Multi-Factor Based Stroke Risk Analysis

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Abstract
This research study aims to understand various factors such as health conditions, work type, marriage status, smoking status, age and other factors on the risk of someone having a stroke. This research study uses T Tests and 95% Confidence intervals based on binary factors to analyze risk of strokes, and using T Tests and intervals to compare among groups. However, when there were range based variables such as age and glucose level, what was done was that there were bar graphs to compare among age ranges for risk of stroke or glucose ranges, or BMI ranges as well. What was seen was that marriage, and work type were unexpectedly strong predictors to predict stroke risk, while heart disease and smoking again showed themselves to be strong predictors as well. Additionally, what was seen was that there was an influence of age and corresponding factors to certain factors as well that could skew data, such as heart disease and age being correlated and thus skewing results, or even with work type, older people being in certain sectors which could skew risks of stroke. However, in total, this paper examines precedents of stroke risk factors, and sees their actuality, while also seeing unexpected results as well with other factors.

1. Hypothesis

Null Hypothesis**:** None of the variables will be connected to stroke risk

Alternative Hypothesis: All of the variables will be connected to stroke risk

2. Introduction

Stroke is, according to "Stroke Facts," a leading cause of death for Americans, as it is the third leading cause of death behind cardiovascular disease and cancer. Every single year, 1 in 6 deaths from the over 700,000 people that die of heart disease are from strokes, and that is just heart disease-related; more are not from heart disease. Every 3 minutes and 11 seconds, one person dies from a stroke in the country, and 800,000 people every year get strokes, and 87% of strokes are caused by blocking blood flow to the brain, and strokes have serious consequences. Strokes can lead to a loss of movement and sensation, loss of control over speech and thinking, cognitive impairment, or loss of reasoning, memory, and vision, as well as paralysis or inability to perform certain functions, such as seeing or remembering. Additionally, if oxygen can't get through the vessels fast enough, someone can die as well from a stroke. In the cerebellum, if a stroke happens, people may lose balance, become dizzy, have frequent migraines, experience nausea and vomiting, and lose the ability to walk. In the brain stem, it can lead to breathing and heart function problems, problems with body temperature, balance and coordination issues, weakness, paralysis, trouble performing daily functions like eating and speaking, loss of vision, or even comas or worse death. This is extremely problematic, as over 200,000 people per year die of a stroke. However, strokes can be indeed predicted and preventable and what can be used is data and machine learning on traits and aspects of patients such as heart disease, hypertension and smoking and diabetes obviously. However other habits as well can hint at strokes, such bas marital status, where someone lives, gender, or even employment types and age, and this will be explored, and we will conduct statistical analysis tests and as a result predict the risk of stroke through the use of statistical analysis, such as the T test methodology, chi square test methodology for classes like marital status or gender, and other analysis methods such as bar graph visualization and analysis for factors of stroke and traits. Thus, this paper will be able to possibly help those who view it learn more about stroke prevention beyond just what is normal to understand This paper will have an intro, methodology that will detail CRAAP test and the use of different statistical test, a literature review with factors in dataset and stroke connection, and then data with analysis of various statistical tests of T Tests, and use bars for range based variables.

3. Literature Review

Next is the literature review, which will feature multiple factors, including the connection between gender, age, BMI, glucose level, hypertension, heart disease, marital status, work type, residence, and smoking status. We will analyze this through a literature review and multiple sources to understand how they can predict stroke rates and identify connections.

Gender had been seen in multiple research reports to be a causative factor for stroke mortality and in general stroke incidence, Overall, what have been seen is that according to ("About Women and Stroke"), stroke has been the leading cause of death for women, and 1 in 5 women form age 55-75 have a stroke, and this is due to the fact with age, stroke risk is proven to increase, and stroke risk for women is higher due to the fact that they live longer than men on average. Additionally, women have been proven to have a higher risk of other types of risks that cause strokes, which are hypertension, of which women, on average 40% blood pressure of 130/80 mmHg or take medication for blood pressure, and only ¼ of women with hypertension have their blood pressure controlled to less than 130/80. They also have higher blood pressure and a risk of blockages that start during pregnancy when they have elevated blood pressure. Next off, 1 in 9 women smoke as well, which also increases blood pressure, especially when combined with birth control medication. According to Abdu and Seyoum, men have a higher risk of stroke, roughly 3 times more likely to get a stroke before 50, and this is due to the higher proportion of men who end up smoking, drinking, and having high cholesterol. As 36% of men on average smoke, globally, versus 7% of women, and smoking is 5 times more likely in men, smoking is known to increase blood pressure and, as a result, weaken the vessels and possibly cause blockages in the brain. Also, in men, alcohol use is more common, as stated in the paper, and that causes a higher risk of stroke. Alcohol is proven to increase stroke risk by 1.6x in men, and alcohol causes this as it causes vasodilatation and increases corticosteroids and catecholamines, which leads to elevated systolic and diastolic blood pressure, and hypertension, which harms and narrows blood vessels even further, and thus causes the risk of ischemic stroke. Next off for men as well, they have a higher risk due to prevalent higher cholesterol levels, and women's risk increases after 50, but don't exceed them till later on. Before 50 men tended to as well have 3x chance of stroke due to their much higher LDL cholesterol levels,which are correlated to atherosclerosis which causes ischemic stroke due to blockages, and also with women they get increase stroke risk post menopause and is mainly after 55-75 range due to loss of estrogen as it increases HDL and lowers LDL which prevents strokes, but when that goes away that increases stroke risk. However, after 55, women tend to have a higher risk than men, and this persists through the ages of 55-75, with 1 in 5 women, as previously stated, and(Seshadri et al.) stating that one in 6 men has it between these ages. And for women, as stated, their risk dramatically goes up because they also have a higher chance of AFib compared to men, and they also don't often get anticoagulants as well, less often than men, which also increases the risk of strokes. In general, for women, high alcohol consumption increases the risk of stroke by 2.3 times compared to 1.6 times for men, and women with high cholesterol, under 60, had an ischemic stroke rate risk increase by 2.3x. Women over 65 have a higher hypertension rate than men, and they also get lower prescriptions of antihypertensives, which causes a higher risk of ischemic and hemorrhagic strokes. This is due to the higher risk of hypertension. And also, women and men have equal risk of diabetes according to the paper. However, women have higher consequences due to possible sex pathophysiological mechanisms such as endothelial function and inflammatory response and lipid abnormalities more prevalent in women and also less treatment prescribed, and other rush factors like hypertension and smiling cause higher risk of stroke in women than men and are worse on women like women who smoked had a 25% chance jiger for strokes than men who did so. Additionally, for women, they have been proven to (Ospel et al.), women, on average, receive less thrombolysis to prevent ischemic stroke as they are more likely to live alone. They are also seen to not be as much of a candidate as men for procedures or even unrelated to this heavier medication, more invasive amounts. Also, they have a higher risk of Atrial fibrillation, which causes strokes more and also disqualifies many for tpA.However, for Endovascular clot removal, these tended to be similar among both women and men in use.BUt women have on average less long hospital stays and less rehab despite more severe stroke, due to likely their age where clinicians who may see older or poor pre store health or older age will be less aggressive on ace ad les invasive treatments which will likely harm them in the long run and cause more stroke rates or even with prevention this applies as well. And also for women, the paper states that a stroke is harder to diagnose due to stroke mimics, which can sometimes be predicted rather than an actual stroke.

