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Personalized Approaches to Pharmacotherapy and Physiotherapy in Obstetric Treatment: Improving Medication Safety and Physical Wellness for Pregnant Women

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Abstract

Individualized pharmacology and physical therapy are two areas that have the potential to revolutionize obstetric care, providing evidence-based therapies that will have improved maternal and fetal health outcomes. Individualized pharmacology is the formulation of drug regimens that maximize safety and effectiveness during pregnancy, based not only on drug characteristics but also on pharmacogenomics, physiological values, and the unique clinical profiles of individual women. That is to say, pregnant women undergo episodic changes in their physiological functions depending on the stage of pregnancy, and recognizing and maximizing the available pharmacological conditions reduces the risks of teratogenicity and neonatal complications. Physical therapy can have similar benefits targeting generalized musculoskeletal pains, such as pelvic girdle pain and low back pain, while also optimizing mobility to prevent other complications, including gestational diabetes and preeclampsia. Furthermore, by bundling these two disciplines together, health care providers can provide comprehensive care that maximizes the safety of drug selection or dosing and physical decompensation. This review will cover clinical applications such as pharmacogenomic-guided dose adjustments of antidepressants and exercises and physical activities, discuss issues such as count-of genetic tests and availability, inter-disciplinary collaboration, and ethical issues such as equity of access to tests and informed consent. The future notes will discuss scalable models, computerized and other personalized medications, and expanded access to telehealth care and delivery of health care. We hope that this review and documentation demonstrate two emerging disciplines that have the potential to revolutionize obstetric care, thereby maximizing the safety and physical well-being of all women and improving maternal and fetal outcomes.

Keywords: drug safety, perinatal care, personalized pharmacotherapy, physical therapy, health of women

Introduction

Pregnancy can produce complex physiological changes, drug metabolism, increased plasma volume, hormonal changes, and musculoskeletal changes that lead to large demands regarding drug management and the health of

the patient. The physiological changes and drug metabolism changes, particularly how both the activity of cytochrome P450 enzymes can increase and joint ranges of motion change to impact medication born risk, require personalized information regarding the potential for medication use, and dose differences for maternal and fetal

safety in pregnancy (Wilkinson, 2018). Personalized pharmacotherapy could involve using pharmacogenomics tests as well as patient-specific physiological data and clinical information to ensure the most informed choice regarding medications and dosing in an individual, maximising medication safety and limiting the risk of teratogenicity and neonatal withdrawal syndrome (Shields & Lysterly, 2019).

Testing for genetic polymorphisms for cytochrome P450 enzymes, such as genotype for CYP2D6, can allow for more personalized dosing of antidepressants, with the goal of removing negative side effects, while also maintaining efficacy (Smith et al., 2021). In addition, there has been a large injection of literature associated with the physiotherapy aspect of obstetric care, alongside obstetricians managing and treating women during pregnancy, highlighting how physical therapy treatment can address changes like pelvic girdle pain, impacting up to 70% of pregnant women, as well as functional limitations from gestational diabetes (Clinton et al., 2017; Vleeming et al., 2019).

Physical therapy can a number of different treatment options, but may specifically highlight pelvic stabilization exercises, and aquatics therapy, which can reduce pain and improve cardiovascular fitness, and psychological states because of the risk of developing demonstrable complications from preeclampsia if a pregnant woman remains sedentary (Davenport et al., 2018). Utilizing personalized pharmacotherapy in conjunction with physical therapy will supportively shape an embedded model of care that utilizes the best possible pharmacologic protection as well as physical functioning. This review will highlight clinical applications, formulation challenges, ethical concerns, and technological innovation that support such paradigms, ensuring maternal-fetal outcomes are maximized with clinically directed, patient-specific protocols designed to shift obstetric care delivery and realize the promises of benefits.

Methods

A narrative review, this article collated and reviewed the peer-reviewed scientific literature accessed via PubMed, Scopus, CINAHL, and Web of Science, using the time frame of 2015-2024. Search terms used were "personalized pharmacotherapy," "pharmacogenomics," "physical therapy," "obstetric care," "medication safety," "maternal health," and "pregnancy outcomes." Inclusion criteria included articles that have discussed pharmacotherapy or physical therapy in pregnancy, with a critical focus on safety, efficacy, and clinical outcomes. A total of 46 studies were selected, which comprised randomized studies with small sample sizes, cohort studies, systematic reviews, and meta-analyses. This selection process was made with a critical analysis regarding the review of new evidence, contemporary practice trends, and clinical values in maternity services.

