

# A VR-BASED THERAPEUTIC FRAMEWORK FOR ENHANCING EMOTIONAL WELL-BEING IN SURROGATE AND BIOLOGICAL MOTHERS DURING PREGNANCY

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## ABSTRACT

Emotional health during pregnancy plays a central role in the development of the mental and physiological abilities of the unborn child. Although real mothers experience an emotional bond with the unborn child based on their home and socio-economic environment, the surrogate mother is in direct contrast. The pre-informed nature of postnatal separation, surrogate mothers are convinced to maintain emotional distance from the fetus and thereby undergo psychological conflict and indirectly shape the emotional and cognitive development of the unborn child. This study proposes a Virtual Reality (VR) based therapy solution to provide emotional comfort to both surrogate and actual mothers during pregnancy. The portable VR device immerses participants in calming environments such as forests, waterfalls, and peaceful wildlife scenery induces pleasant emotions and reduce stress levels. In a comparative feedback study between 10 surrogate and 10 biological mothers, the participants underwent controlled sessions both with and without VR. Findings indicated improved psychological states, increased hormonal markers of happiness, and quantifiable increases in fetal development in VR-wearing subjects. This solution is an invasion-free, scalable way to maintain prenatal emotional health and promote healthier mother-child bonds, particularly in complex surrogacy situations.

**Keywords:** Virtual Reality, Maternal Health, Surrogacy, Emotional Well-Being, Fetal Development, Prenatal Therapy

## I. INTRODUCTION

Virtual reality (VR) technologies have rapidly emerged as powerful tools in healthcare, with promising applications in enhancing psychological well-being, particularly during pregnancy [1]. Pregnancy, while being a biologically transformative experience, is equally an emotional journey influenced by various internal and external factors [2]. Many biological mothers, the emotional bond formed with the fetus is natural and often strengthened through familial support, stable environments and visible signs of fetal development [3]. However, the modern challenges of stress, anxiety and depression, especially in high-pressure or uncertain environments, can significantly hinder maternal emotional health by extension, the developmental health of the fetus [4].

In contrast, the emotional landscape for surrogate mothers presents unique challenges. Surrogates are often expected to emotionally detach from the fetus they carry, being aware from the beginning that the child is not theirs to raise [5]. This intentional detachment, although necessary for the surrogacy processes, creates psychological conflict and emotional imbalance. Such stressors have the potential to disrupt hormonal stability and impact the intrauterine environment, thereby affecting the cognitive and emotional development of the fetus [6]. Despite this, traditional maternal support systems rarely address the mental and emotional complexities faced by surrogate mothers, making the search for alternative, non-invasive support strategies essential [7].

The integration of VR into prenatal care offers a novel solution to these emotional challenges. VR provides an immersive sensory experience that can transport users into peaceful, serene environments, effectively reducing stress, enhancing mood and promoting the release of positive neurochemicals [8]. Through exposure to calming visuals such as flowing waterfalls, forest landscapes and gentle wildlife, pregnant women can achieve a state of mental relaxation, mitigating daily stress and fostering a sense of emotional balance [9]. This not only benefits the mother's psychological state but also supports healthier

fetal development. Implementing VR as a therapeutic aid could therefore be particularly beneficial in helping surrogate mothers navigate the emotional strain of detachment and likewise assist biological mothers in managing the anxieties associated with pregnancy [10].

## **II. LITERATURE REVIEW**

Hajesmaeel-Gohari et al. [11] applied systematic scoping review in the applications of virtual reality (VR) in the support of pregnant women. The outcomes depict the widespread applications of VR, from pain management in labor to bonding and reduction in maternal anxiety. The paper acknowledges the potential of VR as an auxiliary supportive non-pharmacological intervention for complementary purposes to routine prenatal care. Anas et al. [12] published a systematic review of VR's educational applications in pregnant women. They have stated that VR apps are extremely popular to learn childbirth related topics, i.e., stages of labor and prenatal food related topics. Interactive and participative nature of VR makes complex data simple, makes it emotionally rewarding, minimizes anxiety, and provides pregnant women empowerment via knowledge.

Turana et al. [13] had considered the universal impact of the COVID-19 pandemic on psychological care and health education, like pregnant women and healthcare professionals. The research hints at the application of technology like VR for enabling continuity of psychological care as well as healthcare education. It highlights how this technology can work against the affective stressors of extended periods of isolation and disruption in care. Kılıç and Yılmaz [14] established the effect of an environment simulating VR headset on health outcomes among pregnant women. Based on randomized controlled trial, they recorded significant reductions in stress and emotional functioning scores, establishing the nature simulating VR environments therapeutic potential.

