Introduction

Group Members: Patrick Xiao, Reiley Vogel, Alexandra Brady

One in five U.S. adults experiences mental illness (cited from Mental Illness – National Institute of Mental Health (NIMH)). Understanding trends in mental health patterns is critical for identifying emerging concerns within specific demographics. Anticipating fluctuations in diagnoses can enable practitioners to provide more effective patient care by allowing time to research new treatment methodologies, explore innovative forms of care, and ensure they are equipped to support individuals with sensitive needs. Accurately prescribing treatments is essential to patient outcomes, but serving as a reliable support system is equally valuable. Early intervention and prevention strategies have the potential to reduce symptom severity or even prevent the onset of mental health conditions altogether. Additionally, healthcare systems can leverage these insights to allocate resources more strategically and efficiently.

Our team utilizes tools such as NLP and sentiment analysis to investigate the potential for predicting mental health diagnoses from clinical notes. This approach aims not only to assist patients in managing their symptoms earlier but also to empower clinicians to anticipate potential cases and ensure that necessary resources are readily available. Our overarching goal is to determine whether artificial intelligence can serve as an efficient and reliable resource for clinicians to better understand the evolving health needs of current and future populations, enabling them to strategically plan and deliver more proactive care.

Overview

Initially, we aimed to analyze anonymized clinical notes, but due to data access limitations, we shifted focus to publicly available data. Our project aims to analyze two key datasets: one focused on mental health treatments, capturing patient details like age, diagnosis, and treatment outcomes, and another exploring sentiment data sourced from multiple platforms including social media posts such as Twitter and Reddit.

For our question, we're asking: **How can we use patient data and sentiment analysis to predict treatment outcomes or identify factors influencing mental health conditions?** Some of the tasks that we will perform in order to answer this includes applying NLP to sentiment data to extract themes using BERT embeddings and topic modeling, building predictive models to correlate patient characteristics and sentiment patterns with treatment outcomes, and conducting some exploratory analysis to identify any critical factors such as stress levels or therapy types.

Why This Matters

Mental health is a growing public health challenge, and traditional diagnostic practices often rely on delayed, reactive approaches. Our project explores the potential of combining patient metadata with NLP-driven sentiment analysis to proactively identify mental health conditions and anticipate treatment outcomes.

The ability to predict diagnoses or treatment outcomes based on text data and patient profiles could revolutionize how we approach mental health care. Our models offer the possibility of earlier intervention, more accurate diagnoses, and optimizes resource allocation-all of which are vital in a system where time and attention are limited. This project helps bridge the gap between unstructured public discourse and clinical insight, potentially enabling healthcare systems to understand and respond to emerging mental health trends in real time.

Datasets Used

Dataset 1 (Sentiment Analysis for Mental Health):
https://www.kaggle.com/datasets/suchintikasarkar/sentiment-analysis-for-mental-health

Dataset 2 (Mental Health Diagnosis and Treatment Monitoring):
https://www.kaggle.com/datasets/uom190346a/mental-health-diagnosis-and-treatment-monitoring

Data Cleaning

To ensure the quality and consistency of our data, we began by cleaning the sentiment dataset, which contained free-form text statements from social media platforms like Twitter and Reddit. To do this we:

- Removed corrupted entries, such as unnamed columns and rows with missing values
- Applied a custom text-cleaning pipeline that included lowercasing, removing URLs, mentions, hashtags, punctuation, and numbers.
- Removed common stopwords using NLTK and applied lemmatization to reduce each word to its base form (essential to normalize language variation).

```
# Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

```
import re
import nltk
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from nltk.stem import WordNetLemmatizer
from sklearn.feature_extraction.text import TfidfVectorizer, CountVectorizer
from sklearn.decomposition import LatentDirichletAllocation, NMF
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import accuracy_score
from wordcloud import WordCloud
from textblob import TextBlob
import spacy
from transformers import BertTokenizer, BertModel
import torch
from collections import Counter
from wordcloud import WordCloud
from textblob import TextBlob

# Download NLTK resources
nltk.download('punkt')
nltk.download('punkt_tab')
nltk.download('stopwords')
nltk.download('wordnet')
nltk.download('omw-1.4')

# Configurations
nltk.download(['punkt', 'stopwords', 'wordnet'])
pd.set_option('display.max_columns', None)
sns.set_style('whitegrid')
plt.rcParams['figure.figsize'] = (12, 6)


# Set style for visualizations
sns.set_style('whitegrid')
plt.rcParams['figure.figsize'] = (12, 6)
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
[nltk_data] Downloading package punkt_tab to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt_tab.zip.
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data] Downloading package omw-1.4 to /root/nltk_data...
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package stopwords to /root/nltk_data...
```

```
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

```
# Dataset 1: Mental Health Diagnosis Treatment
df_treatment = pd.read_csv('mental_health_diagnosis_treatment_.csv')

# Dataset 2: Sentiment
df_sentiment = pd.read_csv('Combined Data.csv')
```

```
df_treatment.head()
```

