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Survival Analysis of the Risk Factors Affecting the Survival Time of Diabetic Patients

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Abstract

This study aimed to analyze the risk factors that affect the survival time of diabetic patients. It used the diabetes health indicators dataset (2015) collected from the American population by the "Centers for Disease Control and Prevention," United States, through the "Behavioral Risk Factor Surveillance System" in 2015. The dataset comprised 70,692 responses, among which every 320th sample was selected to get the estimated sample size of 221 using the systematic sampling method. The collected data was analyzed through a statistical package for the social sciences (SPSS) software 27.0. The outcomes found that risk factors such as age, high cholesterol, smoking, heavy alcohol consumption, physical activity, high blood pressure, heart disease or attack, general health, serious difficulty in walking or climbing stairs, and stroke were significantly associated with the risk of diabetes. General health was a significant predictor of the risk of diabetes. The estimated survival probability of diabetic patients decreases as their age progresses due to risk factors such as smoking, heavy alcohol consumption, stroke, high blood pressure, and heart disease or attack. Also, it decreases with their age if those patients are physically inactive. These findings highlight that more active strategies are required to comprehensively control risk factors to reduce the burden of diabetes among the general inhabitants.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder that affects millions of people worldwide and is increasing in prevalence, particularly in low- and middle-income countries. The term Diabetes Mellitus is derived from the Greek word "diabetes," meaning "to pass through," and the Latin word "mellitus," meaning sweetness, like honey. The condition, often abbreviated as diabetes, states to a set of diseases that lead to increased blood sugar levels because the body cannot produce or utilize insulin properly. DM has several categories: Type 1 (T1) and Type 2 (T2). T1-DM usually occurs in children or adolescents, while T2-DM is more common in middle-aged and older adults who have poor lifestyle and dietary choices, leading to persistent hyperglycemia. The pathogenesis of T1-DM and T2-DM differ significantly, resulting in different etiologies, presentations, and treatments for each type (National Library of Medicine, 2023). The inability of cells to utilize blood glucose leads to significantly higher glucose levels in the bloodstream over a long period, over the years, causing irreversible

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damage to internal organs and the body, leading to multiple complications. The cause of DM is little known; however, in DM, sugar builds up in the bloodstream due to genetic or environmental aspects in both type 1 and type 2 DM (Diseases & Conditions, Mayo Clinic).

DM is a long-term medical condition that can have substantial individual, social, and financial consequences (Julia et al., 2012). Furthermore, DM is a severe universal public health concern, with its high prevalence and enormous costs that seriously threaten individuals and societies worldwide (Runqi et al., 2020; Kimberly et al., 2015). It is a prevalent chronic illness with several complications that add to the healthcare burden worldwide. The International Diabetes Federation has predicted that the number of cases globally will increase by 50% by 2030 from 366 million in 2011 (Cheng et al., 2015). This chronic disease, characterized by hyperglycemia, can cause a triad of common symptoms such as increased hunger (polyphagia), excessive thirst (polydipsia), and frequent urination (polyuria). If left untreated, the disease can damage multiple organs and systems in the body, such as the heart, kidneys, nerves, and blood vessels, which can lead to a reduced quality of life and increase the risk of death from complications (Liu et al., 2010). DM and its complications not only have a financial impact but are also a significant cause of death and disability across the globe. Based on data from high-income countries, chronic DM can cause multiple health problems starting at age 40 and shorten life expectancy by 5-7 years (Chen et al., 2020; Gregg et al., 2014; Bracco et al., 2020). Microvascular and macrovascular complications of DM are well-defined and increase mortality, such as a twofold increase in cardiovascular mortality, which is one of the many complications that contribute to the augmented rate of mortality (Hirakawa et al., 2017). Further, patients with DM and other lifestyle diseases were more likely to experience an intermediate or fast decline in the estimated glomerular filtration rate affecting renal function, which is associated with the highest risk of all-cause mortality (Van et al., 2023). A 21-year longitudinal study also demonstrated that the adjusted all-cause mortality risk increased by 117% with the presence of chronic kidney disease and cardiac autonomic neuropathy, independent of other diabetic-associated microvascular complications (Sacchetta et al., 2022).