Individualized Pharmacotherapy for Obstetric Practice

Pharmacogenomics and Drug Safety

The science of gene variation of drug response, pharmacogenomics, is the foundational science of obstetric practice due to the pharmacokinetic variations during gestational-related changes (i.e., Changes in hepatic enzymes and renal clearance (Shields & Lysterly, 2019). With the advancement of trimesters of pregnancy, there is variation in the activity of enzymes such as cytochrome P450 enzymes, CYP2D6 and CYP3A4, respectively, which ultimately cause variation in drug efficacy and affect dosage options for drug metabolism (Anderson & Carr, 2020). These are the major enzymes that metabolize the majority of prescribed drugs for pregnant women, including antidepressants, antihypertensives, and antiepileptics. While Smith et al. (2021) provided one example of genotyping for the CYP2D6 variant used for SSRI (e.g., sertraline) dosing to prevent unwanted and potentially adverse outcomes like maternal serotonin syndrome or neonatal adaptation syndrome, a specific example of pharmacogenomic risk. Also, based on the rise of prescribed SSRIs among pregnant women, there is pharmacogenomic relevance with SSRIs having unique and varying relevance in terms of dose reduction; many SSRIs are prescribed for

anxiety and depression for 6-8% of pregnant women (Reefhuis et al., 2017).

Similarly, antiepileptic drugs such as valproate have unique teratogenic risk, i.e., neural tube defects, and necessary precautions to be taken (Tomson et al., 2018). Genomic pharmacy tests can identify patients who have genetic susceptibilities to adverse effects, allowing clinicians to switch to alternative agents that are safer, such as lamotrigine, which has a safer track record when used in pregnancy (Holmes et al., 2020). Other research has suggested that the application of pharmacogenomic dosing of analgesics, such as opioids in labor pain, can reveal the potential for reducing risks of neonatal opioid withdrawal syndrome with optimized drug exposure in pregnant women (Desai et al., 2020). These examples illustrate the pharmacological possibilities for safe drug therapy through personalized therapy tailored to an individual's genetic and physiological features.

In addition to genetic factors, patient-specific clinical details such as maternal weight, renal function, and underlying disease can be included in a personalization of pharmacotherapy treatment options. Antihypertensive drug treatment with labetalol is a unique dosing concern because of the variability of maternal blood pressure response and concerns with placental perfusion (Magee et al., 2019). In addition, there are higher tech types of monitoring methods, including therapeutic drug monitoring (TDM), when health care professionals can remain current on drug levels during treatment, which will allow accurate therapeutic ranges as well (Johnson et al., 2023). Utilization of pharmacogenomics is limited even though it offers the possibility of personalized pharmacotherapy because of issues such as the cost of genetic tests, limited availability of genetic tests, and education of health care professionals to assist with interpreting genetic results (Haas et al., 2022; Klein et al., 2021). These issues need to be resolved in order for personalized pharmacotherapy to be routinely used as part of obstetrical practice.

Common Medications and Safety Considerations

Certain drug classes, i.e., antihypertensives, antidepressants, and analgesics, are part of pregnancy in a

consistent way, whereby each of these needs good planning to provide maternal benefit in light of fetal protection. Antihypertensive drugs, such as labetalol and methyldopa, are commonly used in the treatment of gestational hypertension and preeclampsia. Labetalol is a beta-blocker that is valued for its efficacy and relatively safe status, but the dose needs to be individualized because of inter-individual variability in maternal hemodynamic response and effect on placental blood flow (Magee et al., 2019). For example, an overdose can be associated with fetal bradycardia; thus, maternal blood pressure control and fetal heart monitoring need to be carefully performed (Brown et al., 2023). Another antihypertensive, nifedipine, may be taken, with caution given potential complications of maternal hypotension that could compromise uteroplacental perfusion (Sibai et al., 2020).

