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Is Being Single a Risk Factor for Previously Undetected Abnormal Glucose Tolerance?

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Abstract

Background: Type II diabetes represents a chronic disease with costly consequences. It is important to identify all risk factors to allow patients the opportunity to counter its progression. The aim of this study was to evaluate the association between marital status and previously undiagnosed abnormal glucose tolerance (AGT) in a northern Colombian population.

Methods: Secondary data analysis of a cross-sectional screening study in a northern Colombian adult population ages 18-74 using healthcare insurance company data from 2014-2015. The main exposure was marital status, while the outcome was AGT. A descriptive analysis of the variables in the database was conducted, and chi-square analysis of categorical covariates and a t-test of continuous covariates were performed. Unadjusted and adjusted linear regression models were used to evaluate the association between marital status and AGT.

Results: Single individuals had a 20% decreased odds of having AGT compared to married individuals (odds ratio (OR) 0.80, 95% confidence interval (CI) 0.7 - 1.0), but this association disappeared after adjusting for covariates (OR 1.0, 95% CI 0.7 - 1.2). There was a 40% increased odds of AGT in women compared to men (OR 1.40, 95% CI 1.1 - 1.8). Hypertension increased the risk of AGT by about 60% (OR 1.60, 95% CI 1.2 - 2.1), while obesity was associated with an 80% increased odds of developing AGT (OR 1.80, 95% CI 1.3 - 2.4).

Conclusion: Our study suggests that screening for abnormal glucose tolerance may not be necessary in specific marital status groups.

Keywords: impaired fasting glucose; impaired glucose tolerance; hyperglycemia; glucose metabolism disorder; marital status; undiagnosed diabetes

1. Introduction

Type 2 diabetes mellitus is a disease with few overt symptoms that seldom bring patients to seek medical attention. As a result, many diabetics often go undiagnosed for a significant period of time. However, it is one of the most common illnesses to plague mankind and it continues to become more prevalent. It is also one of the leading causes of morbidity and mortality in developing countries - in the Colombian population alone, it is estimated by the International Diabetes Federation that there will be 3.34 million type II diabetics by the year 2035 (International Diabetes Federation [IDF], 2013). One study showed that the diagnosis of diabetes has been increasing in the Colombian adult population, either from increased research/awareness of the disease or as a result of increasing rates of obesity (Barengo & Tamayo, 2015). Given that it is such a costly disease, it is important to identify all the factors that increase the likelihood of developing diabetes. For those afflicted, its management represents a difficult task, often requiring help from those close to them. It has been shown that married individuals generally have better disease management and better health outcomes than unmarried individuals (Manzoli et al., 2006; Robards et al., 2012). However, successful prevention or management of diabetes is difficult to achieve and can be largely dependent on personal motivations as well.

From an evolutionary perspective, single individuals are more motivated to find a mate. In today's age this means networking more and attempting to expand one's social circles through public interactions that are often held at dining establishments such as restaurants and bars. This may lead to unintentional or unrecognized unhealthy eating habits, ultimately resulting in higher rates of diabetes. Furthermore, single individuals lack the spousal support that can help develop and maintain healthy lifestyle habits, which often benefit from having a partner as a motivating factor. This dynamic is often included under heavily researched "social networks" that can influence health behaviors, particularly in the form of encouragement and accountability (August et al., 2013). Married individuals may often accompany one another to and remind each other of their doctors' visits, resulting in higher health literacy, earlier and increased detection of possible health conditions, better medical follow-up, and increased compliance with medical treatment. Additionally, married people may not put as much effort into finding a mate as they have already secured one, resulting in healthier choices due to more stable dining habits. Married individuals can share the time and responsibility required to make healthy lifestyle choices. For example, they can alternate their roles as the primary cook which can make the responsibility of eating healthy more bearable. One study suggests that when the perceived marriage market decreases in quality, single individuals invest less resources toward securing a mate and thus devote less time to maintaining a desirable image of strength and health (Harris et al., 2017). Finally, although outside the scope of our investigation, married individuals with families to support may prioritize securing nourishment for their dependents over themselves. Single individuals on the other hand prioritize their own survival and well-being.