Managing DM effectively requires consistent engagement in self-care behaviors, which must be performed daily. As per a recent study, the risk of lifestyle diseases like DM increased with the number of unhealthy habits and health behaviors, and these unhealthy habits include smoking, slow gait speed, eating fast, and poor sleep quality (Ueno et al., 2023). Effective DM management involves regular exercise, healthy eating habits, blood glucose monitoring, and regular visits to healthcare providers to prevent complications and manage body weight (Golden et al., 2012 & Agardh et al., 2011). Survival analysis is a branch of statistics that studies time-to-event data and is often used in medical research. The statistical methods for data analysis deal with the outcome variable of interest, which is the time until an event occurs, which is used to examine the probability of an event happening over time, such as the likelihood of a patient surviving after a particular medical condition (Clark et al., 2023). The statistical survival analysis method entails examining time-related data from a well-defined starting point to the occurrence of a specific event or endpoint (Collet, 2014). Regression is a widely used semi-parametric method for analyzing survival data, especially in healthcare, to estimate the patient's survival time by examining the functional relationship between the dependent and independent variables. Analysis helps evaluate individual predictors, analyze policy impacts that involve changes in predictor values, and predict response variables for a specific set of predictors (Chatterjee & Hadi, 2012). Preventive measures are crucial to control DM, and delaying the onset of type 2 DM can significantly reduce the risk of premature mortality (Rojas-Martinez et al., 2024). Determining the survival rate will help policymakers design and strategize preventive measures that can be implemented at the right time to prevent diabetic complications and subsequent morbidity and mortality.

Therefore, research on survival analysis and the influence of risk factors on mortality is essential to address this problem effectively and efficiently by raising awareness and investing in prevention and treatment measures to alleviate the burden of this disease by reducing the mortality rate. Although most research focuses on survival analysis of various disease conditions, studies are sparse on the influence of risk factors and the survival time in diabetic patients. Notably, survival analysis of risk factors focusing on survival time among DM cases would provide adequate information to plan and execute early screening of risk factors and health promotion tasks, comprising spreading of related info in the healthcare centers, community activities, mass media, and appropriate management of DM, which might

influence the primary and secondary prevention of DM. In addition, this study intends to fill the existing research gap by analyzing the risk factors affecting the survival time of diabetic patients.

METHODS

Data Source and Study Population

This study was conducted on the diabetes health indicators dataset (2015), which was collected from the American population by the "Centers for Disease Control and Prevention (CDC)," in the United States through a health-related telephone survey titled "Behavioral Risk Factor Surveillance System (BRFSS)" in 2015. The diabetes health indicators dataset (2015) has three files and is available on the Kaggle website. Among those files, this study retrieved the file with a clean dataset of 70,692 survey responses to the BRFSS2015 by the CDC. This binary dataset contains an equal split of respondents, with "0 for no DM" and "1 for prediabetes or DM."

Study Sampling

In this study, the sample size was calculated as 221, grounded on 17.44% of the prevalence of diabetes (Brar et al., 2022) and the precision and confidence level of 5% and 95%, respectively. The formula used for estimating the sample size was $n = [(Z_{1-\alpha / 2})^2 p (1-p)] / d^2$. A systematic sampling method was used to randomly choose the estimated sample size 221 among the total 70,692 samples. Subsequently, the sampling interval was calculated as 320 by dividing 70,692 (total samples) by 221 (estimated sample size). The researchers randomly select a starting point by choosing one sample between the 1st and 320th samples in the dataset. From that chosen sample (i.e., starting point), every 320th sample was selected to reach the estimated sample size of 221. This study adopted a systematic sampling method for sample selection since it is easy to apply, time-saving, and cost-efficient; it eliminates clustered selection, possesses minimal risk, reduces variations in the sample, and ensures sample representativeness (Ross, 2021; GeeksforGeeks, 2024). However, a careful selection of every 320th sample was performed by the researchers to overcome bias resulting from incorrect interval selection of the sample, which might lead to biased outcomes and an unrepresentative sample (Hayes et al., 2025).