	Patient ID	Age	Gender	Diagnosis	Symptom Severity (1–10)	Mood Score (1–10)	Sleep Quality (1–10)	Physical Activity (hrs/week)	Medicati
0	1	43	Female	Major Depressive Disorder	10	5	8	5	Mo Stabiliz
1	2	40	Female	Major Depressive Disorder	9	5	4	7	Antipsycho
2	3	55	Female	Major Depressive Disorder	6	3	4	3	SS

```
df_sentiment.head()
```

	Unnamed: 0	statement	status
0	0	oh my gosh	Anxiety
1	1	trouble sleeping, confused mind, restless hear...	Anxiety
2	2	All wrong, back off dear, forward doubt. Stay ...	Anxiety
3	3	I've shifted my focus to something else but I'...	Anxiety
4	4	I'm restless and restless, it's been a month n...	Anxiety

```
df_treatment.isna().sum()
```

	0
Patient ID	0
Age	0
Gender	0
Diagnosis	0
Symptom Severity (1-10)	0
Mood Score (1-10)	0
Sleep Quality (1-10)	0
Physical Activity (hrs/week)	0
Medication	0
Therapy Type	0
Treatment Start Date	0
Treatment Duration (weeks)	0
Stress Level (1-10)	0
Outcome	0
Treatment Progress (1-10)	0
AI-Detected Emotional State	0
Adherence to Treatment (%)	0

dtype: int64

```
df_sentiment.isna().sum()
```

	0
Unnamed: 0	0
statement	362
status	0

dtype: int64

```
df_sentiment.dropna(inplace=True)
```

```
df_sentiment = df_sentiment.drop(columns=['Unnamed: 0'])
```

```
df_sentiment.isna().sum()
```

	0
Unnamed: 0	0
statement	0
status	0

dtype: int64

```
print(df_treatment.info())
print(df_sentiment.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 500 entries, 0 to 499
Data columns (total 17 columns):
 #   Column                          Non-Null Count  Dtype 
---  ------                          --------------  ----- 
 0   Patient ID                      500 non-null    int64 
 1   Age                             500 non-null    int64 
 2   Gender                          500 non-null    object
 3   Diagnosis                       500 non-null    object
 4   Symptom Severity (1-10)         500 non-null    int64 
 5   Mood Score (1-10)               500 non-null    int64 
 6   Sleep Quality (1-10)            500 non-null    int64 
 7   Physical Activity (hrs/week)    500 non-null    int64 
 8   Medication                      500 non-null    object
 9   Therapy Type                    500 non-null    object
 10  Treatment Start Date            500 non-null    object
 11  Treatment Duration (weeks)      500 non-null    int64 
 12  Stress Level (1-10)             500 non-null    int64 
 13  Outcome                         500 non-null    object
 14  Treatment Progress (1-10)       500 non-null    int64 
 15  AI-Detected Emotional State     500 non-null    object
 16  Adherence to Treatment (%)      500 non-null    int64 
dtypes: int64(10), object(7)
memory usage: 66.5+ KB
None
<class 'pandas.core.frame.DataFrame'>
Index: 52681 entries, 0 to 53042
Data columns (total 3 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   Unnamed: 0  52681 non-null  int64 
 1   statement   52681 non-null  object
 2   status      52681 non-null  object
dtypes: int64(1), object(2)
memory usage: 1.6+ MB
None
```

```
import re
import string
```

```
import nltk
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer

stop_words = set(stopwords.words('english'))
lemmatizer = WordNetLemmatizer()

def clean_text(text):
    # Lowercase
    text = text.lower()
    # Remove URLs
    text = re.sub(r"http\S+|www\S+|https\S+", '', text, flags=re.MULTILINE)
    # Remove mentions and hashtags
    text = re.sub(r'\@\w+|\#', '', text)
    # Remove punctuation
    text = text.translate(str.maketrans('', '', string.punctuation))
    # Remove numbers
    text = re.sub(r'\d+', '', text)
    # Remove stopwords and lemmatize
    words = text.split()
    words = [lemmatizer.lemmatize(word) for word in words if word not in stop_wo
    # Join back into a single string
    return " ".join(words)

# Create a new column with cleaned text
df_sentiment['clean_statement'] = df_sentiment['statement'].apply(clean_text)

# Preview cleaned text
df_sentiment[['statement', 'clean_statement']].sample(5)

