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REVIEW

The Role of Artificial Intelligence in Improving Maternal and Fetal Health During the Perinatal Period

Perinatal Dönemde Anne ve Fetüs Sağlığının İyileştirilmesinde Yapay Zekanın Rolü

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Abstract

This traditional review aims to explore the role of artificial intelligence (AI) in maternal and fetal health during the perinatal period, examining its applications in obstetrics and the implications for healthcare professionals. A comprehensive literature review was conducted to analyze the current applications and potential of AI in improving maternal and fetal health outcomes throughout pregnancy and the postpartum period. The researcher conducted a literature review using appropriate keywords in the PubMed, Google Scholar, ScienceDirect, Web of Science, and Cochrane Library databases from 2013 to 2024. AI technologies show significant potential in enhancing diagnostic accuracy in clinical settings by identifying complex medical data in fetal and maternal health, assisting in risk assessment, and enabling early detection of complications. These applications facilitate early pregnancy detection, genetic screening, continuous monitoring of maternal health parameters with real-time alerts for deviations, and early detection of fetal abnormalities through advanced imaging. The application of AI during pregnancy, childbirth, and the postpartum period enhances the quality of care and patient satisfaction, while also raising important ethical considerations regarding patient privacy, data security, and decision-making responsibility. AI applications are transforming clinical practices in maternal and fetal health through advanced diagnostic capabilities, predictive modeling, and personalized care interventions, thereby contributing to the reduction of morbidity and mortality rates for both mothers and babies and the improvement of health outcomes.

Keywords: Artificial intelligence, fetus, health, mother, pregnancy

Öz

Bu geleneksel derlemenin amacı, yapay zekanın perinatal dönemde anne ve fetüs sağlığındaki rolünü araştırmak, doğum alanındaki uygulamalarını ve sağlık profesyonelleri için çıkarımlarını incelemektir. Yapay zekanın gebelik ve doğum sonrası dönemde anne ve fetüs sağlığı sonuçlarını iyileştirmedeki mevcut uygulamalarını ve potansiyelini analiz etmek için kapsamlı bir literatür taraması yapılmıştır. Literatür taraması iki araştırmacı tarafından, 2013-2024 yılları arasında PubMed, Google Akademik, ScienceDirect, Web of Science and Cochrane Library veri tabanlarında uygun anahtar kelimeler kullanılarak yapılmıştır. Çeşitli veri tabanlarından elde edilen makalelerden benzer olanlar, Türkçe ve İngilizce tam metnine ulaşılamayanlar ve arama terimleri dışında olanlar derlemeden hariç bırakılmıştır. Yapay zeka teknolojileri, fetal ve maternal sağlıkta karmaşık tıbbi verileri belirleyerek, risk değerlendirmesine yardımcı olarak ve komplikasyonların erken tespitini sağlayarak klinik ortamlarda tanısal doğruluğu artırmada önemli bir potansiyel göstermektedir. Bu uygulamalar, erken gebelik tespitini, genetik taramayı, sapmalar için gerçek zamanlı uyarılarla maternal sağlık parametrelerinin sürekli izlenmesini ve gelişmiş görüntüleme yoluyla fetal anormalliklerin erken tespitini kolaylaştırmaktadır. Yapay zekanın gebelik, doğum ve doğum sonrası dönemlerde uygulanması, bakım kalitesini ve hasta memnuniyetini artırırken, aynı zamanda hasta gizliliği, veri güvenliği ve karar verme sorumluluğu ile ilgili önemli etik hususları da gündeme getirmektedir. Yapay zeka uygulamaları, gelişmiş tanı yetenekleri, öngörücü modelleme ve kişiselleştirilmiş bakım müdahaleleri yoluyla anne ve fetüs sağlığında klinik uygulamaları dönüştürüyor ve sonuç olarak hem anneler hem de bebekler için morbidite ve mortalite oranlarının azaltılmasına ve sağlık sonuçlarının iyileştirilmesine katkıda bulunuyor.

Anahtar Kelimeler: Yapay zeka, fetüs, sağlık, anne, gebelik

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Introduction

Despite significant progress in maternal health in recent years, maternal and perinatal deaths remain high each year. During pregnancy and after, there are 295,000 maternal deaths and 2.4 million neonatal deaths annually. Most of these deaths occur in low- and middle-income countries. Lack of prenatal care, limited access to life-saving treatments for mothers, fetuses, and newborns, and complications arising during and after pregnancy are the main causes of maternal and neonatal deaths (1).

Pregnancy is a physiological process that provides all the conditions for normal fetal growth and subsequent birth. However, while this process continues normally, complications can sometimes develop. For example, complications such as gestational diabetes and preeclampsia during pregnancy, or stillbirth, cesarean section, macrosomia, and respiratory distress during the perinatal period can occur. The search for new strategies for early diagnosis, screening, and risk assessment can alleviate the severity of these changes. This also reduces the health risks to mother and child. Interestingly, in recent years, researchers have used artificial intelligence (AI) applications to find solutions to these problems (2).

