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INTERNATIONAL UNIVERSITY**



**SCHOOL OF COMPUTER SCIENCE AND ENGINEERING**

**STATISTICAL METHODS**

**PROJECT REPORT**

**Semester 2, 2023 - 2024**

**Course by PhD Pham Hoang Uyen**

**Topic: Mental Health In The Pregnancy During The COVID-19**

GitHub repository: [Statistical Methods Project](#)

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## Table Of Contents

<b>I. INTRODUCTION</b>	<b>3</b>
1. Abstract	3
2. Purpose	3
3. Project Timeline	3
<b>II. DATA PROCESSING</b>	<b>4</b>
1. Dataset Descriptions	4
2. Dealing with missing values	5
a) Identifying Missing Values	5
b) Handling Missing Values	6
3. Dealing with outliers	6
<b>III. DATA PROCEDURE</b>	<b>7</b>
1. Descriptive Statistics	7
a) Edinburgh Postnatal Depression Scale	7
b) PROMIS Anxiety Scale	9
c) Maternal Education	12
2. Normality Testing	14
a) Methodology	14
b) Expected Results	14
c) Transforming PROMIS Anxiety and EPDS Scores Using Yeo-Johnson Transformation	15
3. Regression Analysis	16
a) Least-squares Regression Line	16
b) Four Key Assumptions Of Linear Regression	16
4. Confidence Interval	18
a) The confidence interval for population mean EPDS and PROMIS Anxiety scores	18
b) The confidence interval for population variance and standard deviation EPDS and PROMIS Anxiety scores	19
c) The confidence interval for population proportion EPDS and PROMIS Anxiety scores	20
5. Hypothesis Testing	20
a) The Difference in Mean EPDS Scores Across Different Age Groups of Mothers	20
b) The Difference in Mean Anxiety Scores Across Different Age Groups of Mothers	21
<b>IV. CONCLUSIONS</b>	<b>22</b>
1. Achievements	22
2. Restrictions	22
<b>REFERENCES</b>	<b>23</b>

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# I. INTRODUCTION

## 1. Abstract

The COVID-19 pandemic posed significant mental health challenges for pregnant individuals. This dataset aimed to understand the impact of COVID-19-related stresses on pregnant individuals during the COVID-19 Pandemic (PdP) project in Canada, primarily focusing on the relationship between postnatal depression, anxiety, and maternal demographic factors. The findings can help identify vulnerable populations and inform targeted mental health interventions to support the well-being of pregnant people in future public health emergencies.

## 2. Purpose

- Examine the relationship between prenatal depression (as measured by the Edinburgh Postnatal Depression Scale) and anxiety (as measured by the PROMIS Anxiety Scale) among the pregnant participants.
- Investigate how maternal demographic factors, particularly age and education level, may have influenced the mental health outcomes of pregnant individuals during the COVID-19 pandemic.
- Identify vulnerable populations of pregnant individuals who may have been disproportionately affected by pandemic-related stresses in terms of their prenatal depression and anxiety levels.
- Provide insights that can inform the development of targeted mental health interventions and support services to better assist pregnant people during future public health emergencies.

## 3. Project Timeline

STAGE	TASK	MEMBER	WEEK
PLANNING	Build the planning	Trang	1
	Topic research	Trang & Minh Sang	
	Establish the analysis's objectives and purpose	Trang & Minh Sang	
	Research for science-based information on the topic	All	
DATA PROCESSING	Collect dataset	Trang	2-3
	Data cleaning	Quang Sang	
DATA PROCEDURES	Descriptive Statistics	Minh Sang	
	Normality Testing	Khang	

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	Regression Analysis	Trang	4-7
	Confidence Interval Construction	Quang Sang	
	Hypothesis Testing	Long & Minh Sang	
<b>PRESENTATION</b>	Report Writing	All	8-9
	Presentation Slide	All	

## II. DATA PROCESSING

### 1. Dataset Descriptions

A dataset consisting of 10,772 pregnant individuals from across Canada likely provides a good representation of the target population, allowing for robust statistical analyses and generalization of findings.

Attribute	Data Type	Description
OSF_ID	Integer	Unique identifier for each participant
Maternal Age	Float	Maternal age (years) at intake
Household Income	Object	Total household income before taxes and deductions in 2019
Maternal Education	Object	Maternal education level (1 - Less than high school, 2 - Diploma, 3 - High school diploma, 4 - College/trade school, 5 - Undergraduate degree, 6 - Master's degree, 7 - Doctoral degree)
Edinburgh Postnatal Depression Scale	Float	Score from the Edinburgh Postnatal Depression Scale
PROMIS Anxiety	Float	Score from the PROMIS Anxiety scale, ranging from 7 to 35, with higher scores indicating greater severity of anxiety
Gestational Age At Birth	Float	Gestational age at birth (in weeks)
Delivery Date	Object	Delivery date (converted to month and year of birth)
Birth_Length	Float	Birth length (in cm)
Birth_Weight	Float	Birth weight (in grams)

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Delivery Mode	Object	Mode of delivery (Vaginally or Caesarean-section)
NICU Stay	Object	Whether the infant was admitted to the neonatal intensive care unit (NICU) or not
Language	Object	Survey language
Threaten Life	Float	Perceived threat to the participant's own life during the COVID-19 pandemic, measured on a scale of 0 to 100
Threaten Baby Danger	Float	Perceived threat to the unborn baby's life during the COVID-19 pandemic, measured on a scale of 0 to 100
Threaten Baby Harm	Float	Perceived worry about potential harm to the unborn baby due to exposure to the COVID-19 virus, measured on a scale of 0 to 100

## 2. Dealing with missing values

### a) Identifying Missing Values

- First, variables related to birth outcomes and delivery details, such as Birth Length, NICU Stay, Delivery Mode, Birth Weight, Delivery Date, and GAbirth, exhibit substantial missing data, ranging from approximately 37% to 49% of observations missing. These high rates of missing information for key variables related to birth and delivery could potentially impact analyses involving these factors.
- Secondly, variables measuring mental health aspects, including PROMIS Anxiety and EPDS, have relatively lower missing rates of around 11%. While still substantial, the degree of missingness is not as severe as for the birth outcome variables.
- Third, variables capturing perceptions related to COVID-19, such as Threaten Baby Danger, Threaten Life, and Threaten Baby Harm, have similar and relatively low missing rates of around 8%.
- Finally, demographic information variables, including Household\_Income, Maternal\_Education, and Maternal\_Age, exhibit the lowest levels of missingness, ranging from 1% to 2% of observations missing.

