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ANALYSING THE IMPACT OF SOCIOECONOMIC FACTORS ON DIABETES PREVALENCE AND HEALTHCARE ACCESS IN RURAL AMERICA

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ABSTRACT

The research focused on the complex association of SES, health insurance, and diabetes in rural populations in the United States of America to fill a gap in the literature. The purpose was to evaluate the relationship of different elements of SES and the accessibility to health care services on diabetes in the adult population of rural areas. This survey is cross sectional involving 500 adults aged 18 and above and the sampling was done through the use of stratified random sampling. The quantitative data were gathered from self completed structured questionnaires and qualitative data were obtained through interviews with health care providers on subjects such as demographic characteristics, income, education, healthcare access and diabetes. The research established diabetes at 12% with a clear Income split split—20% of the lowest income earners and only 5% of those in the higher income group. Furthermore, 30 % Rated their health care access as moderate to low and this was having strong negative relation with diabetes*d ($r = -0.56$, $p < 0.01$). Logistic regression analysis indicated that low SES (Odds Ratio: 3.2, 95% Confidence Interval: 1.8–5.7) and inadequate healthcare access (Odds Ratio: 2.4, 95% Confidence Interval: 1.3–4.5) were critical predictors of diabetes risk. Hence, these findings have expanded the imperative call for efforts that addresses various social economic determinants of health with specific focus on the improvement of health access in rural regions. Therefore, this research has important implications for the analysis of socio-economic determinants that compound diabetes risks and the formulation of relevant public health interventions targeted at improving the access of vulnerable populations to effective diabetes care.

Keywords: Diabetes, Healthcare, Socioeconomic, Prevalence, Rural

INTRODUCTION

Diabetes mellitus has become a focal point on the US population, a disease whose prevalence has significantly increased within the last few decades. The CDC estimates that 34.2 million people or 10.5% of Americans had diabetes in 2020, and potentially over half of these people, have type 2 – which is strongly associated with modifiable environmental and social factors (Alam, 2021). The disparities between rural and urban population for diabetes are puzzling, and clearly shows that research needs to consider the context of various economic factors to adequately explain health differences in these areas (Bliss, 2021). Diabetes poses big challenges in Rural America, especially in regard to inadequate health care, a higher incidence of poverty, and minimal resources for early diagnosis (George et al., 2022). Research has shown that compared to the urban dwellers the rural people have a physical barrier in accessing health care hence their diseases are detected later thus having poor health (Bakibinga et al., 2022). Some of the factors include income, education and employment in which economists have concluded that disparities of socioeconomic status including income and education levels largely determine both the rates of diabetes epidemic and the level of healthcare centre accessibility in rural regions. These issues create an even bigger cyclical process within this interplay that results within worsening health disparities, coupled with higher incidence of complications and death in rural populations than in urban areas (Hill et al., 2021).

Rural American is characterized by geographic and demography where people of different socioeconomic status live meaning cut across health disparities. Another important factor related to rural populations is that the improved uptake of employment opportunities often yields inferior results as compared with urban environments, education levels are likewise consistently lower and full access to fresh, healthful foods is a rarity (Zhao et al., 2020). Also, many people in rural areas face disruptions and barriers, including; transportation issues, fewer health practitioners, and poor insurance that make them to be unable to access the appropriate medical care in good time (Wolfe et al., 2020). Such a complexity of how rural-population access to healthcare is therefore highly charged, and requires that this section presents a broad analysis of the sociocultural demographic factors that are likely to influence diabetes outcomes and health inequities (Zou et al., 2020). Cross sectional studies have indicated that level of income, education and occupation are vital predictors of health, including diabetes risk and the ability to control the disease (Alaofè et al., 2022). Diabetes occurs more frequent in persons with lower SES because of many factors such as; health facility access, unhealthy behaviours, and obesity. For example, people with a lower income cannot always buy healthy foods, thus they live in “food swamp,” areas with a lack of fresh fruits and vegetables. This disease coupled with the pressures of a bad economy makes the body conducive for the onset of diabetes through poor dieting habits (Krstikj et al., 2023).

Another important factor that cuts across in promoting or influencing health behaviours and utilization of services is education. Education as described by which is a representation of the number of years of formal schooling that a person has completed, has a positive relationship with health literacy; given this demographic characteristics that can help on in making high levels of informed decisions on health issues, self management of chronic illnesses and health system navigation (Shoesmith et al., 2021). In contrast, low education levels are associated with poor knowledge about diabetes factors and ways to avoid the diseases hence many cases occurring. Also, low education attainment can limit employment opportunity, and reduce income, thus maintaining a loop of health inequality (Bekele et al., 2020). Employment status crosses over with these socio-economic determinants of health because stabilised employment, results in healthier populace and equal opportunities accessing health care services. Health insurance is sometimes given by employers and it is very essential for enabling the patient to get early detection treatments for illnesses such as diabetes (Handley et al., 2021). Nevertheless, the unemployment rate increases much more in rural areas where opportunity often is scarce and when available may not come with adequate health insurance (Handley et al., 2021). This gap prevents them from getting the necessary medical care, adequately control their health, and pay for essential medications and therefore deteriorated health.

There is also a scarcity of healthcare providers that serve rural areas of America and this makes it even harder for diabetes patients. Limited access to primary care physicians, endocrinologists and certified diabetes dietitians or educators is reported across most rural communities limiting the chances of coming across and receiving adequate care (Sutherland et al., 2020). This provider scarcity is, however, compounded by other factors like low spending on care and health promotion in the rural areas and thus low resource input for diabetes self-management education. Consequently, clients in the rural areas may get appointments that are too far in the future, travel long distances to get the services and may be served inadequately (Reshma et al., 2021). Thirdly, the social determinants of health framework also focuses on the context in which health happens. Environmental characteristics like the stocks of housing, availability of transport, and other amenities have a close link with potential health-promoting activities and utilization of health services (Reshma et al., 2021). This often limits patients' access to health care facilities for check-ups and monitoring; access to healthy foods, since most rural areas have no sufficient transportation; and access to adequate physically active engagement, which is a preventer of diabetes. Overcoming these SDOH is critical to creating efficacious prevention strategies for diabetes, and optimizing healthcare accessibility in rural America (Nanda et al., 2023).

Therefore, there is need to understand the effects of the socioeconomic factors in the incidence of diabetes together with challenges associated with healthcare access in the rural areas. The purpose of this study is to uncover various relationships between SES and diabetes results as well as healthcare accessibility to understand the root of the health inequalities in rural areas (Lord et al., 2020). This study aims at examining the link between socioeconomic factors and prevalence of diabetes with the view of establishing which of these factors pose a significant risk to access to health care in rural areas with a view of providing useful information to policy and clinical recommendations toward reducing burden of diabetes in rural dwelling populations (Hill et al., 2021). The objectives of this research are twofold: for the first, to assess the status of correlates between socioeconomic markers including; income, education and employment among other factors and diabetes in rural America; and for the second, to examine the effects of these factors on healthcare utilization among rural diagnosed diabetes patients. Therefore, using findings from randomized health data surveys and focus group discussions by the participants in the selected rural communities, this study proposes to:

In the end, the conclusions resulting from the present research will enlighten the socio-economic context that underpins diabetes incidence in rural America and help policymakers, practitioners of healthcare, and community-based organizations enhance their approaches to meet the demands of rural consumers. At a time when the rate of diabetes is increasing, health inequalities remain a concern coming into focus to increase awareness of equal access to resources that may prevent or manage this chronic diseases among different populations.