```

Show hidden output

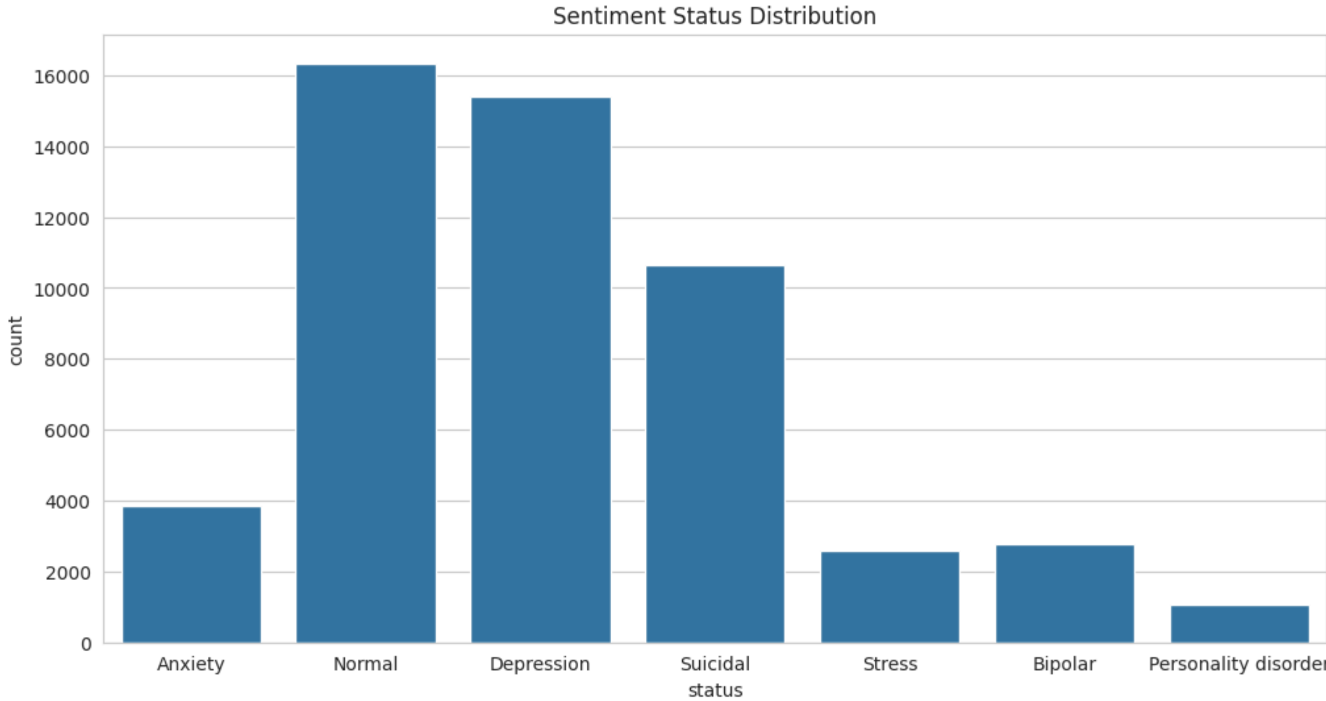
Exploratory Data Analysis

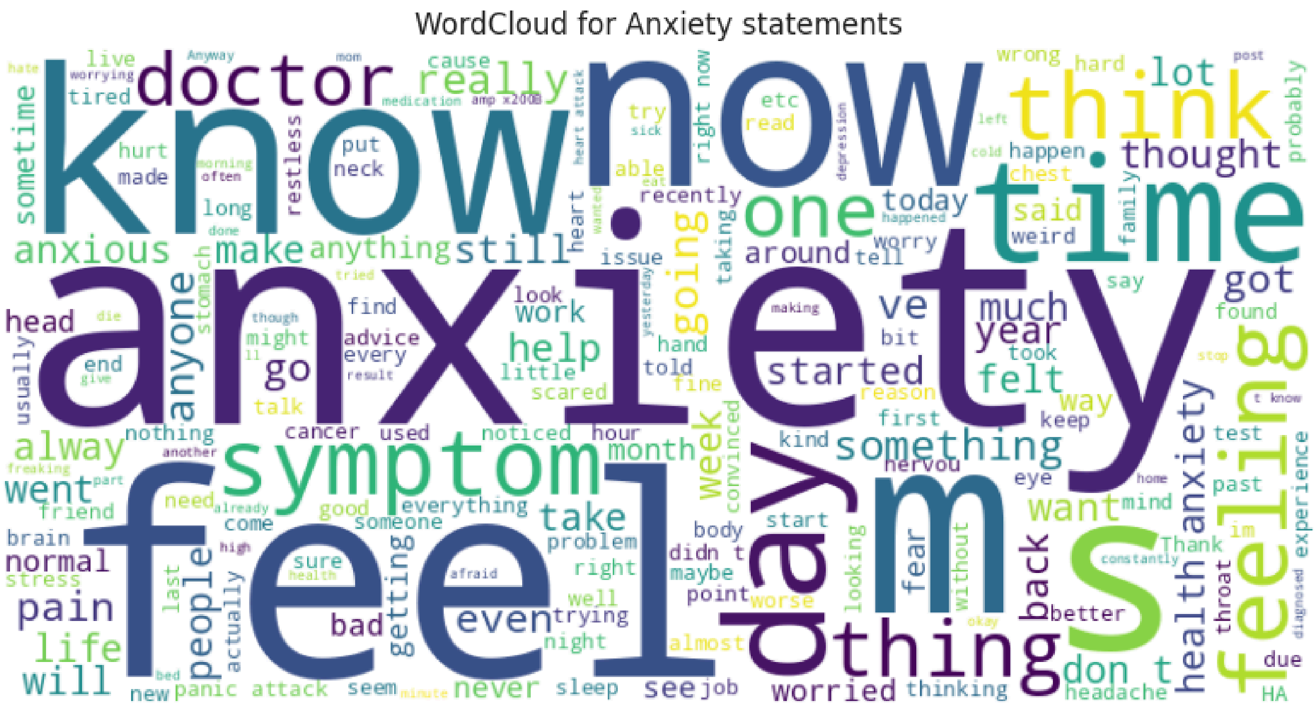
```
# Overview of demographics and treatment
sns.histplot(df_treatment['Age'], bins=20, kde=True)
plt.title("Age Distribution")
plt.show()

sns.countplot(data=df_treatment, x='Gender')
plt.title("Gender Distribution")
plt.show()

sns.countplot(data=df_treatment, y='Diagnosis', order=df_treatment['Diagnosis'].
plt.title("Diagnosis Frequencies")
plt.show()

