DETERMINANTS TO INCREASE IN TYPE 2 DIABETES IN NAIROBI METROPOLITAN AREA

Abstract

The rising prevalence of type 2 diabetes (T2D) in Nairobi's metropolitan area poses a significant public health concern, driven by a combination of genetic predispositions and lifestyle factors. This cross-sectional study, conducted at Kenyatta National Hospital, investigates the contributors to the increasing T2D cases within this urban population. Key risk factors examined include age, family history, body mass index (BMI), waist circumference, and lifestyle behaviors such as physical inactivity and smoking. The study employed both descriptive and inferential statistical analyses, with a sample comprising 47% female participants and 53% male participants. Notably, 71% of participants lacked a family history of diabetes, suggesting lower hereditary risk for some. Multiple linear regression analysis was used, with HbA1c levels as the dependent variable and other factors as independent variables. Results revealed a correlation coefficient (R) of 0.79, indicating a robust model fit, and an R-squared value of 0.62, implying that 62% of the variation in HbA1c levels is attributable to the independent variables. Significant predictors included age, family history, waist circumference, and BMI, all positively associated with higher HbA1c levels at a 95% confidence interval. However, education level and physical activity showed no significant predictive value. These findings highlight the role of modifiable risk factors in T2D prevalence and underscore the need for targeted public health interventions in Nairobi to address this growing epidemic.

Introduction

Type 2 diabetes (T2D) represents a significant health challenge globally, characterized by a complex interaction of genetic predispositions and environmental influences. Key lifestyle factors, including physical inactivity, tobacco use, excessive body weight, and pregnancy-related conditions, elevate the risk of developing T2D. This chronic condition, along with its associated complications, has emerged as a major public health concern, contributing to increased morbidity and mortality rates in both developed and developing nations. In particular, urbanizing regions like Nairobi, Kenya, are witnessing a marked rise in T2D prevalence, driven by shifts toward modern lifestyles often associated with industrialization and urban growth (Wu et al., 2014).

Certain behaviors, such as smoking, exacerbate the risk of T2D by impairing blood circulation, which can elevate blood glucose levels and contribute to disease onset. Similarly, pregnancy poses a unique risk for women, particularly through gestational diabetes, which may develop during the second or third trimester. Healthcare providers recommend regular blood glucose monitoring for pregnant women to mitigate this risk (Diabetes Kenya, 2021). Additionally, mental health conditions, including depression, bipolar disorder, and schizophrenia, have been linked to increased blood glucose levels, further heightening the likelihood of T2D. A sedentary lifestyle, characterized by prolonged periods of inactivity, also significantly increases the probability of developing this condition. Adopting strategies such as weight control, regular physical activity, and balanced nutrition can play a critical role in preventing T2D (Diabetes Kenya, 2021).

The global burden of T2D has been recognized as an epidemic by the World Health Organization, underscoring the urgency of addressing its risk factors (Thibault et al., 2016). Identifying these factors in affected individuals enables the development of targeted intervention strategies. Given that T2D risk often increases with age, regular medical check-ups—ideally every three to six months—are advised to monitor health status and detect early signs of the disease.

Central to T2D management is the hemoglobin A1c (HbA1c) test, which measures average blood glucose levels over a two- to three-month period. HbA1c, or glycated hemoglobin, forms when glucose binds to hemoglobin in red blood cells, reflecting the body's ability to regulate blood sugar. Elevated HbA1c levels indicate poor glucose control, increasing the risk of T2D and its complications, such as cardiovascular issues, vision impairment, and foot-related conditions. Regular HbA1c testing is essential for early detection and management of T2D, particularly in high-risk populations like Nairobi's urban residents (Diabetes Kenya, 2021). The standard unit for HbA1c measurement, adopted globally since 2009, is millimoles per mole (mmol/mol), though percentages are occasionally used for historical context. For individuals with T2D, an HbA1c level of 48 mmol/mol (6.5%) or lower is recommended, while those at risk should aim for levels below 42 mmol/mol (6%). Non-diabetic individuals typically maintain HbA1c levels between 4% and 5.6% (Diabetes Kenya, 2021).