Statistical Analysis

The sample data was analyzed using SPSS (Statistical Package for the Social Sciences) software version 27.0. Descriptive statistics were used to describe the continuous and categorical variables. A Chi-square test was applied to determine the association between risk factors and the risk of DM. Furthermore, multiple logistic regression analysis was performed to reveal the influence of risk factors on the risk of DM. The level of significance was 5% ($p<0.05$).

RESULT AND DISCUSION

While reviewing the Quantiles Regression results, the American population's mean Body Mass Index (BMI) score was 28.91, which indicates overweight based on the classification of Weir and Jan (2023). The 10th percentile of them was 22, i.e., the average weight. The 25th and 50th percentile were 25 and 28, respectively, which denotes overweight; however, the 75th percentile was 32, indicating obesity. Regarding mental health, the American population described a mean score of 4.41 days as they were not mentally sound, and their 75th percentile reported three days of insufficient mental health. On the other hand, their mean score was 6.86 days as they were not physically sound, and their 75th percentile reported ten days of not being physically good (Table 1).

The risk factors such as age, high cholesterol, smoking, physical activity, heart disease or heart attack, heavy alcohol consumption, general health, severe difficulty in walking or climbing stairs, stroke, and high blood pressure were significantly associated with the risk of diabetes ($p<0.05$). However, other risk factors, namely gender, cholesterol checkup in 5 years, fruit intake, and vegetable intake, failed to show a signi-

Table 1. Quantitative Variables with Quantile Regression

Quantiles Regression	Body Mass Index	Mental Health (Days)	Physical Health (Days)
Mean	28.91	4.41	6.86
Standard Deviation	6.502	9.157	10.608
10th Percentile	22.00	0.00	0.00
25th Percentile	25.00	0.00	0.00
50th Percentile	28.00	0.00	0.00
75th Percentile	32.00	3.00	10.00

Table 2. Association between risk factors and the risk of DM

Variables		NoDM [n=110] n (%)	DM [n=111] n (%)	p-value
Age	18-34	16 (94.1)	1 (5.9)	0.000*
	35-49	24 (68.5)	11 (31.5)	
	50- 64	33 (45.8)	39 (54.2)	
	65-79	25 (33.3)	50 (66.7)	
	Above 80	12 (54.5)	10 (45.5)	
Gender	Male	46 (45.5)	55 (54.5)	0.249
	Female	64 (53.3)	56 (46.7)	
High Cholesterol	No	70 (65.4)	37 (34.6)	0.000*
	Yes	40 (35.1)	74 (64.9)	
Cholesterol Checkup in 5 years	No	5 (83.3)	1 (16.7)	0.096
	Yes	105 (48.8)	110 (51.2)	
Smoker	No	70 (59.8)	47 (40.2)	0.002*
	Yes	40 (38.5)	64 (61.5)	
Heart Disease or Attack	No	99 (53.8)	85 (46.2)	0.008*
	Yes	11 (29.7)	26 (70.3)	
Physical Activity	No	21 (31.8)	45 (68.2)	0.000*
	Yes	89 (57.4)	66 (42.6)	
Fruit Intake	No	37 (42.0)	51 (58.0)	0.062
	Yes	73 (54.9)	60 (45.1)	
Veggie intake	No	18 (41.9)	25 (58.1)	0.248
	Yes	92 (51.7)	86 (48.3)	
Heavy Alcohol Consumption	No	100 (48.1)	108 (51.9)	0.044*
	Yes	10 (76.9)	3 (23.1)	
General Health	Excellent	22 (88.0)	3 (12.0)	0.000*
	Very Good	41 (68.3)	19 (31.7)	
	Good	35 (51.5)	33 (48.5)	
	Fair	9 (20.9)	34 (79.1)	
	Poor	3 (12.0)	22 (88.0)	
Serious Difficulty in Walking or Climbing Stairs	No	93 (61.2)	59 (38.8)	0.000*
	Yes	17 (24.6)	52 (75.4)	
Stroke	No	106 (52.5)	96 (47.5)	0.009*
	Yes	4 (21.1)	15 (78.9)	
High blood pressure	No	67 (68.4)	31 (31.6)	0.000*
	Yes	43 (35.0)	80 (65.0)	

* Level of significance at 5%

ficant association with the risk of DM (p>0.05) (Table 2).