Age has additionally been known to link to stroke. A summary of the literature reveals a positive correlation between age and stroke risk. First off, according to (Yousufuddin and Young), stroke and age have an undeniable correlation, and incidences of stroke average double each decade after the age of 55, and 75% of strokes happen to people aged 65 or older. This is because, with age, arterial stiffness often increases, leading to hypertension and structural damage to the vessel. The stiffness arises from a loss of arterial elasticity, collagen cross-linking, and an increased amount of calcium and plaque in the arteries. Furthermore, oxidative stress grows as age goes up, which damages vascular DNA, consequently, and thus harms arteries and makes them weaker, causing atherosclerosis and impairing endothelial function, and this also allows for thrombosis to form as well/ Additionally, mitochondrial dysfunction and decreased nitric oxide exacerbate this, which causes an increased chance of ischemia. Additionally, (Kelly-Hayes) states that the chance of stroke doubles with each decade after 45; however, with people over 65 being a vast majority of the stroke cases in America, more than 70%, and also this article stated that blood pressure, reduction in physical activity, and increased vascular inflammation causes the ruptures of plaque due to pressure and weaker vessels and then also causing endothelial damage which then causes problems with blood flow and ischemic stroke as a result. Additionally, behavioral factors as well can reduce the risk of stroke that is often associated with age, such as lower physical activity and insulin resistance. For adults, exercise was able to reduce stroke risk by 20% for moderately active individuals and 27% for highly active individuals, thus showing that lifestyle factors also impact stroke risk in older adults. Furthermore, (Kokaia) and (Martinez-Curie) support the previous two papers, while stating that the stroke risk doubles every decade after 1945. In contrast, 70% or above of strokes occur in people over 65 years of age, and this is based on biological changes that occur with age. The specific changes are the endothelial damage caused by hypertension. Additionally, endothelial dysfunction, oxidative stress, and plaque accumulation restrict blood flow and increase the risk of vessel blockage in the brain. Also circulation decreases as people age, which means that if they experience an ischemic event, they are more likely to be unable to reperfuse the blood, resulting in a lack of blood flow to the brain. Additionally, the blood-brain barrier becomes more permeable with age, allowing toxic substances to enter the brain as well. Also, hypertension affects over 70% of those over 65. It causes vascular damage directly and plaque rupture and arterial fibrillation as well as a 23.5% increased risk of stroke in people with it before age 80. That allows clot formation in the atria, and high cholesterol and higher blood sugar levels, which often come with age, can cause atherosclerosis and thrombus formation. Furthermore, according to Kokaia and Martinez-Curiel, with age, advanced glycation end products arise. Essentially, these are products formed by proteins and lipids that have undergone glycation. When they bind to their receptor, known as RAGE, they trigger the expression of inflammatory genes and the production of reactive oxygen species, which damage blood vessels by damaging their DNA. As a result, the vessels will likely become damaged.

Heart disease is another critical factor that comes with stroke as a possible result if one has it, a correlated and causative factor. One such study is (Adelborg et al.), stating that 1 year stroke risk for heart failure patients was 1.4% (95% Ci: 1.1-1.7%) and 5 year was 3.9% with a 95% CI (95% CI 3.2% to 4.7%) an these 2 for ischemic stroke, for intracerebral hemorrhage it was 0.5% risk 5 years (95% CI: 0.3%-0.8%) and hazard ratio was (95% CI: 1.67-2.96). Additionally, according to (Alshehri), around 10-12% of strokes, which is 70,000 strokes a year, are caused by atrial fibrillation alone, excluding other arrhythmias, and for AFIb chance of stroke increases 1-20% per person to have a stroke based on individual risk factors, such as age and other heart diseases and hypertension and length of afib as well accelerating risk of stroke. Next off, according to (Sobiczewski et al.), when studying 1183 symptomatic CAD patients without a prior stroke, they discovered 50 strokes, 43 ischemic, and seven hemorrhagic, and 4.2% stroke incidence cumulative over the 7 years of the study. No significant CAD had a 2% risk of stroke (8 out of 335), single vessel disease was 4% (11/293), and multi-vessel disease was 6% (31/555), with $p < 0.02$ for no CAD versus multi-vessel disease. When adjusted for sex, age, cholesterol, medications, and systolic blood pressure, patients with multi-vessel CAD have an 80% higher risk of stroke compared to those without CAD (95% CI 1.03-3.43; HR: 1.8). 64% of strokes in the study occurred within 5 years of CAD diagnosis, and the mean time from enrollment to stroke was 3.7 years for those with strokes. 43 out of 50 strokes were ischemic, and 42% due to small vessel occlusion 23% due to large vessel atherosclerosis, and 35% were undetermined. 7 out of 50 were hemorrhagic. And despite treatments of 89% receiving aspirin, 83% beta blockers, 78% ACE inhibitors, they still had an 80% adjusted risk and a nearly 200% total risk of stroke compared to no CAD, showing that CAD causes stroke risk to go up significantly, and this has also proven to be causative.

Blood sugar levels are also a very concerning risk. However, various connections need to be considered. It is also important to note that blood sugar levels are connected to stroke and cause it, which is known. However, there is also some confusion, as people of older ages, 65 and older, usually have higher blood sugar levels, while also having other factors that can cause strokes as well. So, there is confounding, but still, blood sugar has a causal effect on stroke. First off, according to (Kokaia and Martinez-Curiel), often people with high blood sugar levels, especially those with Type 2 diabetes and older adults, mainly, stroke risk goes up significantly due to vascular damage. High glucose levels lead to endothelial dysfunction by inducing oxidative stress and reducing nitric oxide availability, thereby impairing vasodilation and promoting plaque formation. Over time, this causes weakened vessels and atherosclerosis, where plaques narrow cerebral arteries, predisposing them to rupture or clot formation. Additionally, hypernephronia is common among older people and diabetics, which is critical to consider, as then the plaque may rupture as well, which then causes a stroke. Overall, it is essential to recognize that multiple factors contribute to a stroke. With increased blood sugar levels, advanced glycation end products arise, and essentially those are products formed by proteins and lipids that have gone through glycation, and when they bind to their receptor known as RAGE, they trigger inflammatory gene expression and Reactive Oxygen Species production, which damages blood vessels by damaging their DNA, and vessels will then likely have, and this causes strokes to occur. And that is because plaque forms more easily in these vessels, and they get damaged. This is more common in older adults, so as a result, they are more likely to have hypertension, and this increases the chance of rupture of the plaque. Additionally, a meta-analysis by (Mosenzon et al.), published in Diabetes, Obesity and Metabolism, covered over 64 studies involving more than 775,000 people and found that people with Type 2 diabetes had a 76% higher risk of stroke (Ratio 176, 95% CI 1.65-1.87) compared to non diabetes. Stroke risk was much higher than ischemic stroke, with a hazard ratio of 2.27, doubling the risk, and this is due to hyperglycemia, which damages blood vessels.. High blood glucose levels cause oxidative stress, which damages the endothelium of arteries and reduces nitric oxide production, a critical factor in vessel relaxation. Over time, this leads to endothelial dysfunction and ultimately results in atherosclerosis. While also sugar levels going up in the bloodstream causes AGE formation which stiffens blood vessels and binds to RAGE on vascular and immune cells, which causes plaque instability due to inflammation and also that causes vessels to increase chance of rupture and this also is happening mainly with older people as they often will have a higher risk of high blood sugar and generally weaker vessels, and then coupled with this, that causes immensely increased risk of stroke. And also diabetics then have narrower arteries and are also more likely to be fragile and be pro-thrombotic. And also, each year with diabetes, according to the article, stroke risk increases by 3%, and for 10 years it triples. Explaining through these facts and findings why stroke risk increases with blood sugar levels. Also, blood sugar levels tend to be higher in older people, who often have hypertension and other conditions that will also affect the risk of stroke, so as a result, there may be confounding as well.