Several previous studies examining similar questions to ours showed marital status had a protective factor in the development of glucose metabolism disorders. The specific aim of our study is to determine whether there is an association between marital status and previously undetected abnormal glucose tolerance in the adult population in Northern Colombia. Specifically, we wanted to identify whether single individuals in this population have a greater risk of having undetected abnormal glucose tolerance.

2. Methods

2.1 Study Design and Participants

This study was a secondary data analysis of a cross-sectional screening study. The participants for the study were 18-74 years-old clientele of the health-care insurance company Mutual SER EPSS living in 30 municipalities in the provinces of Atlantico, Bolivar, Cordoba, Magdalena and Sucre located in northern Colombia. Mutual SER EPSS provides healthcare to about 1,300,000 people in these 5 provinces and about 77% of these people live in urban regions. The sample size was calculated according to an estimated sensitivity of 90% and specificity of 80% to detect new cases of Type 2 diabetes mellitus, respectively, considering a confidence level of 95% and an alpha error of 5%. Given an estimated response rate of 70%, the minimum study sample needed was 2550 people. However, the study obtained a higher response rate than expected, ending up with information on 2613 participants. The study sample was calculated for each municipality based on the number of people registered at Mutual SER EPSS. Thus, the study sample was weighted according to the population Mutual SER EPSS has in each municipality with more study participants selected in places where they have more patients registered to whom healthcare is provided. Furthermore, to ensure that there were enough participants in each age group, a stratified sampling was used with 25% of the participants in age groups of 18-35 years, 36-45 years, 46-54 years and 55-74 years. The study participants were randomly selected from the client database of the company. The inclusion criteria for the study were: (1) age between 18 and 74 years; (2) signed informed consent; and (3) living in one of the five provinces (Atlantico, Bolivar, Cordoba, Magdalena and Sucre) of Northern Colombia in 2014-2015. The exclusion criteria were: (1) did not include information on marital status or any other of the variables used in the analysis; (2) received drug treatment for Type 2 diabetes mellitus or previously diagnosed diabetes; (3) pregnancy or breastfeeding; (4) history of cancer; (5) regular use of systemic corticosteroids; (6) hemophilia; (7) inability to stand or communicate; and (8) living in areas of difficult access (Barengo et al 2017). After excluding participants from the questionnaire based on these exclusion criteria, there were 2060 participants left. For the secondary data analysis, after excluding 1 participant for lacking information on marital status, 200 participants for lacking information on hypertension status, and 63 participants for smoking status, the study ended up with 1716 total participants.

2.2 Study Variables

All measurements for the dataset were collected from October 2014 to February 2015. The main independent variable was marital status, with subcategories of married (including free union) and single (including those who are separated, divorced, or widowed). The main outcome variable was abnormal glucose tolerance. All participants underwent an oral glucose tolerance test that was carried out according to the World Health Organization (WHO) recommendations. A fasting blood sample was obtained after 12 hours of fasting, and a 2-hour blood sample was obtained after oral ingestion of a water solution with 75g anhydrous glucose. The glucose tolerance status was classified according to the American Diabetes Association (ADA) 2004 criteria (American Diabetes Association 2010). Individuals who had fasting plasma glucose (FPG) level ≥126 mg/dl or 2h plasma glucose (2hPG) ≥200 mg/dl were classified as having Type 2 diabetes mellitus. Those with 2hPG ≥140 mg/dl but <200 mg/dl, and FPG <100 mg/dl were classified as having isolated impaired glucose tolerance (IGT). Isolated impaired fasting glucose (IFG) was defined as FPG ≥100 but <126 mg/dl, and 2hPG <140 mg/dl. People with 2hPG ≥140 mg/dl but <200 mg/dl, and FPG≥100 but <126 mg/dl were defined as combined IGT and IFG. People with Type 2 diabetes mellitus, IGT or IFG were classified as having abnormal glucose tolerance.