Table 3 shows that only one risk factor named "General Health" was the significant predictor of the risk of DM (p<0.05). However, the remaining risk factors such as gender, high cholesterol, cholesterol checkup in 5 years, BMI, smoking, heart disease or heart attack, physical activity, fruit intake, vegetable intake, heavy alcohol consumption, severe difficulty in walking or climbing stairs, stroke, and high blood pressure were found to be non-significant (p>0.05).

The Omnibus Tests of Model Coefficients are applied to determine that the categorical variables are improved over the baseline model. It utilizes chi-square tests to reveal any significant

Table 3. Multiple logistic regression analysis

Variables	B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
							Lower	Upper
Gender	-0.228	0.210	1.181	1	0.277	0.796	0.528	1.201
High Cholesterol	0.042	0.225	0.035	1	0.851	1.043	0.671	1.623
Cholesterol Checkup in 5 years	0.982	1.109	0.784	1	0.376	2.670	0.304	23.473
Body Mass Index (BMI)	0.020	0.016	1.588	1	0.208	1.020	0.989	1.052
Smoker	0.341	0.206	2.743	1	0.098	1.406	0.939	2.104
Heart Disease or Attack	-0.108	0.265	0.165	1	0.685	0.898	0.534	1.510
Physical Activity	-0.116	0.239	0.235	1	0.628	0.890	0.557	1.423
Fruit Intake	-0.407	0.241	2.854	1	0.091	.666	0.416	1.067
Veggie intake	0.202	0.273	0.547	1	0.460	1.224	0.716	2.091
Heavy Alcohol Consumption	0.073	0.638	0.013	1	0.909	1.076	0.308	3.755
General Health	0.360	0.113	10.089	1	0.001*	1.434	1.148	1.790
Serious Difficulty in Walking or Climbing Stairs	0.053	0.238	0.049	1	0.826	1.054	0.661	1.682
Stroke	-0.532	0.337	2.503	1	0.114	00.587	0.304	1.136
High blood pressure	0.023	0.232	0.010	1	0.920	1.024	0.649	1.614

* Level of significance at 5%

Table 4. Omnibus Tests of Model Coefficients*

-2 Log Likelihood	Overall (score)			Change From the Previous Step			Change From Previous Block		
	Chi-square value	Degrees of freedom	p-value	Chi-square value	Degrees of freedom	p-value	Chi-square value	Degrees of freedom	p-value
961.269	41.144	16	0.001	37.949	16	0.002	37.949	16	0.002

*Beginning Block Number 1. Method = Enter

difference between the new model and Log-likelihoods of the baseline model. If the new model has significantly decreased -2 Log-likelihoods than the baseline, it recommends that the new model describes more of the variance in the outcome and is an improvement. The results showed a highly significant chi-square value (Chi-Square = 41.144, df = 16, p<.005); hence, this new model is significantly better (Table 4).

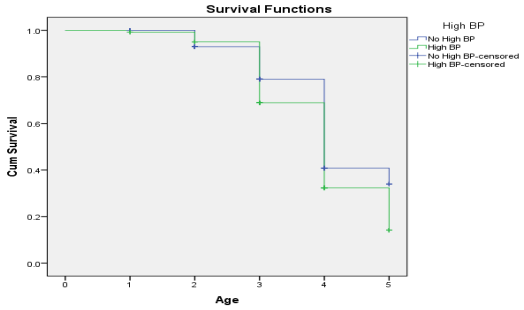

Figure 1. Survival curve showing the estimated survival probability and individuals' age concerning high blood pressure.

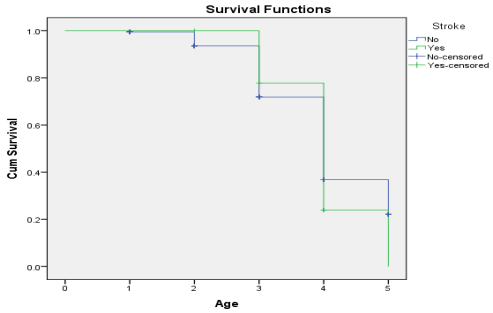

Figure 2. Survival curve showing the estimated survival probability and individuals' age concerning stroke.