Overall, the results highlight that certain groups of variables, particularly those related to birth outcomes and delivery details, have substantially higher rates of missing data compared to others. This pattern of missingness will

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need to be carefully addressed through appropriate handling techniques to mitigate potential biases and ensure robust analysis.

## **b) Handling Missing Values**

### **Key Variables:**

- For categorical variables like Maternal Education and Household Income, which have relatively low missing rates (1-2%), mode imputation can be used. Mode imputation replaces missing values with the most frequent category, and with low missingness, it is less likely to introduce substantial bias.
- For continuous variables like EPDS, PROMIS Anxiety, and Maternal Age, the choice of imputation method should consider the distribution of the variable and the potential missing data mechanism. For EPDS and PROMIS Anxiety, interpolation methods can be considered since imputing missing values with a constant value can introduce bias and distort the data distribution. For Maternal Age, the distribution follows a bell-shaped distribution, mean imputation is a reasonable approach.

### **Other Variables:**

- For variables with high missingness (>30%), such as Birth Length, NICU Stay, Delivery Mode, Birth Weight, Delivery Date, and GA birth, excluding these variables from complex analyses is a pragmatic approach.
- For variables with missing rates around 10%, imputing missing values with a constant value (e.g., 0 for numerical variables or "Na" for categorical variables) is generally recommended.

## **3. Dealing with outliers**

**EPDS (Depression Scale) Outlier Findings:** The dataset contains 20 outliers in the EPDS variable, which accounts for 0.19% of the observations.

**PROMIS Anxiety Scale Outlier Findings:** There are no outliers detected in the PROMIS Anxiety Scale variable.

**Decision on Outlier Handling for EPDS:** The decision to retain the outliers in the EPDS variable for analysis is well-justified based on the following rationale:

- **Clinical Significance:** High scores on the EPDS, even if they are statistical outliers, may represent clinically significant cases of severe depression. Removing these outliers could potentially underestimate the prevalence of individuals at high risk for depression, which is an important aspect to capture, especially in the context of the pandemic.

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- **Real-World Representation:** These outliers might reflect the genuine variability in depression levels within the population, particularly considering the unique stressors and challenges posed by the COVID-19 pandemic. Retaining these outliers can help ensure that the analysis captures the full range of experiences and provides a more accurate representation of the real-world scenario.

### III. DATA PROCEDURE

#### 1. Descriptive Statistics

This section provides a numerical summary of three variables - EPDS (Edinburgh Postnatal Depression Scale), PROMIS Anxiety, and maternal education - to understand the mental health and educational background of postpartum women. EPDS and PROMIS Anxiety are quantitative scores assessing postnatal depression symptoms and anxiety levels, respectively. Maternal education is a qualitative variable representing the participants' educational attainment.

##### a) Edinburgh Postnatal Depression Scale

The EPDS is a widely used 10-item self-report questionnaire that screens for postnatal depression symptoms like mood disturbances, guilt, sleep problems, anxiety, and suicidal thoughts. Scores range from 0 to 30, with higher scores indicating a higher likelihood of postnatal depression. A score of 13 or above is often used as a cut-off, indicating an approximately 80% chance of depression. Scores  $\geq 13$  also suggest a 5 to 17 times higher risk of developing depression compared to the general postpartum population.

##### *Measures of Central Tendency*

The following code snippet was used to calculate the mean, mode, and median of the EPDS scores:

```
mean_EPDS = df['EPDS'].mean()
mode_EPDS = df['EPDS'].mode()[0]
median_EPDS = df['EPDS'].median()
```

Based on the provided statistics calculations, the mean, mode, and median values are 10.16, 9.0, and 10.0, respectively. It can be inferred that the EPDS scores indicate insignificant depressive symptoms among the average pregnant women in the dataset.

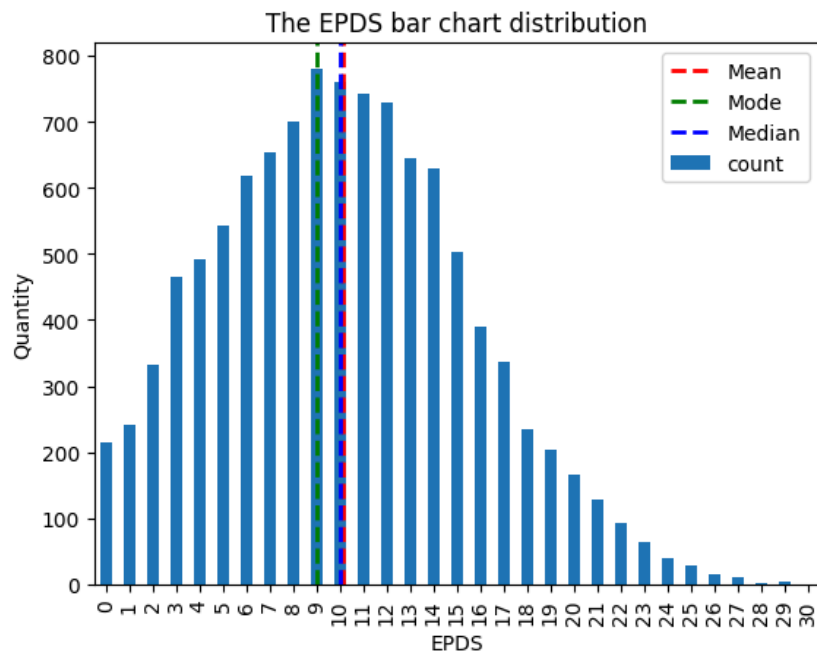
**Before filling missing values:** The mean, mode, and median values are 10.19, 9.0, and 10.0, respectively.

