Diabetes prevalence and effect on Economic Growth: A non-linear Analysis.

Abstract

Diabetes is one of the non-communicable and chronic diseases that occur because of the inability of the pancreas to produce enough insulin in the body, as well when the body cannot use the insulin it produces. According to World Health Organization (WHO), diabetes prevalence has been on the increase both in developed and developing nations in recent times and most people are ignorant of diabetes disease, and its management, which leads to alarming mortality rate. Such situation becomes a great challenge to the world and governments of many countries knowing that high mortality rates, because of diabetes, lead to loss of human capital, which would have contributed to economic growth and development. This study is conducted to analyze the prevalence of diabetes and its effect on economic growth, hence the need to manage it effectively has become the chief cornerstone towards its high mortality rate incidence, which all country governments should adopt. This study will use secondary data collected from reliable sources for its approach. The collection of data is cross sectional which is from different countries in the world. Countries whose data are used in this study are selected randomly. The methodology that was adopted are non-linear model relationship among the variables and the method of analysis were Ordinary Least Square (OLS) model and marginal effects.

This study findings show that estimated adult diabetes population (EADP) has a negative impact on economic growth (GDP/C) when diabetes death related (DDR) is at its mean and minimum values and positive impact when DDR is at its maximum. This implies that at high rate of deaths because of diabetes, economic growth flourishes irrespective of high number of patients infected with diabetes. Also, EADP has positive relationship with GDP/C when cost per person with diabetes (CPPD) is at mean and maximum value and negative relationship when CPPD is at its minimum value. This means when people are wealthy and their riches increases, then EADP will increase, because they have enough money to spend on health care and junk related food intakes. The negative relationship between EADP and GDP/C when CPPD is at minimum simply means that government can no longer support diabetes patients hence decrease in GDP/C leads to minimum expenditure on health care for diabetic patients. In conclusion, EADP has a negative impact on GDP/C considering DDR at mean and minimum value and CPPD at its minimum value. This result proves a dilemma in the world because of diabetes. This study is originally from the author.

Keywords: Cost per person with Diabetes (CPPD), Diabetes Death Related Rate (DDR), Estimated Adult Diabetes Population (EADP), Income per Capita (GDP/C).

1: Introduction

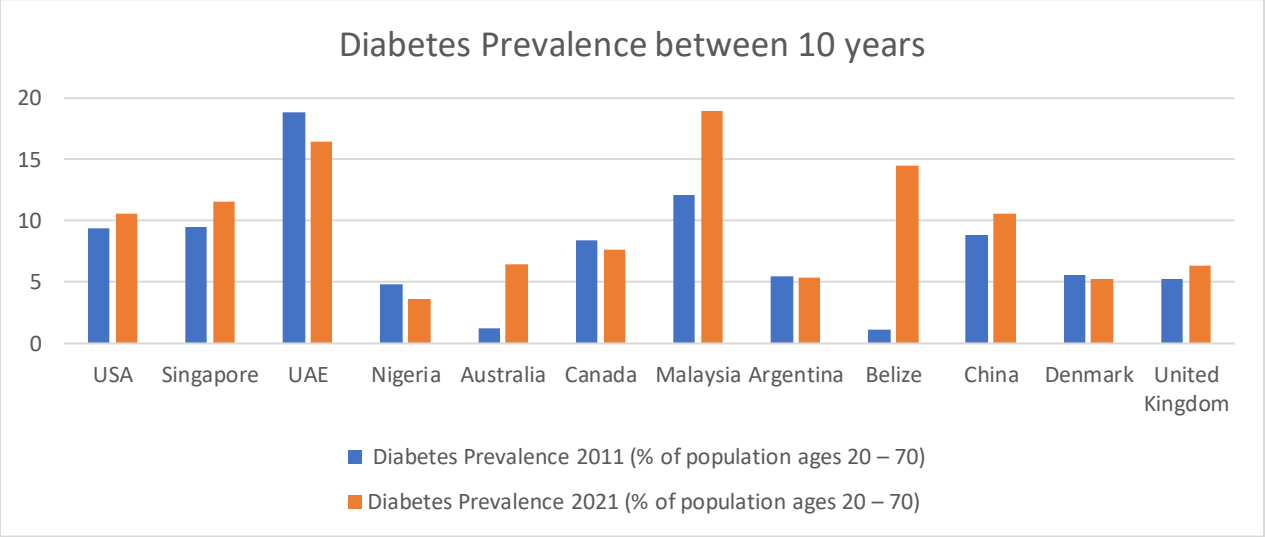
Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone that regulates blood glucose. Increased blood sugar or raised blood glucose, which is medically known as Hyperglycaemia is when the effects of Diabetes are not controlled in the body overtime, which leads to high and serious damage to many organs in the body system, mostly the blood vessels, nerves, kidney, as well as the heart. In 2014, 8.5% of adults aged 18 years and older had diabetes. In 2019, diabetes was the direct cause of 1.5 million deaths and 48% of all deaths due to diabetes occurred before the age of 70 years. Another 460 000 kidney disease deaths were caused by diabetes and raised blood glucose causes around 20% of cardiovascular deaths. Between 2000 and 2019, there was a 3% increase in age-standardized mortality rates from diabetes. In lower-middle-income countries, the mortality rate due to diabetes increased 13%, (Roglic, 2016).

