

The BMI and Mental Illness Nexus: A Machine Learning Approach

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Abstract— In this paper, we reveal the correlation between two seemingly unrelated topics which is BMI and Mental Illness using a Machine Learning approach. Body mass plays an important part for mental illness e.g., Depression and anxiety. It deals with a person's mass and height. A person's weight has a drastic effect on their lifestyle and health. Large valued BMI's are linked to all kinds of diseases ranging from diabetes to heart disease. Mental disorders and obesity are chronic conditions which need attention and care. This paper compares the relationship BMI has to mental diseases. We have used Machine learning algorithm to solve the problem concerned. To find the relationship between the features of our dataset, we performed Linear Regression. Here we tried to find the relationship between BMI and Mental Illness, depression more specifically. We also observed experimentally that the risk of a person who was overweight, obese or extremely obese to develop a psychiatric illness were 45-90 per cent higher than a person of average weight. We received an accuracy value of 0.690, after applying Linear Regression to the dataset. Using more sophisticated machine learning techniques would increase the precision. Experimental findings indicate that the method presented is almost equivalent to other state-of-the-art models.

Keywords—BMI, Mental Illness, Machine Learning, Linear Regression, Depression, Obesity.

I. INTRODUCTION

BMI stands for Body Mass Index. It is derived from the mass and height of a person. It is a convenient metric that decides whether a person is underweight, overweight, obese or normal.

The weight of a person drastically effects their lifestyle and health. Large valued BMI's are associated with all sorts of illnesses ranging from diabetes to heart disease. According to a report published by McKinsey Global Institute, 30% of the world population is obese or overweight. This number is likely to increase in the near future as life becomes more sedentary.

BMI is not just an indicator of physical health but also mental health. Studies show that most people who are obese

or overweight have some degree of depression or anxiety. If not checked, it may lead to serious illnesses in the future. This paper compares the relationship BMI has to mental diseases.

In a study done on the general population of 6 European countries, the results showed that, compared to individuals of normal weight, people who are obese were likely to have more mood swings or more than one mental disorder.

This holds true for children as well. Children who are depressed often had higher BMI's compared to children who weren't.

For many years, researchers were skeptical about the relationship between obesity and depression, but today it is well recognized that obesity can increase the risk of mental illnesses and vice versa.

Mental disorders and obesity are chronic conditions that require care and attention. Through this paper, we can predict the chances of a person suffering from a mental illness by looking at their BMI. Few studies have also shown that obesity is not a sure-fire way of predicting mental illness or depression. Keeping in mind some of the exceptions to this case, the majority can be assumed to follow this trend.

The cause of the relation might be due to several factors such as, but not only, fat-shaming and bullying. It has also been seen that this trend is pretty accurate in the Western countries compared to the rest of the world.

The relation also depends heavily on the gender and the age group of the people in question. In the UK, a study has shown that the percentage of obese children between the age of 2 and 15 has increased significantly since 1995. Childhood obesity is of great concern since the children who are obese have a 22-90% chance that they will be obese even as adults.

Other than mental disorders, obesity is also linked with several negative health issues such as Type 2 Diabetes, cardiovascular diseases, cancers and even death. Ethnicities also have an impact on this trend, but it is out of the scope of this paper.

The main reason for writing this paper is that Mental illnesses are prevalent all over the world. Knowing the underlying factor and related conditions of mental health, it will be easier to make the world a better place for people suffering from such ailments. The bidirectional relationship between these two factors can help physicians get to a conclusion and prescribe medications accordingly.

II. LITERATURE SURVEY

Reference [1] proposed a 3D CNN architecture for predicting Age, Memory and BMI from brain MRI images. The model predicts the mean values of all parameters. The use of Computer Vision in medical imaging for segmentation and classification are outlined. It validated a lot of architectures with varying number of layers and filters and finally chose a 5 layer 3D CNN which was the best performing one. After training the model, they generated heat-maps of the models.

Another paper that was published recently [2] also uses a few techniques of Computer Vision to predict the BMI of the person using images that are obtained from social media. Since most of the images were noisy, they had to manually clean the data and got a total of 4206 faces with all the relevant information. The BMI prediction system consisted of 2 stages namely: deep feature extraction and training a regression model. It proposed a novel face-to-BMI system whose performance was on par with human judgement. They also made the model to not assume the BMI based on race. Issues related to algorithmic bias and ethical considerations were discussed.

