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Relationship between Body Mass Index, LDL Cholesterol, and Diabetes Control in Indigenous Populations

Relación entre índice de masa corporal, colesterol LDL y control de diabetes en población indígena

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ABSTRACT

Introduction: Diabetes is a chronic disease that affects various populations and presents unique challenges due to factors such as body mass index (BMI), blood pressure, and low-density lipoprotein (LDL) concentrations. Additionally, there is a lack of specific studies on Indigenous populations. **Objective:** To evaluate the relationship between BMI, blood pressure, and LDL cholesterol concentrations with glycemic control in Indigenous patients with diabetes. **Methods:** A cross-sectional study was conducted at the MALLAMAS Indigenous Health Provider (IPS) from 2020 to 2024. Data on BMI, blood pressure, LDL cholesterol, and glycated hemoglobin (HbA1c) were analyzed using descriptive techniques and logistic regression models. **Results:** Among the 609 Indigenous individuals analyzed, 38.95% were men. Each additional unit of BMI reduced the odds ratio for having HbA1c > 7% by 6.7% (OR = 0.933; 95% CI: 0.885-0.984). Patients with poorer glycemic control showed higher systolic (p = 0.0356) and diastolic (p = 0.0004) blood pressure levels. Uncontrolled hypertension significantly increased the odds of poor glycemic control (p = 0.022). No significant association was observed between LDL cholesterol and glycemic control. **Conclusion:** Uncontrolled hypertension and elevated BMI are associated with poorer diabetes control in this population; however, the lack of association between LDL cholesterol and glycemic control suggests the need to explore other contextual factors. These findings underscore the importance of comprehensive and culturally sensitive diabetes management in Indigenous communities.

Keywords
diabetes mellitus; body mass index; arterial pressure; cholesterol; LDL; indigenous people.

RESUMEN

Introducción: La diabetes es una enfermedad crónica que afecta a diversas poblaciones y presenta desafíos únicos, debido a factores como el índice de masa corporal (IMC), la tensión arterial y las concentraciones de lipoproteínas de baja densidad (LDL); además, faltan estudios específicos en poblaciones indígenas. **Objetivo:** Evaluar la relación entre el IMC, la tensión arterial y las concentraciones de colesterol LDL con el control glucémico en pacientes indígenas con diabetes.

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Métodos: Estudio transversal en la IPS indígena MALLAMAS entre 2020 y 2024. Se analizaron datos sobre IMC, presión arterial, colesterol LDL y hemoglobina glucosilada (HbA1c) mediante técnicas descriptivas y modelos de regresión logística. **Resultados:** De los 609 indígenas analizados, el 38,95% eran hombres. Cada unidad adicional en el IMC disminuyó en un 6,7% los *odds ratio* de presentar HbA1c > 7% (OR = 0,933; IC95%: 0,885-0,984). En los pacientes con peor control glucémico hubo concentraciones más altas de presión arterial sistólica (p = 0,0356) y diastólica (p = 0,0004). La hipertensión no controlada incrementó significativamente los *odds* de un mal control glucémico (p = 0,022). No se observó una asociación significativa entre el colesterol LDL y el control glucémico. **Conclusión:** La hipertensión no controlada y un IMC elevado se asocian con un peor control de la diabetes en esta población; sin embargo, la falta de asociación entre colesterol LDL y control glucémico sugiere la necesidad de explorar otros factores contextuales. Estas observaciones resaltan la importancia de un manejo integral y culturalmente sensible de la diabetes en comunidades indígenas.

Palabras clave
diabetes mellitus; índice de masa corporal; presión arterial; LDL-colesterol; pueblos indígenas.

Introduction

Diabetes is a chronic disease affecting millions of people worldwide, including various indigenous populations. These communities face unique challenges in disease management due to genetic, cultural, and socioeconomic factors. Among the risk factors associated with diabetes control are body mass index (BMI), blood pressure levels, and low-density lipoprotein (LDL) cholesterol concentrations. Previous studies have demonstrated that elevated BMI, hypertension, and high LDL cholesterol complicate diabetes management and increase the risk of cardiovascular complications and other comorbidities (1,2).