Additionally, there is another factor that is critical to consider among the risks of strokes. The marital status of someone has been proven in multiple studies to be able to aid in the prediction of stroke risk. One such example is (Andersen and Olsen), a study following 58,847. Adults aged 40+, the study learned that divorced people had a 23% higher chance of stroke compared to people who were married. And the risk of stroke per 1000 people was 1.96 for married people, 1.52 for non married, 2.36 per divorced and 5.43 for widowed, this study has also stated that divorced risk of stroke was 1.23 ratio compared to married, 95% CI of 1.19-1.27 and unmarried men had 95% CI 1.03 to 1.11 range with a point estimate of 1.07. But unmarried women showed a 0.97 RR value and a 95% CI of 0.97 to 1.03 for stroke risk. But overall, on average, when one sees a large sample of people excluding gender, just overall in the data, married people have a significantly higher chance of stroke compared to unmarried people. Additionally, (Maselko et al., "The Intersection of Sex, Marital Status, and Cardiovascular Risk Factors in Shaping Stroke Incidence: Results From the Health and Retirement Study") actually has found that never married when adjusted to sex and other factors like financial resources or socioeconomic factors, being never married or widowed had higher risk of stroke, and widowed can be likely attributed to age, and in studies data it was every married yes or no, so widowed counted under the married portion, thus that may skew the data to seem as if married individuals have increased stroke risk. However, on average, as seen in the studies, being married correlates with a slightly lower risk of stroke, with an average prevalence ratio of 1.03-1.11 (95% CI) and a point estimate of 1.07, indicating a 7% increase; however, the 95% CI range was 3-11%. However, divorced and unmarried individuals faced even higher risks. Furthermore, marital transitions have actual in(Honjo et al.) proven to increase stroke risk significantly, and that may skew the risk of stroke in this dataset for this study on stroke risk and factors, What was seen in this study in 90,000 Japanese adults (40-69) was that 20-30% increased stroke risk hemorrhagic stroke during a transition in a marriage such as being married to divorced or widowed, and those were seen in one of the studies here to have a 2.36 per 1000 and 5.43 per 1000 value for stroke risk as well for adult aged 40 or above. This is due to increased stress levels and vascular inflammation, along with higher blood pressure, which can cause a vascular rupture and thus hemorrhagic stroke. Additionally, for a divorced or widowed group, median and mean ages would be significantly higher, thus the stroke risk will be higher as a result. Showing that this is more of a correlation than a causation.

Hypertension is also another thing connected to stroke, and it has actually been proven to be a causative factor for strokes. According to (Hörnsten et al.), in adults aged five and older with higher SBP over 160 had a hazard ratio of 1.19 with a 95% CI of 1.08-1.30 per 10 mmHg increase and SBP elevation was not associated with higher stroke risk if under 140 mmHg and DBP at least 90 mmHg had a hazard ratio of 2.45 and 95% CI 1.47-4.08 and 160 mmHg and above vs under 140 had a hazard ratio of 2.8 and a 95% CI of 1.53-5.14. This is due to the fact that high blood pressure (SBP systolic) increases arterial stiffness, damages the endothelium, and creates microvascular degeneration, which then will cause a higher risk of hemorrhagic and ischemic stroke.

Next off is residence, as that crucially connects to one's risk of stroke. First off, according to (Sealy-Jefferson et al.), a study of 30,000 USA adults aged 45+ showed that people living in rural areas had a 30% higher chance of stroke, even when adjusted for age, sex, and race. This is due to the fact that, on average, according to the authors, there was poorer hypertension control, higher diabetes risk, and lower control of it and smoking, and reduced primary care access in rural areas. This was not a causative connection; that was because rural areas had a higher chance of known risk factors like smoking or diabetes. Next off, another study was using 512,715 Chinese adults and analyzing their profiles and found that rural residents had a 20% higher risk of stroke compared to urban residents, despite adjustments to lifestyle socioeconomic status, and comorbidities, rural living had a significantly higher risk of stroke, as rural areas had higher emergency response wait times and poorer delays in blood pressure management and poorer access to care which then increased stroke risk in these areas as stated by the authors. Also, from 2015 to 2020, the rural risk of stroke increased by 12.9% while the urban risk of stroke decreased by 15.5% regarding ischemic stroke. Their study also pointed out that "The rural and urban ASMRs of intracerebral hemorrhage decreased by 24.9% and 27.4%, and those of subarachnoid hemorrhage decreased by 29.5% and 40.4%, respectively." As a result, hemorrhagic stroke decreased in both regions, although the urban region had nearly an 11% higher decrease in risk. In conclusion, this higher risk in rural areas is due to factors of stroke that get amplified because of rural living. According to (Mukaz et al.), risk ratio for hypertension on a 95% CI was [95% CI 1.11-1.42, 1.25] for hypertension, [95% CI 0.99-1.33, 1.15] for diabetes, for heart disease [95% CI 1.02-1.39, 1.19], and those were the main factors of heart disease used in this study, and thus shows why strokes are more common in rural areas

According to (Luo et al.), smoking and stroke risk have an extremely strong correlation, where in 25 prospective studies involving 3.7 million participants, the risk of stroke for smokers was 90% higher than the non-smoker risk ratio, and the 95% CI showed it was anywhere from 55%-134% higher risks. Even lighter smoking of 5 cigarettes a day increased stroke odds by 44% and grew higher based on the level of smoking. And research has even found that stroke risk decreased significantly post quitting, subsiding to near non-smoker levels 3-5 years later. Early showing a causal relationship. Smoking causes damage to blood vessels through endothelial dysfunction, which in turn raises blood pressure and promotes vessel narrowing and blood clotting. It also has proven to increase inflammation and oxidative stress, which causes strokes as well. Additionally, according to (Wang et al.), a study using NHAES data cross-sectionally from 9176 USA adults found that smokers with higher nicotine exposure had 2.64 times higher odds of stroke compared to non-smokers (PE: 2.64, 95% CI: 1.51-4.61) vs non-smokers Other smoke components like carbon monoxide and tar showed that they elevated stroke risk, but slightly, and also the study also found that higher biochemical exposures not just smoking alone resulted in higher stroke risk. This is due to the neurovascular inflammation, narrowing of the arteries, and blood clots formed, caused by smoking and atherosclerosis. And stroke is proven to be caused by smoking, not just correlation alone. Additionally, higher blood pressure caused by smoking causes a higher risk of thrombus formation and clot and plaque rupture, which causes ischemic stroke.

BMI is another factor considered in the evaluation of strokes. One such article detailing its importance is (Kroll et al.), where it was stated when studying 1.3 middle aged women in the United Kingdom following them for more ret than a decade and the study stratified BMI in 5kg/m^2 increments and used PIssion regression to calculate relative risk for ischemic stroke intracerebral hemorrhage and subarachnoid hemorrhage and BMI and stroke type relationship was important as for ischemic stroke every 5 kg for body mass was 21% higher on average risk of ischemic stroke (RR: 1.21; 95% CI 1.18-1.23; p<0.0001) and this is due to the pathophysiological role of obesity in atherosclerosis l systemic inflammation, and insulin resistance. But for intracerebral hemorrhage, it was inverse, surprisingly, for every 5kg/m^2 rise in BMI, the risk of intracerebral hemorrhage was down by 11%(RR=0.89; 95% CI:0.86-0.92; p<0.0001). Researchers of this paper posited that a higher BMI may be protective against intracerebral vessel wall integrity or reflect systemic volume status. Additionally, subarachnoid hemorrhage has no association, meaning these conditions are rather independent of each other, such as BMI. This shows that based on strokes, BMI may be connected to strokes in a different way, but mainly the most noticeable stroke connection is ischemic, and this is due to the connection with atherosclerosis likely because obesity has been proven to accelerate atherosclerosis processes, which cause strokes, and also growing BMI is correlated often with habits that cause atherosclerosis and also inactivity which is proven to cause vessels to have higher risk of blockages and narrowing, causing risk of stroke. Additionally, age may play a part, due to the fact that as people age, the risk of unhealthy levels of BMI do go up, which also may coincide with other factors that cause strokes as well such as increased rates of atherosclerosis and blood sugar and hypertension, so that as a result may coincide with age and these factors, being correlated with strokes even more as a result. Furthermore, according to (Wei et al.), through the proportional hazards model and a Chinese cohort of 12,161 people aged 45 and older developing non linear models in stroke risk what was seen that on the population, a

1kg/m^2 increase in BMI was associated with a 2.5% increase in stroke risk (HR:1.025;95% CI 1.01-1.04) but this relationship varied based on baseline BMI. A key inflection point was observed at 26.6 kg/m^2. Below this threshold, there was a 4.4% increase per 1 kg (HR = 1.044), suggesting that individuals with leaner BMI levels may be generally more vulnerable. However, the risk above 26.6% did not change significantly for every 1 kg/m^2 increase. However, generally, ischemic strokes, which are over 75% of strokes, are very closely associated with BKI and increase due to it. When considering gender as well under 25.94 BMI, it was a 7.6% increase per 1kg below 25.94 (HR: 1.076; 95% CI 1.034-1.119) and for women, more linear at (HR= 1.021;95% CI 1.002-1.040), much more consistent for women as well and men was nonlinear correlation. Additionally, it is important to note that BMI coincides with other factors like atherosclerotic and other poor habits, such as smoking and poorer habits in general.