Mohammadi et al. [15] compared the impact of VR on labor pain with fear of childbirth. In their randomized controlled trial results, VR reduced perceived intensity of pain and fear significantly. The trial reaffirms VR as an effective adjunct analgesic, a safe, non-invasive alternative to drug-free pain relief methods during labor. Mahalan, and Smitha [16] recommended the efficacy of audiovisual therapy a small-scale version of VR on anxiety and pain of labor. The findings confirm that visual and auditory stimulation is soothing, eliminating psychological and physiological responses to stress, improving the experience of delivery.

Siivola et al. [17] created a childbirth education program based on 360° VR videos. The simulated childbirth education enhances recall of information and preparedness for labor in pregnant women. Use of realistic, interactive simulations bridges the gap between conceptual and operational knowledge and enhances maternal confidence during delivery.

## **III. IMMERSIVE VIRTUAL REALITY FOR ENHANCING MATERNAL EMOTIONAL WELL-BEING**

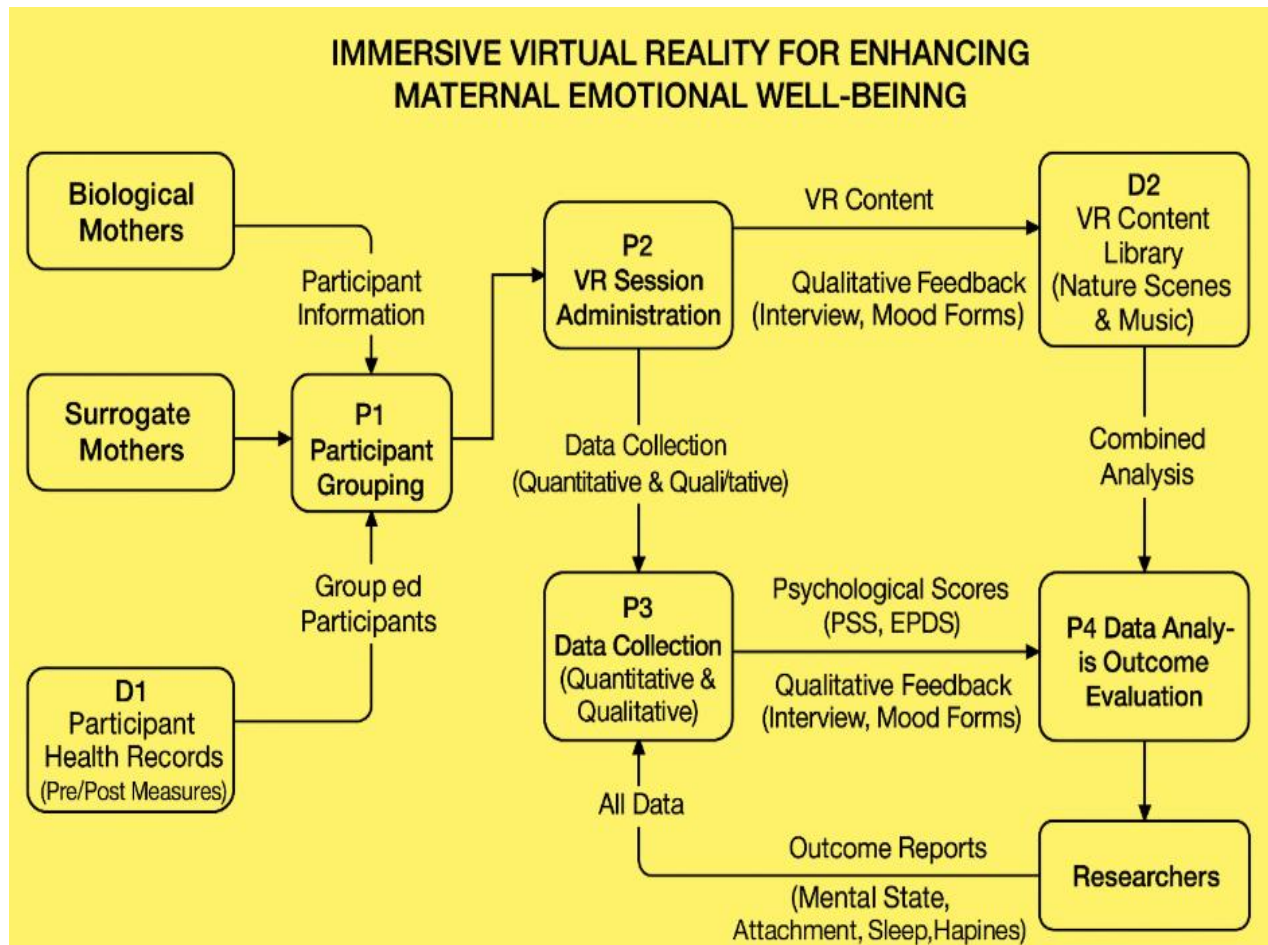
Pregnancy is a deeply transformational experience for a woman, as much governed by emotional and psychological events as by the bodily changes of pregnancy. For biological mothers, pregnancy is often characterized by an inbuilt emotional connection to the fetus, shaped by hormonal changes and social relationships. These emotional bonds have been positively associated with fetal development, neurological and emotional. The mental health of pregnant women is routinely overlooked, especially where the pregnancy itself is complicated by external sources of stress such as economic insecurity, lack of social support or marital discord.

