Machine Learning In Psychological Diagnosis
(Technical Topic)

How Improved Mental Disorder Diagnoses Affects Stakeholders
(STS Topic)

A Thesis Project Prospectus
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By
Tyler Rasmussen

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: _____

Advisor

Kathryn A. Neeley, Department of Engineering and Society

Introduction

According to the Center for Disease Control (CDC), suicide rates have risen by 37% from 2000 to 2018 and more than 1 in 5 U.S. adults will experience mental illness (CDC, 2023). Despite the ongoing mental health crisis, there exists a lack of mental health care for many individuals due to barriers to treatment and diagnosis that prevent treatment (Rivers et al. 2024 Introduction). Due to the non-physical nature of these diseases, it is often difficult to see how common they really are. For example, 6 in 100 people have experienced trauma that could cause Post Traumatic Stress Disorder (Wang et al. 2023 P. 1655). It is clear that there exists a failure to address this mental health crisis. The use of machine learning to diagnose mental disorders, while a nascent area of research, shows promising results in meeting these needs.

Despite the urgent need for healthcare for mental health patients, figure 1 below (Rivers et al. 2024 P. 5) shows how common current barriers to treatment for healthcare are. With the advent of smart technology, telehealth, and electroencephalography sensors, diagnoses could be done virtually without an in-person visit when combined with machine learning (Othmani et al. 2023 P. 24134). This could decrease the cost, travel, and time of diagnoses and allow for early and better treatment of mental disorders. Using these data gathering techniques the technical topic will explore machine learning techniques that have the possibility to allow for more efficient and cost-effective diagnoses reducing the most common barriers to treatment such as cost and time. These techniques would allow computers to take diagnostic data and train models that would be able to diagnose patients.