Work status actually may correlate with stroke rates, According to (Toivanen et al.), self employed risk ratio compared to employees was (IRR: 1.71; 95% CI: 1.60-1.83) and LLC owners (1.67;95% CI 1.52–1.83), no significant difference was in these groups after adjusting for gender age and country of origin, but the reason for self employed being higher was likely due to age due to business owners on average likely being older on average compared to those who are employed. And this is only an association now, with the accusative factor likely, and age may also be a reason. Also, self-employed people, on average, have higher stress, a higher risk of irregular hours, and a lack of career stability, which may slightly contribute to higher BP levels and a higher risk of stroke. However, it is not considered statistically significant in general as a difference when all is adjusted either way, as seen in the statistics of the study. However, according to Harvard (Salamon), an analysis of 4,624 US women showed that self employed people had a 34% reduced risk of obesity and 43% for hypertension reduction even after adjusting for healthcare access, thus showing that there is a correlation to stroke factors and work status, for which shows that self employment ma have a chance at stroke risk prediction.

4. Methodology

This research project implemented a multi-stage methodology to examine stroke prevalence across multiple demographic, clinical, and behavioral dimensions and lifestyle factors. The data used originated from public data for strokes or no stroke basic machine learning training data, and it included categorical and continuous variables, some known to be connected with strokes and others not very. This methodology was driven by statistical rules and public health research methodology standards, aiming to evaluate specific factors and their relationship to stroke occurrence through both raw categorization differentiation and binary comparison. It utilized the T-test, bar graphs, and other methodologies to assess connections between factors and strokes. This dataset included patient histories of over 11,500 patients, encompassing variables such as sex, glucose levels, body mass index, work type, and employment structure, which included marital status, residence type, smoking status, hypertension status, and heart disease. Some variables had multiple categories. For example, smoking was categorized as current, former, and never. Although these options were not analyzed in this manner, a binary variable was also used to distinguish between those who smoked at all and those who did not. Each observation included the person's data and a binary indicator for whether they had a stroke. The entire dataset was then analyzed for frequencies across classes. Prior to any statistical competitions and testing, the data had been pre-processed, and the missing values in the BMI and smoking status were removed and identified, and not computed into the data. This wasn't an issue, as for every single class or category of a variable, there were over 30 people, so bias wasn't an issue. The data had been tested in multiple ways, one of which was non-binary using all the categories and then another which was using binary for variables in the categories where were two and then they were compared for simplicity, just to see between if presences or not of certain variables could be able to correlate ton if someone has a stroke or not, and basically yes for a variable meant one and no meant 0. For example, the gender categories were Male, Female, and Other, but they were transformed into Male at one and Female at 0. Also, there were smoking status categories which had former smoker, current smoker, unknown, and then never smoked, which just became smoke (1) or no smoke (0), and excluded unknown. Then work type as well had employed person (1) and non-employed by someone or working for oneself (0). This was also in the dataset. Ever married, heart disease, and hypertension were already 0 for a no and 1 for a yes. There would be testing to determine the importance of these variables and their connection to strokes. Additionally, levels were critical, as they helped identify advancements in certain groups.

Next off is statistical estimates, which we did use 95% Confidence intervals to look for the true mean proportion of people who had a stroke under certain factors to see if there was a connection between that factor, and basically the formula for that was as follows:

$$CI = \hat{p} \pm z^* \cdot \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

Figure 1

Z will equal 1.96 here.This allows for an interval estimate, a point estimate, and then a certain margin of error that the true mean proportion could vary from. These ones were only done for the binary, as well as it would be extremely complex to do across multiple beyond two groups for certain variables. A T Test was also conducted to examine the proportions. Two-sample t-tests were used to determine if there was any true mean proportion difference between the two groups and categories for the variables. Each got a T statistic and a certain p value, and the conventional 0.05 alpha value was used, and if it was under .05 then there was a difference in proportion of stroke patients per group and then the example of significant findings could include finding a statistically significant difference married and non marries under 0;05 for stroke rates or with heart disease, etc. And for T Tets, the main conditions were met. Less than 10% of the population for that category was used; there was a large sample size, and there was an appropriate measurement level.

Beyond binary comparisons, categorical variables with multiple levels would be analyzed to explain more nuanced patterns. Smoking status and work type had their original categories for specific summaries because they allowed for more in-depth visualizations of what truly happened within datasets or what caused averages for certain things to be much higher than others, and how each subcategory affects the statistics for the category of variables itself. And it could help reduce stroke risk among certain subgroups. For continuous variables such as age, glucose levels on average BMI data would be binned into fixed width intervals to facilitate the visualization and the partition based inference and this was divided into deciles (0-10, 10-20, etc.) for age and average glucose would be bins of 25 mg/dL and that ranged form 50-300 and then BMI would be 5 unit intervals and this binning strategy allowed the detection fo non linear relationships and threshold effects and bars of stroke portions across the bins showed large upwards and other such trends that will later be discussed. And mainly with age and glucose levels, as well as a connection to stroke at a higher frequency. The graphs were further structured as they should be, as they were titled, labelled appropriately on the axes, and they were scaled correctly and had a baseline at 0.

The methodological foundation of this analysis ensures adherence to statistical principles, including the use of t-tests. Additionally, the researchers made a concerted effort to follow academic guidelines, limiting bias in the study's data. The main things that were verified in this for hypothesis tests in that there were 10% condition fulfilled to assure independence randomly selected sample it was randomly selected form a group of people as stated in the source of the dataset and there was 10% of the humans of the USA in this for each category of variables and then the formula for large counts was met for each fo these categories. $n*p>=10$ & $n*(1-p)>=10$ were both met here. In addition to statistical and computational rigor, the reliability of the datasets and all their sources was evaluated using the CRAAP testing methodology. The CRAAP test is the standardized framework for evaluating source credibility in academic research and currency was verified by noting that the dataset was uploaded within the past 5-10 years and have current trends in stroke rates and epidemiology and pertains to those reeds and to assure that sources are rather uploaded in the last 5-10 years as well and pertain to stroke epidemiology. Relevance is determined by examining the research question and then the dataset structure and content, which specify the factors and tasks. Additionally, it will assess the relevance of articles by examining their importance and how they relate to factors in the datasets and stroke. And then the authority, as established, was a Kaggle dataset. Then, the accuracy and sources of this information will be compared to other sources as well. Authority is also critical, so it is essential to ensure that PhDs and doctors, such as physicians and other healthcare providers author the research papers. Additionally, verifying that these papers come from reputable research journals is crucial. For this purpose, these articles will serve as academic resources, helping to educate the people here.

In conclusion, the methodology for this stroke risk analysis paper rests on a foundation of statistical principles, data preparation, and thorough variable designs. By employing binary and full approaches, along with tests and bar graphs based on ranges statistical analysis, this study aims to comprehensively understand multiple factors that are currently and not yet fully understood regarding strokes. And it can also discover connections between scientific variables and the likelihood of increasing stroke risk. This visual analysis not only enhanced interestability but also demonstrated the soundness of the approach. Furthermore, a comprehensive methodology revealed possible methods that can be retained or utilized in future health outcomes and studies.

