



RESEARCH ON MEDICAL AND STRUCTURAL REQUIREMENTS FOR CREATING A SMART PRENATAL SUPPORT DEVICE FOR PREGNANT WOMEN

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Abstract: This research explores the scientific and practical foundations for developing an intellectual prenatal support device based on "Smart-textile" technology, taking into account the anatomical and morphological characteristics of pregnant women. Utilizing ultrasound specialists' surveys and biomedical monitoring, innovative solutions integrated with a digital system have been developed to protect maternal and fetal health.

Keywords: Smart-textile, smart clothing, prenatal support device, telemedicine, ultrasound monitoring, non-standard body shape, digital healthcare.

Introduction. Today, global practices—particularly in countries such as the USA, South Korea, and Germany—are witnessing the rapid advancement of telemedicine and "Smart-textile" technologies. However, existing smart clothing is mostly designed for standard body sizes and fails to fully account for the dynamically changing body characteristics of women that manifest starting from the 12th–14th week of pregnancy.

In Uzbekistan, large-scale reforms are also being implemented to develop the digital healthcare system. In particular, initiatives driven toward digitizing the healthcare sector have established a necessary foundation for implementing remote monitoring tools into practice[1].

Based on the aforementioned data, the primary objective of this research is to systematize medical and consumer requirements in designing smart clothing (a prenatal support device) that accounts for the physical body changes during pregnancy[2].

To develop an enhanced prenatal support device for pregnant women, a survey was conducted among highly qualified ultrasound specialists with extensive clinical experience. The survey took place at the NTD Center in Namangan city, Namangan region, the 1st Multidisciplinary Family Clinic, the maternity complex, the "DIDISAH" private enterprise, the Pop district multidisciplinary family clinic, and the Rural Physician Office (QVP) in SANG village[3].

The survey participants included highly qualified ultrasound specialists with 5 years of work experience (20%), between 5 and 10 years of experience (10%), and more than 10 years of professional experience (60%).

During the ultrasound examination process, the utilization rate of prenatal support devices among pregnant women was analyzed. According to the observation results, 50% of the respondents reported using prenatal bandages regularly, 40% utilized these devices periodically, and 10% noted that they rarely used them (Figure 1). These indicators confirm a high demand for prenatal support devices among pregnant women and underscore the necessity of further optimizing their structural design.

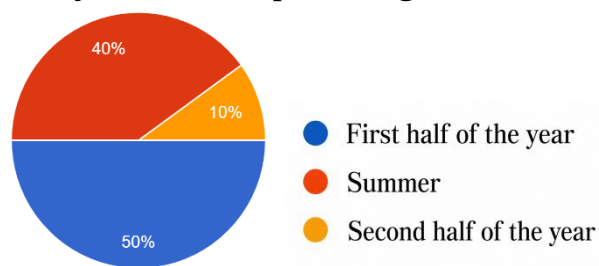
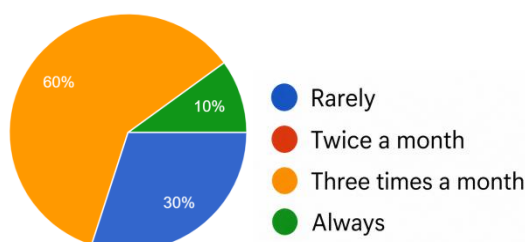


Figure 1. Survey results on the utilization rate of prenatal support devices.

Within the scope of the study, the opinions of medical specialists regarding the frequency of ultrasound monitoring during pregnancy were analyzed. Sixty percent (60%) of the physicians consider it appropriate to undergo ultrasound examinations in each trimester, 30% emphasized the necessity of monthly screenings, and 10% recommended an unlimited number of examinations based on individual clinical indications (Figure 2). This distribution is substantiated by the specific medical objectives of each period: in the first trimester (weeks 11–14), ultrasound confirms intrauterine pregnancy, determines the number of fetuses, and, most crucially, ensures early detection of the risk of genetic abnormalities (e.g., Down syndrome); the second trimester (weeks 18–22) serves as the "golden period," allowing for a detailed anatomical evaluation of all internal organs (heart, brain, kidneys) to detect developmental anomalies; in the third trimester (weeks 30–34), fetal weight, intrauterine presentation (e.g., cephalic or breech), placental maturity, and amniotic fluid volume are assessed to plan the optimal delivery method (vaginal birth or cesarean section) (Figure 3)[4].



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Figure 2. Survey results on the frequency of ultrasound (US) monitoring.



Figure 3. Fetal development changes by trimester.