Research indicates that individuals of African descent face a higher risk of T2D compared to other racial groups, necessitating targeted awareness campaigns in regions like Nairobi (Diabetes Kenya, 2021). Education plays a vital role in equipping communities with knowledge about T2D risks and prevention strategies, including the importance of routine HbA1c testing. Local diabetes education programs can enhance public understanding and encourage proactive health management. The motivation for this cross-sectional study stems from the alarming increase in T2D cases within Nairobi's metropolitan population, aiming to identify the factors driving this trend and inform public health interventions.

Methods

This study utilized HbA1c measurements to explore the relationships between health-related factors, selected socio-demographic variables, and average blood glucose levels over a two- to three-month period in a Nairobi-based population. Conducted with support from the Kenya Diabetes Management and Information Centre (DMI Centre) at Kenyatta National Hospital, the research aimed to address the escalating prevalence of type 2 diabetes (T2D) in Nairobi's metropolitan area. The cross-sectional study was carried out from June 12, 2019, to September 15, 2019, in various suburbs of Nairobi, with participants selected based on records from local diabetes clinics and Kenyatta National Hospital (KNH), which formed the sampling frame.

The study population was restricted to individuals aged 25 to 60 years who had no prior diagnosis of diabetes. This age range was chosen because the risk of T2D increases significantly after age 40, capturing individuals 15 years before and up to 20 years after their 40th birthday. A simple random sampling method was employed to select participants from the sampling frame. The researcher contacted potential participants via phone calls to obtain their consent for participation. Research assistants and nurses then visited consenting participants to collect data using a questionnaire, weighing scales, tape measures, and a sphygmomanometer for blood pressure measurement. Blood samples were drawn from all participants to measure HbA1c levels using the AFINIONTM device, which provides accurate HbA1c readings in mmol/mol.

Some participants recruited for the study did not provide complete information, resulting in datasets containing only their generic ID codes with missing values. Additionally, the HbA1c variable, which recorded glucose levels in mmol/mol, had instances of missing data. To handle this, the study used the default LISTWISE deletion mechanism in SPSS, which automatically excludes cases with missing values for any variable included in the analysis, ensuring that only complete observations were used in the statistical computations.

Data analysis was performed using SPSS version 26, encompassing both descriptive and inferential statistical approaches. Descriptive statistics were generated to summarize the dataset. In SPSS, this was achieved by navigating to Analyze > Descriptive Statistics > Descriptives. Variables were selected from the left column of the descriptive window, highlighted, and moved to the right column for analysis using the arrow button. The Options button was used to specify which descriptive statistics (e.g., mean, median, standard deviation) to include, and the OK button was clicked to produce the summary statistics output.

For inferential analysis, multiple linear regression was employed to examine the associations between various risk factors and T2D, with HbA1c as the dependent variable and independent variables including sex, age, ethnicity, education level (edu), family history of diabetes (family), waist circumference (waist), body mass index (bmi), systolic blood pressure (sbp), physical activity level (activity), and smoking status (smoker). To ensure the validity of the multiple regression analysis, the dataset was tested against eight key assumptions:

1. **Continuous Dependent Variable**: The dependent variable, HbA1c, was measured on a continuous scale, satisfying the first assumption. If this assumption were not met, ordinal regression would have been considered for ordinal variables (e.g., Likert-scale data).
2. **Multiple Independent Variables**: The study included multiple independent variables, which were a mix of continuous (e.g., age, bmi), interval (e.g., waist, sbp), and categorical (e.g., sex, ethnicity) variables, meeting the second assumption.
3. **Independence of Residuals**: The Durbin-Watson statistic was used to assess autocorrelation in the residuals. A value of 1.88 was obtained, indicating positive autocorrelation (values from 0 to less than 2 suggest positive autocorrelation, while 2 to 4 indicate negative autocorrelation).
4. **Linear Relationships**: Scatter plots and partial regression plots were generated to confirm linear relationships between HbA1c and the independent variables. The results demonstrated linearity, but if non-linearity were present, non-linear regression or data transformation in SPSS would have been considered.