**Conclusion:** Obviously, there is no gap of variation between these measured values.



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## Frequency Distribution



In this analysis, we categorized individuals into two distinct groups based on their scores. The two EPDS groups were defined as follows:

- Group "0-13": These scores indicate a lower likelihood of depressive symptoms or a lower risk of developing a depressive disorder, with the frequency of 7918.
- Group "13-above": These scores indicate a higher likelihood of experiencing depressive symptoms or a higher risk of developing a depressive disorder, with the frequency of 2854.

The EPDS score frequency histogram shows a slightly right-skewed distribution. The peak is around 10, suggesting this is the most common score, with most individuals having lower EPDS scores indicating a lower likelihood of depressive symptoms. The central tendency measures (median, mode, mean) are in close proximity, implying that while the distribution is right-skewed, the skewness is not extreme, and higher scores in the right tail do not substantially pull the mean away from the mode and median.

However, the right skew indicates a concerning number of participants with elevated EPDS scores above 13, which are associated with an increased risk of postnatal depression. This highlights the need for targeted screening and support for those individuals at higher risk.

## Measures of Dispersion

- Standard deviation:

The standard deviation of EPDS scores is roughly 5.369, which is relatively large, indicating a high degree of variability and dispersion.

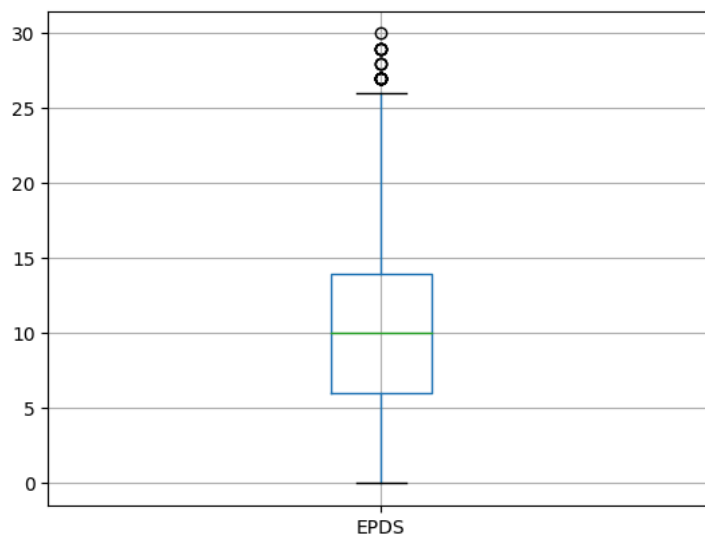
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The sizable standard deviation suggests there are many EPDS scores that deviate significantly from the mean and median, especially in the extended right tail of higher scores.

**Before filling missing values and removing outliers:** The standard deviation of EPDS scores before filling missing values is roughly 5.505, slightly more spread.

- Five-number summary & Boxplot:

Min	Q1	Median	Q2	Max
0	6	10	14	30



The minimum of 0 and low 1st quartile (Q1) of 6 suggest a concentration of lower EPDS scores, with 25% having scores  $\leq 6$ , indicating minimal postpartum depression symptoms.

The large gap between the 3rd quartile (Q3) of 14 and maximum of 30 highlights the stretched right tail, demonstrating a significant number had elevated EPDS scores and more severe postpartum depression symptoms.

The wide interquartile range ( $IQR = 8$ ) reflects high variability and dispersion in EPDS scores across the population.

## b) PROMIS Anxiety Scale

Anxiety during pregnancy involves feelings of fear, worry, restlessness, and apprehension, which can arise due to factors like hormonal changes, physical discomfort, anticipation of childbirth, or concerns about the baby's health.

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Participants rated the intensity/frequency of 7 statements (e.g., "I felt fearful," "I felt anxious," "I felt worried") on a 0-5 scale, using the PROMIS Anxiety module scores. The score interpretation is:

- 7-15: None to slight anxiety
- 16-19: Mild anxiety
- 20-27: Moderate anxiety
- 28-35: Severe anxiety

This analysis allows assessing the levels of pregnancy-related anxiety experienced by participants and identifying those who may need additional support.

### *Measures of Central Tendency*

The following code snippet was used to calculate the mean, mode, and median of the Anxiety scores:

```
mean_PROMIS_Anxiety = df['PROMIS_Anxiety'].mean()  
mode_PROMIS_Anxiety = df['PROMIS_Anxiety'].mode()[0]  
median_PROMIS_Anxiety = df['PROMIS_Anxiety'].median()
```

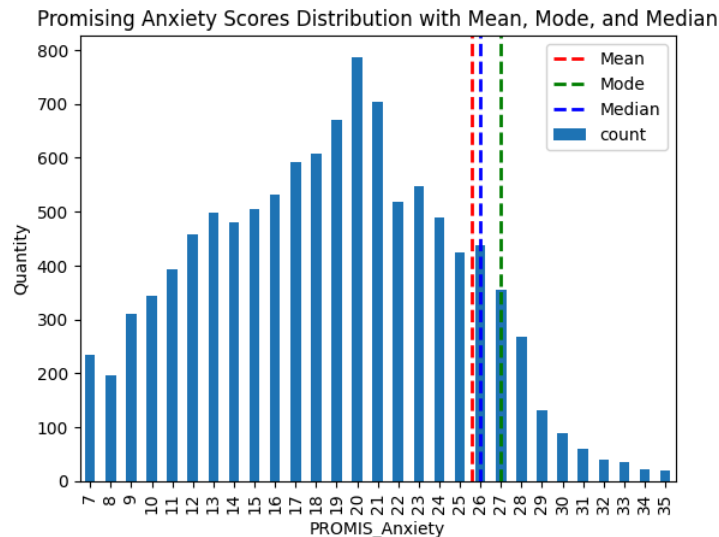
The mean (18.62), mode (20.0), and median (19.0) anxiety scores indicate a mild level of anxiety among the average pregnant women in the dataset. Experiencing mild anxiety is understandable and expected during pregnancy due to factors like stress, hormonal changes, and concerns about the baby's well-being. However, the scores generally falling outside the "Moderate" or "Severe" ranges suggest that anxiety levels are manageable for the majority of the pregnant women in the dataset.