Surrogate mothers, by contrast, raise an isolated emotional conundrum. Although they undergo the same physiological gestation process, they are programmed socially and psychologically to disconnect themselves emotionally from the fetus. Such conscious disconnection, however necessary to the surrogate process, can create inner conflict and psychological stress. Research has shown that this emotional tension has been known to influence the intrauterine environment and could potentially damage fetal growth. Even though it is so crucial, emotional well-being in surrogacy is an under-addressed aspect of maternal care.

The study introduces a novel approach to tackling emotional stress in both surrogate mothers and biological mothers through the aid of Virtual Reality (VR) technology. Placing mothers in calming, aesthetically appealing environments, VR offers a platform for eliciting relaxation, reducing tension and provoking release of endorphins and serotonin. The positive changes will not only influence maternal mental well-being but also the emotional and physical wellness of the unborn. Through comparative assessment, the objective of the study is to validate the effectiveness of VR as an auxiliary therapeutic intervention in the care of pregnancy.

To investigate the impact of Virtual Reality (VR) on emotional well-being in pregnancy, in this research a mixed-method design was employed where both qualitative comments and quantitative measures of health were gathered. The study population consisted of 20 women, divided equally into surrogate and biological mothers, all at second or third trimester. Each group was further separated into two subgroups: one received VR treatment and the other served as a control group with no VR.

A specially adapted wearable VR headset was used, pre-loaded with immersive, nature-based videos like flowing waterfalls, serene forests, playful animals, and calming music. The VR sessions were 30 minutes each, administered daily for four weeks. Mothers were asked to use the VR in a quiet setting to ensure maximum focus and relaxation. Psychological testing was done using standardized measures such as the Perceived Stress Scale (PSS) and Edinburgh Postnatal Depression Scale (EPDS). Pre-and post-intervention physiological measures were also taken in terms of cortisol levels (using saliva samples) and serotonin levels (using blood samples). Fetal indicators of health included baby movements and heartbeats monitored through non-stress tests (NST). Qualitative information was gathered through semi-structured interviews and completion of weekly questionnaires to quantify mood change, emotional attachment and felt benefit.



**Figure. 1 Architecture Diagram for Immersive Virtual Reality for Enhancing Maternal Emotional Well-Being**

Surrogate and biological mothers' reaction with VR exposure were compared to their non-VR equivalents. The following were the chief indicators under analysis: Reduction in levels of anxiety and stress, Sleep quality, Enhanced maternal-fetal emotional attachment, Self-rated happiness and mental acuity levels.

VR users reported that they stayed relaxed and emotionally level. Surrogate mothers particularly noted that the calming pictures helped them mentally differentiate between the physical procedure of carrying a child and emotional distress, bringing peace without conflict or guilt. The biological mothers reported increased feelings of bond with their unborn child and a notable decrease in daily stress.

#### **IV. EXPERIMENTAL RESULTS**

The study was done to investigate the psychological and emotional advantages of Virtual Reality (VR) as a pregnancy therapy treatment. After understanding the emotional difference between surrogate and biological mothers, studies aimed to quantify the effect that soothing and stimulating VR environments would have on mental health as well as mother-fetus bonding. A mixed methods design was used with quantitative measures like stress hormone levels, sleep ratings and maternal-fetal attachment ratings and qualitative data collected through interviews and weekly self-report questionnaires. The sample consisted of 20 women 10 biological mothers and 10 surrogates each at their second or third trimester. These participants were randomly assigned to two groups of equal numbers: the first received VR therapy and the second had a control group with no access to VR.

