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## The influence of stress during pregnancy on the central nervous system of mother and her child

### Wpływ stresu w okresie ciąży na ośrodkowy układ nerwowy matki i jej dziecka

<https://doi.org/10.34766/fetr.v47i3.914>

**Abstract:** Pregnant women may experience high levels of stress, including those associated with finding oneself in a new reality. In addition, the new reality is the COVID-19 pandemic, which has contributed to the deterioration of the mental state of many people. Chronic stress can lead to the neuroanatomical changes in the mother's brain, but also in her baby. It leads to atrophy of neurons in the hippocampus and prefrontal cortex, and to the growth and enlargement of the amygdala, i.e. those structures that are responsible for emotions. The mother's emotions also shape the synapses in the fetus, and the neurotransmitters secreted by the mother modify the development of the baby's brain. Research is ongoing in many countries on the consequences of anxiety and depression in pregnant women during the COVID-19 pandemic. For this reason, it is important to take care of psychological well-being, for example by using the techniques of cognitive behavioral therapy. Support from relatives during pregnancy and childbirth is also an extremely important element in the proper development of the central nervous system of the unborn child.

**Key words:** COVID-19, pregnancy, neurodevelopment, stress

**Abstrakt:** Kobiety w ciąży mogą doświadczać dużego poziomu stresu, między innymi związanego z odnalezieniem się w nowej rzeczywistości. Ponadto tą nową rzeczywistość stanowi także pandemia COVID-19, która przyczyniła się do pogorszenia stanu psychicznego wielu osób. Przewlekły stres może doprowadzić do wystąpienia zmian neuroanatomicznych w mózgowiu matki, ale także u jej dziecka. Dochodzi do atrofii, czyli zaniku, neuronów w hipokampie i korze przedczołowej oraz do rozrostu i powiększania się jąder migdałowatych, czyli tych struktur, które odpowiedzialne są za emocje. Emocje matki kształtują także synapsy u płodu, a wydzielane przez matkę neuroprzekaźniki modyfikują rozwój mózgowia dziecka. W wielu krajach toczą się badania nad konsekwencjami lęku i depresji u kobiet w ciąży w czasie pandemii COVID-19. Z tego względu ważne jest odpowiednie zadbanie o swój (i dziecka) dobrostan psychiczny, np. poprzez stosowanie technik z terapii poznawczo- behawioralnej. Wsparcie ze strony bliskich osób w trakcie ciąży oraz porodu jest także niezwykle ważnym elementem w prawidłowym rozwoju ośrodkowego układu nerwowego matki i jej dziecka.

**Słowa kluczowe:** COVID-19, ciąża, rozwój układu nerwowego, stres

#### Introduction

Many factors influence the child's psyche and health. One of them is the mental state of the mother during pregnancy (Traylor, 2020). The stress a mother experiences (as a result

