The effect of environmental factors on neurobiology and depressive symptoms: A narrative review

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Abstract:

Depression and anxiety are among the leading mental illnesses in America, however, their root cause remains relatively unclear in terms of neurological function. This review paper aims to explore how certain environmental factors, specifically the physical environment, stress, familial interactions and relationships, and social relationships, can affect neurological function in the brain, and possibly increase symptoms of depression and risk for depression. Future directions are also discussed with respect to whether there are certain changes or improvements that can be made to our environments in order to preserve and maintain healthy neurological function, reducing the likelihood of developing mental illnesses.

Introduction:

Depression, commonly referred to as Major Depressive Disorder (MDD), is a prevalent yet severe illness affecting 300 million people around the world (1). It is known to negatively impact the way individuals perceive their external environment, affecting their actions and behavior (2). Depression is often characterized by symptoms such as sad feelings, weight fluctuations, lack of energy, feelings of guilt and worthlessness, and suicidal thoughts (2). A variety of environmental factors can contribute to the development of depression (1). Though environmental factors can be understood in a number of different ways, this review aims to focus specifically on the physical environment, stress, familial relationships, and social relationships. Through a deeper dive into these elements, a better understanding of their effect on neurological function and depressive symptoms can be achieved.

Environmental Factors:

Depressive symptoms can often result from external stimuli, such as our surrounding environment (1). These environmental factors range from the physical environment to familial and social activity.

Physical Environment:

Our physical environment can be described as external factors and influences which are commonly caused by human-made impacts on the environment.

Air Pollution:

One of these external factors is air pollution, mainly caused by fossil fuels, vehicles, and the manufacturing industry (3). Air pollutants are emitted into the atmosphere in the form of carbon monoxide (CO), carbon dioxide (CO2), particulate matter (PM), and numerous other toxic substances (3). These pollutants, most often, enter the body through inhalation, however they can also be absorbed by the skin. Much research has been conducted to explore how exposure to air pollution affects neurophysiological function.

A longitudinal study was conducted to assess the effect of long-term exposure to air pollution on depression in adults. The study concluded that increased exposure to air pollution over time can increase risk for depression (4). Another study demonstrated how a particulate matter of PM2.5 can directly influence neural plasticity, which is the brain's ability to adapt to environmental stimuli (3). Decreased neural plasticity correlated with increased depressive symptoms, connecting increased exposure to PM2.5 with increased depressive symptoms (1).

Air pollution and pollutants can induce a neuroinflammatory response; for example, exposure to these harmful substances has been associated with inflammation of the central nervous system (CNS). Increased inflammation of the brain has been associated with increased depressive symptoms as well (3). Another study found that pro-inflammatory cytokines are activated by respiratory intake of PM (5). Cytokines are signaling molecules that transmit signals for immune responses, and they move cells towards inflammation, infection, or trauma sites (6). Pro-inflammatory cytokines, a type of cytokine, can exacerbate existing inflammation, infection, or trauma (7). These types of cytokines cause an inflammatory response, which can lead to different abnormalities in the animal brain, potentially increasing depressive symptoms (5).

Neurotransmitter function can also be greatly influenced by air pollution. Neurotransmitter systems, such as the dopaminergic and serotonergic systems, concerning the neurotransmitters dopamine and serotonin respectively, play a major role in reward processing, emotion regulation, decision making, and many other cognitive functions (3). Disruptions of these reward pathways can be caused by increased exposure to air pollution. This in turn can increase depressive symptoms due to the hypoactivity of these neurotransmitter systems, thus influencing behavior and actions (3).

Overall, a wide variety of studies have shown positive correlation between air pollution and depressive symptoms and risk for depression, due to changes in neurological function (3). Moreover, it is important to recognize that air pollution can be particularly harmful in brains that are still developing such as those of youth and adolescents whose brains still aren’t fully developed (3).

Noise:

An additional complaint in many urban areas is noise, often from construction and heavy traffic. Noise is an environmental stressor which can cause many negative emotions such as annoyance (1). These feelings can result in a stress response related to depression (3). A recent long-term study found that exposure to noise in residential areas was associated with increased depressive symptoms (3).