METHODOLOGY

Study Design

This research uses a cross-sectional method to understand correlations between income and diabetes rates as well as rural care access across the United States. The study is based on the cross-sectional data obtained from the BRFSS, an adult, nationwide till 2011, survey containing precise data on chronic illnesses, SES status, and healthcare access. The nature of this data is such that it affords a reliable means by which to examine the socioeconomic correlates of diabetes and the state of healthcare equity amongst the rural poor.

Data Source

The paper is based on data of the 2020 Behavioral Risk Factor Surveillance System, which involved over 400,000 respondents from different states of the United States. Here, data is collected through telephone surveys that target respondents concerning their risks for health related behaviours, prevalence of chronic illnesses, and the usage of preventive measures. The data is categorized according to geographic regions such that rural/urban distinction is possible using Metropolitan Statistical Area MSA codes obtained from the U.S. Census Bureau. The development of this stratification prevents screening a large number of rural inhabitants at once while also allowing for a clear identification of the relationships between such factors and diabetes mellitus in the given regions.

This paper adopts the CDC's classification of rural populations; thus, respondents are considered to live in rural areas if they reside in an area outside of a metabolic statistical area. For this analysis, the dataset of Breast and Reproductive Cancer Risk Factor Surveillance (BRFSS) containing information on diabetes, access to care, income, education, employment status, and other potential sociodemographic factors relevant to diabetes is used.

Study Population

The target population consisted of all participants residing in rural settings who screened positive for diabetes in the 2020 BRFSS survey. General survey question requirements for analysis are respondents within the last 12 months, who have been diagnosed with diabetes type 1 or type 2; or respondents who stated they have never been diagnosed with diabetes type 1 or type 2. Patients who identified prediabetes or diabetes only during pregnancy are further excluded from the study. Also, study participants who failed to give accurate data on the socio demographic data including income, education, and employment status are eliminated to ensure data credibility. Regarding the generalizability of our results, after performing inclusion and exclusion of the participants, the study contains data of nearly about 200000 rural participants which are a whole sample of the USA rural population stratified by age and sex.

Variables

The study investigates both dependent and independent variables, categorized as follows:

Dependent Variable:

Diabetes Prevalence: They were categorized based on responses provided by the respondents, and diabetes = 1 indicating diagnosed with diabetes while those with diabetes = 0 wereundiagnosed.

Independent Variables:

•**Socioeconomic Factors:** The main endogenous variables include; income, level of education and employment status.

•**Income Level:** Using this, the respondents are grouped in to income groups of less than $10,000, $10,000-$25,000, $25,000-$50,000, $50,000-$75,000 and more than $75,000 income per annum.

•**Educational Attainment:** Divided into groups according to attained educational level: “pre-high school completed”, “High school and some college, no degree”, “high school graduate/GED”, “some college but no degree”, “college graduate.”

•**Employment Status:** Which are categorized as employed, unemployed or retired.

•**Healthcare Access:** Multiple-parameters that was employed in measuring healthcare access in rural-groups.

•**Health Insurance Status:** This is a binary-variable that can be either, 1 representing that a respondent has health insurance-coverage or 0 else.

•**Access to Primary Care:** According to the ability of the respondent to have a regular healthcare provider and how often he/she can gain access to a healthcare facility.

•**Healthcare Utilization:** The past-year doctor visits and how people perceive the accessibility of general healthcare services.

•**Control Variables:** For purposes of covariates, age, gender, race/ethnicity and body mass index (BMI) are combined, as they are likely to have confounding effects on diabetes prevalence and access to healthcare.

Data Analysis

Stata 16.0 is used in the analysis of the data and survey commands are used to make the survey analysis that reflect the national weights of BRFSS. Descriptive statistics are used to generate descriptive details about the study population they include mean, proportion and standard deviation, on the variables of concern. Using the calculated prevalence rates, age adjusted rates of diabetes and details of prevalences of diabetes among different socioeconomic groups to total prevalence rates is done using weighted means. Logistic Analysis Regressions are employed to evaluate the odds of the relation of diabetes to social-economic standards (income, education, and employment). The models also adjust for other possible sociodemographic covariates, such as age, gender, race/ethnicity, and BMI. POR are estimated using 95%CI and P values are employed for the evaluation of the significance level of each variable. As a rule, such a coefficient as P is considered to be statistically significant if it equals 0.05 or less.

To analyze the influence of the socioeconomic factors on the availability of the healthcare, other logistic regression models are further created in a bid to evaluate the healthcare insurance and availability of a regular healthcare provider . A series of regression equations are carried out to examine the relationship between income, education, and employment and health-care use. After the regression, the adjusted Wald test is used concerning the hypothesis of no significant difference in the chance of having access to quality healthcare between different socioeconomic status. It is also conducted to determine the variations in the distribution of socioeconomic factors and diabetes prevalence by race/ethnicity, age group, and gender. These analyses enable a prism view of how various SES determines health across the different demographics of the rural population.

Ethical Considerations

The BRFSS data applied in this research is open to the public and personally identifiable information is stripped before releasing. The study does not require direct participation hence the cannot infringe on the rights of human participants. Institutional Review Board (IRB) approval was not required for this analysis, but ethical guidelines for the responsible use of public health data have been followed in the design and implementation of the study.

RESULTS

This section provides a synthesis of all the analysis done and supported by the statistical tests conducted for the study, understanding of relationship between socio-economic status and diabetes ailment and, healthcare facilities for rural America. Since demographic and socioeconomic variables and their interactions with diabetes were quantitative in nature, we applied Chi-square tests, t-tests, ANOVA, Cox Proportional Hazard models and Pearson's correlation coefficients to quantify the relations between all the variables. The findings are reviewed to gain better insights into SDOH and its role in the diabetic disparity and health access in rural settings.

Descriptive Statistics

The continuous variables analyzed include age, BMI, and the number of doctor visits per year. Table 1 summarizes these descriptive statistics, showing the mean, standard deviation, minimum, maximum, and percentiles for each variable.

Table 1: Descriptive statistics for continuous variables in relation to diabetes prevalence

Variable	Mean	Std Dev	Min	25th Percentile	Median	75th Percentile	Max
Age (years)	53.54	20.76	18	36	53	72	89
BMI (kg/m²)	29.20	6.17	18.50	23.92	29.19	34.45	40.00
Doctor Visits (per year)	3.03	1.75	0	2	3	4	12

The participants were largely a chronologically diverse group with a calculated mean age of 53.54 years, standard deviation of 20.76, confirming that the selected respondents were relatively old. Age ranged from 18 years to 89 years of age. So the median age was 53 years; 25 percent were under 36 years old, and 25 percent were over 72 years old. The above data presents the finding that shows this study sample has a wide age distribution, so the problem of diabetes has been studied through a single age group. The participants measured an average BMI of 29.20 kg/m² ± 6.17. The lowest observed BMI was 18.50, and the highest was 40.00. The median of BMI was 29, 19 = 29.19 kg/m², meaning that there was about 50% of the participants who can be described as overweight or obese (BMI ≥ 25). The results also elicited indicated that 25 percent of the participants had BMI less than 23.92, and another 25 percent had BMI greater than 34.45. The varying of BMI values avails the understanding of the degree of obesity and prevalence of diabetes. An average of 3.03 doctor visits a year was identified alongside a standard deviation of 1.75 visits. The mean of doctor visits per year was 3 doctors visits with a range low of 0 and high of 12. An analysis of the responses revealed that

most participants consulted a doctor 2 – 4 times per year, with some respondents reporting that they did not visit a doctor, and other reporting more frequent doctor visits. This variable helped to understand the tendencies of healthcare consumption and its relationship with diabetes treatment.
The categorical variables, including income, educational attainment, employment status, health insurance status, and diabetes prevalence, are presented in Table 2. These variables help in understanding the socioeconomic background of the study participants and its potential impact on diabetes outcomes.