The concept of AI was first defined by John McCarthy as "the use of machines and programs that think, perceive, analyze, synthesize, make correct decisions using inferences, and mimic human behavior with minimal human intervention". Artificial intelligence, based on the functions of the human brain, can also be defined as the transfer of human-like abilities such as thinking, interpreting, analyzing, and decision-making to systems like computers, robots, and programs (1,2). In health management, the applications of AI are quite extensive. National and regional health institutions/organizations around the world use AI applications for identification, decision-making, and implementation of general administrative decisions (3). The World Health Organization and global health systems recommend the use of AI technologies to standardize applications, reduce inequalities, optimize services, identify potential deficiencies, and enhance efficiency and performance (4). Various applications (mobile health, robotic, etc.) in healthcare services aim to diagnose diseases before they progress, prevent unnecessary treatments, conduct screenings and analyses quickly and accurately, assist healthcare personnel in making correct decisions, and empower patients to manage their own current conditions through AI technology (5-7).

Artificial intelligence-based support systems aim to determine the most suitable treatment for the patient by analyzing the outcomes of various previously applied treatment methods and clinical "big data" databases. By implementing these systems, we can achieve rapid diagnosis and increased treatment success rates for diseases like cancer, immune system disorders, and neurological diseases, which require a "precision medicine" approach for treatment based on numerous parameters (3,8).

The integration of AI into the field of maternal-fetal medicine and obstetrics represents a significant step towards the improvement of healthcare services. AI has shown remarkable potential in improving the accuracy and timing of diagnoses in obstetrics. Another promising aspect of AI in childbirth is its capacity to tailor care plans to individual patients. In this care plan, they analyze the patient's medical history, genetic factors, and real-time health data to create personalized treatment strategies. Care provided at this level not only improves patient outcomes but also reduces the risk of unnecessary medical interventions (9).

Recently, the use of AI during pregnancy and postpartum has been rapidly increasing (3,6,10). Researchers have observed positive results from the use of AI technologies during the perinatal period in areas such as remote pregnancy monitoring, genetic screenings, fetal development, and postpartum (11). In this review, we focus on the use of AI methods in maternal and fetal health, obstetrics, and the role of healthcare professionals, with the aim of raising awareness in this emerging field.

This research is a traditional review study. In the study, the role of AI in maternal and fetal health during the perinatal period was investigated, and its applications in the field of childbirth and implications for healthcare professionals were examined. A comprehensive literature review was conducted to analyze the current applications and potential of AI in improving maternal and fetal health outcomes during pregnancy and the postpartum period. The researcher conducted a literature review using appropriate keywords in the PubMed, Google Scholar, ScienceDirect, Web of Science, and Cochrane Library databases from 2011 to 2024. Articles obtained from various databases that were similar, those whose full text could not be accessed in Turkish and English, and those outside the search terms were excluded from the review.

Use of AI in the Prenatal Period

The health of the mother and fetus during pregnancy is very important. It is necessary to ensure the well-being of both the mother and the developing fetus to monitor continuously and to intervene in a timely manner (12). Fetal and maternal health encompasses the care and assessment of the expectant mother's and the developing fetus' health from the beginning of pregnancy until the baby's birth. This process also involves a series of complex procedures that are vital for a successful pregnancy and a healthy birth. Maternal health during pregnancy is not only related to the physical health of the expectant mother but also includes her emotional and psychological well-being (13). In this process, AI applications have been developed in areas such as facilitating the diagnosis, treatment, and care processes of pregnant women, predicting risky situations that may arise during pregnancy, managing diseases that occur during pregnancy, improving the living standards, reducing maternal and neonatal mortality and morbidity associated with pregnancy, genetic screenings, and monitoring fetal development (Figure 1) (14).