5. Data & Data Analysis

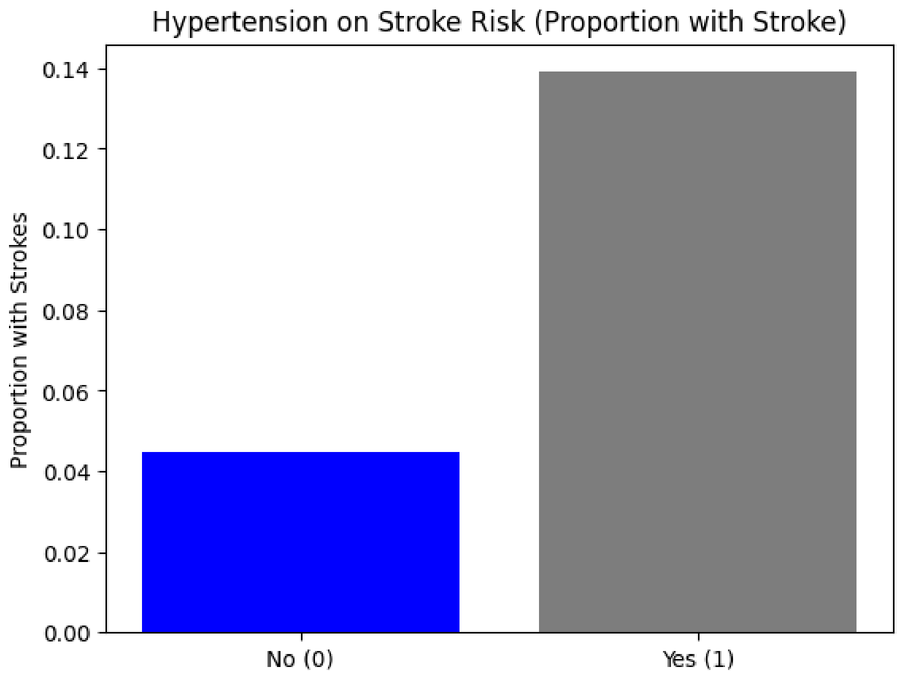

Figure 2

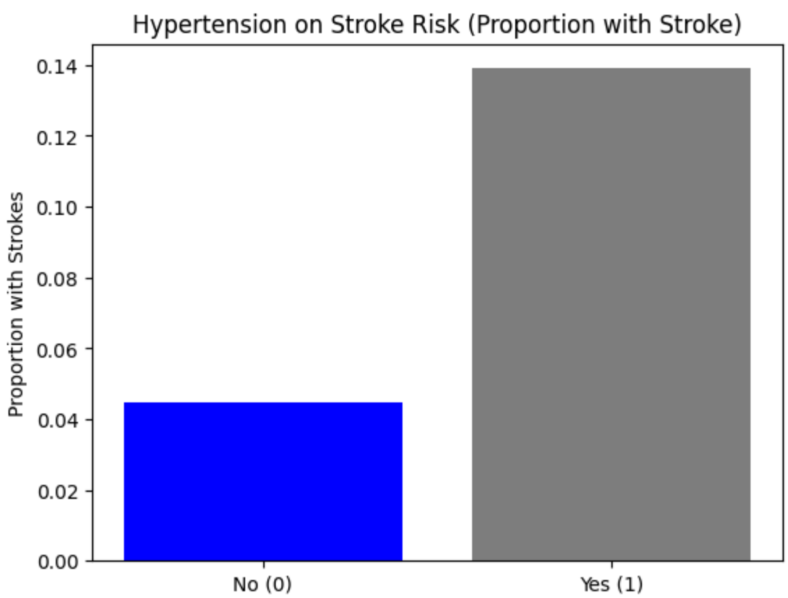

Figure 3

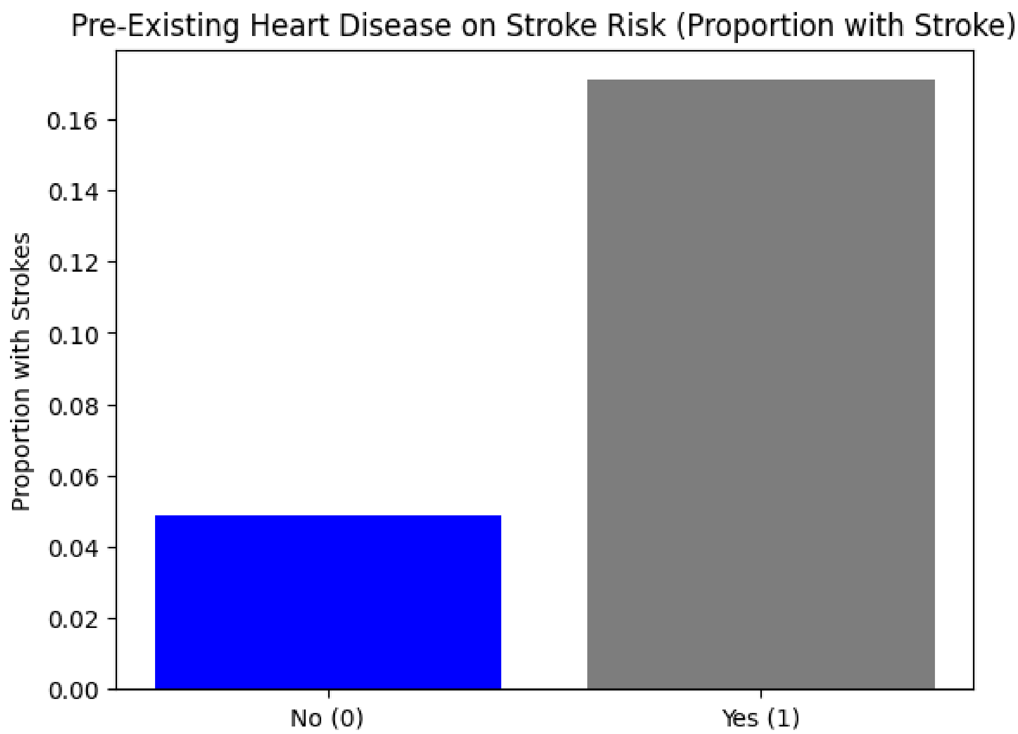

Figure 4

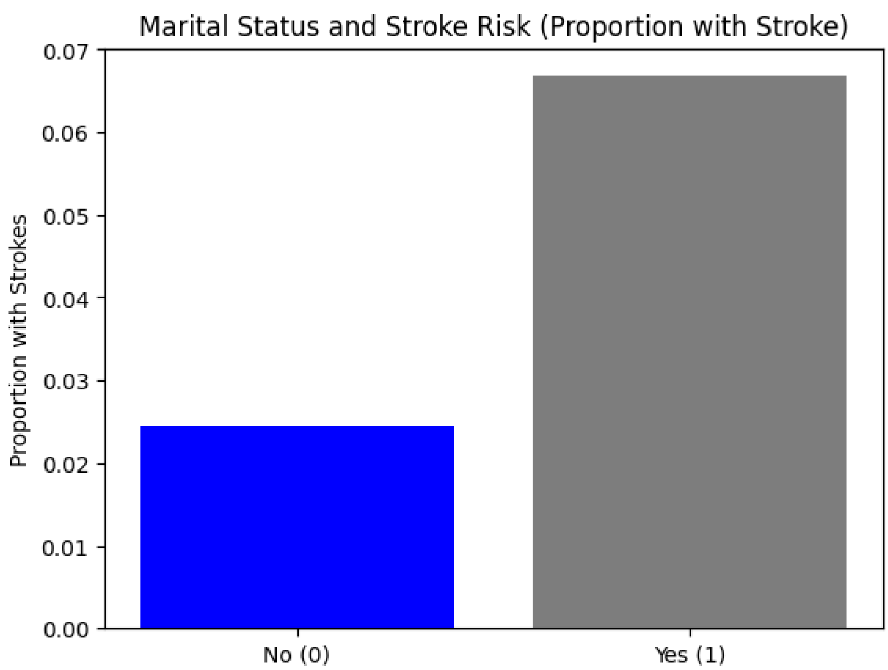

Figure 5

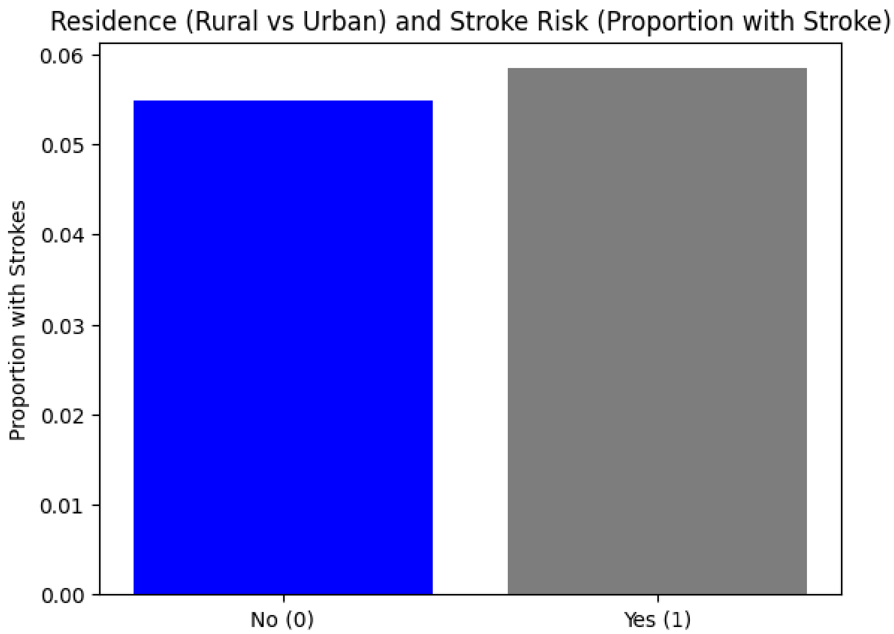

Figure 6

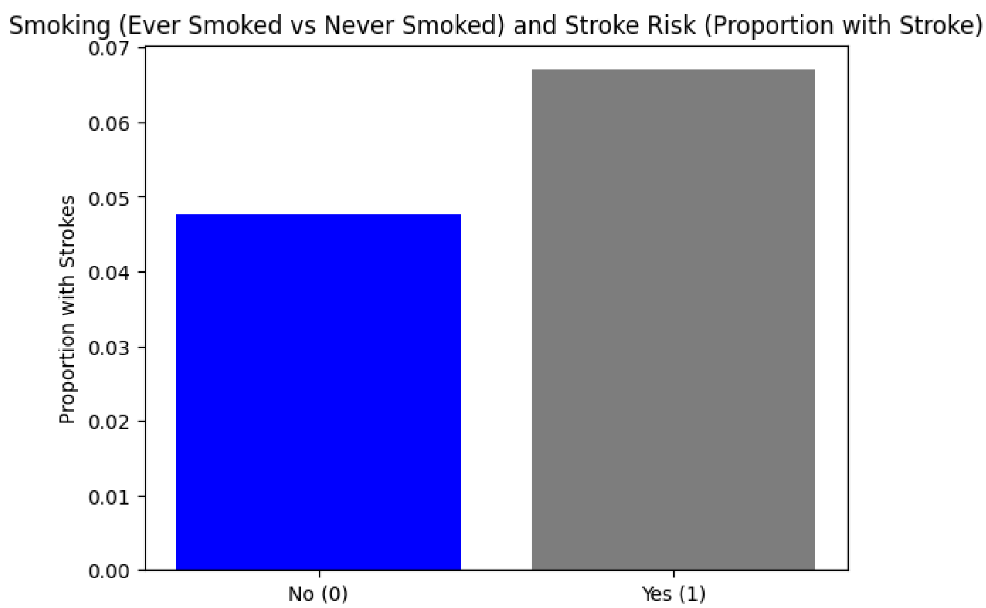

Figure 7

Figure 8

Group	Group 1 (Ye	Group 1 95	Group 1 95	Group 0 (N	Group 0 95	Group 0 95	T-Statistic	P-Value
gender_bin	0.061123	0.048606	0.07364	0.053753	0.044238	0.063269	0.918344	0.358516
hypertensic	0.139013	0.106905	0.171122	0.044886	0.03762	0.052153	5.598124	3.61E-08
heart_disea	0.171053	0.122174	0.219931	0.048846	0.041533	0.05616	4.836042	2.38E-06
married_bir	0.06679	0.05739	0.076189	0.024561	0.014186	0.034937	5.909544	3.93E-09
residence_I	0.058434	0.04764	0.069229	0.054826	0.044163	0.065488	0.466026	0.641225
smoking_bi	0.066946	0.054969	0.078922	0.047569	0.037978	0.05716	2.474526	0.013391
work_binar	0.051437	0.043283	0.059591	0.076408	0.057344	0.095471	-2.35912	0.018504

Figure 9

What can be seen is that in gender, there was no overlap between the ranges for male vs female fro risk of stroke, as for males the rate of stroke ended up running from (0.048-0.074) and for females it was (0.044-0.63) which means females die have a slightly lower change of getting strokes but that could likely 35% likely be explained by chance alone, and it likely due to how small the difference was for stroke rates among genders could be explained by chance alone. However, this also shows one thing, that possibly there could be variation in the data for age, as previously in the literature states, men on average are more likely to have a stroke than women, except likely during older years for women. But this does generally connect to the risk of men with stroke being higher on average.

Next, hypertension is considered. The ranges for Group 1 (Hypertension) and Group 0 (Hypertension not present) did not overlap. For Group 1, the 95% confidence interval was (0.11-0.17), and for Group 0, it was (0.04-0.052). The T-statistic value was very significant, with a P value of 3.61E-08, indicating a significant difference in stroke rates between the