of many different strong experiences) primarily changes the functioning of her brain and affects the development of her baby's brain. Traumatic experiences (death of a spouse or close family member, physical or psychological harassment, mobbing, etc.) evoke many negative feelings and emotions, such as insecurity, fear, feeling of emptiness, anger, aggression, hostility, guilt, longing, regret, helplessness, internal chaos, anxiety attacks, confusion, absent-mindedness, a sense of shame, and may cause the use of defense mechanisms (e.g. suppression, repression). The Polish study of pregnant women by Lachowska and Szteliga showed that the worst worries concern miscarriage, childbirth, going to the hospital as well as the health and life of the child. The difficult economic situation (financial problems, housing conditions, difficulties with work) intensified worries about health as well as about the relationship with her husband or partner (Lachowska, Szteliga; 2019). In the face of such experiences, the secretion of, for example, glucocorticosteroids (cortisol) changes. The concentration of some hormones increases (e.g. cortisol), while others decrease (e.g. sex hormones). The concentration of cortisol in chronic stress increases up to 10 times, which has a destructive effect on neurons in the central nervous system (CNS). It leads to atrophy of neurons in the hippocampus and prefrontal cortex, and to the growth and enlargement of the amygdala, i.e. those structures that are responsible for emotions. Mother's emotions also shape synapses in the fetus, and neurotransmitters secreted by the mother modify the development of the child's brain (Carrion 2007; Rajkowska, 2007; Abbasi, 2020). Repeated severe stress or chronic stress can damage the hippocampus, which no longer inhibits the stress response. Then, increasing stress stops neurogenesis, i.e. the formation of new neurons, and causes neuron atrophy. This is always the case in the face of stress and negative emotions, regardless of age, in the fetus and adulthood. In many studies, during the use of positron emission tomography (PET), disturbances in cerebral flow and glucose metabolism in the structures of the limbic system, cingulate gyrus, and prefrontal cortex, which proves the reduction of the functions of these brain structures in chronic stress (Noriuchi, M., Kikuchi, Y., Mori, K., Kamio, Y., 2019). In addition, neuroimaging studies of the brain using functional magnetic resonance imaging (fMRI) showed in the hippocampus atrophy of dendrites of pyramidal cells in the CA3 region and the dentate gyrus cells, i.e. in centers responsible for recognizing emotions and managing them (Hotsenpiller, 2007; Pawluski, 2012). Increased concentrations of glucocorticosteroids also inhibit the secretion of the brain-derived neurotrophic factor (BDNF), which corresponds, among others, to the formation and plasticity of neurons. Impaired neurogenesis causes the hippocampus to shrink and the appearance of numerous symptoms, including depression (Masi, 2011). Changed by chronic stress can also cause antisocial behavior, hyperactivity, and other personality disorders (Teicher, Andersen, Polcari, Anderson, & Navalta, 2002; O'Donnell, 2017). Lupien (2011) confirms that the stronger the mother's stress, the greater the volume of the baby's amygdala. He explains that

this phenomenon has its biological justification, because an enlarged amygdala may have a protective role, increasing adaptation to unfavorable and stressful living conditions in the future, when probably, due to the mother's illness and insufficient care, the child will depend mainly on himself. When a mother experiences trauma or depression while pregnant, her mental state has a fundamental impact on the mental and physical health of her child (Sandman, 2015). The increase in pregnancy anxiety changes the concentration of cortisol in the amniotic fluid. This can cause cognitive and language impairment in her child later in life (Glover, 2009; Laplante, 2008; Buss, 2011; Whitehouse, 2012; Lindsay, 2019; Ars, 2019). Newborns with mothers suffering from depression also have decreased activity in the left hemisphere of the brain, mainly in the left frontal lobe. It has been proven that the stronger the mother's negative emotions influence the occurrence of the child's brain wave disorder (Bruder, 2005). In addition, the effects of chronic maternal stress on the function of the hypothalamic-pituitary-adrenal (HPA) axis have been demonstrated (Emack, 2011).

### **1. The impact of stress related to the COVID-19 pandemic on pregnant women**

A similarly difficult situation for women is the time of isolation during the COVID-19 pandemic. When the media around the world reported the growing number of new cases and deaths from COVID-19, it has had a significant psychological effect on people around the world. A representative study of the Polish population showed that the severity of depressive symptoms during the COVID-19 pandemic increased from 16.2% to 36.6% in the group of people aged 18 to 34 (Gambin et al., 2020). Research on the consequences of anxiety and depression in pregnant women during a pandemic is ongoing in many countries (Kajdy et al., 2020). An Irish study from April 2020 showed that after a month of forced isolation and the resulting lack of contact with relatives, 44% of pregnant women had a depressed mood and 14% of the deteriorated financial situation due to lack of work, 4% worsened relationships with a partner and 11 % reported tensions with family members staying in the same household (Milne et al., 2020). An American study found that in the studied sample, 21% of pregnant women showed a moderate level of anxiety. The protective factor was the higher age of women and pro-health behavior during pregnancy (Preis et al., 2020). Another Irish study found that before the COVID-19 pandemic, 83% of pregnant women surveyed were not worried about their health, and since the pandemic, as many as 50.7% of them were worried about it all the time; 35% of them isolate themselves out of fear of contracting the virus, and for the same reason 32% of them have since worked from home, 46.5% questioned the safety of the means of transport used so far, and 66.2% started buying food online (Corbett et al., 2020). The results of the cited studies are interesting because, in fact, studies on the influence of the coronavirus on the course of pregnancy conducted since the beginning of the COVID-19 pandemic show no serious threat to pregnant women. Women