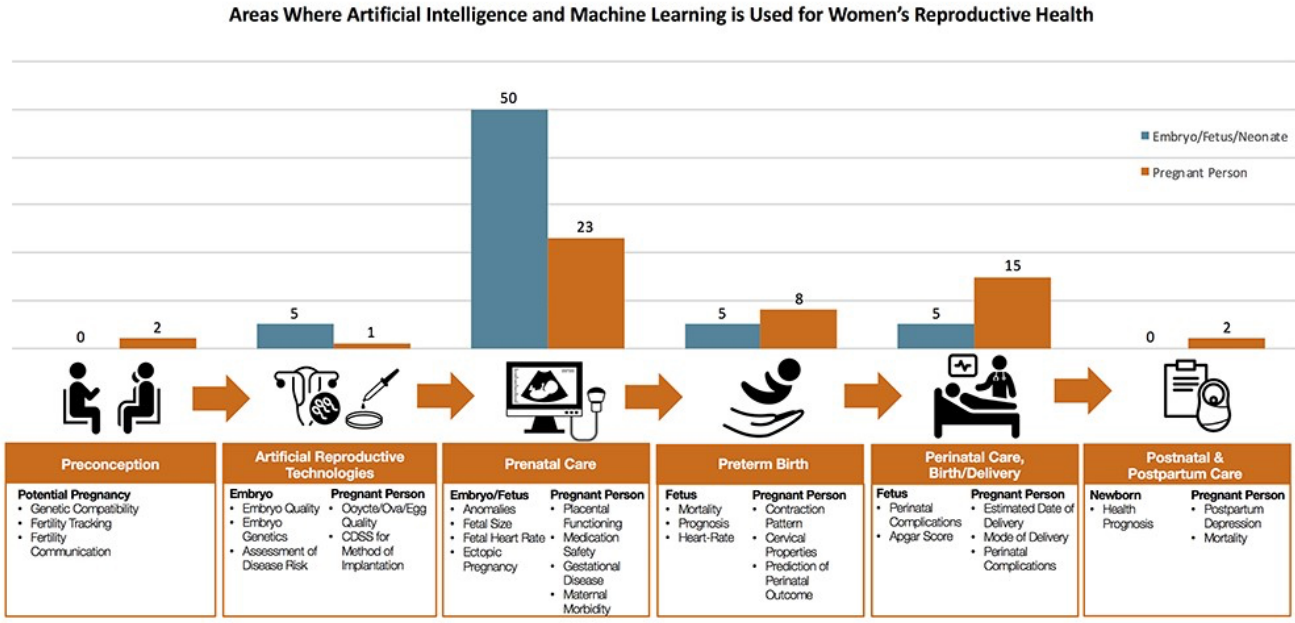

Figure 1.
Artificial intelligence applications in pregnancy and fetal health (15)

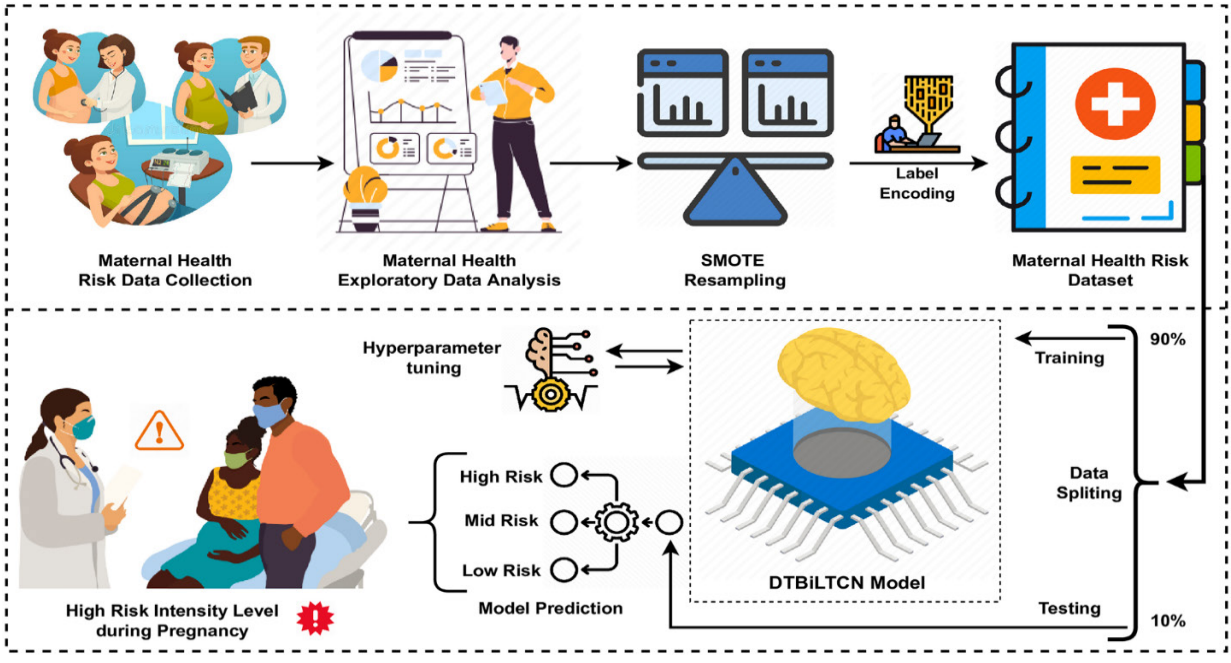

Figure 2.
Artificial intelligence application model for determining maternal health risk (16)

Some of the developed AI applications are mentioned below.

AI for Screening and Managing Diseases in Pregnancy

There are studies using AI in the diagnosis of diseases during pregnancy. Raza et al. (16) have revealed through their AI application, which analyzes maternal health and predicts health risks during pregnancy, that the strongest indicators of maternal health, discovered through data analysis, health risk are diastolic and systolic blood pressure, heart rate, and the age of pregnant women (Figure 2). The model has shown that health risks in pregnant women can be predicted in a timely manner, and thus it can be life-saving by reducing health complications (16).