non-hypertension and hypertension groups. This difference was likely not due to chance alone. This is an expected result because hypertension causes blood vessel damage over time, which causes a higher risk of blockages, which, as a result, causes increased risk of hemorrhagic stroke. The extremely small p-value of 3.61E-8 shows this to be true, as hypertension is causally proven to connect with stroke. Additionally, there is a correlation between age and natural blood vessel weakening, which may also be linked to heart failure, both of which are age-related. However, hypertension, as seen here, increases stroke risk and is both positively correlated and causally connected with stroke.

Next off, heart disease as well was seen to increase stroke rate significantly, as what group 1 had for stroke rate was a proprton 95% confidence interval of (0.12-0.22) and a group 0 stroke rate of (0.042-0.056) meaning that the true mean proportion for no heart disease stroke rate was 0.042-0.056 and for heart disease it was 0.12-0.022 for true mean proportion. The p-value of 2.38E-06 was well below the 0.05 alpha value, indicating a significant association between the connection and a stroke, which is not coincidental. This is a predicted result due to heart disease, like coronary artery disease being positively correlated to ischemic stroke due to atherosclerotic plaques being more common for the brain when heart arteries are blockage and vessels as well, and afi as well which causes approximately 20% of strokes due to the fact that it increases risk of clot formation due to blood flow, which increases risk of stroke.

Next off is marriage, with Group 0 (non married) population with a stroke rate of (0.015-0.035) meaning that right 0.015-0.035 proportion of people who have not been married or are not married have strokes, but rather as well group 1 who were married had a stroke rate of (0.057-0.076) meaning that 0.057 to 0.076 is a range we can be 95% confident that the true mean proportion of people in marriages or have been married have strokes. The p-value was 3.93E-9, indicating a significant difference in stroke rates between married and non-married individuals.