Experimentations with various multivariate regression algorithms and multi-layer perception feed forward artificial neural networks (MLPFFANN) have been done in one of the researches [3]. It says that the algorithm that uses 20 neurons in the hidden layer results in the lowest error after taking an average of 30 runs. It basically shows the machine learning approach for predicting the risk of weight gain in young people. The results obtained show a prediction accuracy of over 90%. The study involved the use of algorithms such as linear regression to carry out a comparative analysis of the accuracies of prediction. They also used Linear Support Vector Machines, Quadratic Support Vector Machines, Decision Trees and Ensemble algorithms.

A similar study has been done to predict the BMI of an individual through facial images [5]. The paper uses techniques like Convolution Neural Networks(CNN) and Artificial Neural Networks(ANN) to perform the study. The paper uses Viola-Jones Face detection algorithm for detecting only the facial features. The images were fed into a feature extraction model and then out into the Artificial Neural Networks (ANN) model. The evaluation metric used was Mean Absolute Error(MAE). The best performance was given by an XceptionNet model with an MAE value of 4.1.

The research papers discussed till now give us a clear picture on how to predict the BMI of a person by looking at various characteristics. But it does not, in fact, give us the idea of the relationship between the factors that this paper is talking about. We can use the methods outlined in the above papers to determine the BMI of a person if it is not provided directly in a dataset or if we have a dataset with different attributes. To study the affiliation between BMI and mental illnesses, we look further in the following papers.

The relationship between obesity and common mental disorders are clearly explained in this paper [4]. Obesity was found to be associated with the prevalence of mental disorders such as depression and anxiety. The analysis uses a cross sectional data from 7043 adults. Trained interviewers approached houses with eligible adults to collect information about their mental well-being. Logistic Regression was used to find out if there is any association between BMI and any mental disorder. They found that high BMI was strongly related to common mental disorders and that it varied with gender and age. The machine learning algorithms were executed in R language. It concludes that age and gender differences must be taken into account while investigating the link between BMI and mental disorders. The graphs of BMI vs Mental Disorder for men and women of different age groups were significantly different. In our paper, we are not taking into account the Gender or the Age group of the individual.

The Singapore Mental Health Study surveyed the residents of Singapore aged 18 and above to elucidate the association between BMI and mental disorders [6]. Their conclusions were unique and different from the ones reported from Western Countries. In their survey, they found three main ethnic groups in Singapore- Chinese, Malay and Indian. The survey took a year to complete and they collected data from all ethnicities and age groups. All the statistical analysis were performed using the SAS software system. Chi-square tests were used in the bivariate analysis and the Standard Errors(SE) and significance tests were estimated using the Taylor series linearization. Their results showed that the percentage of people who are either underweight or obese had either anxiety disorder, OCD or alcohol dependence compared to the people under the normal weight category.

This paper focuses mainly on statistical approaches to find the similarity whereas we are using a machine learning approach by utilizing linear regression. Also, we are not taking into account the ethnicity in this paper.

III. CORRELATION OF BMI WITH HEIGHT, WEIGHT AND MENTAL ILLNESS

The weight and height have a direct influence on the BMI of a person. The reason is that BMI accurately catches the connection somewhere in the range of weight and tallness, which infers that the slope of log weight regressed on log height, is 2. BMI isn't autonomous of height; weight doesn't generally change with the square of height; and the connection somewhere in the range of weight and tallness varies fundamentally among men and women.

Realizing your BMI can give you a thought of how sound your weight is. Athletes and individuals with a muscular body may have a BMI that would characterize them as overweight or obese, despite the fact that they are plainly fit. This is on the grounds that a BMI doesn't recognize what level of an individual's all out weight is made out of muscle and what rate is fat, as per the CDC. It's possible to be in a normal BMI range but still have an unhealthy amount of fat compared to lean muscle.

Body Mass Index (BMI) will in general be higher among shorter adults, particularly ladies. Regression investigation of $\log(\text{weight})$ on $\log(\text{height})$ uncovered that the inverse relationship among BMI and height was increasingly obvious in more older grown-ups and more strong in ladies than in men, with little change over schedule time.