According to information from World Diabetes Atlas, in 2024 about 589 million adults between the age of 20 – 79 years are living with diabetes globally and that means one out of nine people is diabetic. It is predicted that in 2050, the total number of adults with diabetes will increase to 853 million, indicating one out of eight people live with diabetes. About 81% of adults with diabetes are from middle income countries. It is recorded that diabetes caused 3.4 million deaths in 2024. There are about 43% of undiagnosed adults living with diabetes and 90% of them are from low- and middle-income countries. The global health expenditure in 2024 against diabetes was US$1.015 trillion which represents 338% increase over the past 17 years, yet the surge for diabetic patients continues to prevail. It is rated that one out of five pregnant women is affected by hyperglycaemia, (Diabetes Atlas, 2025).

The cost per person with diabetes spent by the government each year continues to increase. In some countries, the government cannot afford to spend huge amounts on diabetic patients, and this has resulted in out-of-pocket expenditure by these diabetic patients which is increasingly alarming. In some cases (mostly low- and middle-income countries) some diabetic patients may not be able to afford the medical cost, and they will give up in array. The impact of this scenario on economic growth and development is not friendly. Many people who died because of diabetes are talented individuals which would have contributed immensely to the growth and development of the world economy. If this trend of diabetes continues, it will surely get to a stage when one out of two people

will be diabetic. Figure 1 below is the diabetes prevalence in 10 years (2011 and 2021), in some selected countries.

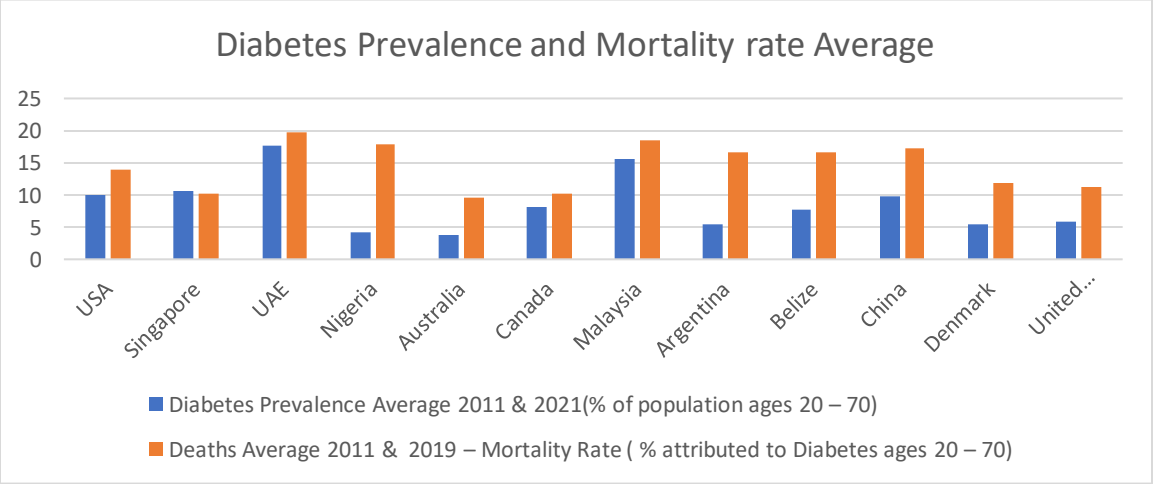
Figure 1: Diabetes Prevalence in some countries between 2011 and 2021



Source: World Bank Indicator 2023.