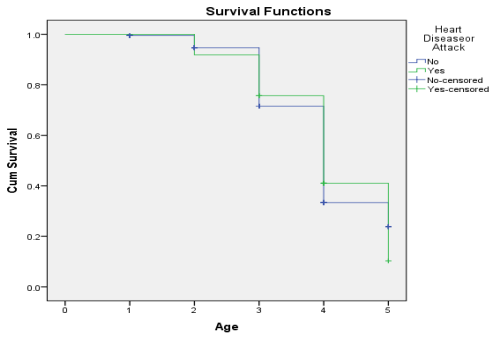

Figure 3. Survival curve showing the estimated survival probability and individuals' age concerning heart disease or attack.

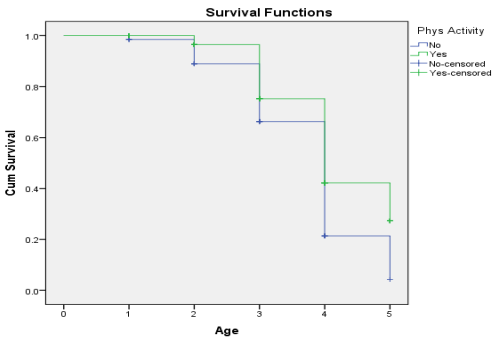

Figure 4. Survival curve showing the estimated survival probability and individuals' age concerning physical activity.

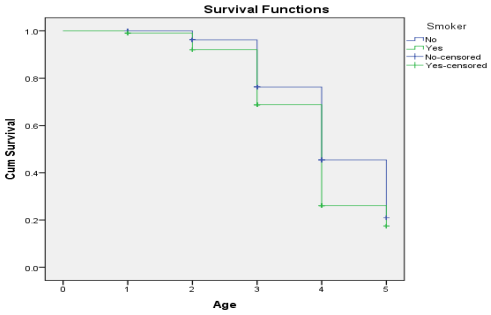

Figure 5. Survival curve showing the estimated survival probability and individuals' age concerning smoking.

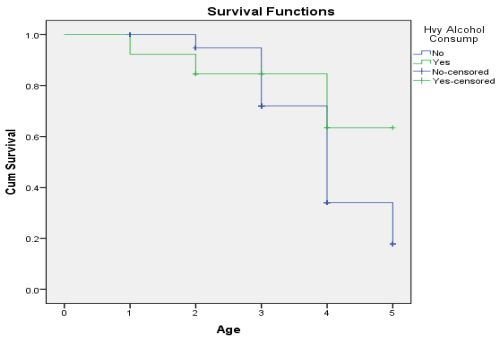

Figure 6. Survival curve showing the estimated survival probability and individuals' age concerning heavy alcohol consumption.

As age increases, the estimated survival probability of patients with DM decreases in the presence of risk factors such as high blood pressure, smoking, heavy alcohol consumption, heart disease or attack, and stroke. Likewise, their estimated survival probability decreases as their age increases if they are not involved in physical activity (Figure 1-6).

Assessing the risk factors of patients with DM is crucial to prevent complications, subsequent morbidity, and mortality and for the implementation of preventive measures. The risk factors were compared between DM patients (n=111) and non-DM patients (n=110), and the findings indicate that risk factors like age, high cholesterol, smoking, heart disease, physical activity, heavy alcohol consumption, general health status, severe difficulty in walking or climbing stairs, stroke, and high blood pressure were significantly associated with the risk of DM. These findings were consistent with the outcomes of a recent Iran-based study; however, that study failed to include factors related to diet or physical activity (Ghadamgahi et al., 2021). Also, previous studies conducted in the United States and Mexico showed similar results for most variables (Kenneth et al., 2001; Alexan-

der et al., 2023). Conversely, a study by Karen et al., (2018) on the United States population showed no significant variation among prediabetes and normal group for dietary factors like intake of fruits, vegetables, and alcohol use. The findings of this study are in congruence with the outcomes of a previous study conducted in Saudi Arabia, which stated that most of these behavioral factors were found to be statistically significant, but the nature of work being physically active or not was not statistically significant (Murad et al., 2014). A European narrative review aimed at identifying vulnerable groups for DM and used sociodemographic and lifestyle-related risk factors. It concluded that low socioeconomic status could significantly increase the risk for prediabetes and diabetes in addition to other diabetes risk factors, but it is often overlooked (Kyrou et al., 2020).