**Before filling missing values and removing outliers:** The mean, mode, and median values are 18.68 , 20.0, and 19.0, respectively.

**Conclusion:** Obviously, there is no gap of variation between these measured values.

### *Frequency Distribution*

- 3,419 individuals experienced minimal/negligible anxiety symptoms.
- 2,402 individuals had mild anxiety with limited impact on daily functioning.
- The largest group of 4,266 individuals experienced moderate anxiety symptoms, potentially impacting daily life through increased worry or restlessness.
- 685 individuals, the smallest group, had severe anxiety significantly interfering with daily functioning and well-being.



This frequency distribution highlights the diversity of anxiety experiences among pregnant women, with the majority falling into the moderate anxiety category, while a significant number also experience minimal/negligible or mild anxiety. The smaller group with severe anxiety symptoms represents those who may require more targeted interventions and support.

### *Measures of Dispersion*

#### - Standard deviation:

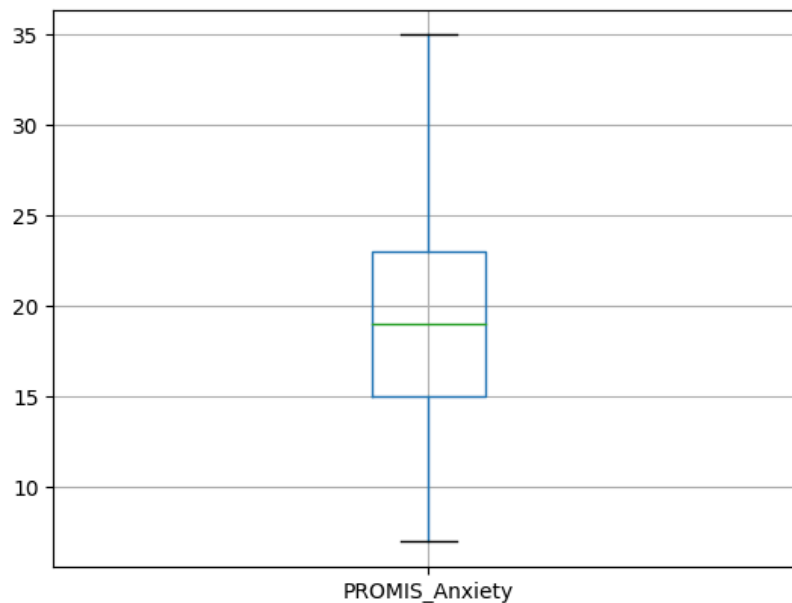
The standard deviation of 5.928 indicates a moderate degree of dispersion or spread in the Anxiety scores among the pregnant women in the dataset.

The high standard deviation suggests that the pregnant women in the dataset represent a heterogeneous population in terms of their anxiety experiences.

**Before filling missing values and removing outliers:** The standard deviation of Anxiety scores before filling missing values is roughly 6.084, slightly more spread.

#### - Five-number summary and boxplot:

Min	Q1	Median	Q3	Max
7	14	19	23	35



The minimum anxiety score of 7 and first quartile of 14 indicate some pregnant women experience very low, almost negligible anxiety levels, suggesting a subset may be highly resilient or have effective coping mechanisms.

The maximum score of 35 indicates some pregnant women experience very high, likely "Severe" anxiety levels, though the majority experience "Mild" to "Moderate" anxiety.

The interquartile range (IQR) of 9 indicates a moderate degree of spread in the middle 50% of anxiety scores, where most pregnant women fall.

This analysis highlights the range of anxiety experiences, with a subset experiencing very low or very high levels, while most fall within a moderate range of anxiety during pregnancy.

### c) Maternal Education

Maternal education is the highest level of education completed by a child's mother or female guardian. It is an important socioeconomic factor studied in health and social sciences, as higher maternal education generally correlates with higher income, occupational status, access to resources, health knowledge, and decision-making abilities that can positively influence the mother's and child's well-being.

The categories for maternal education in our dataset include:

- Less than a high school diploma
- High school diploma
- College/trade school
- Undergraduate degree
- Doctoral Degree

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### ***Frequency Distribution***

Based on the provided frequency calculations, the results are as follows:

- Less than a high school diploma: 142
- High school diploma: 901
- College/trade school: 2760
- Undergraduate degree: 6183
- Doctoral Degree: 786

Overall, the frequency analysis of maternal education levels emphasizes the diversity of educational backgrounds among the mothers in our dataset. It underscores the importance of considering maternal education when examining various outcomes related to maternal and child well-being, such as socioeconomic factors, health outcomes, and educational attainment of the children.

### ***The analysis of mean EPDS for Maternal Education Levels***

The analysis of mean EPDS scores for each group of maternal education provides insights into the relationship between maternal education levels and maternal mental health as measured by the EPDS scale.

- Less than a high school diploma: 13.21
- High school diploma: 11.51
- College/trade school: 10.98
- Undergraduate degree: 9.68
- Doctoral Degree: 8.9

These findings suggest that there may be a correlation between maternal education and maternal mental health, as measured by the EPDS scores. Higher levels of maternal education appear to be associated with lower average levels of depressive symptoms.