A study looked at electrocardiography recordings to create a model that could classify the changes in the heart rate of women with normal blood pressure, high blood pressure, and preeclamptic pregnancies. Researchers found the model to have a specificity of around 80%, indicating its potential for monitoring heart rate changes. It has been determined that another model, based on the classification of each risk factor, such as headache, epigastric pain, nausea-vomiting, and blurred vision, also shows effective performance the likelihood of developing hypertensive diseases in high-risk pregnancies (17). In the studies conducted by Jhee et al., (18) data collected from 11,006 pregnant women from the second trimester to 34 weeks were evaluated using the AI application to predict late-onset preeclampsia. As a result of the study, they found that the AI application was effective for predicting preeclampsia with an accuracy rate of 0.97 (18). Predictive models have demonstrated the ability to accurately determine the onset of hypertension-related disorders that affect fetal development, like preeclampsia and gestational diabetes by using obstetric ultrasounds and blood test evaluations. These evaluations aim to reduce neonatal losses and improve birth outcomes (11).

In another study, the aim was to predict the likelihood of developing hemolysis, elevated liver enzymes, low platelet (HELLP) syndrome during pregnancy using an AI model. In this model, data of pregnant women were classified to determine the likelihood of developing HELLP syndrome. The study observed that the model successfully predicted the likelihood of HELLP syndrome development in pregnant women (11).

In the study conducted by Paydar et al., (19) the pregnancy outcomes of pregnant women affected by systemic lupus erythematosus were evaluated. In this context, clinical decision support systems based on artificial neural networks have been developed to predict the probabilities of spontaneous abortion and live birth (Figure 3). As a result of the study, the success rate of the developed support systems in predicting pregnancy outcomes was reported to be 91% (18).

AI for Fetal Heart Rate Analysis

A baby's heart rate during pregnancy provides important information about its health. AI provides information on how healthcare professionals can interpret these heartbeats. Additionally, it has an extraordinary ability to detect complex patterns and subtle changes in fetal heart rates that may indicate potential health issues. This groundbreaking approach enables healthcare professionals to act quickly and consciously to protect the well-being of both expectant mothers and their babies (13). Hoodbhoy et al. (20) found that in their AI application, which uses cardiotocographic data to predict high-risk fetuses, the prediction accuracy of pathological fetal conditions achieved a high accuracy (>92%) in 2,126 pregnant women in the third trimester.

AI for Prenatal Anomaly Detection

During pregnancy, there are many medical evaluations, such as ultrasound scans, to monitor the baby's development. AI plays a transformative role here with its advanced algorithms. It analyzes the images and data obtained from the evaluation. This situation enables doctors to detect even the smallest and rarest abnormalities in fetal development. The precise insights provided by AI help medical experts make accurate diagnoses at an early stage. When AI finds an anomaly, it sends a signal to doctors to take action. This helps them make wise decisions about their next steps. For example, if AI detects that the baby's organs are developing unusually, doctors can start planning how to treat them or provide advice to the parents. Kim (21), highlight the multifaceted applications of AI in fetal and maternal health in their systematic review, which examines artificial intelligence's contributions to the field of obstetrics. The study observed improvements in fetal examination accuracy in cardiotocography, ultrasonography, and magnetic resonance imaging, as well as in the early detection of maternal-fetal disorders like preterm birth and abnormal fetal growth. They have also stated that it can contribute to continuous monitoring through careful observation of maternal health parameters such as blood pressure and glucose levels in pregnant women, and providing real-time alerts for any deviations (21). In their study, Gomes et al. (1) developed a mobile-compatible AIsystem for evaluating gestational age and fetal malpresentation, and they found that the AI application was comparable to standard fetal biometry predictions and that the scanning time was less than 3 seconds (Figure 4).

Predicting preterm birth with artificial intelligence. Preterm birth continues to be a source of concern as it poses potential risks for both the mother and the developing fetus. In this context, the predictive capabilities of AI are proven to be highly valuable. AI analyzes various data sources, such as maternal health records, lifestyle factors, and medical history. Therefore, we can easily predict the likelihood of premature birth. Healthcare professionals can implement preventive measures and interventions based on these predictions. These include making lifestyle changes for the mother, administering specific medications to her, or creating tailored care plans that meet her needs. Thus, it can help healthcare professionals reduce the risks that may occur during pregnancy. Research on assessing the health of the mother and fetus is widespread. Recent research has demonstrated the effectiveness of AI in distinguishing between high-risk and low-risk pregnancies. Studies have evaluated the accuracy of AI in predicting preterm births (22,23). A systematic review of 127 studies using AI technology to improve pregnancy outcomes has demonstrated its contribution to predicting the risk of preterm birth, chromosomal screening, prenatal education, pregnancy complications, and reducing maternal and neonatal mortality and morbidity (24). Zhang et al. (25) used a cohort study to predict premature birth by applying an AI