Despite the extensive literature on risk factors and diabetes management in the general population, there is a notable lack of studies focused on indigenous populations. Specifically, how BMI, blood pressure, and LDL cholesterol influence diabetes control in these communities remains unknown. Furthermore, diabetes management and control strategies that have proven effective in other populations may not be directly applicable or equally effective in the cultural and social contexts of indigenous populations (3,4).

Addressing this knowledge gap, our hypothesis is that BMI, blood pressure levels, and LDL cholesterol concentrations significantly influence diabetes control in indigenous patients. Specifically, we hypothesize that better control of these risk factors is associated with improved glycemic control in indigenous populations. Although this study does not directly evaluate it, good glycemic control is believed to contribute to a reduction in diabetes-associated complications, according to previous evidence (5).

The purpose of this study was to determine the relationship between BMI, blood pressure, and LDL cholesterol concentrations with diabetes control in indigenous patients, in order to provide crucial information that can guide more effective and culturally appropriate interventions for diabetes management in these communities (6).

The results of this study will not only help fill an important gap in the scientific literature but may also influence the formulation of more effective and culturally sensitive health policies and intervention strategies for diabetes management in indigenous populations (7).

Methods

A cross-sectional study was conducted to evaluate the relationship between BMI, blood pressure levels, LDL cholesterol concentrations, and diabetes control in indigenous patients.

The study population included all indigenous patients diagnosed with diabetes who attended the MALLAMAS indigenous healthcare center (IPS) between 2020 and 2024. The inclusion criteria were:

Being over 18 years old.

Having a confirmed diagnosis of diabetes mellitus.

Having attended at least one medical consultation at the MALLAMAS indigenous IPS.

Patients with severe acute illnesses or incomplete medical history data were excluded. The study variables were:

Independent variables: BMI, systolic and diastolic blood pressure levels, and LDL cholesterol concentrations.

Dependent variable: diabetes control, determined by glycated hemoglobin (HbA1c) levels greater than 7% or 8%.

Information was obtained from the medical records of the MALLAMAS indigenous IPS. BMI measurements were calculated based on height and weight recorded during the most recent consultation. Blood pressure levels were taken during the latest medical consultation. LDL cholesterol and HbA1c values were retrieved from laboratory results recorded within the last three months.

To minimize selection bias, all patients meeting the inclusion criteria were included. Data for this study were retrospectively collected from electronic medical records corresponding to each patient's latest visit. These records are part of the routine care provided to patients enrolled in the diabetes management program at the MALLAMAS indigenous IPS. The program follows standardized protocols for measuring clinical variables, including blood pressure, BMI, and laboratory tests, with validated procedures to ensure accuracy and consistency. Additionally, healthcare staff receive periodic training on proper techniques, instrument use, and result interpretation. Although data were derived from routine clinical practice, data quality is ensured through regular internal audits and adherence to program standards.

The sample size was calculated using the formula for prevalence studies, assuming an expected prevalence of good diabetes control of 50%, a 95% confidence level, and a 5% margin of error. Based on these assumptions, at least 384 patients were required for the study. However, all eligible patients during the study period were included to increase the power of the analysis.

Statistical Analysis

Data were analyzed using Stata software, version 18.0. Descriptive analyses were conducted to characterize the study population. Continuous variables were summarized using medians and interquartile ranges due to non-normal distribution. Normality was assessed with the Shapiro-Wilks test. Categorical variables were summarized using frequencies and percentages. To assess the relationship between BMI, blood pressure levels, LDL cholesterol concentrations, and diabetes control, the Wilcoxon rank-sum test was used for quantitative evaluations, while Fisher's exact test was employed for qualitative assessments of diabetes control.

Multivariate logistic regression analyses were performed to identify factors associated with good diabetes control (HbA1c $< 7\%$ and $< 8\%$). Potentially significant variables ($p < 0.05$) were first identified through bivariate analyses for inclusion in the multivariate model. The assumptions of the logistic regression model were validated by assessing the linearity of continuous variables on the logit scale and checking for multicollinearity using variance inflation factors. Model fit was evaluated using the Hosmer-Lemeshow test and the c-statistic (area under the curve). Additionally, a backward stepwise selection approach based on Akaike's information criterion was used to determine the most parsimonious model. Finally, influence tests were performed to identify any outliers or influential data points that could affect model stability.