### ***The analysis of mean PROMIS Anxiety for Maternal Education Levels***

Similar to EPDS, the analysis of mean PROMIS Anxiety scores for each group of maternal education provides insights into the relationship between maternal education levels and maternal mental health as measured by the EPDS scale.

- Less than a high school diploma: 20.97
- High school diploma: 19.85
- College/trade school: 19.09
- Undergraduate degree: 18.28
- Doctoral Degree: 17.79

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These findings suggest that there may be a correlation between maternal education and maternal mental health, as measured by the PROMIS Anxiety scores. Higher levels of maternal education appear to be associated with lower average levels of anxiety symptoms; however, it appears that even among the highest educated group (mothers with a doctoral degree), the average level of anxiety symptoms remains in the moderate range. This suggests that maternal education alone may not be the sole factor influencing maternal mental health.

## 2. Normality Testing

The goal of this part is to assess the normality of the Promis Anxiety and EPDS (Edinburgh Postnatal Depression Scale) score distributions through visual inspection and statistical testing, in order to guide the selection of appropriate data analysis methods.

### a) Methodology

#### Visualizing Data Distribution

- **Frequency Histogram:** For normal distributions, the histogram should have a bell-shaped curve, with data concentrated in the center and tailing off symmetrically on both sides. Deviations from this shape indicate non-normality like skewness or kurtosis.
- **Scatter Plot:** While histograms give an overview, scatter plots reveal relationships between two variables. For normal data, points should be randomly scattered around a diagonal line. Non-linear patterns signal violation of normality assumptions.

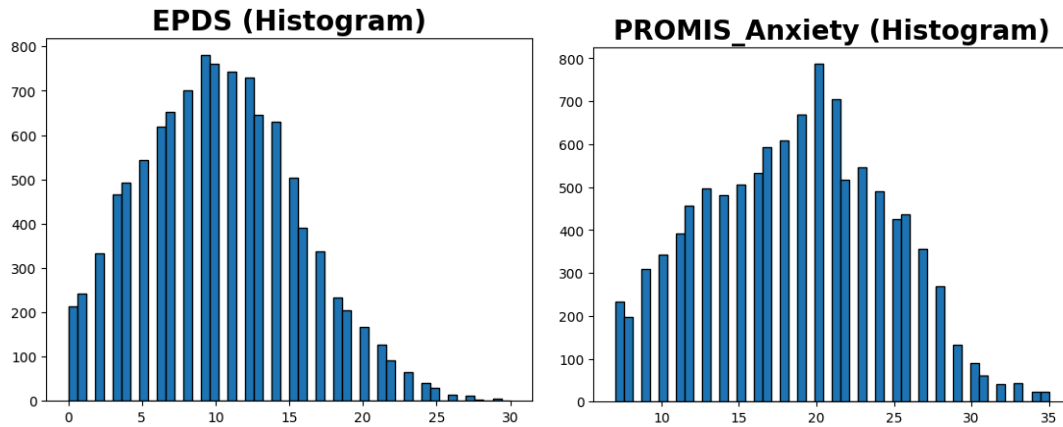
#### Normality Test - D'Agostino K<sup>2</sup> Test

The D'Agostino K<sup>2</sup> test is suitable for large datasets (over 5000 samples). It uses skewness and kurtosis statistics to assess normality. Skewness measures asymmetry, while kurtosis indicates tail behavior compared to a normal distribution. A low p-value suggests significant deviation from normality.

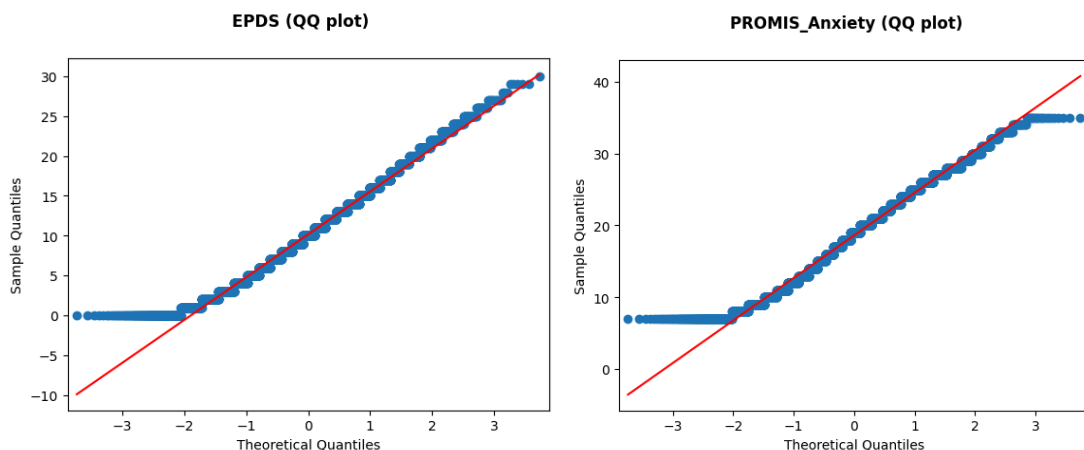
If the D'Agostino K<sup>2</sup> test yields low p-values for either the Promis Anxiety or EPDS score distributions, it indicates a significant departure from normality. In such cases, assumptions of parametric tests may not hold, necessitating data transformations (e.g. Yeo-Johnson) or non-parametric approaches.

### b) Expected Results

- **Histogram:** The histogram of PROMIS Anxiety and EPDS scores do not show a clear bell-shaped distribution, indicating a deviation from normality.



- **Scatter plot:** The data points of PROMIS Anxiety and EPDS scores follow the middle line well, indicating a linear relationship. However, the two tails/ends of the distribution (the leftmost and rightmost portions) do not follow the line as closely. This suggests that while the bulk of the data may follow a linear trend, the extreme values or tails of the distribution are not aligning as well with the overall linear pattern or heteroscedasticity (non-constant variance) in the data.