From figure 1, it is evident that some countries like USA, Singapore, Australia, Malaysia, Belize, China, United Kingdom experienced increase in diabetes prevalence over these years. Also figure 2 below is the diabetes prevalence average between 2011 and 2021 with mortality rate average between 2011 and 2019.

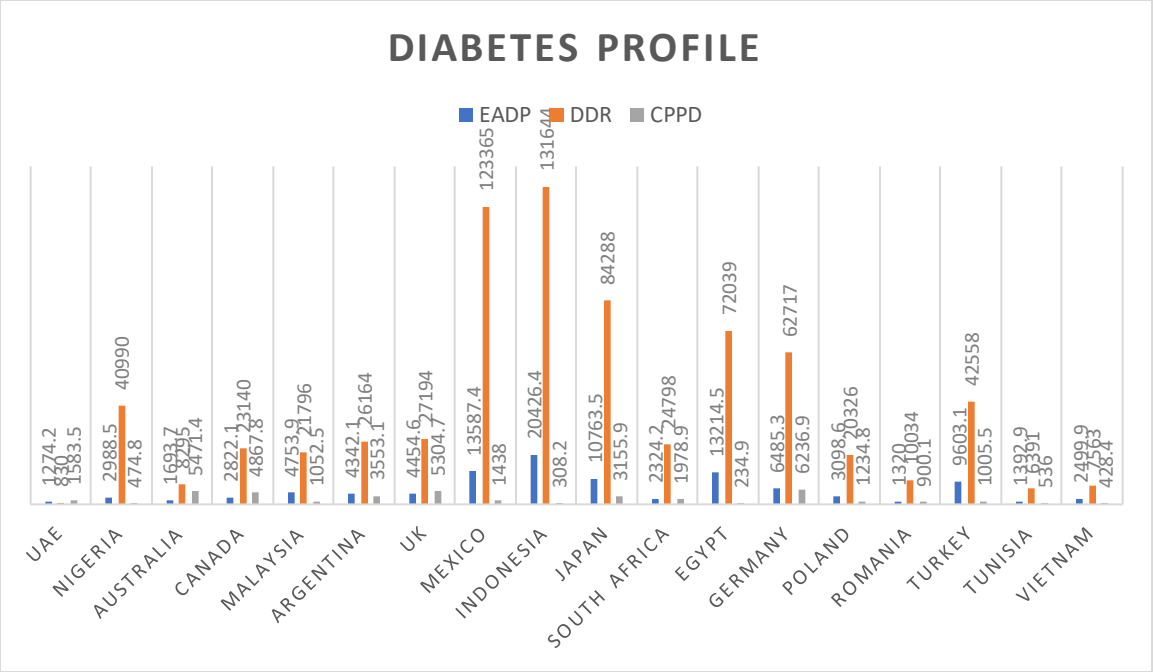
Figure 2. Diabetes Prevalence and Mortality rate



Source: World Bank Indicator 2023.

Figure 2 shows that mortality rate attributed to diabetes for the people between the age of 20 – 70 is at increase considering the countries in which their data are plotted. Increase in death rate because of diabetes and increase in diabetes prevalence is an indication that the fight against diabetes is in the wrong track and the world government is not achieving any success towards their efforts. Recently in 2024, the estimated adult diabetes population between the age of 20 – 70 years in different countries of the world has increased, and this contributed to increase in the death rate on diabetes related deaths in 2024, and not only that, but the cost government also spends on individuals with diabetes in different countries has increased in 2024. Figure 3 below shows the estimated adult diabetes population (EADP), diabetes death related (DDR) cases and cost per person with diabetes (CPPD) in 2024 between the age of 20 – 70 years in different randomly selected countries.