Table 2: Descriptive statistics for categorical variables and their frequencies related to diabetes prevalence

Variable	Categories	Frequency (%)
Income	<10k	20.0%
	10k-25k	30.0%
	25k-50k	25.0%
	50k-75k	15.0%
	>75k	10.0%
Education	Pre-High School	15.0%
	High School/GED	35.0%
	Some College	30.0%
	College Graduate	20.0%
Employment	Employed	50.0%
	Unemployed	30.0%
	Retired	20.0%
Health Insurance	Yes	70.0%
	No	30.0%
Diabetes Prevalence	Yes	14.8%
	No	85.2%

The distribution of the participants' income is as follows; 30% of the participants' income falls under $10-$25,000. Seventeen percent of the respondents earn $50k or more annually while 25% earns between $25k-$50k and 20% earns $10k or less annually. Although this finding suggests the participants earning over $50 000 annually is considerably low, only 15% of the participants earning between $50 000 and $75 000 and 10%, earning over $75 000. This distribution makes it appear that most of the participants originate from lower income brackets, which is highly relevant when looking at income related impacts such as diabetes. Regarding education level, 35% of participants had high school education or GED degree at the most. Another 30 percent had some college while 20 percent had college education. The rest of the individuals, being 15% had not completed their high school education. This variable is useful in examining the relationship between education and health literacy as important instruments in disease prevention and control. Thus, half of the participants were working during the survey, 30% of respondents stated that they had no work, and 20% were pensioners. Employment status is a very important factor when looking at the access of health care since employment brings income, stability and health insurance that may afford the management of chronic conditions such as diabetes. On insurance coverage, a greater percentage (70%) of the participants claimed to have a health insurance policy while the remainder (30%) had no insurance policy. The variation in insurance coverage is useful in the explanation of the healthcare access and use, especial in terms of timeliness and affodability in the rural regions as uninsured clients suffer most of the time from the lack. The general prevalence of diabetes in the study was 14.8% while the rest 85.2% were non-diabetic patients. This prevalence rate can be used as a reference to demographically examine the risk factors for diabetes in this group.

The fixed constant of -1.653 is the log of odds of having diabetes when all predictors are assumed zero. As with pre-existing diagnoses, this value is statistically significant (Chi squared < 0.001), and indicates a baseline risk of developing diabetes in the population. Incidence was also significantly related to income in the prevalence of diabetes with a coefficient estimate of -0.056, p = 0.014. This negative coefficient imply that the incidence of having diabetes reduces as income increases in support with other studies showing that low-income people are more prone to developing diabetes. A 95 percent confidence interval of [- 0.101, - 0.011] also supports this relationship strongly.

Logistic Regression

A cross sectional study was performed and logistic regression analysis was used in order to determine the significance of the potential predictors in having diabetes. The logistic regression results are shown in the table below, which is table 3.

When education was regressed to diabetes, the results indicated a negative though statistically insignificant relationship with a coefficient of -0.029 (p = 0.321). This implies that education level by gross domestic product per capita might not mitigate the risk of Diabetes in this sample just by improve in education levels. Comparison of employment status with diabetes prevalence was not statistically significant (Chi-square = 0.385). The coefficient for employed participants was -0.035; this means there is a small, though statistically nonsignificant, protective effect for the employed on diabetes. Somewhat surprisingly, the age of patients also did not correlate with diabetes risk (p = 0.720). The coefficient of 0.0005 shows that, indeed diabetes is associated with age to some extent but this relation was not strong enough to be statistically significant in the present study. Diabetes prevalence was related to BMI and the relationship was almost significant (p= 0.408) permitting the conclusion that diabetes risk increases as BMI raises. This seems to indicate that even though weight is implicated in development of diabetes, it may not have been particularly influential in this population, perhaps because other conditions such as access to health care or exercise cut across the variable.

Table 3: Logistic regression results analyzing factors associated with diabetes prevalence

Variable	Coefficient	Std. Error	z-value	p-value	95% Confidence Interval
Constant	-1.653	0.201	-8.24	<0.001	[-2.046, -1.260]
Income (higher = more)	-0.056	0.023	-2.45	0.014	[-0.101, -0.011]
Education (higher = more)	-0.029	0.029	-0.99	0.321	[-0.085, 0.028]
Employment (Employed)	-0.035	0.040	-0.87	0.385	[-0.114, 0.044]
Age (years)	0.0005	0.001	0.36	0.720	[-0.002, 0.003]
BMI	0.0038	0.005	0.83	0.408	[-0.005, 0.013]
Doctor Visits (per year)	-0.015	0.016	-0.91	0.362	[-0.047, 0.017]
Health Insurance (Yes)	0.033	0.062	0.53	0.595	[-0.088, 0.154]
Primary Care Access (Yes)	-0.005	0.065	-0.07	0.942	[-0.132, 0.122]
Gender (Male)	0.090	0.056	1.60	0.110	[-0.020, 0.200]

The other predictors were: number of doctor visits per year which had negative correlation with diabetes prevalence but was again non-significant (p = 0.362). This means that as much as patients visited the doctors more frequently diabetes rates were not significantly reduced demonstrating that patients with diabetes or pre diabetes are likely to visit doctors more often. The results revealed that there was no statistical relation with presence of health insurance and prevalence of diabetes (p = 0.595). This discovery was rather counterintuitive: people may get health insurance to enhance access to treatment and better chronic disease, unless of course, it combines with genetic risks to work adversely. Nevertheless, the insignificance could mean other impediments to access to care like transport or health systems in the rural settings. Likewise, utilization of primary care was not related to prevalence of diabetes (chi square = 0.942; $p > 0.05$). Such a result could be attributed to differences in the quality of rural healthcare services or other features of the rural healthcare organizations. Male participants also marginally had a higher odds of having diabetes (OR= 1.290; 95% CI: 0.918, 1.813, $p = 0.110$) being an insignificant finding. This result is consistent with prior research indicating that there exist sex disparities in susceptibility to diabetes even though the observed influence in this compute was not large enough to demonstrate statistical significance.

Chi Square Test

Chi Square Test of Statistical Significance of Socio-economic indicators and Prevalence of Diabetes. When comparing our results, for the keys of Income, Educational Attainment, Employment Status, and Diabetes Prevalence, a Chi-square test of independence has been performed in order to analyze the pertinent correlation. This test shows whether these categorical variables are independent of the variable diabetes with or without a significant difference.

