

# Suicide Risk Assessment Using NLP And Machine Learning

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**Abstract**—In contemporary society, the escalating incidence of suicide poses a significant and growing concern. Addressing this issue requires a profound understanding of its inherent risks and the development of effective strategies for risk reduction. This paper aims to contribute to this imperative by presenting a holistic approach to suicide risk assessment, utilizing the integration of Natural Language Processing and Machine Learning (ML) models. The primary focus of this study is to enhance the precision of suicide risk prediction through the meticulous analysis of textual data associated with at-risk individuals. A dataset “Suicide and Depression Detection” which is available on Kaggle has been utilized to unveil subtle linguistic patterns indicative of suicide risk. The textual data has been converted to lowercase, the punctuations have been removed to ensure clean text, and stemming has been performed to find the root words. TF-IDF Vectorizer has been used to vectorize the textual data. To discern the most accurate predictive model, various machine learning algorithms: Naive-Bayes Classifier, Random Forest, Decision Tree, Gradient Boosting, and K-Nearest Neighbor, were applied.

## I. INTRODUCTION

Suicide is a multidimensional and intricate social issue that cuts beyond national, cultural, and economic lines. The World Health Organization (WHO) estimates that suicide claims the lives of about 800000 people each year (1), making it a major cause of mortality worldwide. This widespread problem not only has a significant effect on people and their families, but it also presents significant obstacles for public health systems across the globe.

For preventative and intervention methods to be effective, it is vital to comprehend the complex elements that are

associated with suicide. Suicidal thoughts and behaviors can be triggered by a variety of causes, including mental health issues, social stigma, economic inequality, and restricted access to mental health resources. Comprehensive research is therefore desperately needed in order to improve our comprehension of these variables and create focused strategies to lower suicide rates globally.

This paper focuses on the performance metrics of some common machine learning models along with NLP tasks to determine the scope of these techniques to further clarify and provide a comprehensible understanding of the applications of these techniques.

It starts off by performing NLP tasks on the “Suicide and Depression Detection” which is available on Kaggle, by converting the textual data to lowercase and removing the punctuations. It then performs stemming to secure the root words post which vectorization is conducted via the TF-IDF vectorizer. With the clean textual data that remains afterwards, some common machine learning algorithms are utilized to train and test models. The models are Naive-Bayes Classifier, Random Forest, Decision Tree, Gradient Boosting, and K-Nearest Neighbor out of which Naive-Bayes gave us the best results. This diverse set of models underwent rigorous evaluation to determine their efficacy in correctly predicting instances of suicide. The results are then shown on a histogram containing the f1-scores of the aforementioned models. The Naive-Bayes Classifier model has an f1-score of 0.8819904 (Highest in our testing), Random Forest has 0.7655578, Decision Tree has 0.7699456, Gradient Boosting has 0.7444396 (Lowest in

Naive Bayes	Precision	Recall	F1-Score
Non-suicide	0.88	0.89	0.89
Suicide	0.88	0.88	0.88
<b>F1-Score</b>	0.8819904		

Fig. 1. Naive Bayes Classifier Outcome.

our testing), and K-Nearest Neighbor has 0.8497434. Further processing and a larger, fine-tuned, and unique dataset will result in better outcomes.

## II. LITERATURE REVIEW

Suicide has become a prominent and concerning issue in the 21st century, with rates doubling compared to the previous century. Extensive research indicates that mental illness plays a significant role in most suicide cases, often posing challenges in providing concrete evidence for such incidents due to their psychological nature (Hogan and Grumet). Global responses to rising suicide rates have led to increased awareness and initiatives within various organizations. Strategies are being implemented to mitigate suicide rates by enhancing public understanding of mental health issues and ensuring effective treatment options according to the United States Surgeon General and National Action Alliance for Suicide Prevention, New Zealand Ministry of Health and NHS England.

According to United States Surgeon General and National Action Alliance for Suicide Prevention, a noteworthy concept and policy in suicide prevention is the emergence of "Zero Suicide," emphasizing the paramount importance of preventing suicides within healthcare organizations. Studies suggest that a decline in suicide rates can be achieved through proactive mental health care. Individuals grappling with psychological health issues are found to be more prone to suicide attempts. While Hogan doesn't explicitly state that mental health is the predominant factor in suicide cases, it remains a research gap. Addressing this gap involves providing comprehensive guidance on mental health to hospitals, families, and individuals dealing with psychological health issues, thereby contributing to suicide prevention (Mulder, Newton – Howes, and Coid 2016).

Kant, in his work "Groundwork of the Metaphysics of Morals," argues that individuals contemplating suicide may see it as a means to end their suffering rather than an intentional act of self-harm (Kant 2002). He emphasizes the responsibility of each individual to preserve their life rather than surrendering to despair. Consequently, the ultimate challenge in preventing suicides lies in the care of mental health. In 2023, NLP strategies are increasingly becoming an important mechanism to sort textual data into more concise, comprehensible, and clean data. According to 'The Recent Advances and Applications of Natural Language Processing' by Bhoi, P. C., Singh, D., and Das, B. R. (May 2023) they mention some trends in 2023 related to NLP, such as virtual assistants, text summarization, sentiment analysis etc.

