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Quantitative Analysis of the Relationship Between Diabetes and Various Health Indicators

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Abstract:

Diabetes is a chronic, widespread disease that affects millions globally. This disease impairs the body's ability to manage blood glucose levels due to inadequate insulin production or reduced insulin efficiency, resulting in hyperglycemia, which causes severe health risks and economic burdens The prevalence and death rate is increasing, especially in low- and middle-income countries. This study analyzes the 2015 Behavioral Risk Factor Surveillance System (BRFSS) dataset, which contains a total of 253,680 survey responses, with 21 variables. In this study, multiple logistic regression, Pearson correlation, and chi-square tests were applied to find the independence and association of different health indicate factors like high blood pressure, high cholesterol, body mass index, smoking, stroke, and heart disease to diabetes risk. The results indicate that diabetes is closely related to health indicators such as High BP, HighChol, and BMI. Smoking alone has a minor effect on the diabetes. The income level has a negative association with diabetes; thus, one could have a higher income to protect against the disease. People with stroke are twice as likely to have diabetes as people without diabetes, which is likely because diabetes damages blood vessels. This study analyzed the various risk factors associated with diabetes, which can greatly help prevent and diagnose diabetes. It also highlights the need for continued research into how lifestyle, genetic, and socioeconomic factors interact to influence diabetes risk and contribute to diabetes prevention and health improvement.

Keywords: Diabetes; High blood pressure; High cholesterol; Stroke; BMI

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1. Introduction

Diabetes is a widespread chronic disease that has a significant impact on the economic health of people around the world. Diabetes is mainly caused by insufficient insulin production or insulin being used ineffectively by the body. Sufferers lose the ability to effectively regulate glucose levels in the blood, leading to a decrease in quality of life and life expectancy. Long-term elevated blood sugar is associated with damage to nerves and blood vessels, as well as damage to body systems. In addition to these health effects, diabetes can lead to cardiovascular disease, kidney disease, and other complications, further placing an economic burden on global health systems. The prevalence of diabetes was on the rise. In 2014, an estimated 8.5% of adults aged 18 years and older had diabetes; By 2019, diabetes will cause about 1.5 million deaths worldwide, with nearly half occurring in people under the age of 70 [1]. 20% of cardiovascular disease deaths are also linked to diabetes, suggesting that it is urgent to understand the multiple risk factors for this disease.

Despite the global impact of diabetes, previous research has often failed to delve into the intricate links between diabetes and a range of lifestyle, genetic, and socioeconomic factors. For example, Chiedu Eseadi pointed out in his article that an increase in the poverty rate would lead to an increase in the incidence of diabetes, and poverty is highly correlated with diabetes. As a result, it is more prevalent among low-income people [2]. K. Z. Walker's article points out the role of weight loss and exercise in preventing diabetes [3]. Much of the previous research has focused on narrowly defined risk factors such as diet and exercise and has not adequately explored the multifaceted influences of income, comorbidities, and healthcare services. As well, there is no quantitative and specific analysis of individual influencing factors. As diabetes prevalence continues to rise, especially in low - and middle-income countries, it is critical to study how multiple risk factors interact to influence diabetes risk.

Previous studies had a broad goal of investigating the relationship between diabetes and a combination of factors such as body mass index, cholesterol, physical activity, smoking, income, and medical services to find the major risk and protective factors associated with diabetes.

This study aimed to fill the gap in diabetes research by using statistical methods to analyze the associations between key health indicators and to include income level and comorbidities as protective factors. By quantifying the relative impact of each factor, this study identified key risk factors for diabetes, with a particular focus on income level. In addition, this study emphasizes diabetes is a major risk factor for stroke. People with diabetes are twice as likely to have a stroke as people without this disease [4].

2. Methods

The analysis is based on 2015 data from the BRFSS, an annual health survey conducted by the Centers for Disease Control and Prevention. The BRFSS is the world's largest health survey, designed to collect data on behavioral health risks, preventive health practices, and healthcare access primarily related to chronic health conditions. The 2015 data source consists of responses from 253,680 individuals and is one of the most complete sources of self-reported health data. The target sample consists of those aged 18 years and older who have responded to the 2015 BRFSS survey. Diabetes status was identified based on self-reported data. The primary sample consisted of individuals with diabetes (n=35, 346) and those without diabetes (n=218, 334). Variables were chosen to mirror those found in the literature as being related to the risk of diabetes. These data contain both continuous variables—for example, BMI and age—and categorical or binary variables—for example, high blood pressure, high cholesterol, and smoking status [5]. The independent sample tests revealed significant differences between diabetic and non-diabetic individuals regarding high blood pressure, high cholesterol, smoking status, heart disease, and history of stroke.