Furthermore, residence type as well which was urban vs rural populations, and rural was group 0 and urban was group 1, group 0 had a stroke rate of 95% confidence interval of (0.044-0.066) meaning we can be 95% confident that the true mean prop of rural predicts that get strokes is 0.044-0.066 and group 1 was 95% range of 0.047-0.069 meaning that we can be 95% confident that the true mean proportion of people with strokes in urban areas is in captured by the interval 0.047-0.069, which was not as significant difference from rural and p value being insignificant indicator at 0.64, meaning difference is likely due to chance alone. Next off is smoking as well, so with smokers, they were group 1, while non-smokers were in group 0, and the smoker group included former and current smokers as well, while unknown, discarded, and non-smokers did not smoke. The 95% confidence interval for Group 1 was (0.055-0.079), which means that we can be 95% confident that the true mean proportion of people who smoke and get strokes is 0.055 to 0.079. And the 95% confidence interval for Group 0 was (0.038-0.057), which meant that we can be 95% confident that the true mean proportion of people who don't smoke who get strokes is captured by the interval 0.038-0.057. The p-value of 0.013 indicated a statistical difference, as evidenced by the non-overlapping ranges. Next off is for work type which was employed (group 1) compared to not employed by someone (Group 0), this had a significant result with group 1 reporting a stroke rate of 95% confidence interval of (0.043-0.060), while group 0 reported a stroke rate of (0.057-0.095), with a p value of 0.018 meaning that employed vs non employed people had a large statistical difference that was statistically significant stroke rates and that also employedS was more likely to have strokes.

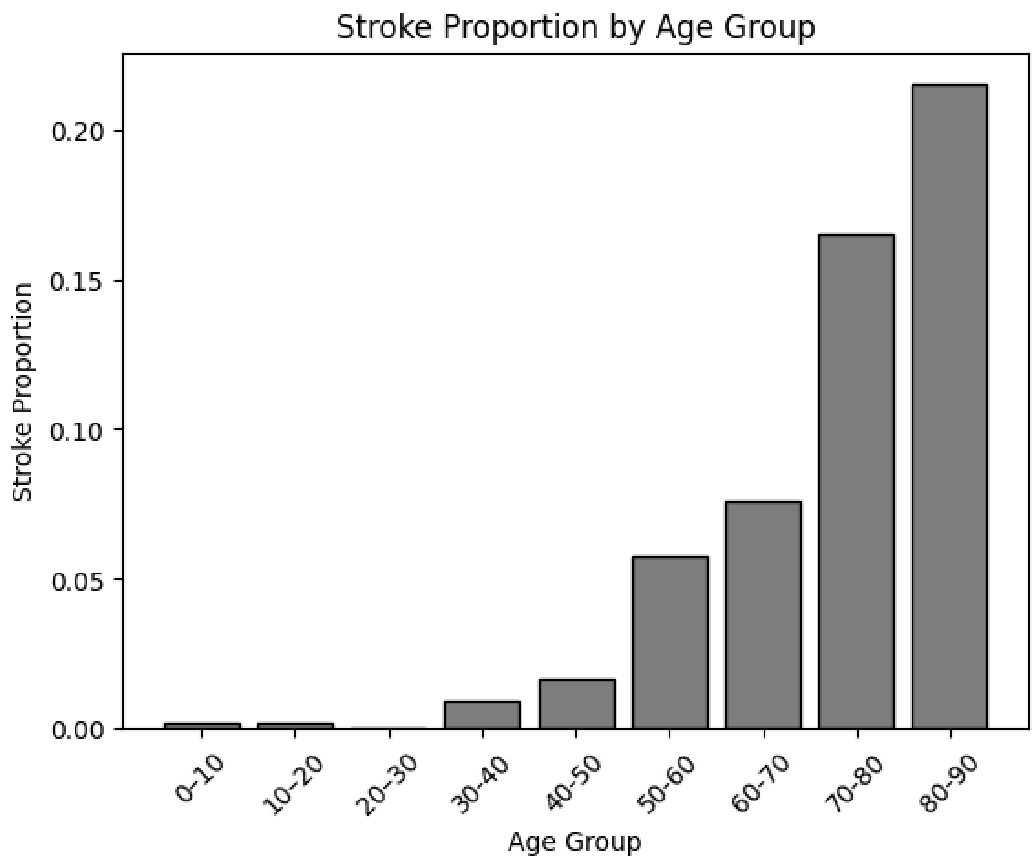

Figure 10

It is also important to consider age, as it is frequently linked to vascular problems that can lead to strokes. There were no 90-100 year olds included as there were none in the data. These issues include blood clots in blood vessels, which limit blood flow to the brain and other age-related health problems. However, the lowest frequency was observed for stroke proportion in the 10-20 age range, with a proportion of nearly 0.005. In contrast, the 70-80 age range showed a proportion of nearly 0.15, indicating that strokes are increasingly likely with age.

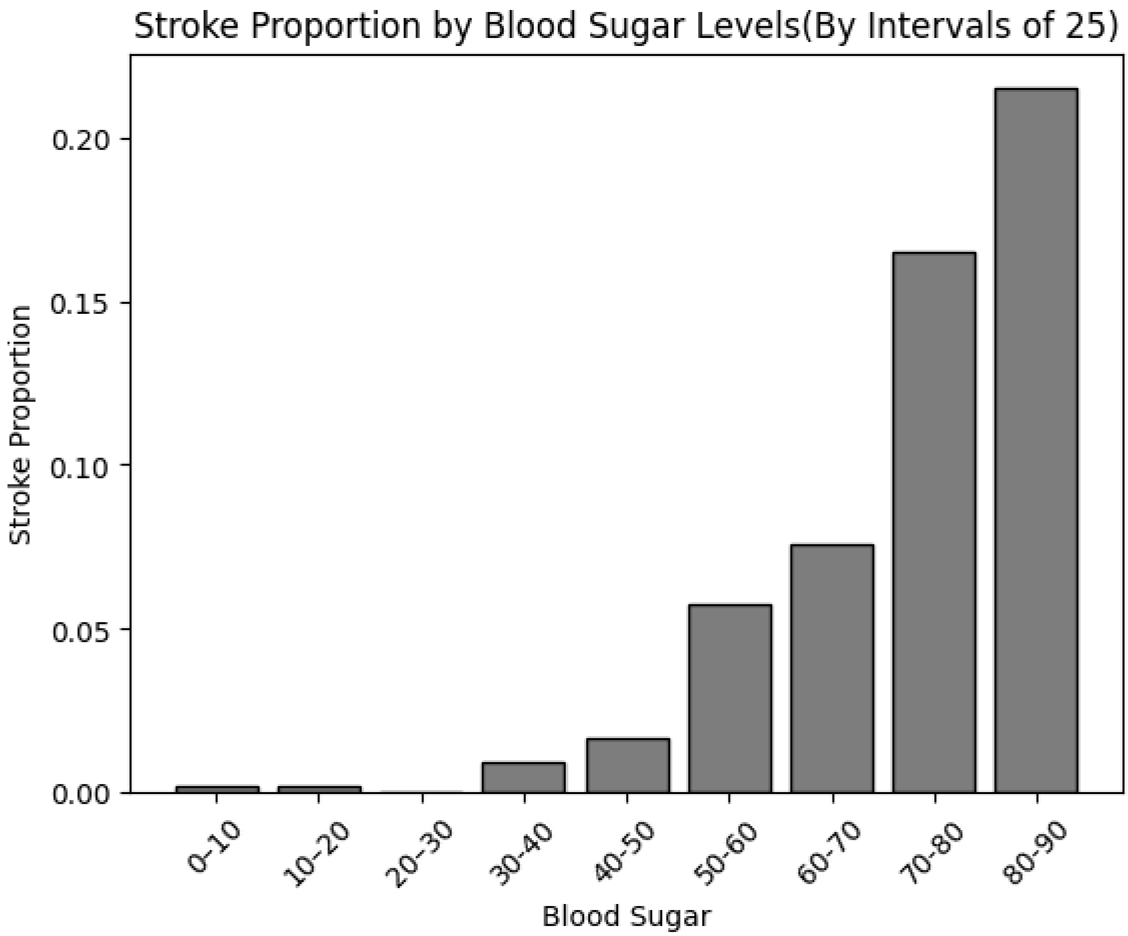

Figure 11

When it came to glucose range, this is an anomaly, as it fluctuated over ranges, with 50-75 having a higher rate of stroke than 75-100, and then it started going back up again, and that drop thus could be explained by chance alone, but in general 250-300 glucose level had higher stroke rate. Glucose is critical because it can form into plaque that blocks the arteries and blood vessels, leading to ischemic strokes. But blood sugar was connected to strokes, as could be seen here.