Antidepressants, like SSRIs such as fluoxetine and sertraline, are prescribed for anxiety and maternal depression present in approximately 6-8% of pregnant women (Reefhuis et al., 2017). Even though considered safe, SSRIs are associated with neonatal adaptation syndrome and neonatal jitteriness and neonatal respiratory depression (Moses-Kolko et al., 2019). SSRIs can also still be personalized via pharmacogenomic results to ensure that doses can be adjusted for changed CYP2D6 drug metabolisms to the patient, thereby reducing drug side effects and not therapeutic drug effect (Smith et al., 2021). For example, sertraline may be the drug of choice due to limited placental transference of the drug, but adjusting doses must be tailored to genetic, clinical, and other considerations, while parents must be satisfied, preventing neonatal morbidity (Huybrechts et al., 2021).

Analgesics, opioids, are prescribed for labor or chronic pain but may have the potential for catastrophic harm, such as NOWS (neonatal opioid withdrawal syndrome) or neonatal abstinence syndrome for the neonate (Desai et al., 2020). These drugs, like morphine and oxycodone, are also prescribed for individualized dosing for maximum fetal protection, but also adequate maternal pain management. These drugs, such as morphine and oxycodone, are thus prescribed individualized regimens for maximum protection of the fetus but for proper management of maternal pain as well. Non-opioids, namely NSAIDs, are

the medications prescribed when available, yet they can still be managed in order to mitigate the risks of overusing a drug through liver toxicity (Lee & McDonald, 2022). Individualized pharmacotherapy is designed to incorporate drug-mediated information, therapeutic drug monitoring, and clinical monitoring so that the drugs can achieve a fine balance between benefit versus risk in protecting both the fetus and the mother (Johnson et al., 2023).

Table 1: Common Medications in Pregnancy and Factors for Safety Considerations

Medication Class	Examples	Indications	Safety Considerations	References
Antihypertensives	Labetalol, Methyldopa, Nifedipine	Gestational hypertension, Preeclampsia	Individualized dosing to prevent fetal bradycardia or maternal hypotension; monitor placental perfusion	Magee et al., 2019; Brown et al., 2023; Sibai et al., 2020
Antidepressants	Sertraline, Fluoxetine	Depression, Anxiety	Risk of neonatal adaptation syndrome; pharmacogenomic-guided dosing to optimize efficacy and safety	Reefhuis et al., 2017; Smith et al., 2021; Huybrechts et al., 2021; Moses-Kolko et al., 2019
Analgesics	Oxycodone, Morphine, Acetaminophen	Labor pain, Chronic pain	Risk of neonatal opioid withdrawal syndrome; prefer non-opioid options; monitor for liver toxicity with acetaminophen	Desai et al., 2020; Lee & McDonald, 2022; Johnson et al., 2023

Challenges to Implementation

Use of individualized pharmacotherapy in obstetric practice has faced many challenges, including limited access to genetic testing, costs for testing, and a lack of consistency in clinician education. Pharmacogenomic genetic testing, e.g., CYP2D6 or CYP3A4 genotyping, is not accessible universally, even in limited-resource settings, which would allow for application to routine practice (Haas et al., 2022). The costs of testing, which a panel requests hundreds of dollars on average, would put prohibitive costs on the patient and the health system without broad coverage by insurance plans (Harris et al., 2020). In addition, not all clinicians are formally trained in pharmacogenomics, which limits the appropriate use of available tests, if nothing else, misinterpretation of the genetic profile (Klein et al., 2021). Doubtful information could engender resistance against a personalized practice context, even a testing option.

There are ethical considerations that complicate adoption. Substantial effort to secure informed consent for genetic testing is necessary because pregnant women will express concerns about stigma, stigmatization, or ramifications for subsequent pregnancies (Lyerly et al., 2018). Access equity becomes a priority, because groups that already face disadvantage, minorities, the poor, have the poorest likelihood to capitalize on an expanded point-of-care pharmacogenomics therapeutic option due to systemic inequities in healthcare delivery (Williams et al., 2019). Point-of-care testing technologies are driving accessibility as rapid genotyping platforms have decreased turnaround time and expense (Johnson et al., 2023). For example, portable devices with genetic results available in a few hours are being evaluated for some obstetric practice, with the potential of instantiating treatment modification in a timely manner (Garcia et al., 2021). Additional expense reduction, broader training, and resolution to ethical considerations are the next steps needed to develop personalized pharmacotherapy for obstetric practice.