Figure 3: Diabetes Profile

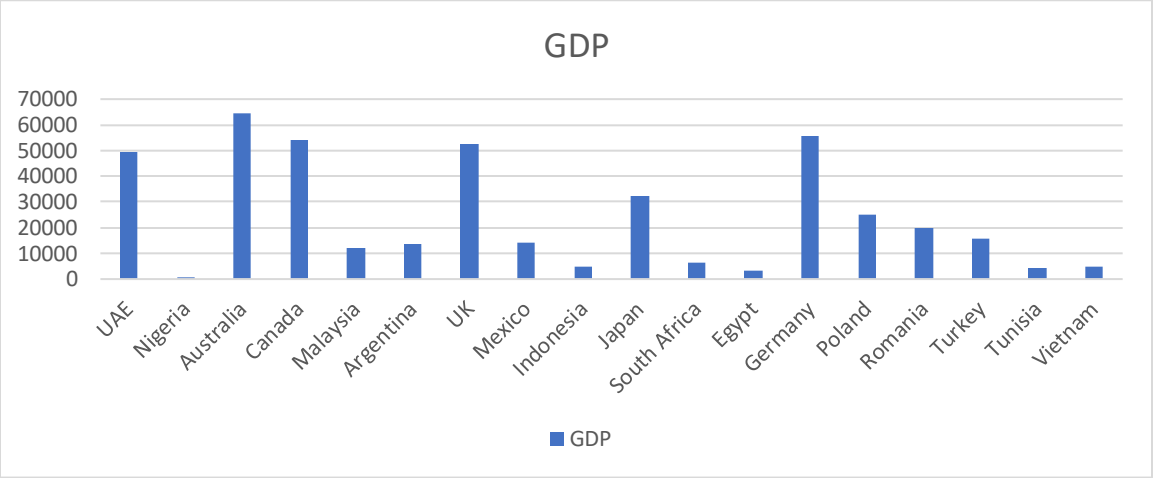


Sources: International Diabetes Federation (IDF) Atlas (2025)

Considering figure 3, diabetes death related (DDR) is high in 2024. This increase is expected to continue over the years. The government is struggling to control the prevalence of diabetes, and this has been affecting economic growth in many countries. Because the money government would

have spent on other economic variables to enhance economic growth is used to fight against diabetes prevalence. Below are few countries and their gross domestic product per capita in 2024.

Figure 4: Gross domestic product per capita of some countries



Sources: World Bank data (2025)

From figure 4, it is observant that some countries have low income per capita (GDP/C) while some have high income per capita, this gap between country's per capita income becomes another devastating condition against appropriate implementation on curb against diabetes prevalence. Considering the devastating situation caused by diabetes prevalence and its mortality rate, this study will answer the question, why is diabetes prevalence at increase and what is its indirect impact on economic growth by putting into consideration this study objective which is to analyze the indirect impact of diabetes prevalence on economic growth. This study significance is to bridge the confusion diabetes prevalence has implemented in many countries knowing that efforts adopted by many countries' government on fight against diabetes seem abortive. This study outcome will help many countries' governments to manage the existing prevalence of diabetes as well put it in control and hence achieve success in curbing diabetes prevalence. The organization of this study is as follows, section one is the introduction, section two is the literature review, section three is data and methodology, section four is the estimation and result analysis, while section five brings the conclusion and policy implications.

2: Literature Review

2.1 Theoretical Review

This study considers the Endogenous Growth Theory (Romer, 1986) which explains how economic growth is enhanced by human capital, productivity and innovation. Endogenous growth theory explains that health is a critical component of human capital and human capital is important for economic growth. When people are healthy, they are more productive and diseases like diabetes reduce productivity, labour efficiency, increase health care costs and diminish health outcome. The indication of weak health outcome leads to weak labour force which causes economic growth to dwindle. This study will adopt this theoretical framework in its analysis.

2.2 Empirical Review

Gojka Roglic (2016) on his article titled "WHO Global report on Diabetes: A summary" stated that Diabetes has been in existence over decades and been recognized as a serious illness, but there has not been any cure anticipated by physicians or healers. It indicated that diabetes prevalence has increased over the decades and WHO member states have engaged in global framework and monitoring of non-communicable diseases with 9 targets to reach in 2025 which diabetes and its risk factors are reflected in the target and indicators such as reduction on exposure to unhealthy diet and physical inability, zero rise in prevalence of diabetes, improved access to medication and reduction to mortality rate are considered.

Forouhi, N. G., & Wareham, N. J. (2019) on their studies "Epidemiology of Diabetes" highlighted causes and consequences of diabetes. Their studies indicated the frequent rise in diabetes prevalence coupled with rise in obesity which have led to premature morbidity, reduced life expectancy, mortality and financial stress and crises patients undergo. The study highlighted how complex diabetes is and mentioned that debates have been on, over the decades. It concluded that experts from World Health Organization and American Diabetes Association have emerged and formulated diagnostic criteria for diabetes knowing that type 1 and type 2 diabetes are main issues on the total diabetes prevalence. The study did not offer any solution to end diabetes prevalence, rather it can be managed.