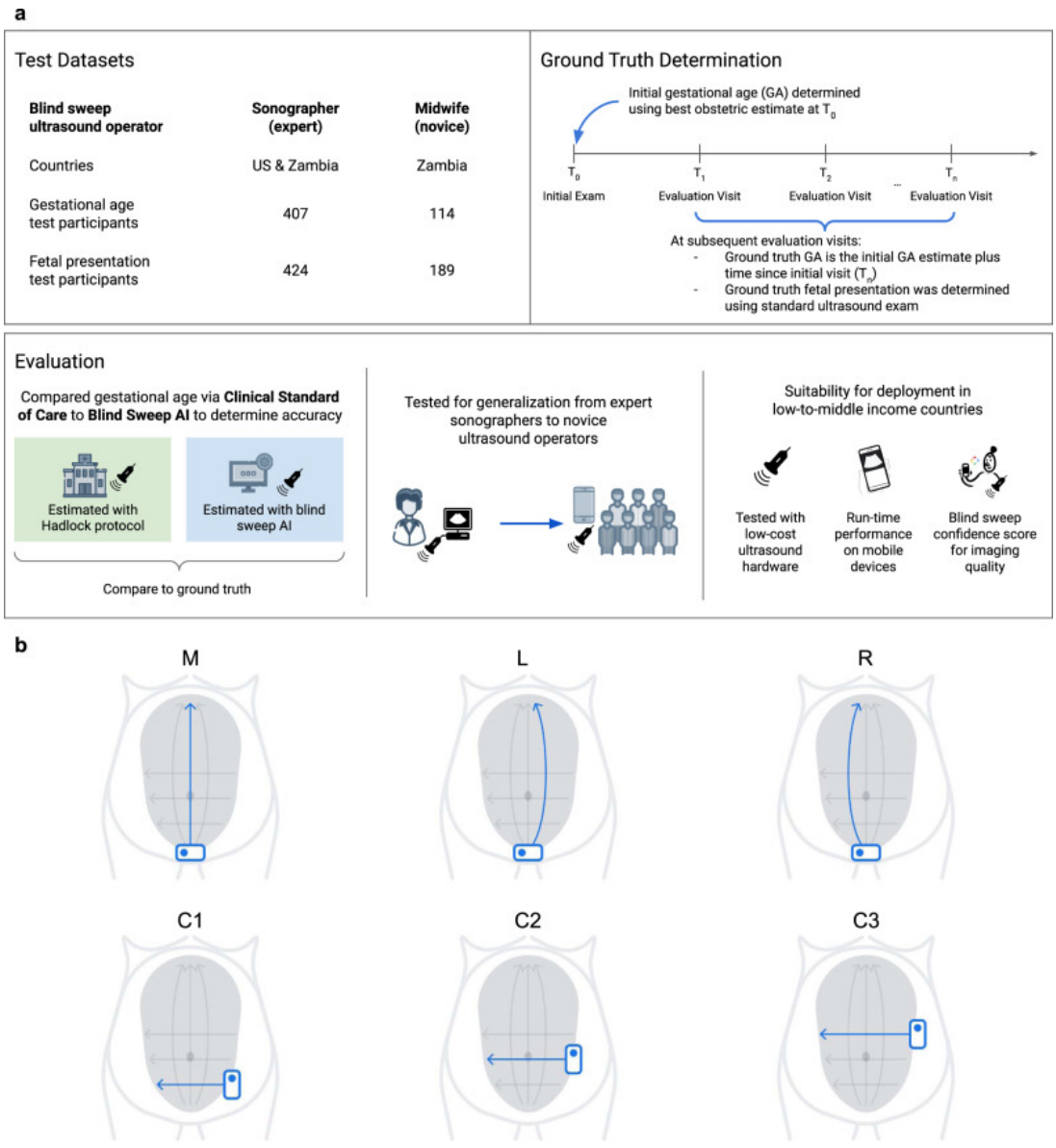

Figure 3.
Application of artificial intelligence in predicting systemic lupus (19)

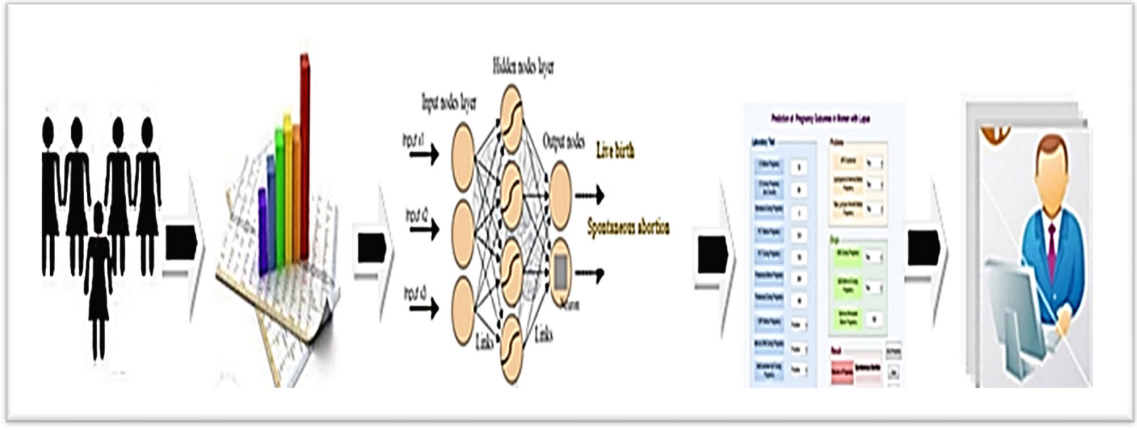

Figure 4.
Artificial intelligence application for antenatal diagnosis (1)