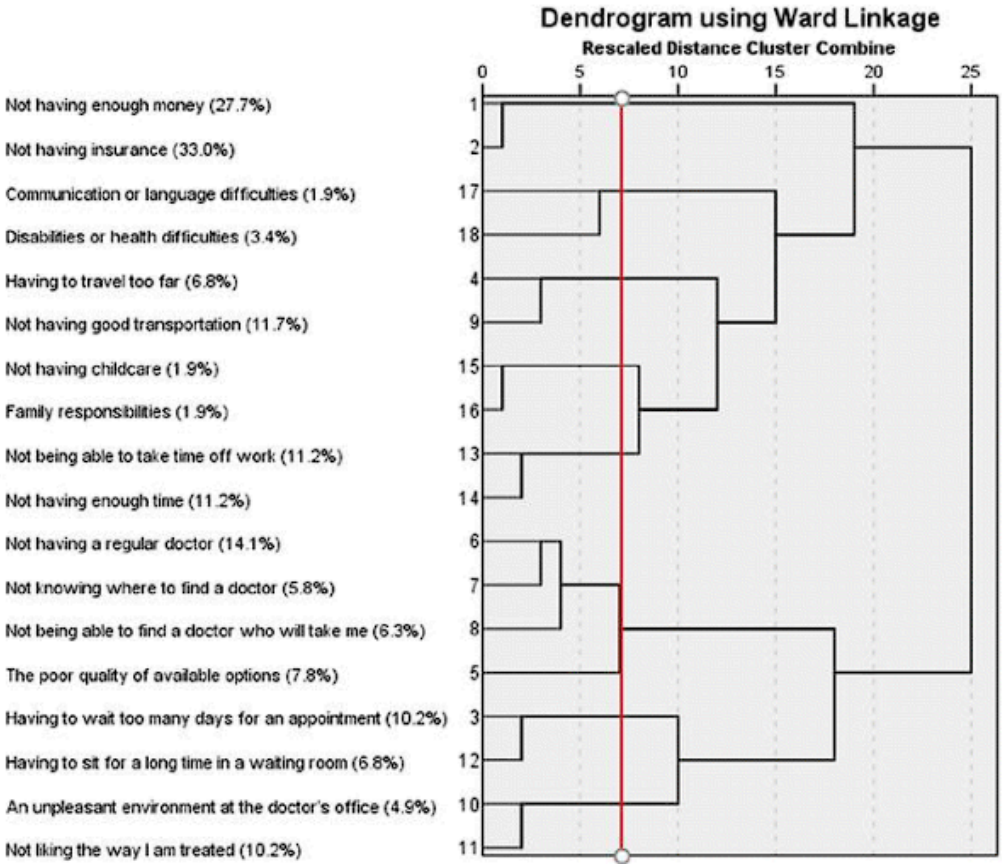

Figure 1. Dendrogram of Percentage of Barriers to Healthcare. Note that finances and time being the most commonly cited barriers. Adapted From Rivers et al, p. 5)

Introducing computerized systems that can take in information difficult for humans to process such as MRI brain scans, could increase diagnostic accuracy for mental disorders with similar clinical symptoms such as Bipolar Disorder and Major Depression Disorder (Huang et al. 2024). The automatization of the process would also decrease the workload of doctors and mental health professionals allowing for better use of resources. This would hopefully bring down costs for Insurance companies, hospitals, and doctors decreasing monetary barriers to treatment. The STS topic will explore the effects of these changes to diagnosis on stakeholders such as patients and their support systems.

Technical Topic: Machine Learning In Psychological Diagnosis.

Currently, diagnosing mental disorders can be difficult and costly in time and resources. In one study investigating misdiagnosis, “rates reached 65.9% for major depressive disorder, 92.7% for bipolar disorder, 85.8% for panic disorder, 71.0% for generalized anxiety disorder, and 97.8% for social anxiety disorder” (Vermani et al., 2011, p. 2). It is clear that misdiagnosis is a common problem in psychology with machine learning being a possible path to a resolution. Failure to find a technical solution to efficient and effective diagnosis will leave patients suffering unable to get effective treatment.

Machine learning techniques used in psychology are varied from simple regression models to more complex neural networks (Othmani et al., 2023, p. 24135). There is no such thing as a single machine learning algorithm that can fit every problem in psychology (Hawes et al., 2023, p. 3). More research is needed to determine the best algorithms for every diagnosis but among the more promising models are random forest trees, recursive ensemble feature selection, and Gaussian process regression (Peralta-Marzal et al., 2024, results). One study was able to train a machine learning model to classify Bipolar Disorder (BPD) and Major Depression Disorder (MDD) with an accuracy of 90.3% (Huang et al., 2024, p. 1) using data from fMRI brain imaging techniques shown in figure 2. Another study was able to train a decision tree model to predict ADHD in youths with a predictive accuracy of 74% (Grazioli et al., 2024, p. 5). A third study was able to train a machine learning algorithm to predict young Schizophrenia disorder patients with an accuracy greater than or equal to 70% using

data of the patient gut microbiomes (Stiernborg et al., 2024, p. 1). However, due to the current limitations of the data pool studies have drawn from, it remains to be seen if these models can be scaled to deal with greater amounts of data and patients (Portugal et al., 2023, conclusion).