5. **Homoscedasticity**: The consistency of variances along the regression line was verified by plotting residuals against unstandardized predicted values. The results confirmed homoscedasticity, indicating uniform variance across the model.
6. **No Multicollinearity**: Correlation coefficients were inspected to ensure that independent variables were not highly correlated with each other. The analysis showed no evidence of multicollinearity, which would otherwise complicate the identification of individual variable contributions to HbA1c variance.
7. **No Significant Outliers**: The dataset was checked for outliers and highly influential points using the studentized deleted residuals test. No significant outliers were found, ensuring the predictive accuracy of the model.
8. **Normality of Residuals**: Normal P-P plots were used to assess the distribution of residuals. The plots indicated that residuals were approximately normally distributed, confirming the dataset's suitability for multiple regression.

Since the dataset satisfied all eight assumptions, it was deemed appropriate for multiple linear regression analysis. The analysis was conducted in SPSS by following these steps:

1. Navigate to Analyze > Regression > Linear to open the Linear Regression dialogue box.
2. Transfer the dependent variable (HbA1c) and independent variables (age, waist, bmi, sbp, f_sex_female, f_family_yes, f_ethnicity_a, f_ethnicity_b, f_ethnicity_oth, f_edu_higher, f_activity_moderate, f_activity_active, f_smoker_yes) to their respective fields using the appropriate buttons.
3. Click the Statistics button to select additional options, including confidence intervals at 95% for regression coefficients, while retaining default settings.
4. Click Continue to return to the Linear Regression dialogue box.
5. Click OK to generate the regression output for further analysis.

This rigorous methodology ensured that the study's findings were robust and reliable, providing a solid foundation for analyzing the risk factors associated with T2D in Nairobi's metropolitan population.

Results

Descriptive statistics revealed that of the 300 participants in the study, 141 (47%) were female, and 129 (43%) were male. Regarding education, 212 individuals (70.7%) had a basic or lower level of education, while 58 (19.3%) had attained higher education. For family history of diabetes, 213 participants (71.0%) reported no family history, whereas 57 (19.0%) indicated a family history of diabetes, suggesting a lower hereditary risk for the majority. In terms of ethnicity, 134 participants (44.7%) were Black, with the remaining participants comprising Asians, Whites, and other ethnic groups. This distribution implies that 55.3% of the study population may face a higher risk of developing type 2 diabetes due to ethnic predispositions.

The table below shows the summary statistics of the scale variables in the dataset.

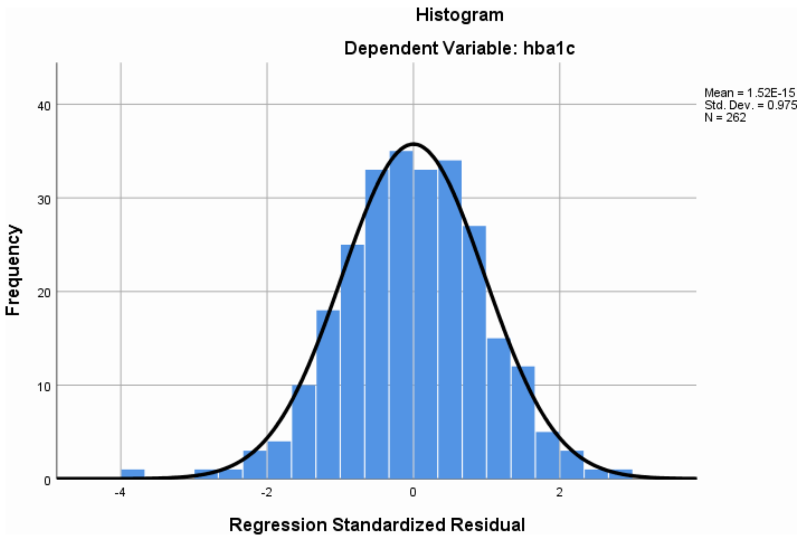
	Age	HbA1c	waist	bmi	sbp
Mean	40.60	34.13	81.99	27.04	128.41
Median	41.00	34.00	81.50	26.45	128.00
Std. Deviation	6.25	7.56	12.35	4.81	13.14

Table 1. A table showing the summary statistics of age and HbA1c variables

The table indicates the mean and standard deviation for each continuous variable as follows: Age (M = 40.60, SD = 6.25), HbA1c (M = 34.13, SD = 7.56), Waist (M = 81.99, SD = 12.35), BMI (M = 27.04, SD = 4.81), and SBP (M = 128.41, SD = 13.14). The median values were 41.00 for Age, 34.00 for HbA1c, 81.50 for Waist, 26.45 for BMI, and 128.00 for SBP.