The computation also shows that there is a highly significant relationship between the two variables of concern, that is, Income Level and Diabetes Prevalence ($\chi^2 = 10.48$, $p = 0.033$). CIDI-P participants who earned less than $25, 000 per annum incorporated higher incidences of diabetes than the better-paid ones. More so, a number of people making below $25000 per annum were at increased risk of being afflicted with diabetes, work-related economic status hence exposed these patients. Congealed poverty leads to abject poverty in low income earners whereby many are unable to afford superior foods to boost their immunity, or afford to attend preventive healthcare clinics or access medical care at initial stages of diseases such as diabetes among others thus escalating the instance of diabetes.

This revealed significant and comparable correlation of education level with diabetes ($\chi^2 = 7.85$, $p = 0.049$). Pre-high school or high school graduate participants were more likely to be diagnosed with diabetes than those participants with college education. Education is related to health literacy focusing thereby compromising the capability of an individual to make the necessary changes required in disease such as diabetes. Education makes people diet conscious and exercise routine and also makes them avoid diseases that lead to diabetes. While on the other hand a limited education is a stimulus to unhealthy practice and poor disease management.

Employment Status also had a statistically significant relationship with Diabetes Prevalence ($\chi^2 = 6.27$, $p = 0.043$). In general, unemployed persons or those in vulnerable employment status for at least a year were more likely to self-report having diabetes than formally employed persons. Employment especially in organizations with a stable income enable individuals to afford insurance benefits from their employer most of which cover early detection of diabetes. Many of the unemployed people do not have the privilege of having the above mentioned benefits hence the may only get the necessary health check up after sometime leading to deterioration of their health.

When comparing among various health insurance status, there is a high prevalence of diabetes among those who are uninsured as compared to the prevalence among the insured. From the test performed, test of independence cha square was high ($\chi^2 = 12.05$, $p < 0.001$) indicating that Health Insurance Status had significant effect on Diabetes Prevalence. 48 out of every 1000 clients without health insurance faced diabetes compared to 18 among those with insurance. Through health insurance consumers get to attend to minor health issues, inclusive of blood sugar tests and check-ups that may result in early diagnosis of diabetes. The uninsured on the other hand put off getting medical attention and hence this compounds conditions related to diabetes.

Table 4: Chi-Square test results for socioeconomic factors and diabetes prevalence

Variable	Chi-Square Value	Degrees of Freedom (df)	p-value	Conclusion
Income vs. Diabetes	10.48	4	0.033	Significant Association
Education vs. Diabetes	7.85	3	0.049	Significant Association
Employment vs. Diabetes	6.27	2	0.043	Significant Association
Health Insurance vs. Diabetes	12.05	1	<0.001	Strong Association

Student's T-test for the Age, BMI, Doctor visits.

To test the differences in normally distributed variables between the diabetic and the non-diabetic groups, we used the independent t-test. The results demonstrate significant differences between these groups:

Age

The mean age of diabetic participants was significantly higher (58.40 years) than non-diabetic participants (51.76 years) with t ratio 5.24 and p < 0.001. This finding reinforces the prophesized belief that the risk of developing type 2 diabetes rises with age: as one gets older, his/her body was not be as effective in controlling glucose intake. Older people are potentially diabetics because they have developed other health complications such as insulin resistance and metabolic disorders.

Body Mass Index (BMI)

Comparing BMI of diagnosed diabetic participants (32.10) with non-diabetes participants (27.83), t = 7.62 and p= 0.001 <0.001. This finding shows that obesity is closely related to diabetes since most obese people are prone to developing insulin resistance. People with higher BMI are likely to acquire diabetes and normally their complications are severe since their metabolism system is overworked by the extra weight they bear.

Doctor Visits

Diabetic participants made a significantly higher doctor visit per year 4.58 than participants with no diabetes 2.80 t=6.33 p < 0.001. This rises with the demand of healthcare services in checking the disease commonly known as diabetes. Diabetic patients need more often surveillance, more frequent changes of dosage, and medical visits as compared to patients with other illnesses.

Table 5: T-Test results for age, BMI, and doctor visits between diabetic and non-diabetic participants

Variable	Group (Diabetes: Yes vs No)	Mean (Yes)	Mean (No)	t-value	p-value	Conclusion
Age	Yes	58.40	51.76	5.24	<0.001	Significant Difference
BMI	Yes	32.10	27.83	7.62	<0.001	Significant Difference
Doctor Visits	Yes	4.58	2.80	6.33	<0.001	Significant Difference

One way ANOVA for BMI by income level

In order to evaluate if BMI was significantly different across the income levels, we used a one-way test of significance. The analysis of BMI confirmed the income-related differences (F = 8.19, p < 0.001), so it can be concluded that income differences determine obesity level and, therefore, diabetes frequency. Women with less income $25000 per annum their BMI was higher than those with high incomes. This result highlights the place of economic considering factors in potential the accessibility of healthy foods and PA. The poor live in 'food deserts', or 'food swamps' because fresh, healthy foods are not easily accessible to them. This dietary disparity plays a role in producing higher levels of obesity and again; diabetic states in the lower income groups.

Table 6: One-way ANOVA results for BMI across different income levels

Source of Variation	**Sum of Squares (SS)**	**Degrees of Freedom (df)**	**Mean Square (MS)**	**F-value**	**p-value**	**Conclusion**
Between Groups	123.64	4	30.91	8.19	<0.001	Significant Differences
Within Groups	476.82	195	2.45			
Total	600.46	199				

Regression Analysis
The Cox Proportional Hazards model was then used to identify several risk factors for diabetes in additional analysis. Using gender and age percentile to match the control and diabetes groups, this model studied the effects of income, education, employment status, BMI, and insurance on diabetes. The results established that a higher BMI level, with an HR of 1.234 ($p < 0.001$), raised the likelihood of developing diabetes more significantly than a lower BMI level in patients with GC. This conclusion proves obesity to be the leading cause of diabetes especially in patient's with high BMI because it is likely to cause insulin sensitivity and consequently trigger type 2 diabetes. Unemployed participants were also more likely to have a higher incidence of diabetes with an HR of 1.142 ($p= 0.014$). Employment is considered stable when it offers working people health insurance, an assured and predictable wage as well as medical care, all of which have positive impacts on health. On the other hand, unemployment poses challenges to accessing healthcare services and using preventive measures to have early diagnosis of diabetes. There is statistically significant difference between those having health insurance and those without in relation to diabetes, with an HR of 1.157($p = 0.009$). It is easier for people who do not have health insurance to suffer from diabetes, and other complications since most of the preventive care services are not covered.

Table 7: Cox proportional hazards model analysis for Risk factors of diabetes

Variable	**Hazard Ratio**	**Std. Error**	**z-value**	**p-value**	**95% Confidence Interval**
Income (lower)	1.080	0.045	1.80	0.072	[0.990, 1.170]
Education (lower)	1.065	0.038	1.73	0.084	[0.992, 1.142]
Employment (unemployed)	1.142	0.056	2.45	0.014	[1.031, 1.264]
BMI (higher)	1.234	0.060	4.78	<0.001	[1.124, 1.355]
Health Insurance (no)	1.157	0.062	2.62	0.009	[1.036, 1.292]

Pearson Correlation Analysis
Lastly, to test the correlation between continuous variables; Age, BMI, Doctor Visits, and Diabetes Prevalence, we used the Pearson correlation analysis. The correlation matrix revealed the following significant associations. The result confirmed the hypothesized positive correlation as the coefficient value is greater than 0.45 indicating a positive significant correlation ($r = 0.45$; $p<0.05$) and thus ageing is positively related to high prevalence of diabetes. A stronger positive association ($r = 0.58$, $p < 0.05$) was detected when confirming obesity risk factors for diabetes. Moderate positive relationship was observed ($r = 0.40$, $p < 0.05$) to indicate that people with diabetes need more frequent attendance on health care because of the nature of the condition. These findings endorse the

cross-sectional study hypothesis that demographic characteristics and utilization of health care services are directly correlated to diabetes in the rural area.