Lifestyle habits and risk factors for Type 2 diabetes mellitus were assessed by interviews using a questionnaire consisting of information regarding sociodemographic factors, personal and family history of Type 2 diabetes mellitus, medical history, tobacco consumption, hypertension, nutritional and physical activity habits. The instruments applied were designed based on the FINDRISC, Stepwise approach to surveillance (STEPS) and International Physical Activity Questionnaire (IPAQ) (Lindström & Tuomilehto, 2003; Craig et al., 2003; Ekelund et al., 2006; WHO, 2013; WHO, 1999).

Age was measured in years. Height and weight were measured without shoes and with light clothing, and these measurements were utilized to calculate BMI as weight (kg) divided by height2 (m2). Waist circumference (to the nearest cm) was measured at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest.

Blood pressure was measured with mercury sphygmomanometer twice from the right arm of the participant in a seated position after at least 5 minutes of rest. The mean value of the first and second blood pressure measurements were used in the analysis. Hypertension was defined as a blood pressure greater than or equal to 140/90 mmHg or current treatment for hypertension (American Heart Association, 2017). Family history of diabetes was assessed either as yes or no, and a positive history was further subdivided as diagnosed diabetes in first-degree or second-degree relatives.

Lifestyle habits such as smoking and physical activity were also assessed. The classification of smoker was based on current smoking with a lifetime history of smoking at least 100 cigarettes. The classification of non-smoker was divided into ex-smoker and never-smoker. An ex-smoker has a total lifetime history of smoking at least 100 cigarettes but quit smoking at least 6 months ago. Those with a lifetime history of smoking less than 100 cigarettes were designated as never-smoker. Physical activity was classified according to IPAQ instructions in three categories: Mild: people who do not meet the criteria for the moderate or high categories were considered low/inactive; Moderate: any of the following three criteria: (i) three or more days of vigorous activity at least 20 minutes per day; (ii) five or more days of moderate intensity activity or walking at least 30 minutes per day; (iii) five or more days of any combination of walking, moderate intensity or vigorous intensity activities that reached a minimum of at least 600 minutes/week; High: any of the following two criteria: (i) intense physical activity in at least three days and accumulating at least 1,500 minutes/week; (iii) seven or more days of any combination of walking, moderate intensity or vigorous intensity activities that reached a minimum of at least 3,000 minutes/week (IPAQ, 2006).

Lastly, socioeconomic factors such as ethnicity and level of education were also taken into account. Ethnicity was identified as Afro-Colombian, Indigenous, ROM/Gitano, or as none of the above. Education was identified as uneducated, primary education, high school/secondary education, or above high school.

2.3 Statistical Analysis

A descriptive analysis of the data collected from the Colombian Diabetes risk score database was performed and included measures of centrality and dispersion. Next, potential confounders were controlled for. Of the potential confounders discussed above, including age, BMI, blood pressure, smoking history, physical activity level, family history of diabetes, race/ethnicity, and level of education, all variables except age were categorical variables. Differences in distribution between potential categorical confounders with marital status and abnormal glucose tolerance were evaluated with chi-square and bivariate analysis, using a p value of 0.2 for significance. For the continuous variable of age, a t-test was used to assess differences between covariates and marital status, respectively abnormal glucose tolerance. Subsequently, collinearity diagnostics were utilized to evaluate for any correlation amongst the variables. Finally, unadjusted and adjusted logistic regression models were used to test for the association between marital status and abnormal glucose tolerance. The Hosmer-Lemeshow test was then used to check for the goodness-of-fit of the logistic regression model. Odds ratios and 95% confidence intervals were calculated.