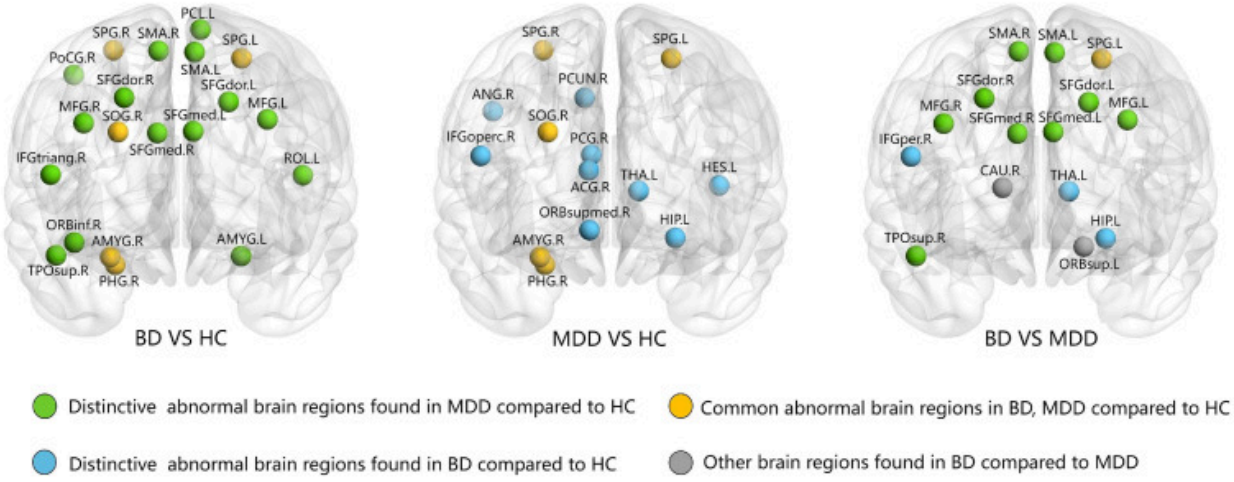

Figure 2. Graph of nodes in brain regions that signify BPD or MDD. Full description of acronyms can be located in the references. (Huang et al., 2024, 3.3. Alterations in Nodal Brain Network Properties).

It is clear that in many cases it may be possible for machine learning systems to have greater accuracy in diagnosing mental disorders than current doctors using the Diagnostic and Statistical Manual of Mental Disorders (DSM). While it is difficult to say the extent that computers can take over this diagnostic work due to limited sample sizes in data, the possibility that they could greatly assist doctors in diagnosing should not be underestimated. While it is unlikely that computers will completely replace doctors in diagnosing mental disorders, they will be able to assist in other ways. Doctors could read computer given reports much like how radiologists assess reports given to them by their machines. The DSM could integrate certain machine learning models and provide

guidance on diagnosing using certain metrics such as how accurate the computer believes its diagnosis to be. Doctors could also provide questionnaires for patients to fill out and machine learning algorithms could flag patients most likely to have certain disorders such as ADHD. (Grazioli, et al., 2024 p. 2).

Thus it is feasible in the near future for machine learning techniques to be implemented in clinical practice. Whilst it may not completely eliminate the need for in person visits with psychiatrists it would add an additional tool in many doctors' tool boxes.

STS TOPIC: How Improved Mental Disorder Diagnoses affects Stakeholders

Various stakeholders such as patients, friends and family of patients, doctors, health insurance companies, and governments stand to benefit from improved mental disorder diagnosis. Currently, all of these stakeholders are negatively affected by poor mental illness diagnosis. Whilst it is obvious the stake patients have in this problem often overlooked are the patients support systems. Better diagnosis may result in reducing the burden of care of friends and family of patients helping them be more understanding by giving their illness a label. These community support systems for patients stand to benefit indirectly from effective treatment of patients by reducing the amount of care and burdens they shoulder by supporting, living with, and taking care of patients. Currently, misdiagnosis negatively affects society by misleading patients and their support systems and increasing costs of treatment.

