being included into healthcare procedures, large datasets are necessary for most AI systems to learn from different ethnics and populations. Some populations are considered a risk group for severe pregnancy-related disorders such as preeclampsia, obesity and other illnesses. While some illiterate societies might confuse real medical care with health information meant for laypeople, raising the possibility of grave health effects. Yet many human population groups have a long history of being either completely absent or inaccurately represented in biological datasets. AI is prone to reinforcing bias if the training data is not reflective of the population variability. This can result in disastrous results, incorrect diagnoses, and inability to generalize data.

In this context Ventola 201424 said that AI tools like social media and platforms have the potential to improve health outcomes for individuals and society as a whole, as well as for professional growth and development. But when used incorrectly, the potential health risks associated with these technologies are significant. Health care organizations and professional associations provide clear and useful guidelines

that health care professionals should adhere to in order to avoid common consequences of improper use of digital tools.

In this regard, one thing for another is mentioned, in a research about telehealth Smith et al 202325found a likeness in the regularity of face to face antenatal care visits proposes that telemedicine meets headed to greater communication with midwives and did not take the place of face-to-face interactions. During the COVID-19 pandemic, Spanish-speaking patients had the lowest likelihood of using telehealth-delivered antenatal care; a small but considerable percentage of patients had no or few telephone encounters, while a significant number had high telemedicine use. Future antenatal care delivery that incorporates telemedicine should take quality, mother and provider satisfaction, access, overabundance, and provider burden into account. 25

Among barriers that may contribute to non-adherence to antenatal visits, women have mentioned barriers related to maternal healthcare system. Also, barriers related to maternal healthcare users and barriers related to the social support system. Nyando et al 2023[26] found that the majority of pregnant women believe that antenatal care visits during the first trimester are only for women with pre-existing health conditions such as back pain, headache, or HIV/AIDS. In addition, first trimester pregnancies were seen as too small to warrant antenatal care. Antenatal women's awareness, health systems, socioeconomic and individual barriers may have influenced compliance with initial antenatal care during the first trimester. Adding, the contributors had inadequate knowledge about the necessary slandered number of ANC visits. Addressing knowledge gaps and overcoming financial, personal, and health barriers can improve women's early prenatal care visits. [26]

Maternal healthcare system barriers could be barriers related to quality of service, delivery and Human Resources, along with Essential Equipment Maternal healthcare system barriers include financial barriers, access barriers, communication and information barriers, medical system barriers, and emotional barriers.[27]

These barriers can prevent pregnant women from accessing the necessary care and support during pregnancy, childbirth, and postpartum. The financial barriers in the maternal healthcare system can greatly hinder pregnant women from receiving necessary care. These financial barriers can include the cost of prenatal and postnatal exams, hospital fees, medications, and transportation to healthcare facilities.[28]

This study sheds light on the ongoing attempts to enhance women's health by investigating and elucidating the impact of artificial intelligence tools on their well-being. Correct and comprehensive information is becoming more and more crucial for those in the healthcare industry to learn from in order to provide users with the most accurate and unbiased information possible and to enhance the experience of expectant mothers. The first step is to safeguard AI tools' advantages while limiting their potential for harm. Whether a user is looking for information regarding prenatal care or is just looking for a transcription service that accurately recognizes and transcribes the phrases for women's antenatal anatomical changes, this strategy, among others, can help make AI a positive healthcare tool for users worldwide.

Recommendations

The study's conclusions allow health programs to inform the community as a whole about antenatal care services and health promotion. The results may also be used by policymakers and medical professionals to improve prenatal care recommendations, which will lower the maternal and/or fetal morbidity and mortality rates. The study goes on to advise health managers to organize and carry out high-quality, necessary prenatal care programs. In order to foster an environment that will encourage expectant mothers to seek out prenatal care, AI algorithms should include information on courteous maternity care. Future studies should take into account expectant mothers from a range of socioeconomic backgrounds in order to better understand these attitudes and obstacles.

Disclosure Statement

- **Ethical approval and consent to participate:** This study was approved by the ethical committee of the faculty of nursing, Irbid National University. All participants provided written informed consent prior to their inclusion in the study. Participants were assured of the confidentiality of the study and can withdraw at any time.
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