## III. METHODOLOGY

We used a dataset "Suicide and Depression Detection" available on Kaggle to explore the capabilities of Natural Language Processing and some common Machine Language models. Posts from the Reddit platform's "SuicideWatch" and "depression" subreddits are included in the dataset. The Pushshift API was used to gather these posts. The dataset comprised posts from "SuicideWatch" between December 16, 2008, when it first started, and January 2, 2021. Posts from January 1, 2009, to January 2, 2021, were gathered under the category "depression." The dataset consists of approximately 232074 texts from the aforementioned subreddits out of which we have used 10000 sample texts and split it into two parts: Suicide - 4952 and Non-suicide - 5048 to balance the outcomes. In our testing, we incorporated samples of the texts of 1000, 5000, 10000, 20000, 50000, and 100000. We noticed that 10000 sample texts generate an accuracy of 0.88 and do not increase significantly in case more than 10000 samples are used. The paper starts off with loading the dataset into the code. The dataset has a shape of 232074 and 3 columns of which one is an unnamed column, one is text column, and the last one is the class column. The unnamed column contains the number of the text in the whole dataset, the text column contains all the textual data retrieved from the aforementioned subreddits, and the class column contains the binary classification values (Suicide and Non-suicide). Firstly, we changed the textual data into lower cases and removed all the punctuations to clean the data for further processing. We then tokenized and removed stopwords, performed stemming to find the root of the word, and then vectorized the data using TF-IDF vectorizer. After these steps were completed, we incorporated the machine learning models (Naive-Bayes Classifier, Random Forest, Decision Tree, Gradient Boosting, and K-Nearest Neighbor) to determine which of these models perform the best in identifying the instances of suicide and non-suicide. We also included code that incorporates the best performing model, takes an input, and then predicts if it is a suicide or a non-suicide. We utilized confusion matrix for each model to find the Precision, Recall, and F1-Score of each model.

## IV. RESULT ANALYSIS

From our testing we found that the Naive-Bayes classifier has the highest overall F1-score (0.8819904) meaning that the model has a low number of false positives and false negatives. It is able to accurately identify positive instances and is able to grasp a majority number of actual positive instances. It has high precision and also high recall. The second best is KNN with F1-score (0.8497434) meaning that it almost performs as well as the leading model but has a higher proportion of false positives and false negatives comparatively. The third best in our testing is Decision Tree with F1-Score (0.7699456) which is significantly lower than the leading two models as mentioned. This means it has a much higher proportion of false positives and false negatives than the leading model which could have potential reliability issues. The fourth model model

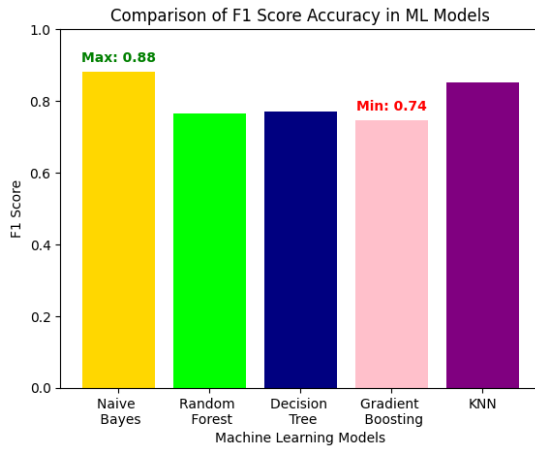


Fig. 2. Comparisons of the Models.

is Random Forest with F1-score (0.765578) which is on par with Decision Tree but slightly worse. The lowest amongst the models we implemented is Gradient boosting with F1-score (0.744396) which is worse than Random Forest and Decision tree both, meaning it has the highest number of false positives and false negatives out of all the models. In this scenario, the Naive-Bayes classifier performs the best and can potentially be used to train further, with added NLP processing, fine-tuned datasets, and in general increase the variability of the dataset may improve accuracy and f1-score.

## V. FUTURE WORK AND LIMITATIONS

This study is trying to learn more about suicide risk by looking at information from different places, using new technology that helps understand language and patterns better. But there are some limits to this study. We're mostly using information from Reddit, so what we find might not be true for other websites or groups of people. We're also watching how things related to suicide change over time, which helps us see how things like therapy or changes in society can make a difference. However, we know we might be missing some important things, like how money or what's happening in society can affect mental health. To fix this, in the future, we'll work on improving our technology to understand patterns better, use different information sources, and think about how external factors like money and society play a role. We also want to make sure what we learn works for different kinds of people and cultures, not just one group or platform.

## VI. CONCLUSION

In conclusion, suicide poses a global challenge necessitating a comprehensive approach. Recognizing diverse triggers, including mental health issues and societal factors, is crucial. Ongoing research, particularly in refining machine learning models and Natural Language Processing, holds promise for enhancing predictive capabilities. Future efforts should prioritize longitudinal studies, cross-cultural analyses, and innovative interventions like real-time monitoring. Ethical

considerations, community engagement, and interdisciplinary collaboration are vital for responsible and effective suicide prevention. Embracing these insights and future directions can pave the way for a more compassionate and informed approach to mitigating the impact of suicide on individuals and society.

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