3: Data and Methodology

3.1 Data

This study used secondary data which are collected from trusted and reliable sources. The collected data are cross sectional which comprises data from different countries for the year 2024. The 31 countries used in this study are selected randomly and the data are collected from International Diabetes Federation (IDF) Atlas and World Bank Data. The independent variables are "estimated adult diabetes population (EADP)" which is measured in numbers ranging from 20 – 79 years expressed in thousands. Second independent variable is "Diabetes Death related (DDR)" which is also measured in numbers from 20 – 79 years old and expressed in thousands. The third independent variable is the "cost per person with diabetes (CPPD)" for the age 20 – 79 years old and it is measured in United states dollars (US$). The sources of all independent variables are IDF Atlas 2025. The dependent variable is economic growth which its proxy is gross domestic product per capita (GDP/C) and it is measured in United states dollars (US$) and its source is from world bank data.

3.2 Methodology

The method of analysis in this study is the ordinary least square (OLS) method and the marginal effect. This method is used because the data collected is cross-sectional data, which is only for the year 2024, involving randomly selected countries. As such, OLS methods suit well to cross sectional data analysis. Considering the non-linear relationship in the model, this study will emulate (Brambor et al., 2006) in the interaction of the independent variables to analyze the indirect relationship between the core independent variable (EADP) and the dependent variable GDP/C to fulfil the objective of this study via marginal effect calculation outcome.

Empirical Model

The model for this study is adopted from the endogenous growth theory (Romer 1986) expressed earlier. Mathematically, the theory states that

$$\text{Economic growth} = f(\text{human capital, innovation, health, knowledge})$$

Such that;

$$Y = A \cdot H^{\alpha} \cdot K^{\beta} \quad (1)$$

Where Y = output (GDP/C); A = technological efficiency; H = human capital (include health and education); K = Physical Capital (budget); α and β are Elasticities (coefficients) showing the contribution of health/human capital and Physical capital to output/economic growth (GDP/C). Therefore in this study, economic growth is represented by GDP/C, human capital is represented by diabetes death related (DDR), health is represented by Estimated Adult Diabestes population (EADP) and physical capital is represented by cost per person with diabetes (CPPD). Hence, we state this study model as

$$GDP/C = f(EADP \,.\, DDR \,.\, CPPD)$$

Statistically, $$GDP/C_i = EADP^{\alpha}_i.DDR^{\beta}_i.CPPD^{\lambda}_i \quad (2)$$

Where α, β and λ are elasticities (coefficient) of the independent variables, showing their contributions to the dependent variable. The subscript (i) indicates each country used in this study. Equation 2 is statistically reduced to

$$GDP/C_i = A + \alpha EADP_i + \beta DDR_i + \lambda CPPD_i + \mu_i \quad (3)$$

For the analysis of non-linear relationship between the independent variables (EADP) on the dependent variable GDP/C, this study uses multiplicative interaction terms between the independent variables in the model to capture the effect of estimated adult diabetes population (EADP) on economic growth (GDP/C) hence we have

$$GDP/C_i = A + \alpha EADP_i + \beta DDR_i + \lambda CPPD_i + ɦ(EADP \times DDR)_i + \mu_i \quad (4)$$

And

$$GDP/C_i = A + \alpha EADP_i + \beta DDR_i + \lambda CPPD_i + ɤ(EADP \times CPPD)_i + \mu_i \quad (5)$$

Note that *A* is constant in the model, (EADP x DDR) and (EADP x CPPD) are the multiplicative interactive variables that will capture the non-linear relationship in the model while ɦ and ɤ are the elasticities (coefficient) of the multiplicative interactive variables and μ_i is the error term of each country in this study. Interactive models (equation 4 and 5) are different from linear models (equation 3) because of the marginal effects and standard errors associated with interactive models. The marginal effect of EADP on GDP/C in the interactive model of equation 4 and 5 are conditioned on the interactive variables DDR and CPPD as explained by the multiplicative

interactive theory (Brambor et al., 2006), hence the marginal effects are obtained through the following partial differential equations from equation 4 and 5 respectively.