Health Disparities	Marginalized groups have less access to advanced interventions	Policy initiatives for equitable access; community-based programs	Williams et al., 2019
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Table 2: Issues and Resolutions for the Advancement of Individualized Pharmacotherapy for Obstetricians

Challenge	Description	Potential Solutions	References
Limited Access to Genetic Testing	Genetic testing is not widely available, especially in low-resource settings	Expand point-of-care testing; develop cost-effective platforms	Haas et al., 2022; Johnson et al., 2023; Garcia et al., 2021
High Costs	Testing costs (hundreds of dollars per panel) limit adoption	Increase insurance coverage; subsidize testing in underserved areas	Harris et al., 2020
Insufficient Clinician Training	Lack of pharmacogenomic knowledge leads to underutilization	Implement training programs; integrate pharmacogenomics in medical curricula	Klein et al., 2021; Brown & Smith, 2024
Ethical Concerns	Issues with informed consent and privacy in genetic testing	Develop clear consent protocols; ensure patient education	Lyerly et al., 2018

Physical therapy for obstetric patients

Treatment of musculoskeletal conditions

Pregnancy-related musculoskeletal disorders, including pelvic girdle pain (PGP) and low back pain, are ubiquitous, with an estimated 50-70% of pregnant women reporting experiencing musculoskeletal pain that significantly impacts their quality of life (Vleeming et al., 2019). These conditions are influenced by a combination of multifactorial hormonal and biomechanical etiologies, such as hormonal components of relaxin (i.e., joint laxity) and biomechanical components of weight gain that contribute to posture and subsequent biomechanical effects. PGP can arise from sacroiliac joint pain or pubic symphysis pain and can limit mobility and day-to-day functioning. Distension of the abdominal muscles can contribute to low back pain, worsening lumbar lordosis. (Clinton et al., 2017). Physical therapy for these pain conditions is highly effective, including drug-free treatment, which is non-harmful for the fetus.

Stabilization exercises for the pelvic region, as well as transverse abdominis and pelvic floor muscle exercises, can integrate and strengthen the core, increasing strength and pain relief from corrected joint alignments (Stuge et al., 2017). Physical therapy has many modalities that can also correct joint dysfunction and muscle imbalance from soft tissue mobilization, as well as sacroiliac joint mobilization that would lead to pain relief (George et al., 2020). In one randomized study, a prescribed course of physical therapy, including exercise and manual therapy, reduced PGP by 40% in comparison to standard prenatal

care, with benefits sustained into the postpartum period (George et al., 2020). Kegel exercises, which strengthen the pelvic floor muscle, are particularly useful for dealing with the treatment of symphysis pubis dysfunction syndrome and preventing urinary incontinence, which is a common condition for women in late pregnancy (Clinton et al., 2017). These treatments not only alleviate pain but are also valuable for optimizing functional capacity so that women can carry out daily activities and prepare for labor.

Enhancing Physical Well-Being

Physical therapy is fundamentally important for the general body wellness of women during pregnancy, lowering the risk of complications such as gestational diabetes mellitus (GDM) and preeclampsia. Individualized physical activity prescriptions, including moderate-intensity aerobic exercises (30-60% of max heart rate) (e.g. walking, swimming, etc.) and resistance exercises, improve insulin sensitivity, cardiovascular fitness, and muscular strength and decrease the incidence of GDM by 30% (Davenport et al., 2018). Programs are designed to accommodate stages of pregnancy, as they must be safe and effective, e.g., it is vital to determine low-impact movements in the 3rd trimester so that biomechanical challenges are integrated (Mottola et al., 2019). Aquatic therapy is extremely beneficial through the use of the buoyancy of water to lessen stress on joints. Women with concerns is mobility or women who are concerned about obesity, so they are comfortable and have easy mobility (Smith & Michel, 2021). Mottola et al. (2019) established standardized exercise protocols that had a 15% lower incidence of cesarean delivery, establishing these as having better outcomes for obstetrics.

Physical therapy improves the risk of preeclampsia with an improvement in vascular function and a decrease in oxidative stress. For optimal results but not in excess, aerobic exercises, including a brisk 30-minute walk, for 5 days per week, lower systolic blood pressure with an improvement in function of the endothelium, with a central role in the prevention of preeclampsia (Davenport et al., 2018). Physical therapy lowers mass, a fact for an almost

majority of pregnant women categorized as obese, and this reduces the risk of occurrence of gestational hypertension with macrosomia, making this serious complication less likely because of weight loss in this group (Carter et al., 2021). With improvement to mobility and with improvement to strength, physical therapy allies with getting women fit and ready for labor, their postpartum recovery expectations.