application based on time series technology, utilizing more than 25,000 electronic medical records from 5,187 pregnant women from early trimester to the 28th week of pregnancy. As a result of the study, they found that the application predicted preterm birth better (0.73) and had a lower false diagnosis rate (0.98) (25).

Use of AI in the Postnatal Period

Recently, the use of AI in the postpartum period has been rapidly increasing. Although childbirth is a normal physiological process, it is difficult to predict postpartum complications. If complications develop, they can lead to significant medical and socioeconomic burdens for both the family and society. This perspective highlights the significance of using AI applications to predict complications during the postpartum period (7,11,24). Betts et al. (26) developed a machine learning model in their study (n=422,509) to predict the risk of postpartum maternal complications using all medical records from pregnancy to delivery and postpartum newborn records. The model encodes bleeding, wound infection, postpartum hypertensive disorders, and puerperal sepsis. The model has provided successful results in predicting the risk of postpartum hypertensive disorders and wound infection from the coded risks (26). Barbounaki and Vivilaki (27) conducted a study to predict the risk of postpartum maternal hemorrhage, evaluating the use of AI in 38 studies involving 30,867 women. The study demonstrated that machine learning and intelligent systems developed effective models across a wide range of midwifery and obstetric topics, including diagnosis, pregnancy risk assessment, fetal monitoring, and bladder tumors. Furthermore, research has demonstrated the potential of AI as a tool for preventing bleeding. Healthcare workers anticipate its support in timely diagnosis and patient counseling (27).

Research has shown that AI effectively lowers maternal mortality rates. AI examined 7,572 pregnancy records and outcomes in a rural Pakistani study. The study predicted an estimated mortality rate of 238 per 100,000 pregnancies, primarily due to obstetric hemorrhage. Additionally, poverty, the lack of healthcare facilities, and the absence of midwives have significantly contributed to the increase in maternal mortality rates. Another study investigated the role of blood pressure, blood glucose level, body temperature, and other variables in predicting maternal mortality rates in women. The study observed that AI achieved an accuracy rate of 86% in making predictions, indicating its potential to improve maternal mortality rate predictions. Therefore, research indicates that it could assist healthcare practitioners in lowering maternal mortality rates (28). Postpartum education provided by AI is more beneficial for women than other methods. Yin and Wang's (29) study evaluated the impact of pelvic floor rehabilitation training on nursing care for postpartum women with pelvic organ prolapse under ultrasound imaging using artificial intelligence. They observed that ultrasound images processed by the AI algorithm, showed more distinct lesions and significantly improved image quality compared to images without AI (29).

The formation of the mother-baby bond and the well-being of both during the postpartum period are extremely important. Wu et al. (30) conducted a study in China to evaluate the impact of AI on assessing the consistency of infant stool in breastfeeding mothers. They found that this technology assisted mothers in evaluating their baby's stool consistency, thereby effectively contributing to the infants' well-being (30). One of the possible complications after childbirth is postpartum depression. This situation negatively affects both the mother's and the baby's health. In a study, researchers used AI to analyze factors like postpartum pain, depression, psychological distress in women, prepartum self-harm, and paternal postpartum depression. Researchers have determined that AI plays a useful role in early detection and intervention in postpartum depression risk (30-32). Anderson and Maes (33) developed an AI model to predict depressive symptoms in women (n=4,313) who had no previous psychological problems during the postpartum period. Women's individual characteristics, pregnancy stress, stressors, and high levels of depression and anxiety, predispose them to postpartum depressive symptoms (33). Gabrieli et al. (34) conducted another study in which they used a machine learning technique based on the characteristics of infants' crying sounds to identify postpartum depression in mothers. Web or mobile applications can easily integrate this AI-based method. This method, based on the analysis of baby cries, identified depressed mothers with an accuracy rate of 89.5% by using the acoustic properties of specific crying sounds (34).

AI algorithms monitor the health of mothers and babies in the postpartum period. Silva Rocha et al. (35) noted in their systematic review evaluating the use of AI in predicting mortality rates during and after pregnancy that birth weight, gestational age, child's gender, Apgar score, and mother's age play significant roles in predicting mortality rates.

Ethical Issues in AI Applications

• The results of AI applications used in healthcare services directly affect human health and life, requiring careful examination. Electronic record systems allow access to patient records at any time. This situation raises ethical concerns regarding patient privacy and confidentiality. Therefore, it is necessary to implement legal regulations to ensure the security of patient information in health information systems (3,36).