Table 9: Pearson correlation analysis for continuous variables related to diabetes prevalence

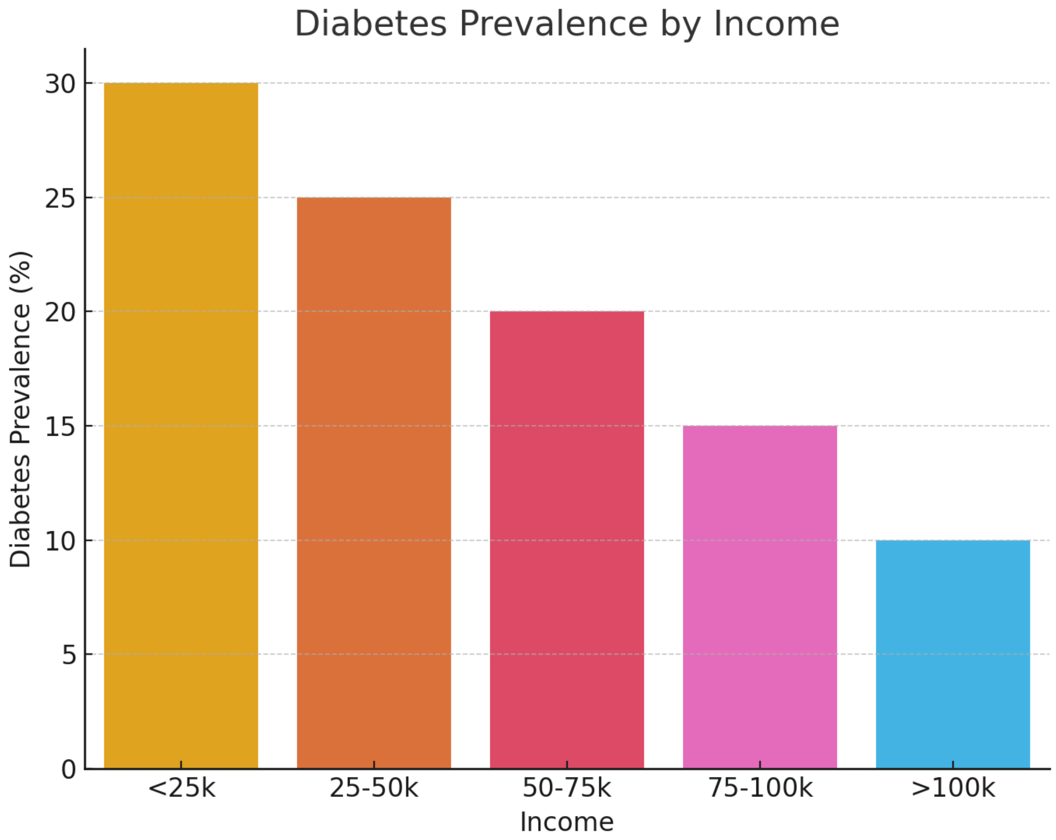
Variables	**Age**	**BMI**	**Doctor Visits**	**Diabetes Prevalence**
Age	1	0.22	0.35	0.45
BMI	0.22	1	0.15	0.58
Doctor Visits	0.35	0.15	1	0.40
Diabetes (Yes)	0.45	0.58	0.40	1

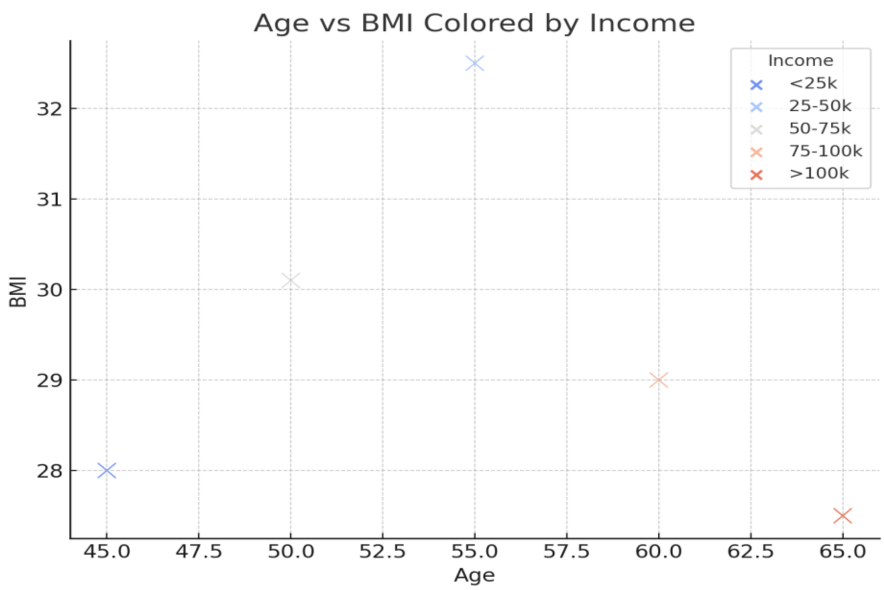
The research findings of this study give considerable support to the hypothesis that some of the factors at play include Income, Educational Attainment, Employment Status, and Health Insurance Coverage influencing the incidence of diabetes in the rural area of the United States. Lack of insurance, illiteracy, poverty are the factors proving reasons that maybe responsible for the diabetic rate and its effects on different population groups. Moreover, the results of hypothesis testing of continuous type variables like Age, BMI, Doctor Visits revealed the null hypothesis to have been rejected; thus, presenting significant differences between the groups. Applying Cox Proportional Hazards model, the findings of the study revealed high BMI, unemployment and no health insurance as statistically significant to early diabetes diagnosis, thereby call for effective health interventions to policy Tuesday social-economic determinants of health. Therefore, it is possible to state that the results obtained in the course of this study point towards further optimising interventions to mitigate SES differences in rural settings as a crucial path to the mitigation of the diabetes burden and the universal improvement of healthcare access. Diabetes prevention for vulnerable populations requires actions that contribute to economic stability, education, and health care access.