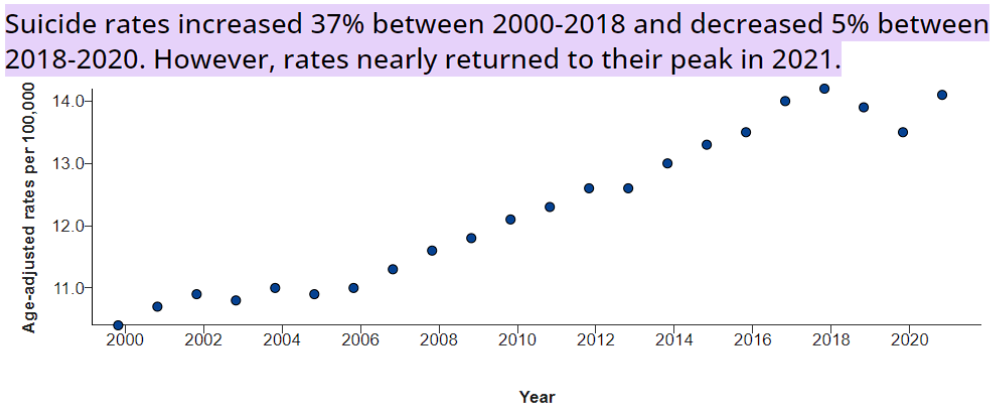

Figure 3. Graph of suicide rates from 2000-2018. Rates increased steadily from 2005 up until 2018. (CDC, 2023)

It is important to take into account the views that patients and doctors have towards computer systems in medicine. Mistrust in computers deciding or assisting diagnosis may compromise the trust patients have in their diagnosis. Doctors mistrusting computer diagnosis may cause them to discard the results of computerized diagnosis entirely. Thus the introduction and use of machine learning algorithms in diagnosis or aid of diagnosis for mental disorders must be met with caution.

Currently, doctors must use their own judgment in conjunction with diagnostic tools such as the DSM, questionnaires, and rarely various sensors for biomarkers. (Othmani et al., 2024, p. 24135). This opens up the possibility of bias and subjectivity into diagnosis for mental health disorders. One study was able to use biomarkers in patients' gut microbiome in order to predict schizophrenia with accuracy greater than or equal to 70% (Stiernborg et al., 2024, conclusion). This is further complicated by the similarity of clinical symptoms of many mental disorders. (Huang et al). Computers can sidestep this bias by only looking at data and using a machine learning model.

Judicious introduction of machine learning into diagnosing mental disorders would alleviate burdened health care systems. Failure to do so would miss out on decreased costs for stakeholders and worsened patient outcomes and prognosis (Peralta-Marzal et al., 2024 introduction, Alazaidah et al., 2024, p. 3). A study done on schizophrenia patients found better patient prognosis the earlier that the disorder was diagnosed (Stiernborg et al., 2024, conclusion). A machine learning model may allow patients to see if they should go to a doctor or not. This would increase awareness and allow for patients to see if they potentially need to get a diagnosis or not.

Leaning on actor-network theory, replacing human actors in doctors with non-human actors in computers, is historically fairly common (Latour, 1992). Often jobs that could be done by humans are made obsolete by technology as Latour in “Where are the Missing Masses” gives us numerous examples of in door closers, traffic men, and Berliner locks. While it is very unlikely a doctor's role will be replaced in the near future, we should not discount technology's ability to do jobs we once thought impossible. On the other hand, Venturi (2010) in “Diving into Magma”, gives us insight into how controversies can destabilize conditions. Computers taking over jobs is a hot controversy with the advent of generative ai. It is such that the utmost care should be made when introducing computer diagnosis to doctors and patients.

Conclusion:

The deliverable will be better knowledge of the role that machine learning technology can play in psychology, specifically mental health diagnosis. This knowledge will be used together with datasets of features of mental health patients in order to complete a prototype machine learning model. This model will classify data of patients into specific mental health disorders. This will assist doctors in diagnosing patients and may let patients know of the potential that they may have a mental disorder without having to see a doctor.

In this way the prototype machine learning model will help add to the growing literature that machine learning can be a useful tool in the field of psychology. It will aim to increase the credibility of machine learning in diagnosing mental disorders and help to increase my knowledge of psychological diagnosis and machine learning. Hopefully by highlighting specific STS challenges in implementing machine learning diagnosis models my deliverable could help as a basis for future research and problem resolution. (1732 words)

References:

Alazaidah, R., Samara, G., Aljaidi, M., Haj Qasem, M., Alsarhan, A., & Alshammari, M. (2024, January 1). Potential of machine learning for predicting sleep disorders: A comprehensive analysis of regression and classification models. *Diagnostics (2075-4418), 14*(1), 27-45.