$$\frac{\partial GDP/C}{\partial EADP} = \alpha + ħDDR \quad (6)$$

And

$$\frac{\partial GDP/C}{\partial EADP} = \alpha + ɤCPPD \quad (7)$$

It is also important to calculate the standard error associated with each of the marginal effect equations identified at equation 6 and 7. Therefore, the standard error of equation 6 and 7 are stated below

$$\sigma \frac{\partial GDP/C}{\partial EADP} = \sqrt{var(\alpha) + DDR2var(ħ) + 2DDRcov(\alpha, ħ)} \quad (8)$$

and

$$\sigma \frac{\partial GDP/C}{\partial EADP} = \sqrt{var(\alpha) + CPPD2var(ɤ) + 2CPPDcov(\alpha, ɤ)} \quad (9)$$

It is important to know that DDR and CPPD are the conditioned variables in equation 6 and 7 respectively.

4: Result & Discussion

4.1 Descriptive Statistics

This study estimation and result analysis starts with the descriptive statistics. The descriptive statistics show the value of the mean, maximum, minimum and standard deviation of all the variables used in this study. Table 1 below is the descriptive statistics table

Table 1: Descriptive Statistics

	GDP	EADP	DDR	CPPD
Mean	31794.62	12080372	69765.11	2727.57
Maximum	103669.9	1.48E8	755511.0	12234.2
Minimum	647.3	21900.0	33.0	79.3
Standard Deviation	31137.43	29040613	148743.8	3102.67

Observations	35	35	35	35

Sources: Authors computation from EVIEW software (2025)

The result of the descriptive statistics shows that estimated adult diabetes population has the highest (maximum) value among other variables. This is an indication that diabetes prevalence is high in the world in recent times. The values of the mean, maximum and minimum of the variables will be used to calculate the marginal effects of the multiplicative interactive terms in equations 6 and 7. The observations, numbering 35, show that 35 countries data were used in this study.

4.2 Covariance Matrix

The covariance matrix table shows the diagonal relationship among the variables in the model. Its value is used to calculate the standard error associated with the marginal effects of the multiplicative interactive variables.

Table 2: Covariance and Correlation Matrix

Covariance	GDP	EADP	DDR	CPPD	EADP*DDR	EADP*CPPD
GDP	9.42E8					
EADP	- 1.61E11	8.19E14				
DDR	- 5.58E8	4.06E12	2.15E10			
CPPD	77960751	-1.02E10	-10407874	9351560		
EADP*DDR	-7.30E13	5.17E14	2.58E15	-5.09E12	3.67E20	
EADP*CPPD	5.65E11	9.54E11	6.69E12	8.85E10	6.02E17	5.11E15

Sources: Authors computation from EVIEW software (2025)

Table 2 is the covariance matrix. Considering the relationships among the variables, it is depicted that GDP and EADP have a negative relationship of -1.61E11, it also proved that GDP and DDR have a negative relationship of -5.58E8. But CPPD has a positive relationship with GDP and negative relationships with EADP and DDR with values of 77960751, -1.02E10 and -10407874 respectively. The relationship obtained from the covariance matrix does not define completely this study objective; hence this study continues with other necessary estimations and analysis to ascertain its objective.

4.3 OLS Coefficient Estimation

The OLS coefficient estimation proves the relationship among the variables in the model. Considering the objective of this study which is to identify the non-linear (indirect) relationship between GDP and EADP, this study will include the conditioning models in equations 4 and 5 in its analysis to achieve its objective. Also, the magnitude of the values of the coefficients of the variables in the unconditional model (equation 3) and conditional models (equation 4 and 5) will not be used in the conclusion of this study analysis because every conditional model have marginal effects which is mostly used to draw the conclusions on the conditional (indirect or non-linear) impact of EADP on GDP. This study result interpretation will come from the marginal effects.

Table 3: OLS Coefficient Estimates

Variables	Unconditional Model(3)	Conditional Model(4)	Conditional Model(5)
EADP	0.2791(0.5306)	0.0123(0.9812)	0.4712(0.4736)
DDR	-0.0745(0.3894)	-0.0788(0.3643)	-0.1230(0.4100)
CPPD	8.5588(0.0000)***	8.5103(0.0000)***	8.3450(0.0000)***
EADP*DDR		4.56E-7(0.3433)	
EADP*CPPD			3.91E-5(0.6867)
CONSATANT	10275.87	11699.71	11035.91

*Source: Author's Computation from Eview (2025). Note: Significant at *10%, **5%, ***1%. The numbers in bracket are the probability value of the coefficient values of the independent variables.*