Results

A total of 609 patients who met the inclusion criteria were included in the study. Regarding exclusion criteria, 5 participants did not have adequate follow-up data, resulting in a final sample of 604 patients. Table 1 presents the relationship between demographic and clinical variables according to HbA1c concentrations greater than 7%.

Table 1.
Demographic and clinical characteristics by glycated hemoglobin levels greater than 7%

Variable	***HbA1C* ≤ 7 (n [%])**	***HbA1C* > 7 (n [%])**	***p-value***
Gender			
Female	352 (69,16)	58 (61,05)	0,151
Male	157 (30,84)	37 (38,95)	
Health insurance type			
Contributory	18 (3,54)	4 (4,21)	0,981
Subsidized	491 (96,46)	91 (95,79)	
Smoker	17 (3,34)	8 (8,42)	0,045
Smoke exposure	57 (11,20)	11 (11,58)	0,999
Alcohol consumption	14 (2,75)	4 (4,21)	0,66
Hypertension	316 (62,08)	51 (53,68)	0,154
Controlled hypertension	302 (95,57)	45 (86,54)	0,022
Body mass index			
Underweight	6 (1,18)	4 (4,21)	0,2311
Variable	HbA1C ≤ 7 (n [%])	HbA1C > 7 (n [%])	**p-value**
Normal weight	108 (21,22)	21 (22,11)	
Overweight	242 (47,54)	40 (42,11)	
Obesity grade 1	112 (22,00)	22 (23,16)	
Obesity grade 2	26 (5,11)	7 (7,37)	
Obesity grade 3	15 (2,95)	1 (1,05)	
Variable: median (IQR)	**HbA1C ≤ 7 (n [%])**	**HbA1C > 7 (n [%])**	**p-value**
Age (years)	66 (58-73)	63 (54-72)	0,07
Systolic blood pressure (mmHg)	118 (110-123)	120 (112-126)	0,13
Diastolic blood pressure (mmHg)	65 (64-67)	67 (64-74)	0,002
Total cholesterol (mg/dL)	163 (135-195)	182 (152-210)	0,0039
HDL cholesterol (mg/dL)	47 (39-56)	47 (40-60)	0,28
Triglycerides (mg/dL)	128 (101-164)	144 (105-210)	0,02
LDL cholesterol (mg/dL)	82,8 (59-113,8)	86 (71-119,1)	0,111
Glycated hemoglobin (%)	5,2 (4,8-5,9)	8,9 (7,7-10,6)	0,0001
Variable	***HbA1C* ≤ 7 (n [%])**	***HbA1C* > 7 (n [%])**	***p-value***
Fasting glucose (mg/dL)	103 (90-119)	173 (119-269)	0,0001
Abdominal circumference (cm)	98 (93-106)	98 (92-108)	0,68
Weight (kg)	66 (60-74)	66 (57-75)	0,79
Height (cm)	154 (149-161)	155 (150-164)	0,29
Body mass index (kg/m²)	27,9 (25,2-30,8)	26,9 (24,3-30,6)	0,99
Creatinine (mg/dL)	0,84 (0,715-0,965)	0,8 (0,7-1)	0,55
Albuminuria (mg/g)	6 (3-13)	11 (5-41)	0,0001

LDL: low-density lipoproteins;
HDL: high-density lipoproteins.

There were no statistically significant differences in gender distribution between the groups with HbA1c ≤ 7% and HbA1c > 7% (p = 0.151). Most patients were enrolled in the subsidized health insurance system, and this variable also showed no significant association with glycemic control (p = 0.981). In contrast, it was found that non-smokers had a significantly higher prevalence of HbA1c ≤ 7% compared to smokers (p = 0.045), highlighting the impact of smoking on glycemic control.

Although no significant differences were observed in the prevalence of hypertension between the groups (p = 0.154), hypertension control showed a relevant association: a higher percentage of patients with HbA1c > 7% had uncontrolled hypertension compared to those with HbA1c ≤ 7% (13.46% vs. 4.43%; p = 0.022).