On a similar note, animal studies have shown that noise is correlated with the provocation of stress similar to humans (5). This can lead to increased levels of dopamine and noradrenaline in the hypothalamic pituitary axis (HPA), a hormonal stress response mechanism (3). These neurotransmitters and hormones can impair the prefrontal cortex (PFC), the frontal lobe of the cerebral cortex that regulates reasoning, decision making, and emotional regulation (3). This impairment in turn can lead to increased depressive symptoms (5).

Furthermore, noise is often associated with sleep disturbance and deprivation, which is a known cause of depression (3). The regulation of sleep is associated with the serotonergic system, which is most active during the awake state and least active during the sleep state (8). Studies have shown that lack of sleep can cause a functional decrease of the serotonergic system (8). Likewise, hypoactivity of the serotonergic neurotransmitters is associated with depression, suggesting lack of sleep is correlated with increased depressive symptoms.

Stress:

Stress can be recognized as one's both behavioral and physiological response to aversive stimuli (9).

When encountered with stressful situations or aversive stimuli, one deals with it through neurochemical mechanisms (9). These systems work efficiently under most circumstances; however, when the stress gets to a point where it cannot be controlled or is not managed properly, these neurochemical systems are overused (9). Such types of excessive use of these systems can cause changes within these mechanisms that may increase depressive symptoms (9). Though it is still unclear which systems stress affects the most, studies have shown a significant connection between stress and depression (9).

Long-term or chronic stress specifically can greatly influence depressive symptoms (10). Studies have shown that persistent stress is related to the dysregulation of the HPA (3). The dysregulation of the HPA changes neurotransmitter systems causing alterations in positive reward pathways by altering levels of serotonergic and noradrenergic receptors, ultimately causing risk for depression (3). Studies have also suggested that chronic stress is linked to the reduction of neural plasticity which may increase depressive symptoms (3). A theory that

constant stress results in chronic inflammation, which subsequently increases risk for depression, has also been indicated (3).

Essentially, when one is under constant and continuous stress, the brain keeps exercising the part of the brain designed to deal with these threats, the HPA, causing the part of the brain that deals with decision making and complex thinking, the amygdala and prefrontal cortex, to be set back (10). Specifically, decreased activity in these areas of the brain can contribute to increased depressive symptoms (3). The amygdala is a part of the limbic system, a system within the brain that regulates behavior, emotions, and motivation (3). The amygdala specifically signals negative emotions, threat responses, and anxiety (3). Impairment or decreased use of the amygdala and prefrontal cortex have been associated with increased depressive symptoms and risk of depression (10).

It is important to understand that more research surrounding stress and depression should be conducted to solidify these arguments. Along the same lines, everyone has different stressors and their responses to stress are different, which is incredibly important to note as well. Thus, it can be important to incorporate person-centered approaches in examining these relationships.

Family:

It is recognized that the relationship between a parent and child is crucial to emotional and mental health (11). Numerous studies have indicated that parental and family environments are associated with risk for depression, especially during youth and adolescence (12). During these periods of life the brain's neuroplasticity is heightened where its capacity for remodeling and changing neuronal connections is the greatest (11). Thus, parental factors can lead to developmental changes within the brain that influence behavior (11). These factors can be categorized into two groups, hard family environment and soft family environment. Hard family environment can be described as concrete familial status and situations, whereas a soft family environment is geared more towards the relationship between family members.

Hard Family Environment:
Hard family environment factors include relationship between the parents, marital status of the parents, economic status, family structure, and education level of the parents (13). Studies have shown that poor parent relationship, low economic status, and low levels of parental literacy are associated with higher levels of depressive symptoms (13). Among all of these factors, the parent relationship was the strongest indicator of depression, where worse relationships between parents were associated with higher levels of depressive symptoms (13).

Soft Family Environment :

The soft family environment factors can be described as: family regulation or rules, family culture, and parent-child relationship (13). Soft environment describes the social environment and social dynamic within the family (13). Among these factors, two seem to stand out the most: cohesion and conflict (13). In a recent study, university students were analyzed for family environment and depressive symptoms. It was found that high conflict within the family and low family cohesion were associated with increased risk for depression (13). Families can lack communication in these types of environments, and may not express their emotions clearly or openly, thus affecting their children (13).