Mental Wellness Benefits

In addition to physical benefits, physical therapy has a significant impact on maternal mental health by reducing stress, anxiety, and depressive symptoms that afflict nearly 20% of pregnant women (Nakamura et al., 2022). Mindfulness-based movement interventions such as prenatal yoga and tai chi blend physical exercise with relaxation exercises to build emotional resilience and reduce cortisol (Sheffield & Woods-Giscombé, 2019). The main elements of these interventions that help women cope with pregnancy-related stressors, such as fear of childbirth and body image, are controlled breathing, stretching, and mindfulness. A meta-analysis by Nakamura et al. (2022) found that prenatal movement and exercise in the form of yoga and aerobic exercise reduced depressive symptoms by a minimum of 25% in the exercise group compared to the control group, demonstrating utility for holistic well-being.

This is especially true for prenatal yoga, which gained popularity because of a two-part benefit to physical and emotional well-being. Evidence shows that regular, weekly yoga sessions improve sleep quality, reduce stress, and improve self-efficacy, resulting in women with the capacity to cope with labor and motherhood (Sheffield & Woods-Giscombé, 2019). Physical therapy group intervention may also offer social connections that assist in reducing feelings of loneliness and stress (White et al., 2023). Physical therapy, as an intervention for both physical as well as mental well-being, is a pharmacologic adjunct that reduces the dosing increments of medications and ultimately maximizes the mother's well-being and health.

Prenatal Yoga/Tai Chi	Stress, Anxiety, Depression	Reduces depressive symptoms by 25%; improves sleep and self-efficacy	Nakamura et al., 2022; Sheffield & Woods-Giscombé, 2019
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Table 3: Physical Therapy Interventions and Benefits in Obstetric Care

Intervention	Target Condition	Benefits	References
Pelvic Stabilization Exercises	Pelvic girdle pain, Low back pain	Reduces pain by 40%; improves joint stability and mobility	Stuge et al., 2017; George et al., 2020
Manual Therapy	Sacroiliac joint dysfunction, Muscle imbalances	Alleviates discomfort ; enhances functional capacity	Clinton et al., 2017; George et al., 2020
Aerobic and Resistance Exercises	Gestational diabetes, Preeclampsia	Lowers GDM incidence by 30%; reduces cesarean rates by 15%	Davenport et al., 2018; Mottola et al., 2019
Aquatic Therapy	Mobility limitations, Obesity	Enhances comfort; reduces joint stress	Smith & Michel, 2021

Combination of Pharmacotherapy and Physical Therapy:

Synergistic effects

Such a combination of individualized pharmacotherapy combined with physical therapy has synergistic effects that would include both pharmacologic and functional issues of maternal care. Pregnant women with gestational diabetes have much help from an adjusted metformin dosing equation to their glucose profiling, and a physical exercise program that increases insulin sensitivity, with better glycemia control (Brown et al., 2020). Similarly, physical therapy functions as a complement to pain management programs, which would decrease the need for analgesics and thus limit drug exposure to the fetus (O'Connor et al., 2021). In a trial run by Lee et al. (2023), pregnant women who were given first-line pharmacogenomic-guided SSRI therapy with prenatal yoga or the combination of SSRI and yoga markedly improved mood as they required less medication, and will benefit from a combination of care models.

Clinical application and concerns

Clinical examples of integrated care are preeclampsia with mobility attained with physical therapy and stress-relieving practices alongside antihypertensive therapy (Wilson et al., 2022). Integration is obstructed, nonetheless, due to transdisciplinary integration, limited

resources, and a lack of standardized systems (Davis et al., 2021). Supporting the education of clinicians for coalescing pharmacotherapy with physical therapy is part of a solution to these limitations (Miller et al., 2023). Virtual health devices, such as wearables, paired with telehealth systems, can provide integration through service delivery with real-time data, generally expanding care access (Taylor et al., 2023; Johnson & Mahon, 2022).