Regarding continuous variables, patients with HbA1c > 7% had significantly higher diastolic blood pressure (p = 0.002), total cholesterol (p = 0.0039), triglycerides (p = 0.02), HbA1c (p = 0.0001), and fasting glucose (p = 0.0001). These findings underscore key clinical factors associated with poor glycemic control.

On the other hand, no significant differences were found in LDL cholesterol (p = 0.111), BMI (p = 0.99), or abdominal circumference (p = 0.68), suggesting that these factors may not be direct determinants of glycemic control in this population. Additionally, although albuminuria concentrations were higher in patients with HbA1c > 7%, this difference reached statistical significance (p = 0.0001), which could indicate renal damage related to inadequate glycemic control (Table 1).

The logistic regression model used to assess factors associated with HbA1c > 7 identified several significant variables, providing insights into the relationship between these covariates and glycemic control (Table 2):

Age: An inverse relationship was observed between age and the risk of HbA1c > 7. For each additional year, the odds of having elevated HbA1c levels decreased by 3.1% (OR = 0.969; 95% CI: 0.949–0.989; p = 0.0026).

Active smoker: Smokers had 2.7 times higher odds of having HbA1c > 7 compared to non-smokers (OR = 2.709; 95% CI: 1.103–6.654; p = 0.0297).

Systolic blood pressure: Each 1 mmHg increase in systolic blood pressure was associated with a 2.2% increase in the odds of HbA1c > 7 (OR = 1.022; 95% CI: 1.002–1.043; p = 0.0321).

Diastolic blood pressure: Similarly, a 1 mmHg increase in diastolic blood pressure increased the odds of HbA1c > 7 by 4.8% (OR = 1.048; 95% CI: 1.009–1.088; p = 0.0146).

BMI: Although BMI showed a significant relationship, it was associated with a 6.7% reduction in the odds of HbA1c > 7 for each additional unit (OR = 0.933; 95% CI: 0.885–0.984; p = 0.0103).

Tabla 2.
Modelo de regresión logística para la hemoglobina glucosilada > 7

Variable	OR	IC2,5 %	IC97,5 %	p-value
Age	0,969	0,949	0,989	0,0026
Active smoker	2,709	1,103	6,654	0,0297
Systolic blood pressure	1,022	1,002	1,043	0,0321
Diastolic blood pressure	1,048	1,009	1,088	0,0146
Low-density lipoproteins	1,001	0,996	1,007	0,6372
Body mass index	0,933	0,885	0,984	0,0103

OR: *odds ratio*; CI: confidence interval. * Hosmer-Lemeshow goodness-of-fit test p-value: 0.6614.

The demographic and clinical characteristics of patients according to HbA1c > 8% are presented in Table 3. No statistically significant differences were observed in gender distribution in relation to diabetes control. A total of 62.07% of female patients had HbA1c > 8%, compared to 68.50% in the group with HbA1c ≤ 8% (p = 0.3958).

Table 3.
Demographic and clinical characteristics by glycated hemoglobin levels > 8%