The histogram below illustrates the distribution of the dependent variable, HbA1c, with a superimposed normal curve, using regression standardized residuals. The plot confirms that the residuals for HbA1c are approximately normally distributed.

Figure 1. A figure showing the histogram with superimposed normal curve



Additionally, a Normal P-P plot was generated to further assess the standardized residual distribution of HbA1c. The plot demonstrated a linear relationship between the dependent variable and the independent variables, supporting the suitability of the regression model.

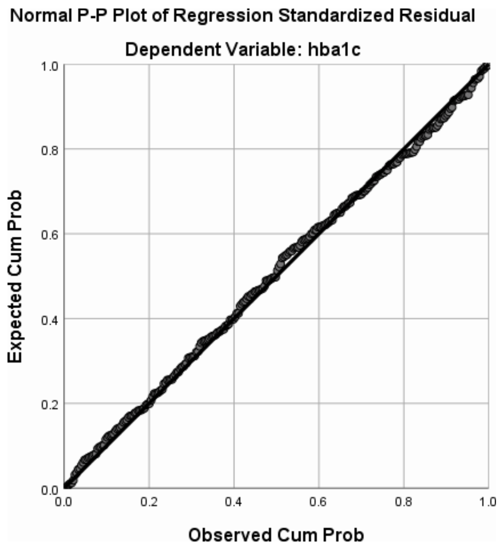


Figure 2. A figure showing the Normal P-P plot of the residuals (errors)

The model summary table below provides key metrics for the multiple linear regression model, including the multiple correlation coefficient (R), R-squared, adjusted R-squared, and the standard error of the estimate, which indicate the model's fit to the data. The multiple correlation coefficient (R) was 0.79, suggesting a strong predictive capability of the model. The adjusted R-squared value was 0.60, and the standard error of the estimate, representing the mean square error of the residuals, was 4.75.

Model Summary

Model	R	R Squared	Adjusted R Square	Std. Error of Estimate
1	.79[a]	.62	.60	4.75

Table 2. A table showing the model summary results of the multiple linear regression

The table below shows the coefficients of the model variables, the confidence Intervals at 95%, that is, the lower and the upper bound of the beta limits, and the level of significance.

Coefficients

Model	Unstandardized Beta	Coefficients Std. Error	Standardized Coefficients Beta	95.0% Confidence Interval for Beta		t	Sig.
				Lower Bound	Upper Bound		
1 (Constant)	2.76	5.58				.50	.62
age	.26	.06	.21	.55	1.82	4.00	.00
waist	.07	.07	.12	.13	7.53	1.08	.28
bmi	.33	.16	.21	.15	6.64	2.08	.04
sbp	.04	.05	.07	.25	3.94	.94	.35
f_sex_female	.1.24	1.33	.08	.20	5.07	.94	.35
f_family_yes	6.72	.74	.36	.95	1.06	9.05	.00
f_ethnicity_a	3.43	.71	.21	.83	1.20	4.82	.00
f_ethnicity_b	1.77	.88	.08	.86	1.16	2.01	.05
f_ethnicity_oth	1.39	1.29	.04	.90	1.11	1.08	.28
f_edu_higher	-1.95	.81	-.12	.78	1.28	-2.42	.12
f_activity_moderate	-5.12	.83	-.29	.68	1.48	-6.18	.00
f_activity_active	-6.35	1.11	-.28	.62	1.61	-5.73	.00
f_smoker_yes	.32	.89	.01	.96	1.04	.36	.72

Table 3. A table showing the coefficients, 95% confidence intervals for the beta results, and the level of significance for the variables

Discussion

The regression coefficients, 95% confidence intervals, and significance levels presented, demonstrate that, at a 95% confidence interval, most independent variables exhibit positive associations with the dependent variable, HbA1c, as indicated by positive lower and upper bounds of the coefficients. This suggests that increases in variables such as age, family history of diabetes, waist circumference, and body mass index (BMI) are associated with higher HbA1c levels, making them reliable predictors of elevated blood glucose in this Nairobi-based study. However, education level and physical activity displayed negative coefficients, indicating that these factors do not positively predict HbA1c levels and may inversely relate to glucose control.