```

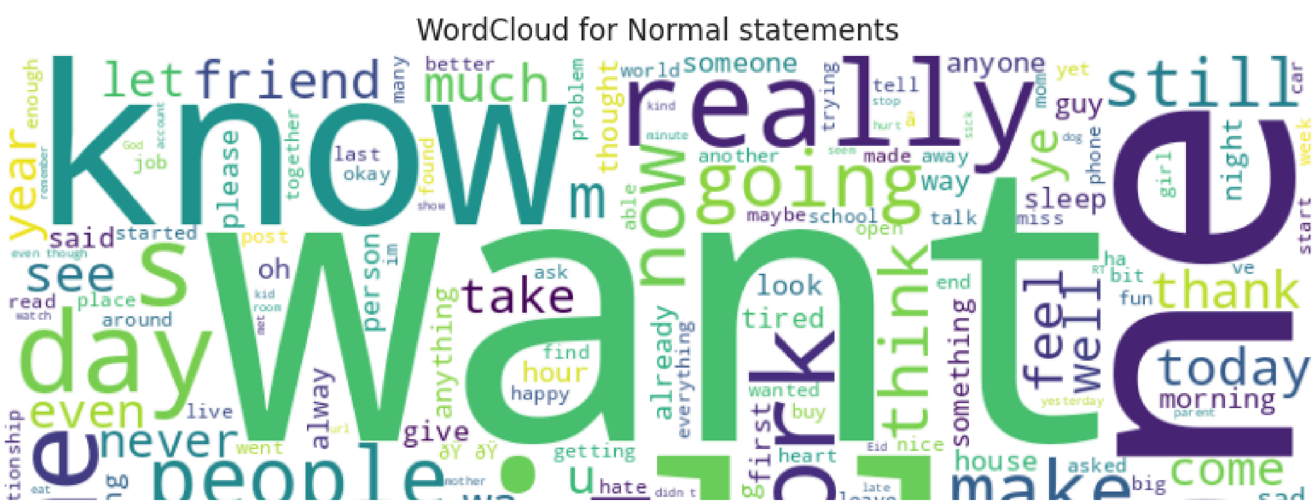
```
# Treatment outcome by therapy type
sns.countplot(data=df_treatment, x='Therapy Type', hue='Outcome')
plt.title("Treatment Outcome by Therapy Type")
plt.xticks(rotation=45)
plt.show()

```

Show hidden output

```
# Sentiment class distribution
sns.countplot(data=df_sentiment, x='status')
plt.title("Sentiment Status Distribution")
plt.show()

# Word cloud by status
for status in df_sentiment['status'].unique():
    text = " ".join(df_sentiment[df_sentiment['status'] == status]['statement'])
    wordcloud = WordCloud(width=800, height=400, background_color='white').gener
    plt.figure(figsize=(10,5))
    plt.imshow(wordcloud, interpolation='bilinear')
    plt.axis("off")
    plt.title(f"WordCloud for {status} statements")
    plt.show()