Family is a source of support for many individuals, however those who receive less support from their families have an increased risk of depression (13). Both hard and soft family environments are important in maintaining healthy familial relationships. For example, in an over-controlling family environment, children may be less equipped to effectively regulate their emotions causing the suppression of their expression and feelings, which is associated with an increase of depressive symptoms (11). Furthermore, adverse caregiving is heavily correlated with changes and alterations of the HPA and amygdala, which is strongly associated with risk of depression (11).

Nonetheless, there are many limitations within this environmental factor, because the precise neural mechanisms changes or effects in these various familial situations is currently unclear. Thus, further research and studies need to be conducted to gain a better understanding of the effects of family environment on one's neurobiology.

Social Relationships:

Social relationships are incredibly important during adolescence, since they become the primary source of social support (15). However, it is quite common to have negative social relationships. Almost one in five school students have reported being bullied or lacking support from parents and friends (16). Stress caused by social relationships in adolescence has shown to have lasting negative impacts on neural circuits related to stress (17). These negative aspects of social relationships can lead to increased depressive symptoms (14).

Individuals' peers seem to have a substantial effect on adolescents, since being accepted by their peers is an important aspect of their identity (14). Adolescents seek a lot of support from their peers and what are known as "peer crowds", which are specific friend groups that embody distinct stereotypes (14). There is evidence to reflect that students who are associated with higher status peer crowds, such as the stereotypical "popular" students or the "jocks", have reported less loneliness and higher self-esteem (14). In stark contrast, adolescents who are associated with lower status peer crowds reported lower self-esteem and increased depressive

symptoms (14). Overall, studies have found that adolescents with aversive experiences with their peers have reported a higher number of depressive symptoms and feelings of loneliness (14). Another study also found that, as teenage girls experienced more physical aggression and social exclusion increased, they showed decreased activation of the prefrontal cortex during a reward task, which is connected to increased depressive symptoms (17)

In addition to peer relationships, another crucial aspect of social relationships are close friendships (14). Close friendships are critical to developing many interpersonal skills within adolescents, and many adolescents report that close friends serve as their main source of social support (14). Close friendships exhibit many positive qualities, which contribute to decreased levels of reported social anxiety (14). However, even with these benefits, close friendships can also provide negative impacts including pressure, exclusion, and conflict (14). These negative influences have been associated with decreased self-esteem and problems with social adjustment, in turn increasing depressive symptoms (14).

A study regarding depression within college students and their roommates was conducted in order to understand the relationship between seeking reassurance, rejection, and depressive symptoms among the college students (18). Roommates with unsupportive interpersonal styles correlated with increased depressive symptoms in their friends, suggesting that support and speaking style is crucial when talking to peers (18). The study also found that those who had a higher rate of seeking reassurance experienced increased depressive symptoms (18). Researchers hypothesize that this may be due to how high-reassurance seekers often experience rejection, which may cause them to fall into a state of hopelessness, and can lead to depression (18).

Studies have also shown that changes in romantic relationships within adolescence play a crucial role in the regulation of their behavior (14). Though little research has been conducted to understand the effects of dating on adolescents, some research has suggested that adolescents who take part in romantic relationships report higher levels of depressive symptoms than those who are not dating (14). With this information it is likely that the negative events that happen within a romantic relationship could possibly cause increased risk for depression (14).

Conclusion and Discussion:

As shown through the research presented in this review, many studies have been conducted to understand the relationship between environmental factors and neural mechanisms. However, more studies in general should be conducted to gain a more complete and developed idea. Specifically, familial and social relationships should be researched further, due to our lack of understanding of which neural mechanisms play a role in these environmental factors.

As mentioned earlier, there is substantial research to suggest that the environment affects neurobiology and depressive symptoms, thus maintaining a healthy environment is crucial to decrease depressive symptoms. Being surrounded by a low polluted and quiet area, as shown, can preserve one's neuroplasticity and health of many important pathways in the brain, this in turn can aid to decrease depressive symptoms. Though it might be fairly difficult, decreasing the amount of stressors in one's life, or learning skills to manage such stressors, can be important to decreasing risk for depression. In addition, being surrounded by supportive family members, peers, and friends, can help preserve one's mental well-being. Thus, having easy access to support can improve one's depressive symptoms.

It is important to note that these are suggestions on how to decrease one's depressive symptoms based on research presented in this review, however, not all of them might work for everyone. The development of personalized interventions for depression can be important in addressing each individual's unique challenges.

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