In contrast to early youth, where taller kids will in fact have higher BMI, grown-ups, particularly ladies and older individuals, show a converse BMI–tallness affiliation. BMI is a heterogeneous measure of weight-for-height; tallness might be a significant and complex determinant of BMI direction over the course of life.

Now we shall cover the topic of the relationship between BMI and Mental Illness.

Epidemiologic information recommends a relationship among depression and obesity, yet discoveries change across studies and propose a more grounded relationship in ladies than men. Higher BMI is related with an around 25% expansion in chances of mood and anxiety issues and a roughly 25% lessening in chances of substance abuse issues. It was seen that there is huge positive relationship among obesity and a huge range of mood and anxiety disorders. Mood and anxiety issues each made free commitments to the risk of being obese and vice versa.

Studies have discovered depression to relate with the beginning of obesity and obesity to foresee the beginning of depression. On-going investigations have indicated that numerous instances of obesity are the aftereffects of such psychological sicknesses such as depression, nervousness, Post Traumatic Stress Disorder (PTSD), food bingeing disorder, and night eating syndrome. Patients who are anxious can be compulsive and eating compulsively and unreasonably adds to heftiness—making the behaviour extremely dangerous.

A common symptom in major depressive disorder is the change in appetite: the appetite of the person may increase or decrease, though more typical is an increase. Depression can result in diminished activity. The increase in cortisol levels represents the psychological perception that eating at night happens at different hours of stress. Many obese patients characterize breakfast hunger as being low to no. This may be a warning that they over-eat at night, since an irregular circadian rhythm characterizes sleep-eating syndrome.

Voraciously consuming food for the most part has all the earmarks of being more common than the well-established dietary problems bulimia nervosa and anorexia nervosa. It is likely an incessant, though steady, disorder as opposed to a transient abnormal eating pattern.

A few investigations have discovered that a disproportionate number of patients with dysfunctional behaviour are obese compared with everyone else. While paces of obesity are expanding internationally, with 39% of grown-ups overweight or obese, there gives off an impression of being a connection between mental disorders and high BMI. As per the World Health Organization, patients with a background marked by Attention Deficit/hyperactivity Disorder (ADHD) have a more prominent possibility of turning out to be obese. Furthermore, a Swedish report found that overweight or obese patients experienced depression as serious as those encountering chronic pain.

Depression and low self-confidence have been seen in obese patients around the globe, in any event, even when there has been no past history of psychological instability. Age and sexual orientation of a patient can decide the intensity of the connection between obesity and dysfunctional behaviour.

Drugs used to combat mental illness are one among the factors that clarifies why intellectually sick patients are at higher danger of obesity. The connection between psychiatric medication and stoutness might be because of the way that psychotropic drugs add to weight gain as well

as make changes in the sensitivity of the body to insulin. Weight adversely affects both physical and emotional wellness, and can prompt an all-out psychological sickness because of poor mental self –image and other physical ailments.

Close to half or 48 per cent of obese people have been diagnosed with depression, compared with the 22.5 per cent of normal weight and overweight people. This will be the basis of our experimental research.

IV. EXPERIMENTAL RESULTS

The data for this study was taken from Kaggle website. It is a collection of the height, weight and BMI index of 500 individuals. Later we have manually calculated the BMI value using the universal formula for it. We have also calculated the percentage of the likelihood of the individual to be diagnosed with a mental ailment. This relationship is obtained by referencing numerous papers and websites on the relation between BMI and various mental illnesses.

We have performed Linear Regression to find the relationship between the features of our dataset. We then compared the features that have a linear relationship and plotted them. Here we tried to find the relationship between BMI and Mental Illness, more specifically, depression and anxiety.

Linear Regression is a supervised machine learning algorithm where the anticipated output is continuous and has a consistent slope. It's utilized to foresee values inside a continuous range, (for example sales, price) as opposed to attempting to arrange them into classes (for example cat, dog). There are two sorts, Simple Linear Regression and Multivariable Linear Regression.

The formula for calculating simple linear regression is as follows:

$$y=mx+b$$

The formula for calculating multiple linear regression is as shown below:

$$f(x,y,z)=w_1x+w_2y+w_3z$$

In our experiment, we have used both these methods to find the correlating factors and their relationships graphically.