```

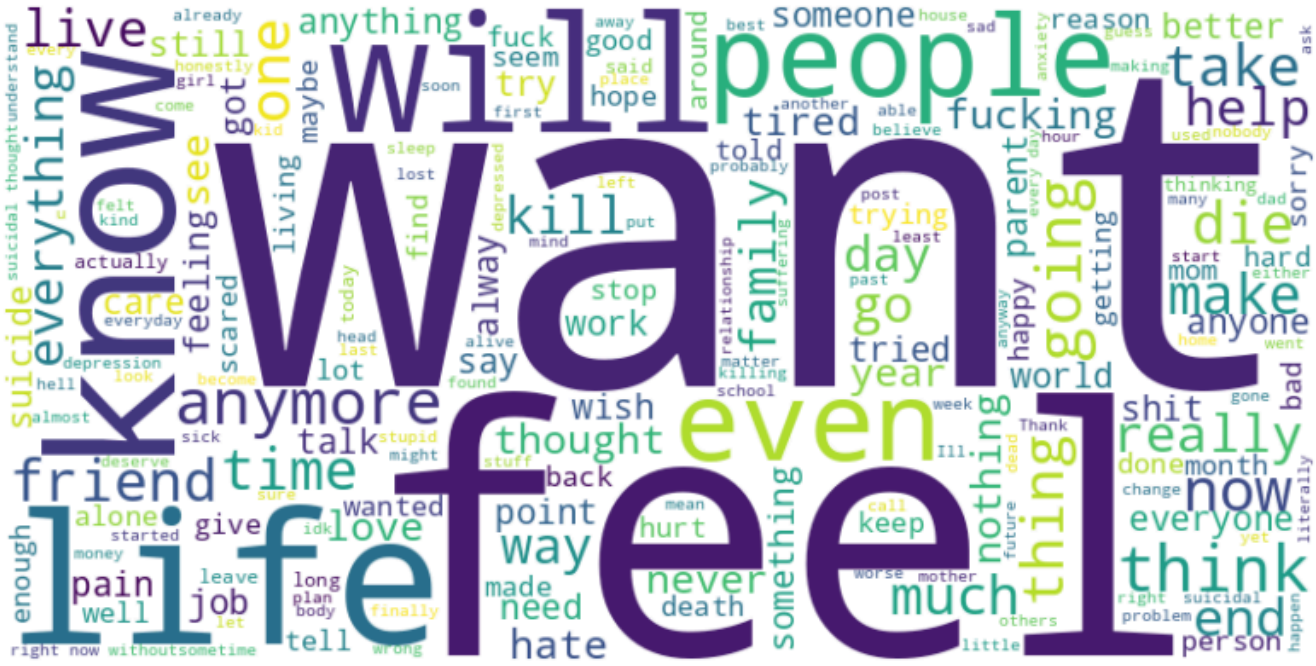

Sentiment Status Distribution
count
0
2000
4000
6000
8000
10000
12000
14000
16000
Anxiety
Normal
Depression
Suicidal
Stress
Bipolar
Personality disorder
status


WordCloud for Anxiety statements
anxiety
feel
know
now
time
think
doctor
symptom
day
feeling
thing
one
really
anxious
started
something
health anxiety
help
year
much
felt
still
got
thought
pain
life
will
people
going
week
month
worried
panic attack

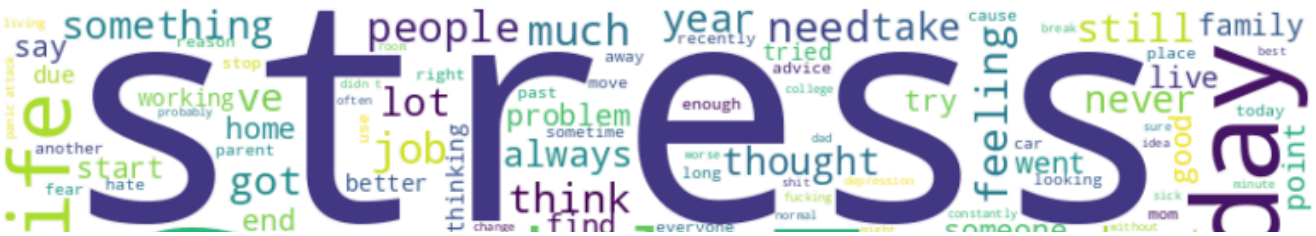

WordCloud for Normal statements
want
know
really
going
friend
let
much
still
day
see
take
people
today
thank
think
feel
well
never
even
tired
make
come