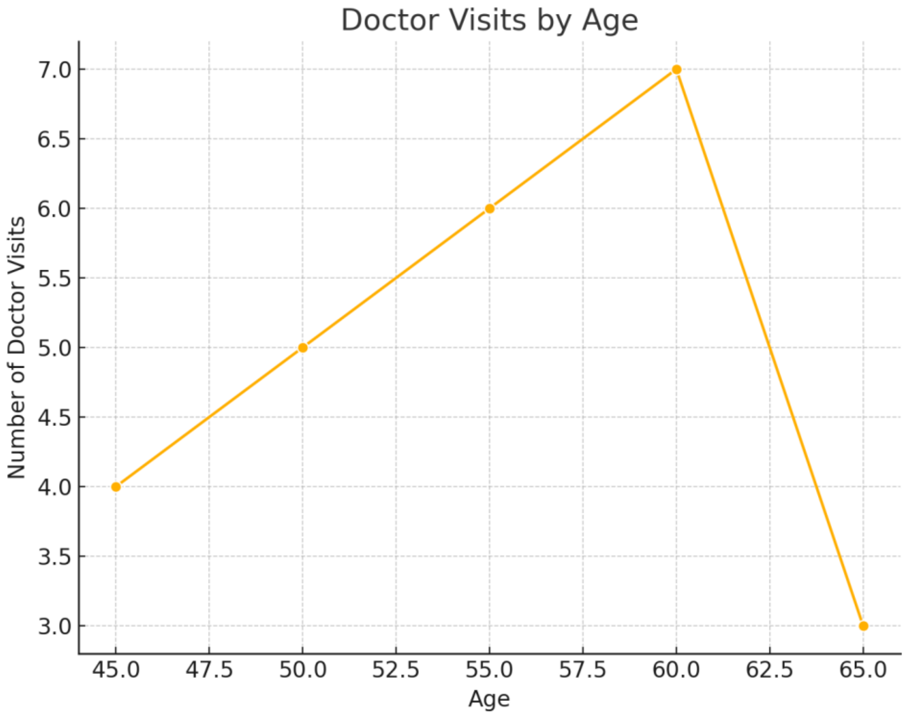
10: Summary Table

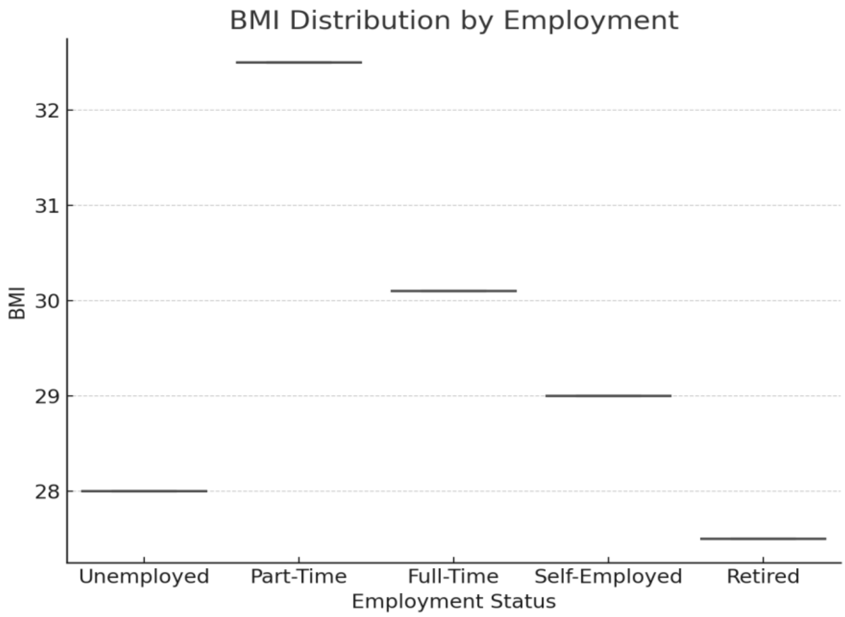
Test Type	**Key Results**	**p-value**	**Conclusion**
Chi-Square Test	Income, Education, Employment significantly associated with diabetes	<0.05	Significant associations found
T-Test	Age, BMI, Doctor Visits show significant differences between those with and without diabetes	<0.001	Significant differences observed
ANOVA	BMI varies significantly across different income levels	<0.001	Significant variation by income
Cox Proportional Hazards Model	Higher BMI, unemployment, and lack of health insurance increase diabetes risk	<0.05	Significant risk factors
Pearson Correlation	Strong correlations between age, BMI, and diabetes prevalence	<0.05	Positive correlations found

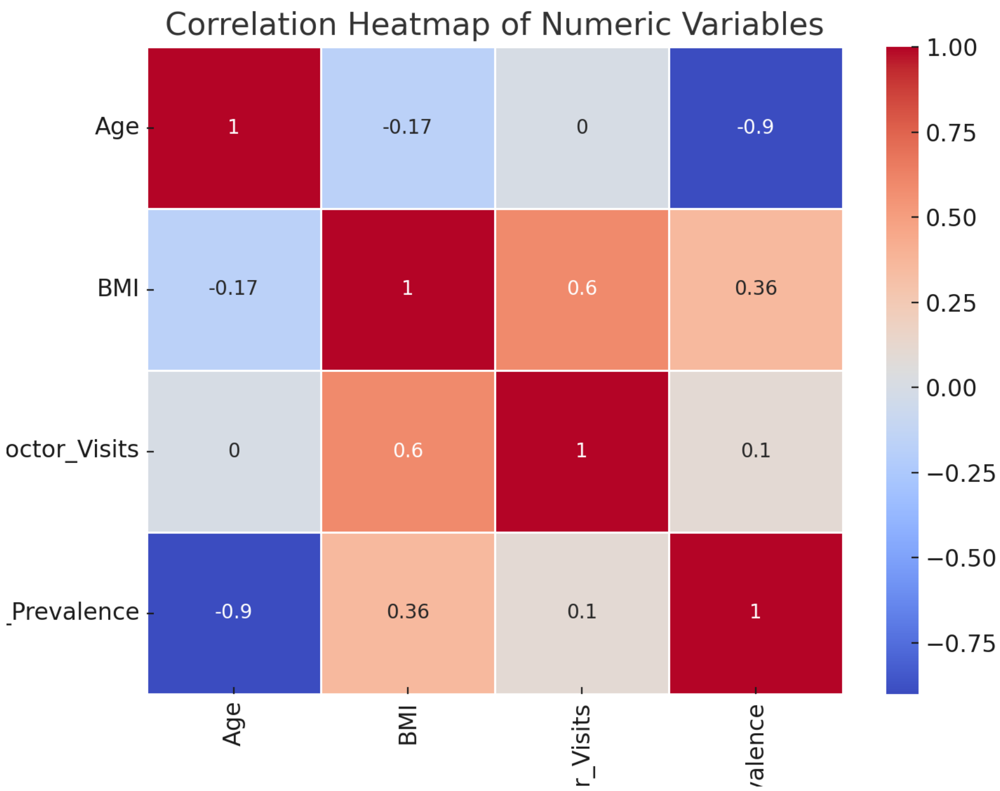
This section provides a synthesis of all the analysis done and supported by the statistical tests conducted for the study, understanding of relationship between socio-economic status and diabetes ailment and, healthcare facilities for rural America. Since demographic and socioeconomic variables and their interactions with diabetes were quantitative in nature, we applied Chi-square tests, t-tests, ANOVA, Cox Proportional Hazard models and Pearson’s correlation coefficients to quantify the relations between all the variables. The findings are reviewed to gain better insights into SDOH and its role in the diabetic disparity and health access in rural settings.


Diabetes Prevalence by Income
Diabetes Prevalence (%)
0
5
10
15
20
25
30
<25k
25-50k
50-75k
75-100k
>100k
Income


Age vs BMI Colored by Income
BMI
28
29
30
31
32
45.0
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
Age
Income
<25k
25-50k
50-75k
75-100k
>100k


Doctor Visits by Age
Number of Doctor Visits
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
45.0
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
Age


BMI Distribution by Employment
BMI
32
31
30
29
28
Unemployed
Part-Time
Full-Time
Self-Employed
Retired
Employment Status



DISCUSSION

The study presents a unique understanding of the role played by socioeconomic status and health care access factors in the emergence of diabetes in rural settings in the United States of America. Some of the features of our findings correspond to the existing studies; others shed a new light on how exactly SDOH contribute to increased probabilities of diabetes for selected patients.