Regression Analysis, in general, is an incredible statistical strategy that permits you to analyse the connection between at least two factors of interest. While there are numerous kinds of Regression Analysis, at their core, they all look at

the impact of at least one independent factor on a dependent variable.

Regression Analysis is a dependable technique for recognizing which factors have an impact on a subject of interest. The process of playing out a regression permits you to confidently figure out which variables matter most, which components can be overlooked, and how these elements impact one another.

We have used Linear Regression as it is utilized to decide the degree to which there is a linear connection between a dependent variable and at least one independent variable. Simple Linear Regression is like correlation in that the objective is to quantify to what degree there is a direct connection between two factors. The significant contrast between the two is that correlation sees no difference amongst independent and dependent factors while linear regression does. Specifically, the purpose for linear regression is to "anticipate" or "predict" the value of the dependent variable based on the values of at least one independent factor.

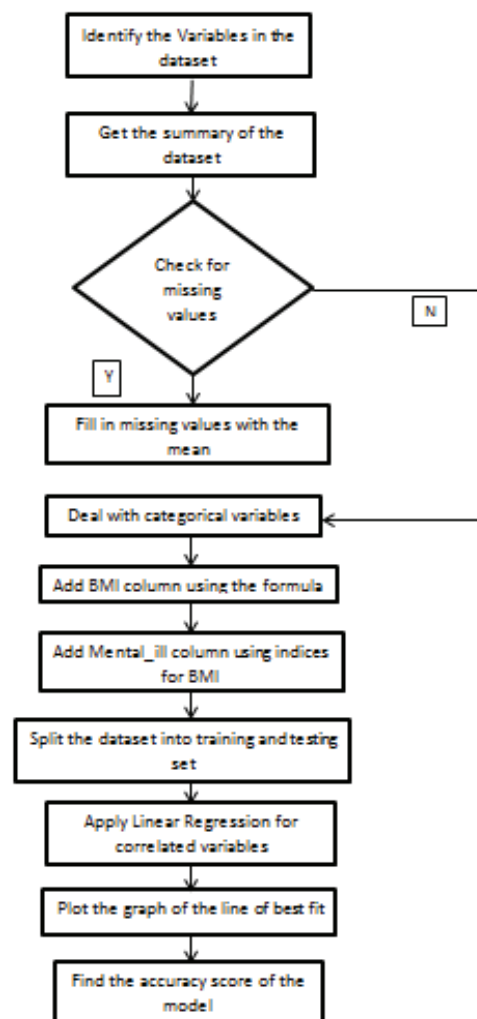


Fig 1: Steps in the methodology

In the dataset that we have used, the relationship between Height vs BMI, Weight vs BMI and a 3D graph of all three features are obtained. The graphs are as given below.

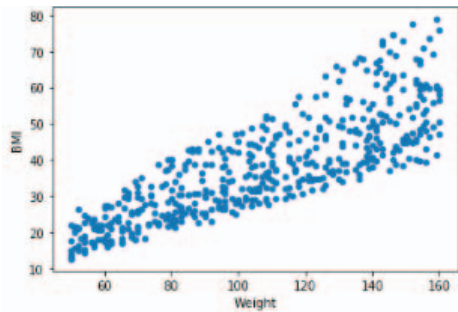


Fig 2: Weight vs BMI

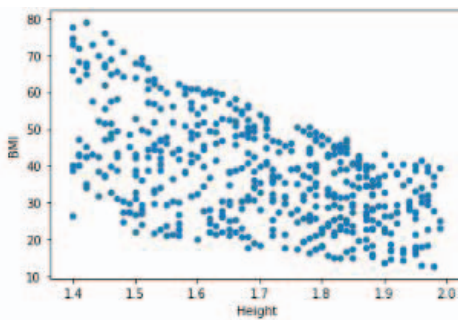


Fig 3 : Height vs BMI

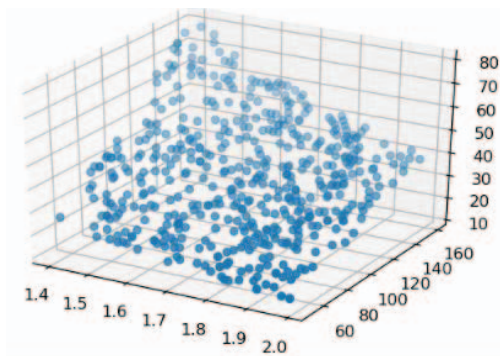


Fig 4: Weight vs Height vs BMI

From our research we have found out that there is a more profound relationship between BMI and Weight than BMI and Height and this is tallying with the graphs that we obtained to understand the dataset. To have a deeper understanding of this relationship, we have used linear regression and used a best fit line in the graph of Weight vs BMI. It is as shown in the figure.