- **Statistical Test:** The D'Agostino  $K^2$  test of PROMIS Anxiety and EPDS scores should yield a low p-value  $7.86e-88$  and  $6.78e-45$ , both supporting non-normality.

### c) Transforming PROMIS Anxiety and EPDS Scores Using Yeo-Johnson Transformation

The Yeo-Johnson transformation is a versatile and adaptable method that can handle positive real-valued data with or without skewness. By applying this transformation, the goal is to achieve improved normality in both the Promis Anxiety and EPDS score distributions. This will enable the use of more reliable statistical analyses and enhance the generalizability of the research findings.

**Expected Result:** Both the Promis Anxiety and EPDS scores do not seem to be normally distributed, which still yield a low p-value  $9.28e-30$  and  $0.0005$  respectively.



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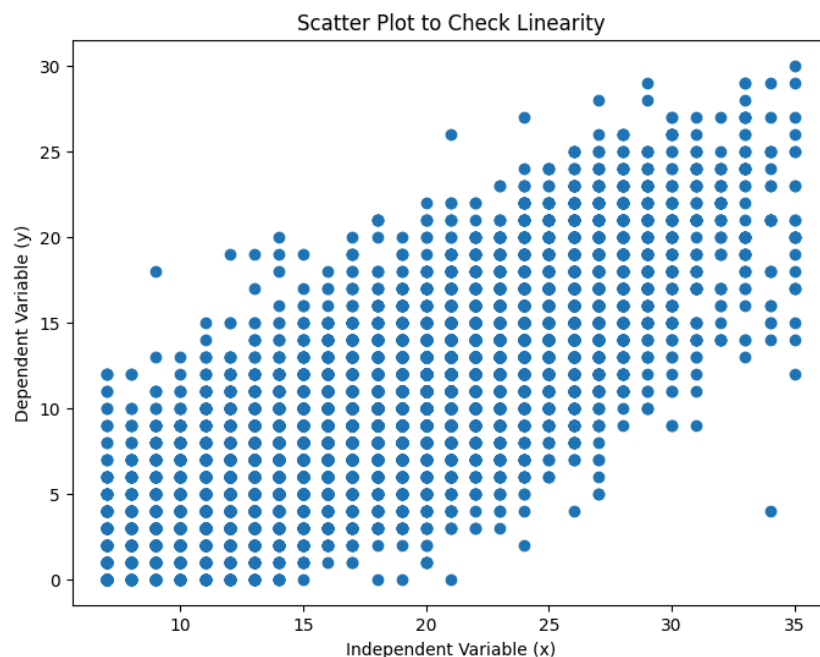
### 3. Regression Analysis

#### a) Least-squares Regression Line

This analysis assumes EPDS scores as the dependent variable and PROMIS Anxiety Scores as the independent variable. The estimated regression equation is: Predicted EPDS =  $-3.4437 + 0.7304 * \text{PROMIS\_Anxiety}$ . The intercept ( $-3.4437$ ) estimates the EPDS score when anxiety is zero. The slope ( $0.7304$ ) represents the increase in EPDS for every one-unit increase in anxiety scores. The R-squared ( $0.650$ ) is the fraction of variance in EPDS explained by anxiety. The adjusted R-squared ( $0.650$ ) is an unbiased estimate accounting for sample size and number of variables.

#### b) Four Key Assumptions Of Linear Regression

- **Linearity:** The relationship between the independent variable(s) and the dependent variable should be linear. We check this by visualizing a scatter plot of the data.

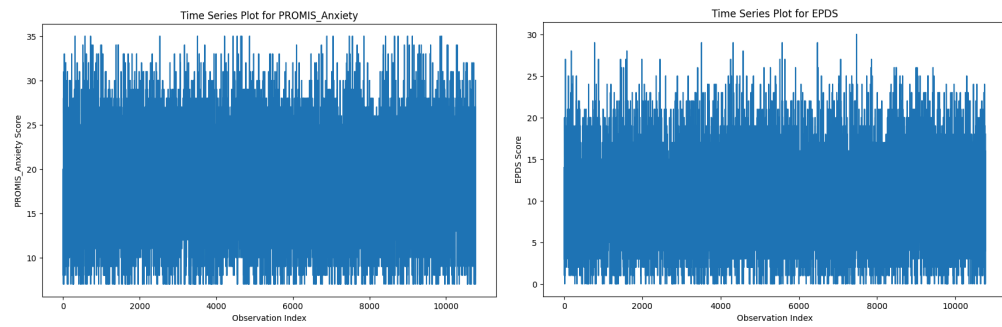


**Conclusion:** The scatter plot visualization highlights a linear positive trend between EPDS and PROMIS Anxiety Scores, without any obvious nonlinear trends or curvilinear relationships. So, the linearity assumption is met

- **Independence:** The observations in our dataset should be independent of each other. This means that the value of one observation does not depend on the value of another observation.

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### **Method 1: Visualizing a time series plot**