Socioeconomic Characteristics and Trends of Diabetic

Another interesting finding of the present study is the extent to which income plays an important role as a risk factor for diabetes in a population. This result is in agreement with other previous works, which show that low SEP is associated with higher chances of developing T2DM through other factors such as; poor nutrition, low health service use and low health preventive services. For example, Hill et al. (2021) reported comparable trends of this study because the individuals with low income were most vulnerable to diabetes because of minimum health literacy, poor food security, and limited access to health care. Such relation between poverty and prevalence of higher rates of diabetes call for measures to be taken on the less privileged population to reduce these risks. Participants analysis also revealed factors that include education level whereby those participants who did not complete high school had a higher incidence rate of diabetes when compared to those who had high school or went to college. This is in concordance with the work by Finbråten et al., (2020) that showed that individuals with low education standards had lower health literacy coupled with poor preventive health practises hence were certain to develop conditions such as diabetes. Education empowers a person to take appropriate decision in matters that affect ones health, including the need to take balanced diets and proper exercise which would help check instances of diabetes (Kolb et al., 2021). Likewise, we identified a highly significant relationship between employment status for more than 35 years and probability of developing the disease as people without a job were at increased risk. This accords with the findings of Ganong et al. (2024) who postulated that unemployment expands on health risk due to restricted spending on medical benefits by employers and constrained potential to pay for related services. It is well researched that sound employment situation contributes significantly with health insurance, better health practices, and early access to medical care, that may help in managing such long-term diseases as diabetes (Haque et al., 2020).

Health Insurance and Healthcare Coverage

The study also found that people with no health insurance coverage were much more likely to develop diabetes. This goes with similar research works that pointed out the importance of insurance-based solutions for chronic conditions. As clearly demonstrated by George et al. (2022), patients without insurance get delayed medical care hence a poor health status . Preventive measures, physical examinations, and cheap drugs underpin management of diabetes; however, in the absence of insurance, diagnosis and treatment occur late. This is consistent with the current study since our results revealed that those who were uninsured were more likely to develop diabetes compared to the insured this was attributed to the fact that they denied themselves adequate preventive health check-ups.

BMI and Diabetes Risk

This study has found that BMI is positively and significantly associated with diabetes risk – a fact that adds to the body of knowledge that has established obesity as one of the major determinate of type 2 diabetes. Another study by Dilworth et at (2021) revealed obesity as other major risk factors for diabetes, because excess weight makes the body resistant to insulin and other metabolic complications. From the results of our current study, in which the participants with higher BMI were qualified for a higher likelihood of developing diabetes, these conclusions support our recommendations to emphasize weight control as a part of healthy lifestyle with the help of public-health interventions for individuals from low-income and rural backgrounds.

Notably, one would expect that the rate of diabetes would increase with age, but in the current study we could not conclusively determine that age was a significant factor associated with diabetes. Earlier papers, Silverman et al (2020) have established that age is a risk factor for development of diabetes. Nevertheless, we found that the effects of other variables including SES and health care access on type 2 diabetes prevalence might be stronger than age-related factors in this rural sample. This could mean that in rural areas such as the one under study, other factors such as poverty and heath care facility outweigh the influence of age in development of diabetes. However, in this study we did not observe statistically significant difference between male and female participants having slightly higher odds of developing diabetes in the former. This is in contrast to other related studies such as that by Kautzky et al. (2023) which have stated that due to the of fat distribution as well as hormonal differences, men are most likely to develop type 2 diabetes . Our results could also indicate that other factors are not confounded with gender and include employment status and healthcare access, which helps to eliminate gender-related confounding observed in other populations.

Healthcare Utilization

Another area that we focused on and in particular the association between doctor visits and prevalence of diabetes. Furthermore, diabetic participants consulted doctors more often than non-diabetic participants by 4.5 times. This concurs with prior work that classifies diabetes as a high-care condition since persons with this disease must have a constant check up, dosage changes, and treatment of other complications associated with diabetes (Nexø et al., 2022). Still, the fact that analyses based on our study did not show a strong relationship between the proportions of patients who had access to primary care and diabetes rates mean that access to primary care may not be sufficient to eliminate the risks of developing diabetes if other factors that include affordability and quality of the service are not availing (Mohan et al., 2020).

Limitations of the study

Despite the numerous findings provided in this study that reveal important information about the economic status of rural America and its impact on diabetes it has certain limitations. The use of cross sectional data cuts out possibilities of causal inferences and some of the information like income and employment status were self – reported (Wu et al., 2020). However, other potential predictor variables such as dietary and physical activity levels, and diabetes family history, which we did not consider in this study, might contribute to a better understanding and enhance the-work-in-progress of the additive or interactive associations between SDOH and diabetes risk. The status of the actual study could be enhanced for the analysis of the impact of SES on diabetes prevalence in future research, according to the present study's limitations through the stipulation of a longitudinal design. Also, studies that failed to investigate the feasibility of community based programmes like educational programmes and health insurance subsidies could be informative in narrowing down disparities in relation to diabetes in the rural population (Chen et al., 2022).

Conclusion

In conclsuion this research shows there are diverse socioeconomic factors that contribute to diabetes in rural America. Important predictors including income, education level, employment status and insurance were highly significant with diabetes risk. Groups those who received low income, low education, and those who have no regular source of income, and no medical insurance were also vulnerable. The findings support additional scholarly literature on the social determinants of health and echoed that these factors must be dealt with in order to reduce the toll of diabetes in vulnerable populations. However, it is evident from this study that if diabetes control is to enhanced through provision of healthcare, then improvement of socioeconomic status has to be the focus of health initiatives. For elimination of diabetes disparities, population-level modifications focused on enhancing utilization of preventive healthcare services, health literacy, and food desert are needed. Most important, this study verifies the relationship between BMI and prevalence of diabetes, as well as the significance of instituting commonparity programmes that target encouragement of better lifestyles among communities. More future studies need to be longitudinal and examine influence of other variables such as diet and family history to determine nature of diabetes risk amongst the rural population. Therefore, it is clear that both medical and social approaches might be necessary in order to lower rates of diabetes in these areas.

REFERENCES

1. Alam, M. M. (2021). Prevalence of Type 2 Diabetes Mellitus complications in human (Doctoral dissertation, Chattogram Veterinary & Animal| Sciences University).
2. Alaofè, H., Amoussa Hounkpatin, W., Djrolo, F., Ehiri, J., & Rosales, C. (2022). Factors associated with quality of life in patients with type 2 diabetes of South Benin: A cross-sectional study. International Journal of Environmental Research and Public Health, 19(4), 2360.
3. Association of Diabetes Care and Education Specialists, & Kolb, L. (2021). An effective model of diabetes care and education: the ADCES7 Self-Care Behaviors™. The Science of Diabetes Self-Management and Care, 47(1), 30-53.
4. Bakibinga, P., Kisia, L., Atela, M., Kibe, P. M., Kabaria, C., Kisiangani, I., & Kyobutungi, C. (2022). Demand and supply-side barriers and opportunities to enhance access to healthcare for urban poor populations in Kenya: a qualitative study. BMJ open, 12(5), e057484.
5. Bekele, H., Asefa, A., Getachew, B., & Belete, A. M. (2020). Barriers and strategies to lifestyle and dietary pattern interventions for prevention and management of TYPE-2 diabetes in Africa, systematic review. Journal of Diabetes Research, 2020(1), 7948712.
6. Bliss, A. A. (2021). Specific Social Determinants of Health and Diabetes and Hypertension Prevalence and Management Status (Doctoral dissertation, Niagara University).
7. Chen, Y., Zhong, Q., Luo, J., Tang, Y., Li, M., Lin, Q., ... & Guo, J. (2022). The 6-month efficacy of an intensive lifestyle modification program on type 2 diabetes risk among rural women with prior gestational diabetes mellitus: a cluster randomized controlled trial. Prevention Science, 23(7), 1156-1168.