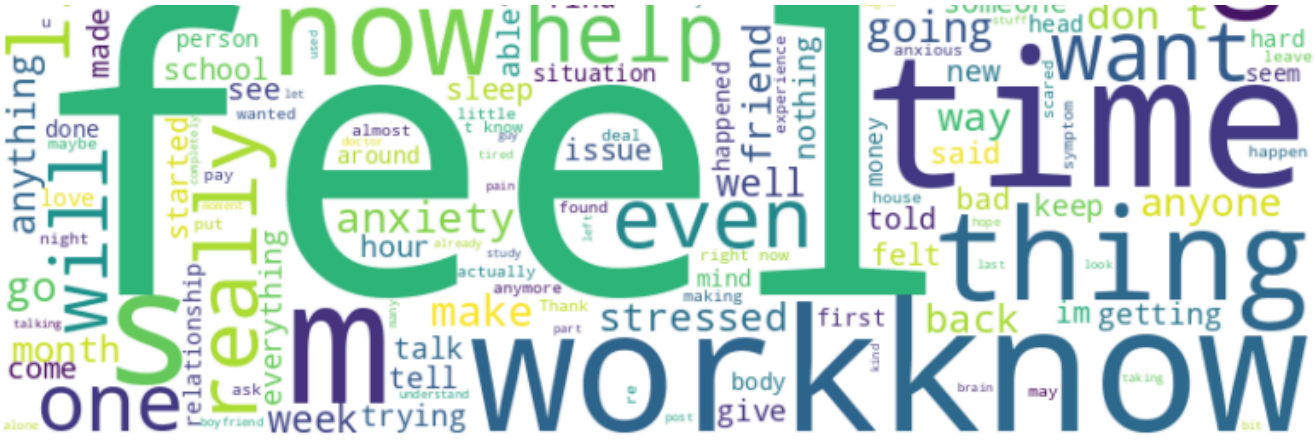
WordCloud for Depression statements

WordCloud for Suicidal statements



WordCloud for Stress statements





WordCloud for Bipolar statements

WordCloud for Personality disorder statements

Named Entity Recognition (NER)

```
nlp = spacy.load("en_core_web_sm")

sample_texts = df_sentiment['statement'].sample(5, random_state=1)
for text in sample_texts:
    doc = nlp(text)
    print(f"Text: {text}")
    for ent in doc.ents:
        print(f"{ent.text} - {ent.label_}")
    print("-" * 80)

```

```
Text: i m and i have bad anxiety debilitating i haven t been able to keep a job
early morning hour - TIME
the hard morning - TIME
don - PERSON
--------------------------------------------------------------------------------
Text: Jessica starred in the musical "Legally Blonde" as Elle Woods, the female
Jessica - PRODUCT
Legally Blonde - WORK_OF_ART
Elle Woods - PERSON
--------------------------------------------------------------------------------
Text: I’m so tired I just don’t see a point to my suffering, I don’t understand
--------------------------------------------------------------------------------
Text: My life 1 year ago was completely different. I was such a chick magnet and
1 year ago - DATE
this past year - DATE
10 years - DATE
one - CARDINAL
--------------------------------------------------------------------------------
Text: RT @no_onespecixl: Know one enjoys my company and I just make everyone mis
--------------------------------------------------------------------------------
```

Topic Modeling with LDA

```
# Vectorize using TF-IDF
tfidf = TfidfVectorizer(stop_words='english', max_features=5000)
tfidf_matrix = tfidf.fit_transform(df_sentiment['statement'])

# Fit LDA
lda = LatentDirichletAllocation(n_components=5, random_state=42)
lda.fit(tfidf_matrix)

# Display top words per topic
def display_topics(model, feature_names, no_top_words):
    for idx, topic in enumerate(model.components_):
        print(f"Topic {idx}:")
```

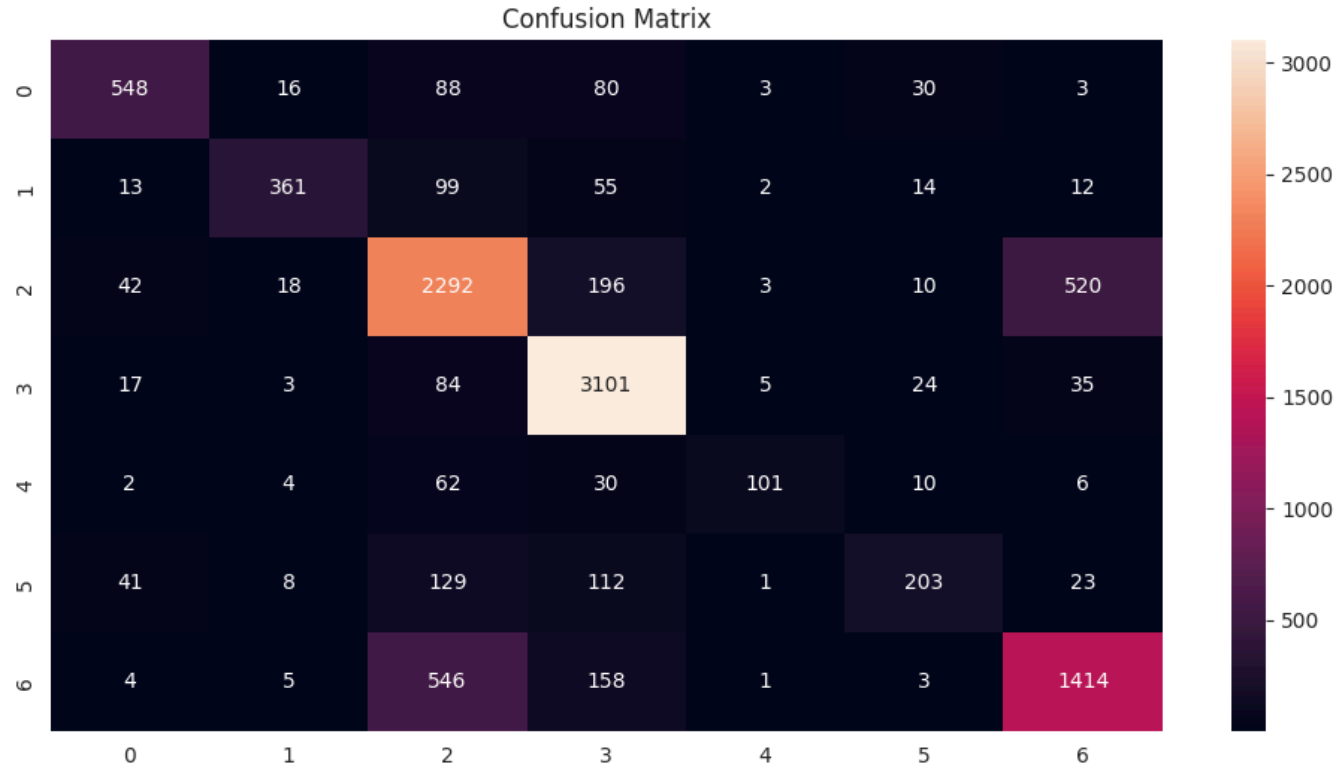
```
        print(" | ".join([feature_names[i] for i in topic.argsort()[:-no_top_wor
        print()

display_topics(lda, tfidf.get_feature_names_out(), 10)