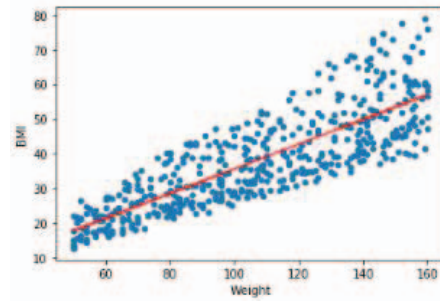


Fig 5: Line of Best fit

When we performed Linear Regression on BMI vs Weight, we got the accuracy score of 0.904. Accuracy is a metric to evaluate classification and regression models. The ideal accuracy is 1. The higher the accuracy score is, the more correct predictions the model would make. It also tells that the BMI has a 90.4% chance of increasing if the weight increases.

Now we move towards looking at the relationship between BMI and Mental Illness. The range of mental illnesses have not been taken into account. Mental illnesses are so varied and diagnosing each disorder changes with the other. Our experiment only deals with predicting whether a person will have a mental illness or not. Predicting the type of mental disorder is beyond the scope of this paper.

We have found experimentally that the chances of a person who is overweight, obese or severely obese to get a mental disorder is 45-90% higher compared to a person with normal weight. The graph below shows the relationship between BMI and Mental Illness. The highest value is capped at a BMI of 37 and hence the predictions for BMI's that is higher than this value would not be very accurate. But it still gives an idea of the relationship.

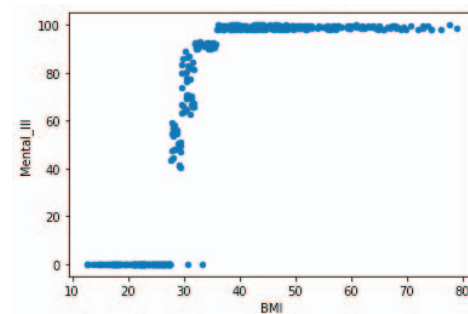


Fig 6: BMI vs Mental Illness

The graph below shows the relationship between BMI, Mental Illness and weight. As we have seen before, there is a clear linear relationship between BMI and weight. So we can take the liberty to get to this graph. This graph has a linear connection as well.

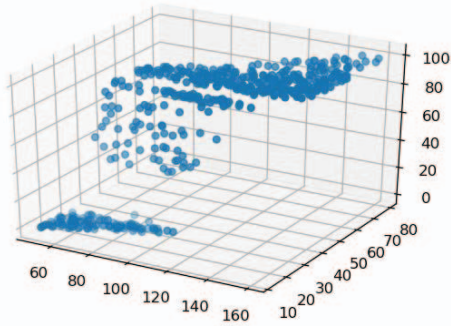


Fig 7: Weight vs BMI vs Mental Illness

After applying Linear Regression on the dataset, we obtained an accuracy score of 0.690. This means the accuracy of the prediction done by the model is 69%. This accuracy can be increased by using more advanced machine learning algorithms.

V. CONCLUSION AND FUTURE SCOPE

By all counts, and with proven results, we found out that there is a relation between the BMI of a person and mental illness. Obesity is linked to increased rates of mental disorders, in particular anxiety disorders and depression. In this paper, we designed a model using linear regression.

Compared to the other models this one gave an accuracy rate of 0.690 that is 69%. While analysing the association between BMI and mental health, we found that this analysis illustrates the significance of understanding the nature of mental condition, prevalence level, height and weight.

Its main benefaction is to provide you information about how BMI is related to mental illness. In the future this can be made more accurate by using complicated and advanced algorithms. The correlation between obesity and depression is important and bidirectional. This relationship can help psychiatrists easily find the underlying causes for mental disorders and for dieticians to discover the actual reason for obesity and other eating illnesses.

VI. REFERENCES

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