Variable	HbA1C ≤ 8 (n [%])	HbA1C > 8 (n [%])	p-value
Gender			
Female	374 (68,50)	36 (62,07)	0,3958
Male	172 (31,50)	22 (37,93)	
Health insurance type			
Contributory	20 (3,66)	2 (3,45)	1
Subsidized	526 (96,34)	56 (96,55)	
Smoker	19 (3,48)	6 (10,34)	0,0316
Smoke exposure	61 (11,17)	7 (12,07)	1
Alcohol consumption	16 (2,93)	2 (3,45)	1
Hypertension	343 (62,82)	24 (41,38)	0,0024
Controlled hypertension	327 (95,34)	20 (80,00)	0,0061
Body mass index			
Underweight	7 (1,28)	3 (5,17)	0,0751
Normal weight	116 (21,25)	13 (22,41)	
Overweight	259 (47,44)	23 (39,66)	
Obesity grade 1	121 (22,16)	13 (22,41)	
Obesity grade 2	27 (4,95)	6 (10,34)	
Obesity grade 3	16 (2,93)	0 (0,00)	
Variable: median (IQR)	**HbA1C ≤ 8 (n [%])**	**HbA1C > 8 (n [%])**	**p-value**
Age (years)	66 (58-73)	62 (53-72)	0,066
Systolic blood pressure (mmHg)	118 (110-123)	120 (110-123)	0,724
Diastolic blood pressure (mmHg)	65 (64-68)	65 (64-75)	0,04
Total cholesterol (mg/dL)	163,5 (135-196)	185,5 (157-213)	0,0014
HDL cholesterol (mg/dL)	47 (39-56)	47 (42-61)	0,11
Triglycerides (mg/dL)	128 (100-169)	144,5 (115-232)	0,019
LDL cholesterol (mg/dL)	81,7 (59-112,3)	101,8 (79-122,2)	0,004
Glycated hemoglobin (%)	5,3 (4,8-6,1)	10,3 (9,2-11,5)	0,0001
Fasting glucose (mg/dL)	104 (90-120)	230 (167-295)	0,0001
Abdominal circumference (cm)	98 (93-106)	98 (91-108)	0,53
Weight (kg)	66 (60-74)	66 (57-75)	0,59
Height (cm)	154 (149-161)	155 (148-161)	0,95
Body mass index (kg/m²)	27,8 (25,2-30,8)	26,8 (24,3-30,4)	0,27
Creatinine (mg/dL)	0,84 (0,71-0,97)	0,8 (0,7-1)	0,43
Albuminuria (mg/g)	6 (3-14)	12 (5-35,3)	0,0067

LDL: low-density lipoproteins;
HDL: high-density lipoproteins.

The results showed a statistically significant difference in smoking habits; 10.34% of patients with HbA1c > 8% were smokers, compared to only 3.48% in the group with HbA1c ≤ 8% (p = 0.0316).

The prevalence of hypertension was significantly lower in the group with poorer diabetes control (HbA1c > 8%), where only 41.38% had hypertension, compared to 62.82% in the group with better control (HbA1c ≤ 8%) (p = 0.0024). Additionally, among hypertensive patients, 20.00% had uncontrolled hypertension in the HbA1c > 8% group, compared to 4.66% in the HbA1c ≤ 8% group, which was statistically significant (p = 0.0061).

No significant differences were found in the BMI classification distribution between groups, although there was a trend toward a higher prevalence of grade 2 obesity in the HbA1c > 8% group (10.34% vs. 4.95%; p = 0.0751). However, this difference did not reach statistical significance.

Table 3 summarizes the demographic and clinical characteristics of patients according to HbA1c > 8%. Statistically significant

differences were identified in several key factors. Smokers had a higher prevalence of HbA1c > 8% (10.34%) compared to non-smokers (3.48%; p = 0.0316). Similarly, patients with uncontrolled hypertension had a significantly higher prevalence of HbA1c > 8% (20.00%) compared to those with controlled hypertension (4.66%; p = 0.0061).

In terms of continuous variables, patients with HbA1c > 8% had significantly higher concentrations of total cholesterol (185.5 mg/dL vs. 163.5 mg/dL; p = 0.0014), triglycerides (144.5 mg/dL vs. 128 mg/dL; p = 0.019), and LDL cholesterol (101.8 mg/dL vs. 81.7 mg/dL; p = 0.004). They also exhibited markedly higher levels of HbA1c (10.3% vs. 5.3%; p = 0.0001) and fasting glucose (230 mg/dL vs. 104 mg/dL; p = 0.0001), reflecting poor metabolic control. Diastolic blood pressure was also higher in the HbA1c > 8% group (p = 0.04).

Although there was a trend toward a higher prevalence of grade 2 obesity in patients with HbA1c > 8% (10.34% vs. 4.95%), this difference did not reach statistical significance (p = 0.0751). No significant differences were observed in overall BMI (p = 0.27) or other variables such as abdominal circumference or serum creatinine. However, albuminuria levels were significantly higher in patients with HbA1c > 8% (12 mg/g vs. 6 mg/g; p = 0.0067).