The regression model for predicting HbA1c can be expressed as: Predicted HbA1c = 2.76 + (0.26 × age) + (0.07 × waist) + (0.33 × bmi) + (0.04 × sbp) + (1.24 × f_sex_female) + (6.72 × f_family_yes) + (3.43 × f_ethnicity_a) + (1.77 × f_ethnicity_b) + (1.39 × f_ethnicity_oth) + (0.32 × f_smoker_yes) – (1.95 × f_edu_higher) – (5.12 × f_activity_moderate) – (6.35 × f_activity_active). This equation illustrates how each independent variable contributes to HbA1c levels when other variables are held constant.

The unstandardized coefficients provide insight into the magnitude of each variable's effect. For instance, the coefficient for age (0.26) indicates that for each additional year of age, HbA1c increases by up to 0.26 mmol/mol, reflecting a positive correlation. Conversely, the coefficient for active physical activity (f_activity_active, -6.35) suggests that higher levels of physical activity reduce HbA1c by up to 6.35 mmol/mol, indicating that increased physical activity is associated with better glucose control and a lower risk of type 2 diabetes (T2D).

Statistical significance, as shown in Table 3, indicates whether the coefficients differ significantly from zero in the population. Variables including age, BMI, family history of diabetes (f_family_yes), ethnicity categories (f_ethnicity_a and f_ethnicity_b), and physical activity levels (f_activity_moderate and f_activity_active) were statistically significant predictors of HbA1c ($p < 0.05$). In contrast, waist circumference, systolic blood pressure (sbp), sex (f_sex_female), other ethnicity categories (f_ethnicity_oth), higher education (f_edu_higher), and smoking status (f_smoker_yes) were not statistically significant ($p > 0.05$).

The model's overall fit is supported by a multiple correlation coefficient (R) of 0.79, indicating strong predictive accuracy. The coefficient of determination (R-squared) of 0.62 suggests that 62% of the variability in HbA1c levels can be explained by the independent variables. The adjusted R-squared value of 0.60, which accounts for the number of predictors, remains close to the R-squared, reinforcing the model's robustness.

These findings highlight that age, family history, waist circumference, and BMI are key risk factors predisposing individuals to T2D in Nairobi's metropolitan population, consistent with global research on T2D risk factors (Wu et al., 2014). The significant influence of these factors underscores their role in driving the rising prevalence of T2D in urban Kenya. However, the negative relationship between education level and physical activity with HbA1c was unexpected, as prior studies suggest that higher education and physical activity typically reduce T2D risk (Diabetes Kenya, 2021). This discrepancy may reflect limitations in the study, such as missing data or the specific demographic profile of the sample.

The study's results align with projections of increasing T2D prevalence in developing nations undergoing rapid urbanization, as noted by Wu et al. (2014). The identified risk factors—age, family history, waist circumference, and BMI—mirror those associated with elevated HbA1c levels in this model. These insights are critical for public health strategies in Nairobi, where T2D and its complications are becoming increasingly prevalent. By identifying these risk factors, this study provides a foundation for targeted interventions to address the growing T2D epidemic in Kenya's urban population.

Conclusion

This research has managed to build and test an accurate regression model to determine the levels of glycated hemoglobin (HbA1c) within the urban population of Nairobi, Kenya. The results confirm that a large proportion of the variability of HbA1c (62%, R2 = 0.62) is accounted for by the variables included within the study model with high accuracy (R = 0.79).The study managed to identify a number of important demographic/physiological variables that act as important positive predictors of high levels of HbA1c. The results showed a positive relation with factors such as age, positive family history of diabetes, as well as important antierotic factors such as BMI. The research confirmed that a positive family history of diabetes significantly increases levels of HbA1c, as well as age as HbA1c increases by 0.26 per year. The study confirmed physical activity as a significant negative predictor of high levels of HbA1c. This is important as it can reduce levels of HbA1c by 6.35 percent. The research study found this important as it can be a useful tool for glucose control. The study found the variable 'education' to be a significant negative predictor of high levels of HbA1c. This study found this important as it can be associated with enhanced awareness of the high levels of type 2 diabetes complications within Nairobi. The result of this study aligns with other similar findings which shows the rise of T2D complications within rapidly urbanizing developing countries such as Nairobi. The research project can be important as it can provide a crucial evidence tool through identifying important factors of high levels of type 2 diabetes complications.

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