The Relationship Between Blood Metal Levels and Depression Indicators: A Statistical Analysis

Mental Health Disorders, such as depression, are influenced by a multitude of factors, including biological, environmental, and chemical elements. In recent years, the focus on heavy metals like manganese and mercury as potential contributors to mental health disorders has grown. This study investigates the relationship between blood manganese and mercury levels and depressive symptoms such as a lack of interest, feelings of depression, and suicide ideation. By leveraging statistical analysis and visualization techniques, we aim to determine whether these metals are associated with depression indicators, utilizing data from the National Health and Nutrition Examination Survey (NHANES).

For this analysis, 2017-2018 data from the NHANES were used, specifically focusing on the blood levels of manganese and mercury in relation to depression related questions. The depression indicators considered are “Feeling Depressed,” also referred to as “Depression Severity” in the visualization labels, and “Suicide Ideation”.

The null and alternative hypotheses that are being observed in this analysis are as follows:

H0 - There is no relationship between the level of mercury in the blood and reported depressive symptoms.

H0- There is no relationship between the level of manganese in blood and reported depressive symptoms.

H1- There is a correlation between the level of mercury in the blood and reported depressive symptoms.

H1- There is a correlation between the level of manganese in blood and reported depressive symptoms.

The study primarily examines whether variations in blood manganese and mercury levels are statistically correlated with these two indicators. The dataset was cleaned, with non-relevant values removed, leaving us with 6,464 valid records. Two types of correlation tests were performed: Pearson’s correlation for linear relationships and Spearman’s rank correlation for monotonic relationships. Boxplots and scatterplots with regression lines were used to visually represent the relationship between the variables and to test for differences in blood manganese levels across different levels of depression symptoms, we used analysis of variance (ANOVA).

The results from the ANOVA test comparing the different levels of depression symptoms to blood manganese level indicate that there is no significant difference between the groups being compared. This is due to the resulting F-statistic = 1.2546 and the p-value = 0.2915. If the F-statistics is close to one with a large p-value, there is not enough evidence to suggest that there is a meaningful variation between the groups that are compared. Conversely, the ANOVA results for blood mercury level compared to feelings of depression indicate a greater variability between the groups that is statistically significant. This conclusion was drawn from the F-statistic result of 4.3907 and p-value of 0.0043.

Through merging the data set that recorded tace levels of metals such as manganese and mercury (PBCD\_J), with the data set representing participant feelings and thoughts of suicide (DPQ\_J), a data frame was created to conduct the analysis. Participants self assessed their levels of “Feelings of Depression” and “Suicidal Ideation” based on numerical levels to determine the severity of the symptom reported:

0: Not at all

1: Several days

2: More than half the days

3: Nearly every day

The data was grouped by blood manganese and blood mercury levels to see if the different trace metals in blood had any effect on mental health symptoms. From the blood sample data and the self reported depression data, we were able to draw several conclusions. Both blood manganese and blood mercury show no statistical correlation with “Feelings of Depression” and “Suicide Ideation”. The correlation statistic for blood mercury versus feelings of depression is statistically significant with a p-value of 0.002, but the negative correlation coefficient is minimal, with a Pearson’s Value of -0.061 and a Spearman’s value of -0.0542. The blood manganese versus feelings of depression statistic is also weakly negatively correlated, with a Pearson’s value of -0.0168 and a Spearman’s value of -0.0267, but it is statistically insignificant with a p-value of 0.1291. A majority of the participants indicated that they did not feel any depressive symptoms or suicide ideation.

We were able to determine a correlation, albeit small, between higher levels of manganese and less frequent thoughts of suicide and depressive thoughts, through the use of scatter plots, heatmapping, and other data mapping structure to present the correlation matrices. Visualized through boxplot graphing, individuals with no suicidal ideations and lower levels of depressive feelings tended to have higher levels of manganese present in their blood. The more intense the thoughts of suicide and depression were in participants, the presence of higher levels of manganese seem to diminish as well. Since the correlation between blood mercury and feelings of depression is statistically significant, it is worth noting that the individuals with the highest level of mercury have indicated that they do not have any depressive symptoms. This could be the result of many factors, such as diet and lifestyle. Mercury is found mostly in seafood, and on average, those who can afford a seafood diet may belong to a higher socio-economic bracket.