The logistic regression model to predict HbA1c > 8% identified several significant variables (Table 4):

Table 4.
Logistic regression model for glycated hemoglobin > 8%

Variable	OR	IC2,5 %	IC97,5 %	p-value
Age	0,9710	0,9474	0,9951	0,0187
Active smoker	36,215	13,292	98,668	0,0119
Systolic blood pressure	10,089	0,9842	10,343	0,4832
Diastolic blood pressure	10,473	10,003	10,965	0,0487
HDL cholesterol	10,223	10,008	10,443	0,0416
LDL cholesterol	10,052	0,9986	10,119	0,1214
Índice de masa corporal	0,9563	0,8954	10,214	0,1839

*OR: odds ratio; CI: confidence interval. Hosmer-Lemeshow goodness-of-fit test p-value: 0.655.

The logistic regression model exploring factors associated with HbA1c > 8% identified several significant covariates and provided insight into the statistical relationships between these variables and glycemic control:

• Age: Each additional year was associated with a 2.9% reduction in the odds of having HbA1c > 8% (OR = 0.9710; 95% CI: 0.9474–0.9951; p = 0.0187).

• Active smoker: Active smokers had 36.2 times higher odds of having HbA1c > 8% compared to non-smokers (OR = 36.215; 95% CI: 13.292–98.668; p = 0.0119).

• Diastolic blood pressure: A 1 mmHg increase in diastolic blood pressure was associated with a 47.3% increase in the odds of HbA1c > 8% (OR = 10.473; 95% CI: 10.003–10.965; p = 0.0487).

• HDL cholesterol: Surprisingly, a 1 mg/dL increase in HDL cholesterol was associated with a 22.3% increase in the odds of HbA1c > 8% (OR = 10.223; 95% CI: 10.008–10.443; p = 0.0416).

Discussion

This cross-sectional study evaluated the relationship between BMI, blood pressure levels, LDL cholesterol concentrations, and diabetes control in indigenous patients. The sample included 604 patients over 18 years of age with a confirmed diagnosis of diabetes who were treated

at the MALLAMAS indigenous healthcare center (IPS) between 2020 and 2024. The results showed that uncontrolled hypertension and smoking were significantly associated with poorer glycemic control, measured by elevated HbA1c levels. Specifically, patients with uncontrolled hypertension were more likely to have HbA1c levels above 7% compared to those with well-controlled hypertension. This association highlights the importance of adequate blood pressure management in diabetes care for this population.

Among patients with HbA1c levels exceeding 8%, significant associations were observed with smoking and uncontrolled hypertension, which were more prevalent in this group. These findings underscore their impact on diabetes control. Additionally, elevated concentrations of total cholesterol, triglycerides, LDL cholesterol, and albuminuria were identified in patients with HbA1c > 8%, suggesting increased cardiovascular and renal risks. Conversely, the absence of significant differences in BMI between groups with HbA1c ≤ 8% and > 8% may reflect specific characteristics of the indigenous population studied, such as differences in body composition, fat distribution, and dietary habits. These factors may have influenced the lack of association observed, emphasizing the importance of considering cultural and social factors when designing tailored management and prevention strategies for this population (8). These findings highlight the need for further studies to explore how these unique characteristics affect glycemic control and associated complications in indigenous communities.

A retrospective analysis of statistical power based on the sample size of 604 patients revealed an approximate power of 21.5% to detect significant associations between BMI and glycemic control (HbA1c > 7%) in this population. This low power reflects the relatively small effect size observed (OR = 0.933), which limits the study's ability to identify statistically significant associations. Although all eligible patients were included, the cross-sectional design and sample size may have been insufficient to detect more subtle effects. This finding underscores the need for additional studies with larger sample sizes or prospective designs to more accurately evaluate the relationships between these variables and their clinical implications. Despite these limitations, the results provide valuable preliminary information that can guide future research in this underrepresented population.

Furthermore, no significant associations were found between BMI and LDL cholesterol with glycemic control. Although elevated BMI and high LDL cholesterol concentrations are recognized risk factors for cardiovascular complications in diabetes, they did not show a statistically significant relationship with HbA1c in our indigenous population. This lack of association may be due to specific factors related to body composition, fat distribution, and dietary habits in indigenous populations that were not fully captured in this study. It is possible that other factors, such as traditional dietary patterns and physical activity, play a more critical role in glycemic control in this specific population.