When analyzing the subjective manifestations of physiological changes during pregnancy, 80% of the respondents reported the presence of lumbar back pain, pressure in the lower abdomen, and a constant feeling of discomfort. Ten percent (10%) indicated that such symptoms appeared periodically, while the remaining 10% stated that they did not experience any pain syndromes (Figure 4). These conditions are not only the result of natural physiological processes but can also serve as clinical indicators requiring timely medical supervision. This, in turn, further underscores the critical relevance of utilizing intelligent devices that support and monitor the body shape of pregnant women.

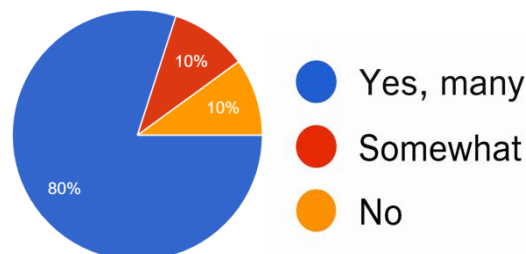


Figure 4. Survey results on the subjective manifestations of physiological changes in pregnant women.

According to the analysis results presented in Figure 5, the functional requirements of pregnant women regarding prenatal support devices were systematized. Eighty percent (80%) of the respondents identified the reduction of lumbar pain syndromes as the primary function of these devices, 60% emphasized lowering the pressure in the lower abdomen, and 20% highlighted the necessity of optimizing the spinal load (compression). These indicators scientifically substantiate that the structural solutions of the "smart" clothing being designed for pregnant women must, first and foremost, be targeted toward correcting strains in the musculoskeletal system.

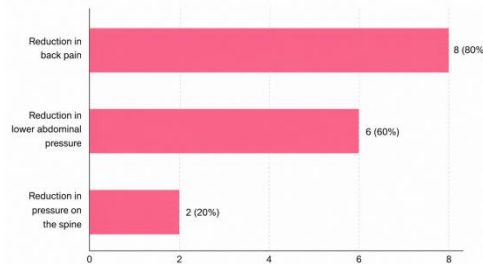


Figure 5. Survey results on the clinical efficacy of prenatal support devices.

When evaluating the professional guidance required, 50% of the ultrasound specialists participating in the study emphasized the necessity of a mandatory consultation with an obstetrician-gynecologist before using a prenatal support device. Forty percent (40%) acknowledged the clinical benefits of these devices, while 30% warned against the potential adverse (harmful) effects of incorrectly selected or unjustifiably applied bandages. Additionally, 20% of the physicians indicated that addressing this matter does not fall directly within their professional scope (Figure 6).



Figure 6. Survey results on the role of medical consultation in the utilization of prenatal support devices.

Noting a minimal level of potential risk associated with the examination, 70% of the physicians emphasized that its diagnostic value and efficacy significantly outweigh this risk. Concurrently, 50% of the specialists consider modern ultrasound practices to be absolutely safe for both maternal and fetal health (Figure 7).

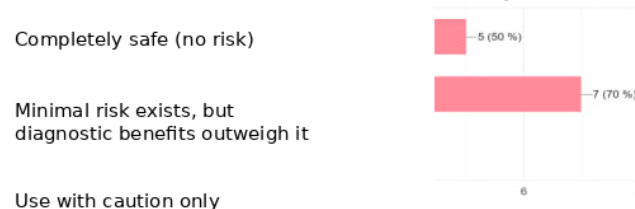


Figure 7. Survey results on the safety level of ultrasound (US) examinations.

Within the scope of the research, the correlation between traditional ultrasound (US) examination and innovative remote monitoring systems was analyzed. Sixty percent (60%) of the specialists evaluated the "smart" prenatal support device as an effective tool that complements ultrasound results and provides dynamic monitoring. While 30% of the physicians emphasized the superiority of ultrasound data in detecting visual

indicators such as placental localization and amniotic fluid volume, 10% maintained a neutral position on this matter (Figure 8).

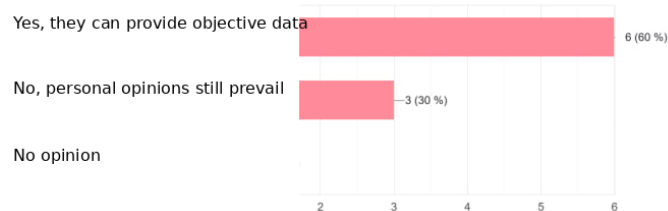


Figure 8. Specialists' opinions regarding the smart prenatal support device (PSD). As a result of systematizing the technological parameters that enhance the diagnostic accuracy of the intelligent device, 60% of the experts identified the integration of a remote doctor-patient communication system as the highest priority area. Furthermore, it was determined that real-time tracking of parameters such as fetal heart rate (50%), fetal movement (40%), and maternal body temperature (30%) in monitoring fetal vital signs significantly increases the clinical value of the device (Figure 9).