While there was a slight trend indicating that individuals with elevated blood manganese levels may be less likely to experience suicidal ideation and depressive symptoms, the association was not strong enough to be considered statistically significant. Further research using the NHANES datasets on blood manganese levels from 2017 – 2018, found a stronger correlation between the two variables in women and people of color. This suggests that other factors, such as underlying mental health conditions, socioeconomic status, and additional health conditions, may play a more substantial role in determining an individual's risk of suicidal ideation. The results of this analysis highlights the complexity of the relationship between manganese exposure and mental health outcomes and underscore the need for further research to better understand the potential interactions between these variables.

We conducted a similar analysis to explore the relationship between blood mercury levels and suicide ideation. Again, both Pearson and Spearman correlation tests were applied. Our results showed the Pearson correlation coefficient to be -0.0187, the Spearman Correlation Coefficient to be -0.0196, and a p-value of 0.2656. These results show an even weaker correlation, suggesting that blood mercury levels have virtually no effect on the presence or serverity of suicidal ideation. The correlation coefficients are close to zero, indicating no meaningful relationship between the variables. We used boxplots to visually compare blood manganese levels against different levels of reported feelings of depression. These boxplots did not reveal any significant trends or outliers that would suggest a link between higher or lower manganese levels and depression severity. Additionally, scatter plots with regression lines were used to further illustrate the relationship between blood mercury and manganese levels and the depression indicators. The regression lines were mostly flat, indicating a lack of strong correlation between the variables. The results from the ANOVA test comparing different levels of suicide ideation to blood mercury levels indicate that there is no significant difference between the groups being compared. This conclusion is supported by the resulting F-statistic = 0.8544 and a p-value = 0.4641. Since the F-statistic is close to 1 and the p-value is large, this suggests that there is not enough evidence to indicate a meaningful variation between the groups.

Based on the statistical analysis of the relationship between blood manganese levels and suicidal ideation, the findings indicate a weak and statistically insignificant correlation. Our results showed the Spearman correlation to be -0.0116, while the Pearson correlation was -0.0176, both indicating no meaningful correlation between blood manganese and suicidal ideation. The p-value of 0.6733 further supports this, showing that the observed association is not statistically significant. These results suggest that blood manganese levels do not play a significant role in influencing suicidal ideation. Visual analyses, including boxplots and scatterplots further prove this conclusion.

There are some confounding variables to consider that may impact the results. For instance, for both “Feeling Depressed” and “Suicide Ideation”, the data under the levels assigned to these indicators are heavily right skewed, with the majority of individuals recording a value of 0: Not at all. Due to this skew in the raw data, it is understood that the analysis would most likely indicate a leaning towards no or less depressive or suicidal symptoms. There could be other personal factors influencing how the participants self assess their depressive and suicidal symptoms.

The weak and statistically insignificant correlations suggest that blood levels of manganese and mercury are not strong predictors of depressive symptoms or suicidal ideations. Future studies may benefit from larger sample sizes or focus on populations with more severe depressive symptoms to better understand the relationship between heavy metals and mental health. Additionally, exploring other factors such as dietary habits, environmental exposure, and genetic predisposition could provide more insight into the role of metals in mental health disorders. Overall, this analysis highlights the complexity of mental health disorders and the need to further research the relationship between metal levels and mental health outcomes.

Data Documentation for Mercury and Manganese levels:

<https://wwwn.cdc.gov/Nchs/Nhanes/2017-2018/PBCD_J.htm#SEQN>

Data Documentation for reported Depression Symptoms:

<https://wwwn.cdc.gov/Nchs/Nhanes/2017-2018/DPQ_J.htm#DPQ100>