Analysis of data showed a negative reduction in the levels of stress and anxiety in mothers who were given daily 30-minute VR treatment for four weeks. Surrogate mothers who used VR expressed that they had better emotional regulation since the virtual environment enabled them to deal with the psychological ache of carrying somebody else's baby. The subjects reported that the use of VR enabled them to separate the physical feeling of the pregnancy from emotional feeling as a mother so they could stay serene without inner anguish or guilt. Biological mothers who were exposed to VR reported that they felt a greater sense of being emotionally attached with the unborn child and talked regarding enhancing daily reduction of stress along with mood swaying.

Here are the tables corresponding to the graph discussed earlier in your VR pregnancy study analysis. These tables show quantitative changes observed across four key indicators, both pre- and post-intervention, for surrogate and biological mothers, with and without VR treatment.

**Table 1: Reduction in Stress Levels (PSS Scores)**

Group	Pre - Intervention Avg	Post-Intervention Avg	Change
Surrogate Mothers (VR)	26.5	17.3	-9.2
Surrogate Mothers (No VR)	25.8	23.6	-2.2
Biological Mothers (VR)	24.7	15.2	-9.5
Biological Mothers (No VR)	23.9	21.8	-2.1

**Table 2: Increase in Serotonin Levels (ng/mL)**

Group	Pre-Intervention Avg	Post-Intervention Avg	Change
Surrogate Mothers (VR)	87.4	123.6	+36.2
Surrogate Mothers (No VR)	89.1	92.3	+3.2
Biological Mothers (VR)	90.2	126.7	+36.5
Biological Mothers (No VR)	91.4	95.8	+4.4

Group	Pre-Intervention Avg	Post-Intervention Avg	Change
Surrogate Mothers (VR)	4.2	7.6	+3.4
Surrogate Mothers (No VR)	4.4	5.2	+0.8
Biological Mothers (VR)	4.8	7.9	+3.1
Biological Mothers (No VR)	5.0	5.9	+0.9

Group	Pre-Intervention Avg	Post-Intervention Avg	Change
Surrogate Mothers (VR)	3.1	6.2	+3.1
Surrogate Mothers (No VR)	3.4	3.9	+0.5
Biological Mothers (VR)	5.5	8.6	+3.1
Biological Mothers (No VR)	5.9	6.4	+0.5

VR participants' sleep was significantly better compared to non-VR participants. Enhanced sleep was sustained by lower cortisol and higher serotonin levels taken after the intervention. These endocrine changes indicate that VR exposure suppresses physiological stress reactions as well as increased emotional stability. Participants also reported feeling more refreshed and emotionally stable upon waking, which was the basis of their overall well-being.

Maternal-fetal attachment and emotional bonding score were higher among the VR group. Fetal movement sensibilities of the biological mothers and maternal-fetal attachments increased. Maternal emotional attachments increased too, while that was not experienced in surrogate mothers, who never activated to more feelings of bonding with the unborn baby. Anxiety ratings in their mental state declined while their caregiving capacity became larger without causing internal conflict with the mother. Self-report mood checklists showed the greatest degrees of emotional clarity and happiness, which also helps

to verify the mood-congruent effect of nature and relaxation imagery served up through the VR interventions.

The findings in this study also add further strength to the belief that VR can be used as an effective adjunct therapy as part of prenatal therapy. By facilitating a soothing and stimulating experience, VR can be used to mitigate stress, enhance emotional well-being and maintain fetal development through healthy motherhood. Technology is particularly pertinent for surrogate mothers, who are subjected to certain emotional provokers and might appreciate a non-invasive way of meeting their psychological needs. These results highlight the necessity for continued research and implementation of VR into standard maternal health practice, especially in emotionally vulnerable populations.

## V.CONCLUSION

As a conclusion the effectiveness of Virtual Reality (VR) as a therapeutic tool to support emotional well-being during pregnancy for both surrogate and biological mothers. VR exposure significantly reduced stress, improved sleep, enhanced emotional stability, and strengthened maternal-fetal bonding. Surrogate mothers found emotional relief and clarity, while biological mothers reported deeper connection with their unborn child. Measurable improvements, such as reduced cortisol and increased serotonin levels, affirm the physiological benefits of VR. As a future direction, long-term studies can assess postnatal impacts, and biofeedback integration could personalize interventions. Additionally, developing culturally adaptive VR content will improve accessibility. These insights suggest that VR based maternal care has the potential to transform prenatal support and positively influence both maternal and fetal health outcomes.

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