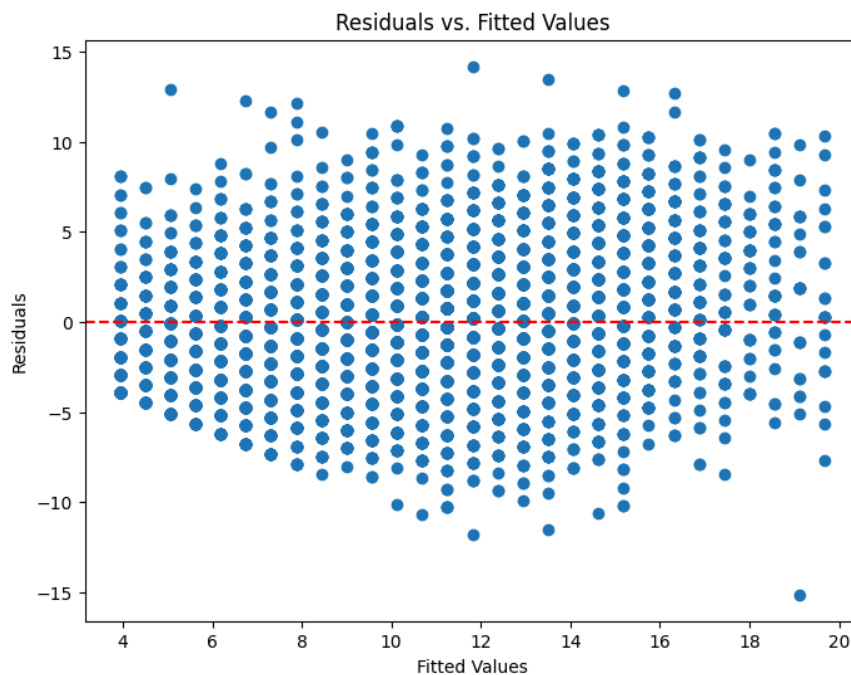
**Conclusion:** By visualizing a time series plot, it does not show a clear upward or downward trend, or if the observations are clustered in groups in EPDS and Anxiety; therefore, it could indicate that the observations are independent.

### **Method 2: Using Durbin-Watson test**

The Durbin-Watson statistic ranges from 0 to 4, with a value of 2 indicating no autocorrelation. Values less than 2 suggest positive autocorrelation, and values greater than 2 suggest negative autocorrelation.

**Conclusion:** Since the Durbin-Watson statistic is close to 2 (1.77), it suggests that there is no significant autocorrelation in our data. This means that the observations are likely independent.

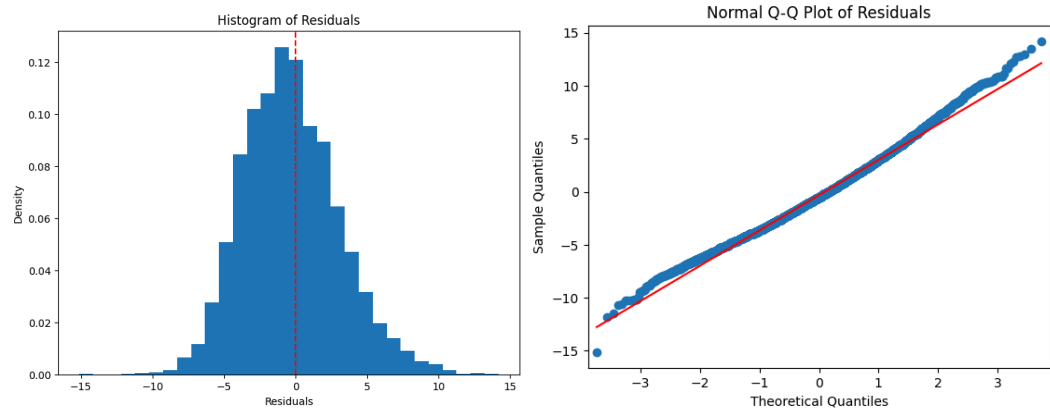
- **Homoscedasticity:** The variance of the residuals should be constant across all levels of the independent variable(s). We check this by visualizing a scatter plot of the residuals versus fitted values.



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**Conclusion:** The residuals are evenly distributed around the horizontal line at  $y=0$ , it suggests that the assumption of homoscedasticity is met.75555555

- **Normality:** The residuals should be normally distributed. You can check this by visualizing a histogram or Q-Q plot of the residuals.



**Conclusion:** The histogram is approximately bell-shaped and centered around zero and the points fall approximately along a straight line in a Q-Q plot; therefore, the residuals are normally distributed.

#### 4. Confidence Interval

To construct robust confidence intervals for the population parameters of the EPDS scores and PROMIS Anxiety scores, we employed a bootstrapping approach. Bootstrapping is a nonparametric resampling technique that allows for the estimation of sampling distributions and confidence intervals without making assumptions about the underlying population distribution.

##### a) The confidence interval for population mean EPDS and PROMIS Anxiety scores

- **95% Confidence Interval for population mean EPDS Scores:**

The 95% confidence interval for the population mean EPDS score is (10.08, 10.27). This means that we can be 95% confident that the true population mean EPDS score falls within this interval. It suggests that, on average, the EPDS score for the population is likely to be between 10.08 and 10.27, which indicates the population has a very lower likelihood of experiencing depressive symptoms or developing a depressive disorder on average.

- **95% Confidence Interval for population mean PROMIS Anxiety Scores:**

The 95% confidence interval for the population mean PROMIS Anxiety score is (18.61, 18.82). This indicates that we can be 95% confident that the true population mean PROMIS Anxiety scale lies within this interval. It suggests that, on average, the PROMIS Anxiety score for the population is likely to be between 18.61 and 18.82, which experience the presence of certain

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anxiety-related symptoms, although they may be less pronounced compared to moderate or severe anxiety.

**b) The confidence interval for population variance and standard deviation EPDS and PROMIS Anxiety scores**

**- *95% Confidence Interval for population variance and standard deviation EPDS scores:***

We are 95% confident that the true variance of the EPDS scores falls within the range of (26.31, 27.69). This means that the spread or variability of the EPDS scores around the mean is expected to lie within this interval.

We are 95% confident that the true standard deviation of the EPDS scores falls within the range of (5.13, 5.26). The standard deviation is the square root of the variance and provides a measure of the average distance between each EPDS score and the mean. Within this interval, we expect the true standard deviation of the EPDS scores to lie.

Overall, the confidence intervals for both the variance and standard deviation of the EPDS scores are relatively narrow, with a 95% confidence level. This indicates that we have a more precise estimate of the true variance and standard deviation of the EPDS scores.

**- *95% Confidence Interval for population variance and standard deviation PROMIS Anxiety scores:***

We are 95% confident that the true variance of the PROMIS Anxiety scores falls within the range of (32.02, 33.63). This means that the spread or variability of the PROMIS Anxiety scores around the mean is expected to lie within this interval.