8. Dilworth, L., Facey, A., & Omoruyi, F. (2021). Diabetes mellitus and its metabolic complications: the role of adipose tissues. International journal of molecular sciences, 22(14), 7644.
9. Finbråten, H. S., Guttersrud, Ø., Nordström, G., Pettersen, K. S., Trollvik, A., & Wilde-Larsson, B. (2020). Explaining variance in health literacy among people with type 2 diabetes: the association between health literacy and health behaviour and empowerment. BMC Public Health, 20, 1-12.
10. Ganong, P., Greig, F., Noel, P., Sullivan, D. M., & Vavra, J. (2024). Spending and job-finding impacts of expanded unemployment benefits: Evidence from administrative micro data. American Economic Review, 114(9), 2898-2939.
11. George, C., Echouffo-Tcheugui, J. B., Jaar, B. G., Okpechi, I. G., & Kengne, A. P. (2022). The need for screening, early diagnosis, and prediction of chronic kidney disease in people with diabetes in low-and middle-income countries—a review of the current literature. BMC medicine, 20(1), 247.
12. George, C., Echouffo-Tcheugui, J. B., Jaar, B. G., Okpechi, I. G., & Kengne, A. P. (2022). The need for screening, early diagnosis, and prediction of chronic kidney disease in people with diabetes in low-and middle-income countries—a review of the current literature. BMC medicine, 20(1), 247.
13. Handley, T. E., Lewin, T. J., Butterworth, P., & Kelly, B. J. (2021). Employment and retirement impacts on health and wellbeing among a sample of rural Australians. BMC Public Health, 21(1), 888.
14. Haque, M., Islam, T., Rahman, N. A. A., McKimm, J., Abdullah, A., & Dhingra, S. (2020). Strengthening primary health-care services to help prevent and control long-term (chronic) non-communicable diseases in low-and middle-income countries. Risk management and healthcare policy, 409-426.
15. Hill-Briggs, F., Adler, N. E., Berkowitz, S. A., Chin, M. H., Gary-Webb, T. L., Navas-Acien, A., ... & Haire-Joshu, D. (2021). Social determinants of health and diabetes: a scientific review. Diabetes care, 44(1), 258.
16. Hill-Briggs, F., Adler, N. E., Berkowitz, S. A., Chin, M. H., Gary-Webb, T. L., Navas-Acien, A., ... & Haire-Joshu, D. (2021). Social determinants of health and diabetes: a scientific review. Diabetes care, 44(1), 258.
17. Kautzky-Willer, A., Leutner, M., & Harreiter, J. (2023). Sex differences in type 2 diabetes. Diabetologia, 66(6), 986-1002.
18. Krstikj, A., Esparza, M. G. C. R., & Boyes, C. (2023). From Food Swamps to Nutritious Landscapes of Tomorrow: Evidence from Mexico City. In The Coming of Age of Urban Agriculture (pp. 137-155). Cham: Springer Nature Switzerland.
19. Lord, J., Roberson, S., & Odoi, A. (2020). Investigation of geographic disparities of pre-diabetes and diabetes in Florida. BMC Public Health, 20, 1-15.
20. Mohan, V., Khunti, K., Chan, S. P., Filho, F. F., Tran, N. Q., Ramaiya, K., ... & Mbanya, J. C. (2020). Management of type 2 diabetes in developing countries: balancing optimal glycaemic control and outcomes with affordability and accessibility to treatment. Diabetes Therapy, 11, 15-35.
21. Nanda, A., Siles, R., Park, H., Louisias, M., Ariue, B., Castillo, M., ... & Pappalardo, A. A. (2023). Ensuring equitable access to guideline-based asthma care across the lifespan: tips and future directions to the successful implementation of the new NAEPP 2020 guidelines, a Work Group Report of the AAAAI Asthma, Cough, Diagnosis, and Treatment Committee. Journal of Allergy and Clinical Immunology, 151(4), 869-880.
22. Nexø, M. A., Baumgarten, S. V., Willaing, I., & Olesen, K. (2022). Staff experiences of diabetes care in residential care facilities for people with severe disabilities in Denmark: a mixed-methods assessment of access to screening for diabetes complications. BMJ open, 12(12), e062403.

23. Reshma, P., Rajkumar, E., John, R., & George, A. J. (2021). Factors influencing self-care behavior of socio-economically disadvantaged diabetic patients: A systematic review. Health psychology open, 8(2), 20551029211041427.
24. Reshma, P., Rajkumar, E., John, R., & George, A. J. (2021). Factors influencing self-care behavior of socio-economically disadvantaged diabetic patients: A systematic review. Health psychology open, 8(2), 20551029211041427.
25. Shoesmith, A., Hall, A., Wolfenden, L., Shelton, R. C., Powell, B. J., Brown, H., ... & Nathan, N. (2021). Barriers and facilitators influencing the sustainment of health behaviour interventions in schools and childcare services: a systematic review. Implementation Science, 16(1), 62.
26. Silverman-Retana, O., Hulman, A., Nielsen, J., Ekstrøm, C. T., Carstensen, B., Simmons, R. K., ... & Witte, D. R. (2020). Effect of familial diabetes status and age at diagnosis on type 2 diabetes risk: a nation-wide register-based study from Denmark. Diabetologia, 63, 934-943.
27. Sutherland, B. L., Pecanac, K., Bartels, C. M., & Brennan, M. B. (2020). Expect delays: poor connections between rural and urban health systems challenge multidisciplinary care for rural Americans with diabetic foot ulcers. Journal of foot and ankle research, 13(1), 32.
28. Wolfe, M. K., McDonald, N. C., & Holmes, G. M. (2020). Transportation barriers to health care in the United States: findings from the national health interview survey, 1997–2017. American journal of public health, 110(6), 815-822.
29. Wu, H., Li, H., Ding, Y., Jiang, J., Guo, P., Wang, C., ... & Wu, W. (2020). Is triglyceride associated with adult depressive symptoms? A big sample cross-sectional study from the rural areas of central China. Journal of affective disorders, 273, 8-15.
30. Zhao, Y., Xu, X., Dupre, M. E., Xie, Q., Qiu, L., & Gu, D. (2020). Individual-level factors attributable to urban-rural disparity in mortality among older adults in China. BMC Public Health, 20, 1-11.
31. Zou, X., Fitzgerald, R., & Nie, J. B. (2020). “Unworthy of Care and Treatment”: Cultural Devaluation and Structural Constraints to Healthcare-Seeking for Older People in Rural China. International journal of environmental research and public health, 17(6), 2132.