• The use of AI applications in healthcare raises contentious issues such as patient privacy, technology-induced errors, role confusion, and ethical concerns regarding human interaction in the profession. In addressing these issues, it is necessary to develop more holistic, transparent, risk-eliminating, and ethically consistent AI systems in the healthcare field. Healthcare professionals need to equip themselves with the necessary knowledge both for understanding what types of tasks these technologies can take over and for their management (37).

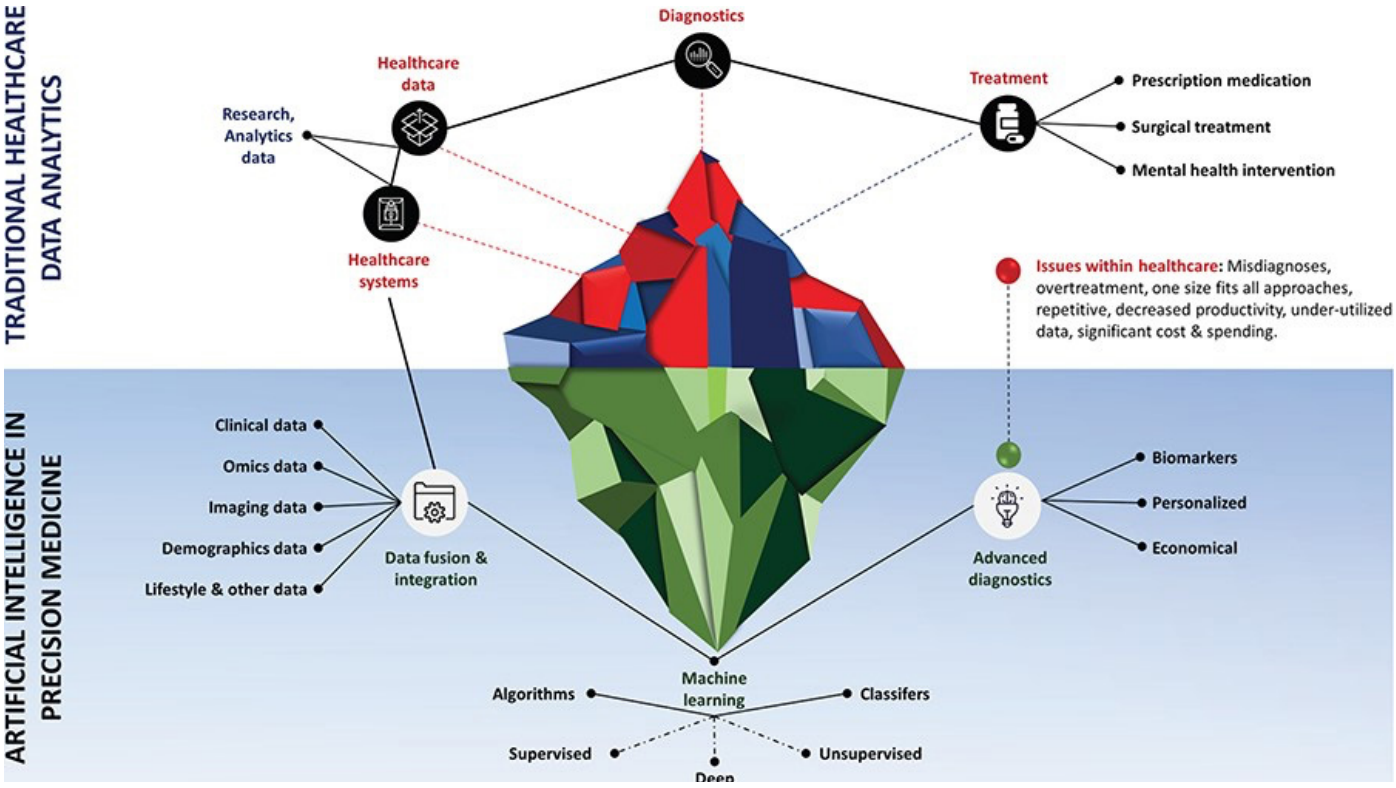

Figure 5.
Ethical dilemmas of Artificial intelligence practices (38)

• The ability of AI to make decisions objectively, uninfluenced by emotions and thoughts, is one of the most important reasons for its favoring in certain fields. While AI is capable of drawing logical conclusions, it's indisputable that they do not do so consciously. It does not seem possible for a machine without consciousness and without the will to take responsibility. The question emerges about the definition of punishment for any wrongdoing by AI (11).

• Ethical rules can change over time. Humans, being social beings, can adapt to these changes, while artificial intelligence, coded according to the ethical understanding of past eras, may not be able to do the same (11).

• The lack of accountability for any harm resulting from the application of AI prompts worry (Figure 5). In this case, the extent of the danger is unknown. We will severely limit the use of applications, as well as our ability to take on decision-making responsibilities, due to the absence of an accuser (38).