All statistical analyses have been performed using R software and SPSS. Therefore, the models will be analyzed in three parts: descriptive analysis, bivariate analysis, and multivariate analysis. Descriptive statistics were calculated for all variables as a means of providing an overview of the sample's demographic and health characteristics [6]. Continuous variables were described as mean and median for central tendency standard deviation and interquartile range for dispersion. For categorical variables, frequencies and percentages were calculated. Comparisons between the diabetic and non-diabetic groups were made for health indicators by independent samples t-tests for differences in means and by chi-square tests for associations of categoricals.

Pearson's product-moment correlation coefficients were calculated to assess the strength and direction of associations between diabetes status and continuous health indicators, such as BMI, age, and income level [7]. The correlation analysis helped identify possible collinear variables that may affect multivariate analysis in addition. To examine the predictors of diabetes, a multiple logistic regression model was developed with controls for various potential confounders [8]. In the present analysis, diabetes status was considered a binary outcome variable; hence, predictor variables included BMI, high blood pressure,

high cholesterol, smoking status, income level, and comorbidities of stroke and heart disease [9]. Ninety-five percent of CIs were computed for each predictor to describe the association of each with diabetes.

3. Results

The association between highBP high Chol and diabetes status was shown in Table 1 grouped by having diabetes or not. Individuals with high BP(24.4%) have a significantly higher prevalence of diabetes compared to those without highBP (6.03%) ($p<0.001$). The people with high Chol(22.01%) have a significantly higher possibility of having diabetes compared to those who don't have high Chol(7.97%) ($p<0.001$).

Table 1. Independent sample test

	diabetes(n=35346)	nodiabetes(n=218334)	P
High BP(0)	8738	136113	<0.001
High BP(1)	26608	82221	
HighChol(0)	11658	134436	<0.001
HighChol(1)	23688	83898	

The association between smoking status, heart disease, and diabetes were shown in Table 2 grouped by having diabetes or not. Diabetes prevalence was also higher among individuals who smoke (16.29%) than those who do not smoke (12.06%) ($p<0.001$). Heart disease was more common in the diabetic group (22.3%) compared to the non-diabetic group (7.3%) ($p<0.001$).

Table 2. Independent sample test

	diabetes(n=35346)	nodiabetes(n=218334)	P
smoke(0)	17035	124214	<0.001
smoke(1)	18311	94120	
HeartDisease(0)	27459	202324	<0.001
HeartDisease(1)	7887	16010	

The association between stroke and diabetes was shown in Table 3 grouped by having diabetes or not. The results show that individuals with diabetes had a higher incidence of stroke (9.3%) compared to non-diabetic individuals (3.2%) ($p<0.001$).

Table 3. Independent sample test

	diabetes(n=35346)	nodiabetes(n=218334)	P
stroke(0)	32076	211305	<0.001
stroke(1)	3270	7029	

These findings indicate that individuals with highBP and highChol have a higher risk of developing diabetes than individuals with lower blood pressure and cholesterol. people who have had a heart attack are more likely to develop diabetes later in life, and smoking increases the risk of diabetes. Diabetes may significantly increase the risk of stroke. Diabetes is a major risk factor for stroke. People with diabetes are twice as likely to have a stroke as people without diabetes [4].

The correlation analysis between diabetes and different health indicators is shown in Table 4. This table highlighted several significant associations between diabetes and various health indicators. Among these, general health ($r=0.2769$) and high blood pressure ($r=0.2543$) exhibited the strongest positive correlations with diabetes status. Other significant health factors included difficulties with walking ($r=0.2053$), BMI ($r=0.2051$), and high cholesterol ($r=0.1949$). Lower correlations were observed for stroke ($r=0.0992$), smoker status ($r=0.0455$), and heavy alcohol consumption ($r=0.066$).

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Table 4. Correlation between different health indicators

Column	Correlation
GenHlth	0.27694
HighBP	0.254318
DiffWalk	0.205302
BMI	0.205086
HighChol	0.194944
Age	0.177263
HeartDiseaseorAttack	0.168213
PhysHlth	0.156211
Income	0.140659
Education	0.102686
PhysActivity	0.100404
Stroke	0.099193
CholCheck	0.072523
HvyAlcoholConsump	0.06595
MentHlth	0.054153
Smoker	0.045504
Veggies	0.041734
Sex	0.032724
AnyHealthcare	0.025331
Fruits	0.024805
NoDocbcCost	0.020048

4. Logistic Regression Analysis of Diabetes and Health Indicators

A logistic regression model was used to assess the relationship between diabetes and various health factors, controlling for potential confounders (Table 5). The results indicate the following key predictors of diabetes. Body Mass Index (BMI) was significantly associated with diabetes status, with an estimated effect size of 0.0604 ($z=72.43$, $p<0.001$). High Blood Pressure showed a substantial association with diabetes (estimate = 1.2308, $z=89.07$, $p<0.001$), suggesting that individuals with high blood pressure are more likely to have diabetes. High Cholesterol also demonstrated a positive relationship with diabetes (estimate = 0.8104, $z=62.41$, $p<0.001$), indicating that high cholesterol is a significant risk factor. Smoking was moderately associated with diabetes (estimate = 0.3552, $z=30.57$, $p<0.001$), suggesting that smokers have a slightly increased risk of developing diabetes.