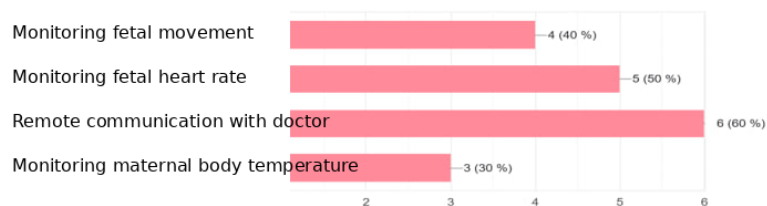


Figure 9. Survey results on technological solutions and their diagnostic importance. Within the scope of the study, the impact of the widespread implementation of the "smart" prenatal support device (PSD) on the level of psychological reassurance and safety among pregnant women was analyzed. According to the survey results, 50% of the physicians acknowledged that the primary advantage of this technology is fostering a sense of being "under constant medical supervision" within the patient. Thirty percent (30%) emphasized that the remote monitoring system liberates pregnant women from the necessity of frequent hospital visits, enabling dynamic monitoring in a home environment. Additionally, continuous communication with the physician (10%) and an automated alert (notification) system for the doctor or patient in emergency situations (10%) were identified as critical factors ensuring fetal safety (Figure 10).

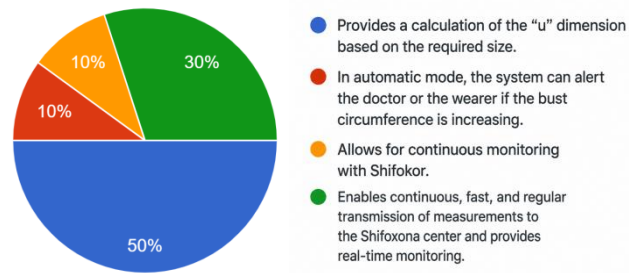


Figure 10. Survey results on the clinical efficacy of utilizing the smart prenatal support device (PSD).

At the conclusion of the survey, under the section "*As an ultrasound specialist, what primary recommendations would you offer to the developers of smart prenatal support devices?*", the physicians outlined the following requirements:

- **Electromagnetic Safety:** Sensors within the smart prenatal support device (such as Bluetooth or Wi-Fi modules) must emit minimal electromagnetic radiation and cause no interference with ultrasound waves. The experts' emphasis on "maximum safety" directly addresses preventing any technological radiation from impacting fetal development.
- **Material Biocompatibility:** Since smart clothing integrates electronic sensors, the fabric may contain synthetic fibers. However, clinicians strictly mandate the use of hypoallergenic and hygroscopic (moisture-absorbing) textiles that guarantee skin breathability. This design feature prevents physical discomfort during extended wear (3–4 hours).
- **Dynamic Ergonomics:** A pregnant woman's body parameters fluctuate throughout the day due to meals or peripheral edema. The smart support device must feature automatic or mechanical elasticity adjustments, as excessive compression can adversely affect uterine blood circulation.
- **Structural Comfort:** The device's lightweight design, non-intrusive sensor placement that prevents skin indentation, and low-profile visibility under daily attire are essential to ensuring the user's psychological reassurance.

An enhanced smart prenatal device is not merely a mechanical bandage; rather, it is a comprehensive biomedical system that accounts for non-standard body shape variations, harmonizes with ultrasound diagnostics, and ensures the psychological reassurance of the patient. Integrating this technology into the digitized healthcare framework (such as DMED) marks an innovative turning point in safeguarding maternal and fetal health.

The survey findings demonstrated that in mitigating the lumbar and pelvic pain syndromes observed in 80% of pregnant women, the prenatal support device serves not

only as a mechanical anchor but also as a primary preventive tool against pathological complications. Eighty percent (80%) of the experts identify this device as a decisive factor in preserving spinal health. Furthermore, 60% of the ultrasound specialists recognized the remote data acquired via the smart support device (such as fetal heart rate and movement) as an innovative instrument that effectively complements traditional ultrasound findings. This paradigm enables a transition from conventional "static" diagnostics to "dynamic" (continuous) monitoring. The implementation of smart technology fosters a sense of being "permanently protected" among pregnant women and optimizes the operational load on the healthcare infrastructure by minimizing unwarranted hospital visits. Factoring in the minimal probability of potential risks, 70% of the physicians designated the deployment of low-frequency sensors that do not interfere with fetal development as a paramount priority for smart clothing design.

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