```

```
Topic 0:
just | like | feel | know | life | want | people | time | really | things

Topic 1:
job | work | money | school | yes | just | want | don | like | life

Topic 2:
want | just | life | die | like | feel | tired | fucking | know | anymore

Topic 3:
http | depression | ðÿ | com | rt | morning | don | good | twitter | https

Topic 4:
anxiety | ve | like | just | don | feel | sleep | doctor | day | heart
```

Sentiment Classification Model

```
from sklearn.linear_model import LogisticRegression

# Prepare data
X = tfidf_matrix
y = df_sentiment['status']

# Split
X_train, X_test, y_train, y_test = train_test_split(X, y, stratify=y, test_size=

# Train model
clf = LogisticRegression(max_iter=200)
clf.fit(X_train, y_train)

# Evaluate
y_pred = clf.predict(X_test)
print(classification_report(y_test, y_pred))
sns.heatmap(confusion_matrix(y_test, y_pred), annot=True, fmt='d')
plt.title("Confusion Matrix")
plt.show()

```

	precision	recall	f1-score	support
Anxiety	0.82	0.71	0.76	768
Bipolar	0.87	0.65	0.74	556
Depression	0.69	0.74	0.72	3081
Normal	0.83	0.95	0.89	3269
Personality disorder	0.87	0.47	0.61	215
Stress	0.69	0.39	0.50	517
Suicidal	0.70	0.66	0.68	2131
accuracy			0.76	10537
macro avg	0.78	0.65	0.70	10537
weighted avg	0.76	0.76	0.75	10537



Trends

```
# Average treatment progress by diagnosis
df_progress = df_treatment.groupby("Diagnosis")["Treatment Progress (1-10)"].mea
df_progress.plot(kind='barh', title="Average Treatment Progress by Diagnosis", f
plt.xlabel("Avg Progress")
plt.show()
```

```
# Correlation heatmap
plt.figure(figsize=(10,6))
sns.heatmap(df_treatment.select_dtypes(include='number').corr(), annot=True, cma
plt.title("Correlation Matrix of Numerical Features")
plt.show()
```

Show hidden output

SpaCy Prediction Model

```
print(df_sentiment['status'].unique())
```

```
['Anxiety' 'Normal' 'Depression' 'Suicidal' 'Stress' 'Bipolar'
 'Personality disorder']
```

```
print(df_treatment['Diagnosis'].unique())
```

```
['Major Depressive Disorder' 'Panic Disorder' 'Generalized Anxiety'
 'Bipolar Disorder']
```

```
status_to_diagnosis = {
    'Depression': 'Major Depressive Disorder',
    'Suicidal': 'Major Depressive Disorder',
    'Anxiety': 'Generalized Anxiety',
    'Stress': 'Generalized Anxiety',
    'Bipolar': 'Bipolar Disorder',
    'Personality disorder': 'Panic Disorder',  # Best-guess mapping
    'Normal': None  # We'll exclude these
}
```

```
df_sentiment['Mapped Diagnosis'] = df_sentiment['status'].map(status_to_diagnosi
df_sentiment = df_sentiment[df_sentiment['Mapped Diagnosis'].notnull()]
```

```
import spacy
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report

nlp = spacy.load("en_core_web_sm")

def spacy_tokenizer(text):
    doc = nlp(text)
```

```
    return [token.lemma_ for token in doc if not token.is_stop and not token.is_

vectorizer = TfidfVectorizer(tokenizer=spacy_tokenizer, max_features=5000)

X = vectorizer.fit_transform(df_sentiment['clean_statement'])
y = df_sentiment['Mapped Diagnosis']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_

clf = LogisticRegression(max_iter=1000)
clf.fit(X_train, y_train)

y_pred = clf.predict(X_test)
print(classification_report(y_test, y_pred))

