

Altitude of Residence and Suicide Risk



From Science to Practice

Using Research to Promote Safety and Prevent Suicide

Overview

People who live at higher altitudes are at increased risk for suicide — a phenomenon that has been documented both in the United States and in other countries.^{1,2,3,4,5,6,7,8,9} One study found that the suicide rate in the United States begins to increase significantly at an altitude of 2,000 feet,³ while other studies have found associations starting between 500 meters (~1640 feet)¹⁰ and 1,500 meters above sea level (~4921 feet).¹¹ In the United States, the association between mean altitude of state of residence and suicide appears to be stronger for Veterans over the age of 35 than for non-Veterans and Veterans ages 18–35.¹²

More research is required to understand the relationship between altitude and suicide. Although recent findings implicate chronic hypoxia as a contributing factor, it is possible that demographic, social, and environmental factors, as well as mental illness, play an important role in the relationship between altitude and suicide. If a causal link between altitude and suicide risk emerged, it would have important consequences for prevention and treatment. For instance, one hypothesis is that a hypoxic decrease in serotonin signaling increases suicide risk at higher altitudes. The decrease in serotonin may reduce the effectiveness of selective serotonin reuptake inhibitor (SSRI) antidepressant medications.¹³ This could have important implications for clinicians who treat the multitude of conditions for which SSRIs are prescribed. Finally, and most importantly, to better prevent suicide at higher altitudes, future research should identify novel treatment targets and test the corresponding interventions. It is important to note that most studies have evaluated the relationship between altitude and suicide risk at the level of the county or state, rather than at the individual level.^{4,14} Available studies are generally unable to examine how the degree of acclimatization, time living at higher altitude, or transition periods may factor into the relationship and confirm the biological explanation for any apparent association.

Key Findings

Altitude, Suicide Risk, and Mental Health

- Suicide rates in the United States are positively correlated with altitude at both the state and county levels. This remains true after accounting for other variables, such as gender, poverty, population density, and access to health care. The relationship has been reported both in the general population and more recently among Veterans over the age of 35.^{3,5,12}
- Several studies suggest that there is an altitude threshold above which the risk for death by suicide increases; however, there is no agreement about where the threshold lies.^{3,10,11,15} Further, while one

study found that the risk of death by suicide increased significantly above 2,000 feet and continued to increase with higher altitudes,³ another study found that the risk increased between 500 and 1,000 meters (~1640 feet) but remained constant as altitude increased above 1,000 meters.¹⁰

- Compared to low altitude suicide decedents (<1,000 m), high altitude suicide decedents ($\geq 2,000$ m) are at increased odds of having family or friends report that the decedent had a depressed mood prior to suicide and having a crisis within two weeks before their death. The lack of studies that address likely confounders (e.g., race, ethnicity, rurality, and other individual-level mental health and interpersonal characteristics) represent a major gap in

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the literature.¹⁶ More recently, however, a population-based cohort study of over 9 million U.S. Veterans found that altitude, as well as other measures of chronic hypoxia, were associated with suicide even after adjusting for individual-level covariates such as race and rurality.¹⁷

- While state-level firearm ownership rates are associated with rates of Veteran firearm suicide, mean state elevation is associated with both firearm and non-firearm suicides, among both Veterans and the general population.^{3,12} This suggests that the relationship between altitude and suicide is not attributable to differences in state firearm ownership rates.^{3,18}
- When looking at average U.S. county-level elevation, suicide rates have a stronger positive relationship with altitude in parts of the northern Plains states (Minnesota, North Dakota, South Dakota) and the Southeast (West Virginia, Virginia, North Carolina, and parts of Louisiana), while there is a negative relationship between suicide rates and altitude in Indiana and Illinois.⁵
- In addition to being associated with death by suicide, altitude was also positively associated with drug-poisoning deaths and negatively associated with population density.¹⁵ This may suggest that risk factors associated with rurality are especially consequential in high altitude, rural areas,¹⁵ though another study found that living at high altitude was the environmental risk factor most strongly associated with suicide death in both rural and urban settings.¹¹
- Living at higher altitudes is correlated with past-year serious psychological distress and with experiencing at least one major depressive episode in the past year.¹⁹ Moreover, a study of physician interns found that relocation from a low-elevation region to a higher elevation was associated with increased symptoms of anxiety, depression, and suicidal

ideation than relocation to another low-elevation region was.²⁰

- People diagnosed with bipolar disorder who live at higher altitudes may be at greater risk for suicide than people diagnosed with other mental health disorders, such as anxiety disorders, major depressive disorder, or schizophrenia.²¹

The Role of Oxygen in Serotonin Signaling and Brain Energy Metabolism

- The partial pressure of oxygen in the atmosphere decreases as altitude increases due to the corresponding reduction in barometric pressure. This can result in chronic hypobaric hypoxia, in which the partial pressure of oxygen in the bloodstream significantly decreases.²² This is one possible explanation for the relationship between altitude and suicide.¹³
- Two mechanistic biological pathways have been identified as potential contributors to the relationship between altitude and suicide. A systematic review of studies found that simulated high altitude leads to a reduction in serotonin synthesis,¹³ a change associated with both major depressive disorder and suicidality.²³ The second pathway involves impaired energy metabolism in the brain (i.e., mitochondrial dysfunction), which mirrors biomarkers associated with depression and suicidal behavior.²⁴
- Chronic hypoxic conditions, including living at a high altitude above sea level, may increase suicide risk in Veterans. Researchers studied three markers of hypoxia (smoking, altitude, and chronic obstructive pulmonary disease, or COPD) in relation to completed suicides. Veterans who had at least one of these conditions had significantly increased odds of suicide, and the odds of suicide among Veterans who had all three hypoxic conditions was nearly four times that of those without hypoxic conditions.¹⁷ And notably, suicide risk among Veterans was shown to increase with each additional 1,000 meters above sea level.¹⁷

Ways You Can Help

- Be aware of the potential influence of altitude in contributing to suicide risk and its potential effect on symptoms of depression, anxiety, and psychological distress. This relationship appears to exist both for those already living at a high altitude and for those who relocate from a low to a high altitude.
- Consider the relationship between hypoxia-related markers other than altitude (e.g., smoking or COPD) and the risk for suicide. The finding that suicide risk increases with the number of hypoxic conditions suggests that patients with multiple conditions may be at especially high risk.



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- Research shows that firearm ownership and firearm storage practices have an influence on suicide rates, independently of altitude. Clinicians working with Veterans who live at high altitudes should include all relevant elements in a suicide risk assessment. Given that altitude may constitute an “invisible” added environmental risk factor, the standard elements of risk assessment and safety planning²⁵ remain as important as ever when working with Veterans who reside at higher altitudes. [Find out more here.](#)

There is no single cause of suicide. It is often the result of a complex interaction of risk and protective factors at the individual, interpersonal, community, and societal levels. To prevent Veteran suicide, we must maximize protective factors and minimize risk factors at all of these levels.

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