Through the integration of pharmacogenomics, site-specific interventional therapy, and clinical knowledge, these models cater to the multifaceted needs of expectant women. Despite issues of cost, availability, and coordination, innovative milestones are being reached through new technology, as well as educational programs. Additional research, coupled with policy action, will be critical for making these novel modes of practice widespread, so that superior maternal and fetal health outcomes are realized globally.

Ethical/Cultural Considerations

It is difficult for individuals to access low-cost personalized care, and those affected the most are minorities and low-income populations. Unbalanced access to genetic testing and physical therapy may otherwise exacerbate health inequalities (Williams et al., 2019). Moral guidelines are that the autonomy of patients for care needs to be safeguarded through ensuring consent for genetic testing (ACOG, 2021). Culturally specific plans of care that are appropriate for diverse patients are optimal for compliance and outcome (Nguyen et al., 2022).

Future Directions

Longitudinal study designs are going to be implemented for subsequent studies to assess long-term results of combined care for maternal and fetal well-being (Clark et al., 2022). Large-scale simulations with combined AI-enabled algorithms and telehealth can facilitate greater availability and individualization (Patel et al., 2024; Kim et al., 2025). Policy interventions and training programs for interprofessional are needed to overcome implementation challenges and facilitate equitable provision of care (Brown & Smith, 2024).

Conclusion

Personalized pharmacotherapy, along with physical therapy, is are new practice models of obstetrics, which provide personalized, custom-designed answers for maximizing drug safety, along with physical well-being.

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النهج الشخصي للعلاج الدوائي والعلاج الطبيعي في علاج أمراض النساء والتوليد: تحسين سلامة الأدوية والرفاهية البدنية للنساء الحوامل

الملخص

يُعد كل من علم الأدوية الفردي والعلاج الطبيعي من المجالات التي لديها القدرة على إحداث ثورة في رعاية النساء الحوامل، من خلال تقديم علاجات قائمة على الأدلة تؤدي إلى تحسين نتائج صحة الأم والجنين. يتمثل علم الأدوية الفردي في صياغة نظم دوائية تزيد من السلامة والفعالية أثناء الحمل، بناءً ليس فقط على خصائص الدواء ولكن أيضاً على علم الوراثة الدوائية، والقيم الفسيولوجية، والملفات السريرية الفريدة لكل امرأة. بمعنى آخر، تخضع النساء الحوامل لتغيرات فسيولوجية متقطعة بحسب مراحل الحمل، ومن خلال التعرف على وتوظيف الظروف الدوائية المتاحة يمكن تقليل مخاطر التشوهات الخلقية ومضاعفات حديثي الولادة. يمكن أن يكون للعلاج الطبيعي فوائد مماثلة في استهداف الآلام العضلية الهيكلية العامة، مثل ألم حزام الحوض والام أسفل الظهر، مع تحسين القدرة على الحركة لمنع مضاعفات أخرى، بما في ذلك سكري الحمل وتسمم الحمل. علاوة على ذلك، من خلال دمج هذين التخصصين معاً، يمكن لمقدمي الرعاية الصحية تقديم رعاية شاملة تعزز سلامة اختيار الأدوية أو الجرعة وتقلل من التدهور البدني. سنتناول هذه المراجعة التطبيقية السريرية مثل تعديل جرعات مضادات الاكتئاب الموجهة بالاختبارات الجينية، والتمارين الرياضية والأنشطة البدنية، كما سنتناقش قضايا مثل عدد الاختبارات الجينية وتوافرها، والتعاون بين التخصصات، والقضايا الأخلاقية مثل عدالة الحصول على الاختبارات والموافقة المستنيرة. سنتناول الملاحظات المستقبلية نماذج قابلة للتوسع، والأدوية المخصصة بواسطة الكمبيوتر وأشكال أخرى، وتوسيع الوصول إلى الرعاية الصحية عن بُعد وتقديمها. نأمل أن توضح هذه المراجعة وتوثيقها اثنين من التخصصات الناشئة التي لديها القدرة على إحداث ثورة في رعاية النساء الحوامل، وبالتالي تعزيز سلامة ورفاهية جميع النساء وتحسين نتائج صحة الأم والجنين.

الكلمات المفتاحية: سلامة الأدوية، رعاية الفترة المحيطة بالولادة، العلاج الدوائي المخصص، العلاج الطبيعي، صحة المرأة.