```

```
/usr/local/lib/python3.11/dist-packages/sklearn/feature_extraction/text.py:517:
  warnings.warn(
                           precision    recall  f1-score   support

          Bipolar Disorder       0.90      0.66      0.77       554
       Generalized Anxiety       0.82      0.75      0.78      1256
Major Depressive Disorder       0.91      0.97      0.94      5221
           Panic Disorder       0.95      0.48      0.64       237

                 accuracy                           0.89      7268
                macro avg       0.89      0.72      0.78      7268
             weighted avg       0.89      0.89      0.89      7268
```

import numpy as np import matplotlib.pyplot as plt import seaborn as sns

Get class labels and their coefficients

feature_names = vectorizer.get_feature_names_out() coefs = clf.coef_ labels = clf.classes_

Plot top N words for each diagnosis

def plot_top_words(coefs, feature_names, labels, top_n=10): for idx, label in enumerate(labels): top_features = np.argsort(coefs[idx])[-top_n:] plt.figure(figsize=(8, 4)) sns.barplot(x=coefs[idx][top_features], y=[feature_names[i] for i in top_features], palette="viridis") plt.title(f"Top {top_n} words for '{label}'") plt.xlabel("Coefficient") plt.ylabel("Word") plt.tight_layout() plt.show()

plot_top_words(coefs, feature_names, labels, top_n=10)

SpaCy Model with XGBoost Classifier

```
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score

label_encoder = LabelEncoder()

# Fit the encoder to the 'y_train' labels and transform both 'y_train' and 'y_te
y_train_encoded = label_encoder.fit_transform(y_train)
y_test_encoded = label_encoder.transform(y_test)

xgb_clf = XGBClassifier(use_label_encoder=False, eval_metric='mlogloss', random_
xgb_clf.fit(X_train, y_train_encoded)

y_pred_xgb_encoded = xgb_clf.predict(X_test)

y_pred_xgb = label_encoder.inverse_transform(y_pred_xgb_encoded)

print("XGBoost Accuracy:", accuracy_score(y_test, y_pred_xgb))
print("\nXGBoost Classification Report:\n", classification_report(y_test, y_pred
```

```
/usr/local/lib/python3.11/dist-packages/xgboost/core.py:158: UserWarning: [00:03
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
XGBoost Accuracy: 0.908778205833792

XGBoost Classification Report:
                          precision    recall  f1-score   support

         Bipolar Disorder       0.88      0.73      0.80       554
      Generalized Anxiety       0.83      0.79      0.81      1256
Major Depressive Disorder       0.93      0.97      0.95      5221
           Panic Disorder       0.96      0.59      0.73       237

                 accuracy                           0.91      7268
                macro avg       0.90      0.77      0.82      7268
             weighted avg       0.91      0.91      0.91      7268
```

Comparison of SpaCy and XGBoost

ChatGPT

```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import matplotlib.pyplot as plt

# Train the Logistic Regression model
from sklearn.linear_model import LogisticRegression
clf = LogisticRegression(max_iter=1000, random_state=42)
```

```
clf.fit(X_train, y_train_encoded)  # Use the encoded labels for training
y_pred_logreg = clf.predict(X_test)

# Train the XGBoost model
from xgboost import XGBClassifier
xgb_clf = XGBClassifier(use_label_encoder=False, eval_metric='mlogloss', random
xgb_clf.fit(X_train, y_train_encoded)
y_pred_xgb = xgb_clf.predict(X_test)

# Create confusion matrix plots
fig, axes = plt.subplots(1, 2, figsize=(14, 6))

# Logistic Regression Confusion Matrix
cm_logreg = confusion_matrix(y_test_encoded, y_pred_logreg)
ConfusionMatrixDisplay(confusion_matrix=cm_logreg, display_labels=clf.classes_)
axes[0].set_title("Logistic Regression")

# XGBoost Confusion Matrix
cm_xgb = confusion_matrix(y_test_encoded, y_pred_xgb)
ConfusionMatrixDisplay(confusion_matrix=cm_xgb, display_labels=xgb_clf.classes_
axes[1].set_title("XGBoost")

plt.tight_layout()
plt.show()

```

```
/usr/local/lib/python3.11/dist-packages/xgboost/core.py:158: UserWarning: [00: 1
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```