We are 95% confident that the true standard deviation of the PROMIS Anxiety scores falls within the range of (5.66, 5.80). The standard deviation is the square root of the variance and provides a measure of the average distance between each PROMIS Anxiety score and the mean. Within this interval, we expect the true standard deviation of the PROMIS Anxiety scores to lie.

Overall, similar to EPDS scores, the confidence intervals for both the variance and standard deviation of the PROMIS Anxiety scores are relatively narrow, with a 95% confidence level. This indicates that we have a more precise estimate of the true variance and standard deviation of the PROMIS Anxiety scores.

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### c) The confidence interval for population proportion EPDS and PROMIS Anxiety scores

- **95% Confidence Interval for population proportion EPDS scores:**

The 95% confidence interval for the proportion of participants with EPDS  $\leq 13$  is (0.7466, 0.7628). This means we can be 95% confident that the true population proportion of participants with EPDS  $\leq 13$  is between 74.66% and 76.28%.

- **95% Confidence Interval for population proportion PROMIS Anxiety scores:**

The 95% confidence interval for the proportion of participants with Anxiety  $\leq 15$  is (0.2778, 0.2948). This means we can be 95% confident that the true population proportion of participants with Anxiety  $\leq 15$  is between 27.78% and 29.48%.

## 5. Hypothesis Testing

This part presents the findings of four hypothesis tests conducted on a dataset related to mental health in pregnant women and mothers during the postnatal period. The specific goal is to explore the difference in Anxiety and EPDS symptoms between young and older mothers. Using the Mann-Whitney U test appropriate non-parametric tests, we were able to check the difference in mean EPDS and Anxiety scores between the two age groups of mothers without making assumptions about the normality of the underlying data distributions.

### a) The Difference in Mean EPDS Scores Across Different Age Groups of Mothers

#### Methodology

We performed a Mann-Whitney U test on the EPDS scores from our dataset. The groups were divided based on maternal age, with one group consisting of mothers under 30 years old and the other group consisting of mothers 30 years old and above. The significance level ( $\alpha$ ) was set at 0.05. We then calculated the p-value to compare with the significance level ( $\alpha$ )

- Null Hypothesis ( $H_0$ ): There is no significant difference in the mean EPDS scores between the two groups of mothers categorized by age ( $\mu_1 = \mu_2$ ). This implies that, on average, the EPDS scores of the young mothers (under 30 years old) and older mothers (30 years old and above) in our sample are the same.
- Alternative Hypothesis ( $H_a$ ): There is a significant difference in the mean EPDS scores between the two groups of mothers categorized by age (

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$\mu_1 \neq \mu_2$ ). This would suggest that the average EPDS score among the young mothers and older mothers in our sample are different.

### **Conclusion**

- The analysis of the Edinburgh Postnatal Depression Scale (EPDS) scores revealed a p-value of 3.17e-16 at a significance level of 0.05. This leads us to conclude the alternative hypothesis ( $H_a$ ). Therefore, our analysis suggests that there is a significant difference in the mean EPDS scores between the two groups of mothers categorized by age.
- This finding highlights the importance of considering age as a significant factor in assessing the mental health of mothers during the postnatal period. The average EPDS score among young mothers was found to be significantly different from that of older mothers. This suggests that maternal age plays a crucial role in the manifestation and severity of postnatal depression symptoms.

## **b) The Difference in Mean Anxiety Scores Across Different Age Groups of Mothers**

### **Methodology**

We conducted a Mann-Whitney U test on the Anxiety scores from our dataset. The sample was bifurcated based on maternal age, with one group comprising mothers below 30 years and the other group including mothers aged 30 years and above. The significance level ( $\alpha$ ) was set at 0.05. We then calculated the p-value to compare with the significance level ( $\alpha$ ).

- Null Hypothesis ( $H_0$ ): There is no significant variance in the mean Anxiety scores across the two age groups of mothers ( $\mu_1 = \mu_2$ ). This suggests that the average Anxiety scores of young mothers (below 30 years) and older mothers (30 years and above) in our sample are identical.
- Alternative Hypothesis ( $H_a$ ): There is a significant variance in the mean Anxiety scores across the two age groups of mothers ( $\mu_1 \neq \mu_2$ ). This indicates that the average Anxiety scores among young mothers and older mothers in our sample differ.

### **Conclusion**

- We obtained a p-value of 6.149e-15 at a significance level of 0.05. This leads us to affirm the alternative hypothesis ( $H_a$ ). Consequently, our analysis indicates that there is a significant variance in the mean Anxiety scores across the two age groups of mothers.

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- This finding underscores the importance of considering maternal age as a key factor when evaluating anxiety levels during pregnancy. This suggests that there may be unique stressors or challenges associated with different age groups that contribute to varying levels of anxiety.

## **IV. CONCLUSIONS**

### **1. Achievements**

- Quantified the relationship between prenatal depression and anxiety levels among pregnant participants.
- Identified how maternal age and education influenced mental health outcomes during the COVID-19 pandemic.
- Highlighted vulnerable subgroups of pregnant individuals disproportionately affected by pandemic-related stresses in terms of prenatal depression and anxiety.
- Provided evidence-based insights to inform targeted mental health interventions and support for pregnant people during future public health emergencies.
- Contributed to understanding the mental health challenges faced by pregnant individuals during the COVID-19 pandemic.

### **2. Restrictions**

The restriction encountered during the analysis was the inability to transform the dataset to achieve normal distributions for the Edinburgh Postnatal Depression Scale (EPDS) and the PROMIS Anxiety Scale scores. Despite attempting techniques such as the Yeo-Johnson transformation, the data did not meet the assumptions of normality required for parametric statistical tests. As a result, the analysis had to rely on non-parametric tests, which may have limited the statistical power and the ability to draw more robust inferences from the data.

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