Regarding the multiple logistic regression analysis, this study observed that all risk factors except general health were non-significant in predicting the risk of DM. It is inferred that the general health of the American population significantly influences their risk of DM. An increase in general health by one unit showed a 1.434 times higher likelihood of being diabetic. In line with this finding, a recent study found that general health was the most affected domain in DM cases (Feyisa et al., 2020). In contrast, Murad et al. (2014) performed a multivariate logistic regression analysis and found a high risk of DM among those who were older than 40 years old, less educated, married or divorced, jobless/housewives, and current smokers. In addition, an earlier study in North Ethiopia estimated the adjusted odds ratios of the risk factors of DM using multiple logistic regression analysis and noticed that smoking, consumption of tobacco products, nonconsumption of fruits or vegetables, inactive and moderate physical activity, being obese or overweight, and hypertension were the significant risk factors for diabetes. It also reported that behavioral and medical-related factors were possible risk factors for diabetes (Tareke et al., 2014). Though the findings of this study differ from previous studies (Murad et al., 2014; Tareke et al., 2014), the risk factors of diabetes that are significantly associated with DM are behavioral factors. Besides, the observations of the present study are obtained from the earlier dataset of the American population in 2015, which warrants further research analyzing the recent massive datasets of various populations to support the significant effect of general health and the nonsignificant effect of other risk factors on the risk of DM. In particular, factors such as family history of DM and type of DM are not found in the survey datasets, which might affect the study outcomes and its generalization. Hence, further research is required to include a family history of DM and the type of DM in the survey to predict the risk of DM. Furthermore, the dataset used in this study was self-reported and obtained through the survey, which relies on survey respondents' memory and recall, leading to bias, inaccuracy, and misleading interpretations. Such drawbacks from self-reported data should be treated with appropriate tactics in future studies.

In the current study, the estimated survival probability of patients with DM declines as age progresses in the presence of risk factors such as high blood pressure, smoking, heavy alcohol consumption, heart disease or attack, and stroke. Also, their estimated survival probability decreases if they are physically inactive. Similar to the findings, an Ethiopian study concluded that family history of DM, increased blood cholesterol, high blood sugar level, uncontrollable blood pressure, overweight, and alcohol and tobacco use were the significant factors contributing to a reduced survival time of DM patients (Teni et al., 2015). Further, males with a family history of DM, type I DM, eye, neurological, and cardiovascular complications, and hypertension had a high risk of death among diabetic patients (Yirdaw et al., 2018). An Indonesian study also found that the factors influencing the survival of patients with type II DM were sex, age, intermittent blood glucose levels, management profiles, comorbidity, and complications (Lomo et al., 2021). Notably, these studies were conducted among the Indonesian and Ethiopian populations; however, the present study was conducted among the American population and also examined risk factors such as general health, diet intake, walking or climbing stairs, and body mass index. It did not study the diabetic complications, family history of DM, and type of DM, which can be performed in future studies.

CONCLUSION

Risk factors such as age, smoking, physical activity, heavy alcohol consumption, high cholesterol, heart disease or attack, general health, serious difficulty in walking or climbing stairs, stroke, and high blood pressure were significantly associated with the risk of DM. General health was a significant predictor of the risk of DM. The estimated survival probability of diabetic patients declines as their age progresses in the presence of risk factors such as smoking and heavy alcohol consumption, high blood pressure, heart disease or attack, and stroke. Also, it decreases with their

age, even if those patients are physically inactive. These outcomes emphasize the significance of public health programs and measures focusing on these factors to limit the burden of DM among the general population. Notably, this study is limited to an old dataset collected from American population in 2015. Hence future studies are warranted to use the recent datasets collected to estimate the survival probability of diabetic patients in different population sets.

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