From Table 3, in the unconditional model (3), EADP and CPPD have a positive relationship with GDP/C. It means an increase in GDP/C leads to increase in EADP and CPPD. It means when people's income increases, estimated adult diabetics population and cost per person with diabetes increases. This is an indication that people like to spend on diabetes causing foods when their income increases with hope, they have enough income to sustain themselves on medications for diabetes. So, one of the major primary causes of diabetes is increase in income, because when people are rich, they spend more on junk food and do less exercise because they believe they have arrived. Also, DDR has a negative relationship with GDP/C, which implies that any increase in DDR leads to decrease in GDP/C. This is true because Diabetes death related means number of people that died because of diabetes and when such happen, there is loss in human capital which contributes to economic growth, with believe that the contribution of the deceased to economic

growth is lessened. This explained analysis will not be used to address the indirect relationship associated with EADP and GDP/C.

However, the indirect impact of estimated adult diabetes population (EADP) on economic growth (GDP/C) is conditioned on diabetes death related (DDR) and cost per person with diabetes (CPPD). To achieve this, the variables have been interacted as shown in the conditional model (4) and (5) in table 3. The coefficient of the multiplicative terms (EADP*DDR) and (EADP*CPPD) at the conditional model (4) and (5) in table 3 cannot be interpreted like an unconditional model (3). They are used to calculate the marginal effect on the conditional variables to predict their result and ascertain its effect, to achieve this study objective.

4.4 Marginal effect of Estimated Adult Diabetes Population (EADP) on Economic Growth (GDP/C)

The indirect impact or nonlinear relationship between EADP and GDP/C is predicted from the result of the marginal effect of Diabetes Death related (DDR) and Cost Per Person with Diabetes (CPPD). Table 4 below is the result of the marginal effect.

Table 4: Marginal effect of EADP on GDP/C

DDR as the conditioning variable				CPPD as the conditioning variable			
DDR	Marginal effect	Std. Error	T-stat	CPPD	Marginal effect	Std. Error	T-stat
Mean	-0.0426***	1.11E10	0.0000	Mean	0.0321***	5.27E9	0.0000
Max.	0.2700***	2.35E13	0.0000	Max.	0.4038***	1.11E10	0.0000
Min.	-0.0744***	1.55E11	0.0000	Min.	-0.0713***	9.00E8	0.0000

*Source: Author's Computation (2025). Note: Significant at *=10%, **=5% and ***=1%.*

The indirect impact (marginal effect) of EADP on economic growth depends on the value of the conditioning variables DDR and CPPD. The indirect impact (marginal effect) was calculated from the formular given at equations 6 and 7 respectively for DDR and CPPD which was tabulated in table 4. The standard error was calculated from equation 8 and 9 for DDR and CPPD respectively and it was tabulated in table 4. The t-statistics are the answers after dividing marginal effect value with standard error value. The mean, maximum and minimum values of DDR and CPPD were obtained from the descriptive statistics table. The α, $\hbar$ and γ used in the calculation are the

coefficient of EADP and coefficient of the interactive variables respectively. The Var(α), Var(ɦ) and Cov(α,ɦ) used in calculating the standard error are obtained from the covariance matrix table.

From Table 4, considering DDR as the conditioning variable, DDR at its mean and minimum has a negative value of -0.0426 and -0.0744 respectively while at maximum DDR has a positive value of 0.2700 and they are significant at 1%. This implies that if Estimated Adult Diabetes Population (EADP) increases by 1% when DDR is at its mean and minimum, then economic growth will decrease by 4.26% and 7.44% respectively, and when DDR is at its maximum, any 1% increases of EADP leads to 27% increase in economic growth. That means when number of people with diabetes increases and there is no diabetes death related recorded, then economic growth will decrease because they will become a burden to the government and they will not be productive. Governments will continue to spend on them hence they will not contribute to economic growth. They will become a liability. On the other hand, when estimated adult diabetes population increases and there is maximum (high) record of diabetes death related, economic growth will increase. This simply implies that the diabetic patients which have been a burden to government have all died hence government will no longer bear their burden and money meant for assisting their medical care will be channeled to other variables for economic growth. Finally, EADP has a negative impact on economic growth when DDR is at its mean and minimum and positive impact when DDR is at its maximum.