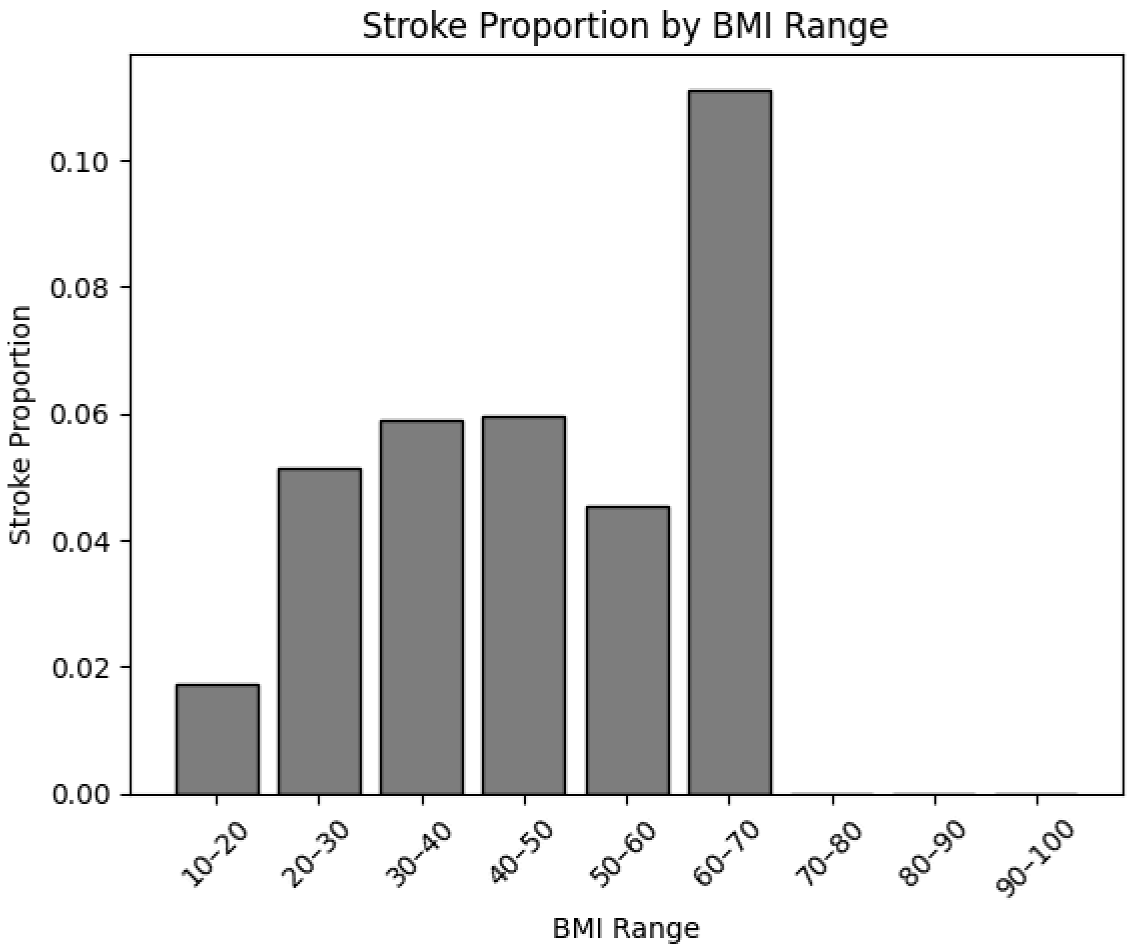

Figure 12

Next is BMI range of which there is a 0.005 proportion in the 17.5-20 BMI range and then it keeps going up till the 30-35 range bmi and then drops an declines from 35-45 range peaking till then at 30-35 range at 0.055 roughly, but then drops to 0.048 and then 0.043 and then significantly grows up until roughly under 0.08 rate of strokes, and generally higher weight bmi was considered at higher stroke risk, and this can be attributed to conditions patients at or above certain bmi may have. But also, as can be seen here there is an important other factor in that BMI allows for atheleroscosis to accelerate, and higher BMI may make it harder to be physically active, so not only does BMI have correlation, it also has causation. The 80-90 range additionally did not have any data due to no people with 80-90 BMIs in the data. Also for 70-80 and 90-100, they had extremely small samples, thus there was lower chance of finding stroke admitted people.

Work Type	95% CI Lower	Point Estimate	95% CI Upper
Private	0.043	0.0509	0.0589
Government Jobs	0.0335	0.0502	0.0669
Self Employed	0.0609	0.0794	0.0979

Figure 13

Next is work type, this is surprising with private having a median of 0.0509 with a 95% CI of 0.043 to 0.0589 and this is in a private business as an employee, while government jobs had 0.0335 to 0.0669 95% confide interval for stroke rates and then parents had 0-0.0069 range and a median of 0.0029 and then non working was 22 people so that was out of the sample for this, and then self employed had a range of 0.0794 median and 95% CI of 0.0609 to 0.0979, and government and private sector work had overlapping ranges so they don't have statistical difference but private and self employed don't overlap and same with children and self employed meaning there is a significant difference in the rates of stroke in these populations that cant be explained by chance alone and children does not overlap with any of these meaning parents of kids managing the kids as a job mainly have much less strokes on average proportion than the other groups, but that is due to age, due to average stay at home parents being usually under 60 is the reason likely, as most stay at home parents have kids graduating by the time they are 60, so stroke rate will loom lower for that.

Smoker Class	95% CI Lower	Point Estimate	95% CI Upper
Former Smokers	0.0613	0.0791	0.0969
Current Smokers	0.0376	0.0532	0.0689
Never Smoked	0.038	0.0476	0.0572
Unknown	0.0219	0.0304	0.039

Figure 14

Next, for former smokers, the average proportion point estimate was 0.0791, with a 95% confidence interval ranging from 0.0613 to 0.0969. In contrast, the never-smoked group had a range of 0.038 to 0.0572, with a point estimate of 0.0476. Former smokers and never smokers had a lack of overlap, meaning there was a difference between the two groups. This can be explained by the age difference in the two groups, as former smokers may be older than non-smokers. Even the current smokers, who despite having overlap with, still had a decently higher proportion of strokes than for current smokers at 0.0376 to 0.0689 with a median value of 0.0532, overlapping with non smokers and former ones, and their stroke rate likely may have been much lower than former ones due to age. However, they did have higher rates of stroke than never smoked on average due to elevated blood pressure and nerve damage caused by stroke, and poorer habits of smokers than non-smokers as well, besides just smoking and age as well may connect. Unknown also had a range of 95% CI 0.0219 to 0.039 and a median of 0.0304, indicating that the number of smokers in the category was likely very low due to the low stroke rates. This category had a group size of 1544, making it relatively large.

6. Conclusion

In conclusion, this study identified multiple predictors of stroke risk based on analysis of over 11,500 patient records and hypertension and heart disease were the strongest predictors of stroke risk compared to individuals without these conditions. Additionally, smoking, ever married and self employed or non employed by others tended to have elevated stroke risk due to low p value scores and significantly higher proportion of strokes than people without those situations, indicating that these factors are connected to stroke in some way, whether correlation or causation, and age and BMI and glucose levels showed significantly elevated increase in risk of stroke, all of which had some causative connection to strokes risk.Residence and gender were not significantly connected however. In summary, these findings of the study show that cardiovascular disease, metabolic weight, and demographic factors and habits such as smoking and pre existing conditions such as hypertension are critical factors of stroke, while work type may also be connected to stroke risk as well as marriage setting. However, it was likely a correlation, not a causation.However, many factors such as hypertension and cardiovascular disease, including those but not limited to show a causative connection with stroke risk.

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