who were diagnosed with the SARS-CoV-2 virus had no breathing difficulties and did not require intensive hospital care. There were also no complications in the born babies. CNS changes were not observed. Newborns tested negative for the virus. The presence of the Sars-CoV-2 virus was also not detected in the milk of nursing mothers (Caparros-Gonzalez, 2020). Adding to the typical challenges of the perinatal period, the COVID-19 pandemic has been interfering with peripartum women's emotional well-being. In April-May 2020, scientists from Canada, have identified a significant increase in mental health symptomatology, particularly in anxiety and depressive outcomes. Results showed that 15% (pre-pandemic), and 40.7% (current) women significantly indicated depression. Additionally, 29% (pre-pandemic), and 72% (current) women presented moderate to high anxiety (Pacheco, 2021).

## **2. Stress during pregnancy and the impact of mental resources on the development of the nervous system of the mother, and her child**

However, it is worth emphasizing that positive emotions and the support of loved ones are also very crucial. In the most difficult cases, great love can work wonders. The saying 'love builds' can be understood literally, because the feeling of love can even lead to an increase in neurogenesis, i.e. the formation of new neurons in the CNS. The intensity of positive feelings is associated, among others, with an increase in the expression of nerve growth factor (NGF), which is responsible for neurogenesis (Emanuele, 2011). This phenomenon was discovered by Rita Levi-Montalcini, winner of the Nobel Prize in Medicine in 1986 (Kucharz, 2013). If the mother, still pregnant or after giving birth to her child, can establish an emotional bond with him and truly love him, then positive emotions, the most important of which is love, will become the driving force not only in the process of minimizing the negative effects of previous events, but also, for example, in parts, repair of child damage. Many studies have shown that mental resources can allow the CNS to develop properly. In addition, even during the COVID-19 pandemic, psychological support has been shown to have an impact on pregnant women (Shahid, 2020). However, it should be emphasized that scientific studies have shown that the COVID-19 pandemic had a psychological impact on pregnant women (Ramiro, 2021), therefore they should be provided with psychological care, especially when their family situation is another factor causing chronic stress. It is also noted that mindfulness and cognitive behavioral therapy have a positive effect on pregnant women who experience chronic stress (Tomforhr, 2016; Romero-Gonzalez, 2020). In addition, not only are mental resources significant, spiritual resources can play a significant role in reducing stress in pregnant women. Many studies show that religion can have a significant impact on mental health (Vaillant, 2013; Weber, 2014; Jaksz-Recmanik, 2014). It should be emphasized that already at the turn of the 19th and 20th

centuries, starting from various research traditions (both theological, philosophical, psychological, and biomedical traditions), the necessity to implement a holistic model of patient care taking into account psychological and even spiritual aspects was noticed in medical practice.

Another important aspect is the changes that occur in the CNS during childbirth. During this time, the mother experiences profound behavioral changes with extensive remodeling of neural circuits. These changes include neurochemical, morphological, and functional plasticity. The continuous generation of new neurons in the hippocampus and the olfactory system is an additional form of neuroplasticity that contributes to motherhood (Levy, 2011). On the other hand, many studies indicate, for example, a relationship between postpartum depression and stressful delivery and negative birth experiences, including a negative assessment of the behavior of medical personnel assisting during the birth of a child and the absence of a loved one during childbirth (Beck et al., 2013; Garthus-Niegel, 2018).

### Summary

As studies have shown, chronic stress affects the CNS of the fetus, primarily reduces the volume of the hippocampus and the amygdala, which in turn translates into a reduction in cognitive functioning and increase possibly emotional difficulties (including a predisposition to psychiatric diseases later in life). However, the use of mindfulness, cognitive-behavioral therapy, and resources, including in the form of a supportive family, can translate into improved functioning of both the mother and the child. In addition, it has been shown that religion can be one of the stress-reducing factors during pregnancy. This is especially important in times of the COVID-19 pandemic, which is one of the factors influencing the occurrence of stress during pregnancy.

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