• The application of AI in clinical practice offers tremendous promise for improving healthcare services, but it also raises ethical issues that we must now address. We must address four important ethical issues: (1) informed consent regarding data usage, (2) safety and transparency, (3) algorithmic fairness and biases, and (4) data privacy; to fully realize the potential of AI in healthcare (39).

The Importance of AI for Health Professionals

AI plays an important role for healthcare workers in disease diagnosis, treatment management, and the decision-making process. It is based on algorithms trained to recognize data patterns, and it enables making predictions and decisions using this data. Healthcare workers in health services, where medical data analysis is necessary, find this analysis particularly important. Learning models in AI can enhance the accuracy of diagnosing and monitoring all medical conditions, including fetal and maternal health (Figure 6). It also offers innovative solutions for early diagnosis, continuous monitoring, and personalized care (40).

AI algorithms can operate in real time, providing actionable insights to healthcare professionals and thereby potentially improving maternal and fetal health outcomes. Interventions based on AI with mother and baby monitoring systems can effectively reduce postpartum complications and protect the physical and mental health of mothers and newborns (41).

AI models enable the early detection of high-risk pregnancies, effective birth planning, and the consideration of transferring the patient to a tertiary center for further monitoring and treatment. Therefore, considering the reduction in the number of patients that healthcare workers care for and the consequent increase in the duration and quality of care, it is anticipated that the need for artificial intelligence-based applications that support healthcare workers in performing their daily tasks will increase even more in the future (41,42).

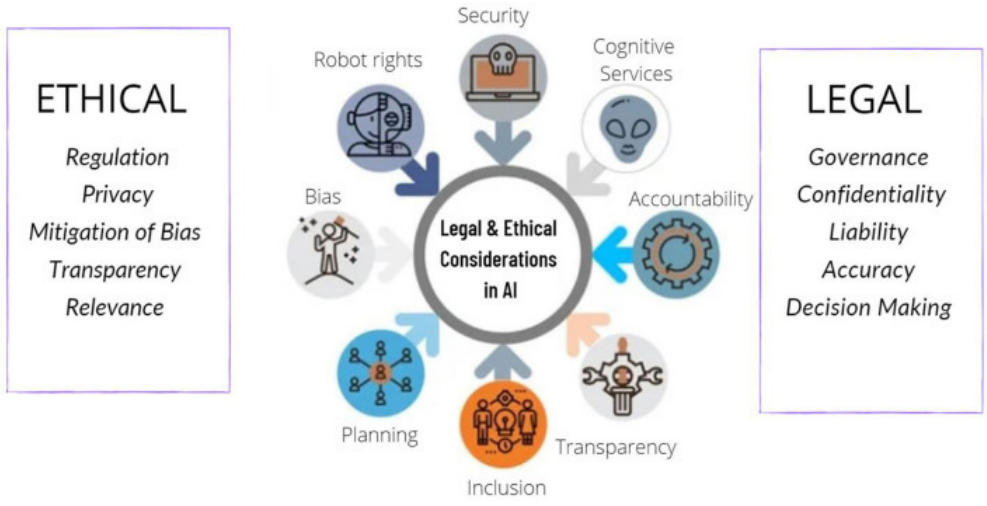

Figure 6.
Artificial intelligence applications and healthcare systems (40)

Conclusion and Recommendations

Through advanced diagnostic accuracy, predictive modeling, and personalized care interventions, AI applications are changing clinical practices in fetal and maternal health and improve patient outcomes. Here, the focus is actually more on reducing fetal morbidity and mortality rates. It is believed that the use of AI in healthcare services will provide many advantages for both patients and healthcare professionals. Healthcare professionals can use AI technologies while providing education and counseling on women's health-related issues during antepartum, intrapartum, and postpartum monitoring and care practices. With these technologies, higher-quality personalized care is provided and the health of both the mother and fetus is improved. We recommend enhancing research in this area and implementing in-service training to increase the use of AI in the healthcare sector.

Contribution to the Field

AI methods play an important role in the diagnosis of diseases, treatment management, and decision-making processes. In particular, they significantly contribute to increasing the accuracy of diagnosing and monitoring all medical conditions, including fetal and maternal health. These methods help healthcare professionals make the right decisions, plan, and implement when providing care to individuals. Thus, individuals are provided with personalized care, and innovative solutions are created. Therefore, it is thought that the increased use of AI methods in the care of individuals will increase the quality of care and make a significant contribution to the field. In addition, it will provide awareness about the importance and necessity of these applications.

Articles obtained from various databases that were similar, those for which the full text in Turkish and English could not be accessed, and those outside the search terms (AI, fetus, health, mother, pregnancy) have been excluded from the review. Therefore, it may have reduced the number of studies scanned. In this context, it is not possible to generalize the research results.

Footnotes

Author Contributions: Concept - Y.Ö.; Design - Y.Ö., E.Ö.; Data Collection and/or Processing - Y.Ö.; Analysis and/or Interpretation - Y.Ö.; Literature Review - Y.Ö.; Writing - Y.Ö., E.Ö.

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