These findings suggest that while uncontrolled hypertension and smoking are key risk factors for poor diabetes control in indigenous patients, BMI and LDL cholesterol may not be as influential in this population. Therefore, interventions to improve diabetes control in indigenous communities should focus on managing blood pressure and reducing smoking while also considering other cultural and lifestyle factors that may affect diabetes management (9).

Our findings are consistent with previous studies identifying hypertension as a critical risk factor for cardiovascular complications and poor diabetes control in indigenous populations. For example, a study conducted in the Jaguapiru village in Brazil found a high prevalence of hypertension (29.5%), particularly among obese and diabetic individuals, reinforcing the need for proper blood pressure management to reduce cardiovascular risks and improve glycemic control in these communities (10). Similarly, in the Mura indigenous population of the Amazon, hypertension affected 26.6% of individuals and was strongly associated with obesity and other

metabolic factors, underscoring its negative impact on disease control, including diabetes (11). These findings highlight the importance of culturally tailored interventions to address hypertension and improve diabetes management in indigenous communities.

In addition, the strong association between smoking and poor glycemic control has also been well-documented. Previous research has shown that diabetic smokers are at higher risk of elevated HbA1c concentrations, which aligns with our findings. One study demonstrated that diabetic smokers had significantly worse glycemic control compared to non-smokers, reinforcing the urgency of implementing targeted strategies to reduce smoking in this population (12,13).

However, our results diverge from the existing literature regarding the relationship between BMI and glycemic control. Numerous studies suggest that elevated BMI is a consistent predictor of poor glycemic control, but we did not find significant differences in BMI categories between groups with different HbA1c levels. This could be explained by differences in body composition and fat distribution in indigenous populations compared to other populations studied. Research has shown that body composition and fat distribution patterns can vary significantly among ethnic groups, potentially affecting the relationship between BMI and diabetes control (14).

Furthermore, although elevated LDL cholesterol concentrations would typically be expected to correlate with poor diabetes control, we did not observe a significant association in our population. This observation contrasts with previous studies that identified a clear relationship between high LDL levels and poor glycemic control in non-indigenous populations. The absence of this association in our sample may reflect variations in diet and lifestyle that were not fully captured in this analysis. It is possible that specific dietary factors traditional to indigenous populations influence the relationship between LDL cholesterol and diabetes control differently than in other populations (15-17).

This study has several limitations. First, its cross-sectional design prevents the establishment of causal relationships between the variables studied. Additionally, the retrospective data collection and reliance on the accuracy of medical records may introduce measurement biases. The lack of information on other potentially influential factors, such as diet and physical activity, also limits the interpretation of the results. However, a key strength of this study is its focus on an indigenous population—an often underrepresented group in research—providing valuable, population-specific information that can guide future interventions and health policies.

The results of this study emphasize the need for diabetes management strategies in indigenous communities. Culturally adapted interventions to reduce risk factors could significantly improve health outcomes in this population. Furthermore, future research should consider longitudinal designs to assess causality and further explore other indigenous-specific risk factors that may influence diabetes control.

Conclusions

This study provides significant evidence regarding the relationship between various risk factors and diabetes control in an indigenous population. Uncontrolled hypertension and smoking emerged as important predictors of poor glycemic control, emphasizing the need for targeted interventions addressing these factors. Although some discrepancies with the existing literature were found, these results offer a foundation for future research and the development of more effective and culturally appropriate strategies to improve diabetes control in indigenous populations.

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Conflict of Interest

The authors declare no conflicts of interest related to this work.

References

1. Young TK, Reading J, Elias B, O'Neil JD. Type 2 diabetes mellitus in Canada's first nations: status of an epidemic in progress. CMAJ [internet]. 2000;163(5):561-6. Disponible en: https://pmc.ncbi.nlm.nih.gov/articles/PMC80466/

2. Dyck R, Osgood N, Lin TH, Gao A, Stang MR. Epidemiology of diabetes mellitus among First Nations and non-First Nations adults. CMAJ. 182(3):249-56. https://doi.org/10.1503/cmaj.090846

3. Harris SB, Gittelsohn J, Hanley A, Barnie A, Wolever TM, Gao J, et al. The prevalence of NIDDM and associated risk factors in native Canadians. Diabetes Care. 1997;20(2):185-7. https://doi.org/10.2337/diacare.20.2.185