These results support the hypothesis that high blood pressure, high cholesterol, BMI, and smoking are significant predictors of diabetes. This highlights the importance of managing these risk factors to potentially reduce the burden of diabetes and its associated complications.

Table 5. Logistic regression of diabetes_binary and different health indicators

	Estimate	Std. Error	z value	Pr(>|z|)
BMI	0.0603542	0.0008332	72.43	0.000
HighBPHigh BP	1.2308447	0.0138182	89.07	0.000
HighCholHigh Chol	0.8104395	0.0129862	62.41	0.000
Smoker1	0.3552459	0.0116197	30.57	0.0

5. Discussion

5.1 Analysis of Results

The study indicates that income level is inversely related to risk for diabetes, consistent with earlier findings that suggest lower-income populations are more at risk due to chronic illnesses such as diabetes. This is due to reduced access to health resources, a healthy diet, and physical exercise [10]. This finding agrees with the work of Eseadi, who argues that diabetes is closely linked to socioeconomic factors, especially poverty, in low- and middle-income countries, since resources are under conditions, and health education is mostly inaccessible. This points out the role of socioeconomic interventions and policy level changes as an instrument of crucial importance in reducing prevalence in lower socioeconomic communities.

It also reports that diabetes is strongly associated with stroke incidence since patients with diabetes are twice as likely to have a stroke compared to those without diabetes. This agrees with previous findings that diabetes is one of the major risk factors for stroke since it severely damages the blood vessels and increases chances for clot formation and reduces blood flow to the brain[11]. Such findings support the priorities of stroke prevention strategies and the integration of diabetes management into broader cardiovascular health interventions.

The analysis further showed that smoking, while being associated with diabetes, had a relatively minor effect versus factors such as high blood pressure and BMI. The complex role of smoking in diabetes risk may somewhat be explained by its effects on metabolic and insulin sensitivity, including those on basal metabolic rate, glucose metabolism, and appetite suppression [12]. However, due to its minimal association, smoking remains a practice that will be targeted based on public health campaigns for its wider health implications and the importance of general lifestyle interventions.

5.2 Suggestions

Given the wide variation across health and socio-economic factors, the study suggests the need for tailored lifestyle interventions based on income level and other demographic distinctions. For example, community-based programs might provide low-cost exercise programs, access to healthier foods, and health education for lower-income and higher-risk communities to reduce disparities in diabetes prevention. Income was inversely associated with diabetes, so targeted efforts should focus on increasing health services and resources in low-income communities as a first step in enabling healthier lifestyles to prevent disease. Also, since the stroke-diabetes association emerged strongly, these findings recommend incorporating diabetes management with cardiovascular health programs to minimize stroke risk in diabetic populations.

Some of the limitations include reliance on self-reported data, which is prone to recall especially in sections related to diet and frequency of exercise limits this study. For example, BMI as a measure of obesity cannot account for the distribution of lean mass and hence may limit the precision of the study‘s obesity classification. Another limitation regards sample selection, where the sample is not assuredly representative of its target population of geographic and socioeconomic diversity, thus affecting the generalizability of findings. Larger sample sizes and the inclusion of people of different geographic and socio-economic spheres are to be aimed at in these directions to ensure better applicability of results. Longitudinal in nature, such research can be made to capture the risk factors associated with diabetes over a while, hence allowing a more valid test of causation and intervention effectiveness. For instance, increased data collection on mental health, family support, and other lifestyle variables will help gain insight into the complex interrelationships that further predispose people to diabetes risk.

4. Conclusion

The study identified high blood pressure, high cholesterol, and body mass index as the leading risk factors for diabetes. Research has also found that diabetes prevalence is seen to be higher in decreasing levels of income; thus, targeting low-income levels is spot on for intervention. The most important link between diabetes with stroke underlines the care to be comprehensive. People need to take certain measures in terms of prevention and interventions. Longitudinal designs and further studies among different populations are required to dissect the extent to which the complex combined effect of various influencing factors has influenced diabetes for refining public health strategies and improving outcomes of diabetes.

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