CDC. (2023, November 29). *Suicide Data and Statistics | Suicide Prevention | CDC*. CDC.gov. Retrieved May 1, 2024, from https://www.cdc.gov/suicide/suicide-data-statistics.html#:~:text=Suicide%20rates%20increased%2037%25%20between,to%20their%20peak%20in%202021.

Grazioli, S., Crippa, A., Rosi, E., Candelieri, A., Ceccarelli, S. B., Mauri, M., ... Nobile, M. (2024, January 1). Exploring telediagnostic procedures in child neuropsychiatry: addressing ADHD diagnosis and autism symptoms through supervised machine learning. *European Child & Adolescent Psychiatry, 33*(1), 139-149.

Latour, B. (1992). Where are the missing masses? The sociology of a few mundane artifacts. In Bijker, W. E. and Law, J., eds. *Shaping technology/Building society: Studies in sociotechnical change.* Cambridge, MA: MIT Press, pp. 225-258

Hawes, M. T., Schwartz, H. A., Son, Y., & Klein, D. N. (2023, October 1). Predicting adolescent depression and anxiety from multi-wave longitudinal data using machine learning. *Psychological Medicine, 53*(13), 6205-6211.

Huang, Y., Zhang, J., He, K., Mo, X., Yu, R., Min, J., ... Liu, M. (2024, February 15). Innovative neuroimaging biomarker distinction of major depressive disorder and bipolar disorder through structural connectome analysis and machine learning models. *Diagnostics (2075-4418), 14*(4), 389-404.

Othmani, A., Brahem, B., Haddou, Y., & Mustaqeem, . (2023, October 15). Machine-learning-based approaches for post-traumatic stress disorder diagnosis using video and EEG sensors: A review. *IEEE Sensors Journal, 23*(20), 24135-24151.

Peralta-Marzal, L. N., Rojas-Velazquez, D., Rigters, D., Prince, N., Garssen, J., Kraneveld, A. D., ... Lopez-Rincon, A. (2024, January 8). A robust microbiome signature for autism spectrum disorder across different studies using machine learning. *Scientific Reports, 14*(1), 1-11.

Portugal, L. C. L., Ramos, T. C., Fernandes, O., Bastos, A. F., Campos, B., Mendlowicz, M. V., ... De Oliveira, L. (2023, October 5). Machine learning applied to fMRI patterns of brain activation in response to mutilation pictures predicts PTSD symptoms. *BMC Psychiatry, 23*(1), 1-13.

Rivers, A. S., Sanford, K., Brewington, M., & Buchanan, A. (2024, January 1). Development of a new measure of encounters with health care barriers: The commonly experienced health care barriers index. Psychological Assessment, 36(1), 30 - 40.

Stiernborg, M., Prast-Nielsen, S., Melas, P., Skott, M., Millischer, V., Boulund, F., ... Lavebratt, C. (2024, January 1). Differences in the gut microbiome of young adults with schizophrenia spectrum

disorder: using machine learning to distinguish cases from controls. *Brain, Behavior, and Immunity, 117*, 298-309.

Venturini, T. (2010). Diving in magma: How to explore controversies with actor-network theory. *Public Understanding of Science*, 19(3), 258-273

Vermani, M., Marcus, M., & Katzman, M. A. (2011). Rates of detection of mood and anxiety disorders in primary care: a descriptive, cross-sectional study. *The primary care companion for CNS disorders, 13*(2), PCC.10m01013. https://doi.org/10.4088/PCC.10m01013.

Wang, X., Yan, C., Yang, P., Xia, Z., Cai, X., Wang, Y., ... Chan, R. C.K. (2024, March 1). Unveiling the potential of machine learning in schizophrenia diagnosis: A meta-analytic study of task-based neuroimaging data. *Psychiatry & Clinical Neurosciences, 78*(3), 157-168.