4. Chopra S, Lahiff TJ, Franklin R, Brown A, Rasalam R. Effective primary care management of type 2 diabetes for indigenous populations: a systematic review. Plos One. 2022;17(11):e0276396. https://doi.org/10.1371/journal.pone.0276396

5. Oster RT, Grier A, Lightning R, Mayan MJ, Toth EL. Cultural continuity, traditional Indigenous language, and diabetes in Alberta First Nations: a mixed methods study. Int J Equity Health. 2014;13:92. https://doi.org/10.1186/s12939-014-0092-4

6. Jiang L, Manson SM, Beals J, Henderson WG, Huang H, Acton KJ, et al. Translating the Diabetes Prevention Program Into American Indian and Alaska Native Communities. Diabetes Care. 2013;36(7):2027-34. https://doi.org/10.2337/dc12-1250

7. Jiang L, Chang J, Beals J, Bullock A, Manson SM, Special Diabetes Program for Indians Diabetes Prevention Demonstration Project. Neighborhood characteristics and lifestyle intervention outcomes: results from the Special Diabetes Program for Indians. Prev Med. 2018;111:216-24. https://doi.org/10.1016/j.ypmed.2018.03.009

8. Gomes HLM, Sombra NM, Cordeiro EDDO, Filho ZADS, Toledo NDN, Mainbourg EMT, et al. Glycemic profile and associated factors in indigenous Munduruku, Amazonas. Plos One. 2021;16(9):e0255730. https://doi.org/10.1371/journal.pone.0255730

9. Bernabe-Ortiz A, Carrillo-Larco RM, Miranda JJ. Association between body mass index and blood pressure levels across socio-demographic groups and geographical settings: analysis of pooled data in Peru. Peer J. 2021;9:e11307. https://doi.org/10.7717/peerj.11307

10. Oliveira GF, Oliveira TRR, Ikejiri AT, Andraus MP, Galvao TF, Silva MT, et al. Prevalence of hypertension and associated factors in an indigenous community of Central Brazil: A population-based study. PLoS One. 2014;9(1):e86278. https://doi.org/10.1371/journal.pone.0086278

11. De Souza Filho ZA, Ferreira AA, Dos Santos J, Meira KC, Pierin AMG. Cardiovascular risk factors with an emphasis on hypertension in the Mura Indians from Amazonia. BMC Public Health. 2018;18(1):1251. https://doi.org/10.1186/s12889-018-6160-8

12. Huang R, Song C, Li T, Yu C, Yao T, Gao H, et al. A cross-sectional comparative study on the effects of body mass index and

exercise/sedentary on serum asprosin in male college students. PLoS One. 2022;17(4):e0265645. https://doi.org/10.1371/journal.pone.0265645

13. Huang J, Lin H, Wang S, Li M, Wang T, Zhao Z, et al. Association between serum LDL-C concentrations and risk of diabetes: a prospective cohort study. J Diabetes. 2023;15(10):881-9. https://doi.org/10.1111/1753-0407.13440

14. Cheran K, Murthy C, Bornemann EA, Kamma HK, Alabbas M, Elashahab M, et al. The growing epidemic of diabetes among the indigenous population of Canada: a systematic review. Cureus. 15(3):e36173. https://doi.org/10.7759/cureus.36173

15. Rusk AM, Kanj AN, Murad MH, Hassett LC, Kennedy CC. Smoking cessation interventions in indigenous north americans: a meta-narrative systematic review. Nicotine Tob Res. 2022;25(1):3-11. https://doi.org/10.1093/ntr/ntac181

16. Tremblay M, Bradette-Laplante M, Witteman HO, Dogba MJ, Breault P, Paquette J, et al. Providing culturally safe care to Indigenous people living with diabetes: Identifying barriers and enablers from different perspectives. Health Expect Int J Public Particip Health Care Health Policy. 2021;24(2):296-306. https://doi.org/10.1111/hex.13168

17. Dedefo MG, Abate SK, Ejeta BM, Korsa AT. Predictors of poor glycemic control and level of glycemic control among diabetic patients in west Ethiopia. Ann Med Surg. 2020;55:238-43. https://doi.org/10.1016/j.amsu.2020.04.034