From table 4 and in consideration of CPPD as the conditioning variable, the marginal effect values show that CPPD has positive values for mean and maximum (0.0321 and 0.4038) respectively, while at minimum it has a negative value of -0.0713 and they are all significant at 1%. The positive result implies that any 1% increase in EADP when CPPD is at its mean and maximum, economic growth will increase at 3.21% and 40.38% respectively. Also, it implies that at 1% increase of EADP when CPPD is at its minimum, economic growth will decrease at 7.13%. In general, it means that increase in estimated adult diabetes population when expenditure per person with diabetes is at maximum or at mean, then economic growth is sustained and when expenditure is at minimum, economic growth decreases. This means at that point, government has no money to support the diabetic patients hence the impact of EADP on economic growth at that point, dwindles the entire economy.

5: Conclusion

This study highlighted the nonlinear relationship between diabetes and economic growth. The motivation behind this study is the daily increase of diabetes prevalence and diabetes death rate in the world in recent time. This has affected economic activities and growth negatively, causing many countries' economies to struggle for growth. The issue of increase in diabetes prevalence needs to be under high consideration to stop its negative impacts on economic growth. There is prove that estimated adult diabetes population affects negatively economic growth, hence there is indirect negative impact it has with economic growth in consideration to diabetes death related cases, which is proved through the result from the marginal effects computed. There is high need for governments of many countries to enforce strategies on fighting against diabetes. This is because world economy may collapse if in the future 1 out of 2 people are diabetic. If such threshold emerges, the world will be a ghost town.

5.1 Policy Recommendation

One of the major reasons that causes diabetes is abundance of wealth. It was highlighted in this study that when people are rich, they spend money extravagantly and mostly on foods that are not healthy. Example, they will start eating fast (Junk) foods which is mostly one of the causes of diabetes. Secondly, they start drinking alcohol like wine because they can afford it, forgetting to understand the high level of its sugar content. When all this sugar intake accumulates in the body, it becomes difficult for the insulin in the body to saturate it, thereby causing high blood sugar which is diabetes.

Therefore, the government of all countries in the world should implement a law to control the selling and purchase of junk foods, alcohol and other food related substances that cause diabetes. Appropriate data check will help the government to monitor offenders and bring them to book.

Government should enact serious penalties on offenders who disobey the government law of selling and purchase of junk foods, alcohol and others. Also, government should encourage restaurants to dish out healthy foods. All restaurants selling junk food should stop and regulatory measures on alcohol sales and purchases should be implemented.

Awareness on the causes, impacts of diabetes should be conducted on weekly basis, this will help citizens who are ignorant of it to take precautions, thereby reducing diabetes prevalence. Building

recreation centers that attract citizens to indulge in daily exercise to reduce accumulated fat is important. Doing it will save lives. Finally, the money government spends on helping diabetic patients should be channeled by implementing strong laws to protect them from being diabetic. Obedience is better than sacrifice.

5.2 Study Limitations

This study looked at the indirect effects of diabetes on economic growth considering diabetes death related and cost per person with diabetics as an agent to its effect. There are many other variables that can serve as agent between diabetes and economic growth relationships. This study used secondary data collection and OLS method with marginal effects for its analysis. Other studies may use primary data or other methods of analysis for the same study purpose. Countries whose data were used in this study were randomly selected, hence there is need for inclusion of omitted countries in the future related studies.

References

Brambor, T., Clark, W. R., & Golder, M. (2006). *Understanding interaction models: Improving empirical analyses*. *Political Analysis, 14*(1), 63–82. https://doi.org/10.1093/pan/mpi014

Diabetes Atlas (2025). https://diabetesatlas.org/data-by-location/global/

Forouhi, N. G., & Wareham, N. J. (2019). *Epidemiology of diabetes*. *Medicine*, *47*(1), 22–27. https://doi.org/10.1016/j.mpmed.2018.10.004

Roglic, Gojka (2016). *WHO Global report on diabetes: A summary*. *International Journal of Noncommunicable Diseases 1(1), 3-8*. https://doi.org/10.4103/2468-8827.184853

Romer, P. M. (1986). *Increasing returns and long-run growth*. *Journal of Political Economy, 94*(5), 1002–1037. https://doi.org/10.1086/261420

World Bank Indicator (2023, 2025). https://databank.worldbank.org/source/world-development-indicators

COMPETING INTERESTS DISCLAIMER:
Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.