2.4 Ethical Considerations

This study followed the Good Clinical Practice guidelines and the guidelines of the Helsinki Declaration. All the data have been collected using previously tested questionnaires and methods. Besides blood samples, no invasive methods were used. The study protocol was approved by the Research Ethics Committee of the Central Military Hospital, Bogotá, Colombia. All participants gave the written informed consent prior to their participation in the study. The study protocol was also presented to the Internal Review Board (IRB) of the Florida International University Herbert Wertheim College of Medicine for approval. This present study was not considered human subject studies as it uses secondary de-identified data.

3. Results

Table 1 details the distributions of various predictors of abnormal glucose tolerance according to marital status. Chi-squared tests for categorical variables and t-test for continuous variables (age only) revealed statistically significant differences in the frequencies between singlehood and partnered for the variables of age, level of education, gender, hypertension, and BMI. Married participants had a mean age 4.5 years higher than single participants ($p < 0.001$). For level of education, partnered participants had higher frequencies of education less than high school than single participants (65.5% vs 51.3%, $p < 0.001$). Partnered participants had a higher percentage of men compared with the single group ($p = 0.036$). Married individuals had higher frequencies of hypertension than their single counterparts ($p = 0.012$). With regards to BMI, single individuals had higher distributions within underweight and normal weight categories while overweight and obesity was more prevalent in married individuals ($p < 0.001$).

Table 1. Characteristics of study participants according to marital status in Northern Colombia, in 2014-2015

	Marital Status		
	Si/Di/Se/Wi*	**Married/Free Union**	**p-value**
	% (N = 646)	**% (N = 1052)**	
Age (years)	17.4 (44.9)	13.2 (49.4)	<0.001
Ethnicity			0.172
Afro-Colombian	22.4 (145)	22.1 (233)	
Indigenous/ROM	2 (13)	3.6 (38)	
None	75.5 (488)	74.2 (781)	
Level of education			<0.001
No school	13.5 (87)	16 (168)	
Less than high school	37.8 (244)	49.5 (521)	
High school	34.4 (222)	26 (273)	
Above high school	14.4 (93)	8.6 (90)	
Men	34.4 (222)	39.4 (415)	0.036
Presence of Hypertension	22.9 (148)	28.4 (299)	0.012
Smoking			0.912
Never	81.9 (529)	81.4 (856)	
Former	12.1 (78)	12.1 (127)	
Current	6 (39)	6.6 (69)	
Level of physical activity			0.185
Low	62.5 (404)	60.3 (634)	
Moderate	21.7 (140)	25.5 (268)	
High	15.8 (102)	14.3 (150)	

BMI			<0.001
Underweight (<18.5)	5.1 (33)	2.2 (23)	
Normal (18.5-24.9)	42.1 (272)	32.9 (346)	
Overweight (25.0-29.9)	34.1 (220)	36.2 (381)	
Obese (≥ 30.0)	18.7 (121)	28.7 (302)	

*Single/Divorced/Separated/Widowed.

Table 2 presents the unadjusted and adjusted associations between the main exposure variable, other covariates, and the outcome variable. With regards to marital status, in the unadjusted model single individuals were seen to have a statistically significant 20% decrease in the odds of developing abnormal glucose tolerance (95% CI 0.7 - 1.0). However, after adjusting for confounders this protective benefit disappeared and there was no longer a significant association between marital status and abnormal glucose tolerance (95% CI 0.7 - 1.2). For age, each additional year increased the odds of developing abnormal glucose tolerance by about 4%, which was similar in both the unadjusted and adjusted models (95% CI 1.03 - 1.05 and 1.02 - 1.04, respectively). Results for ethnicity showed that compared with the reference ethnic category, which was classified as none, being Afro-Colombian or Indigenous/ROM does not change the odds of developing abnormal glucose tolerance in either the unadjusted or adjusted analysis. Individuals with no formal school education had two times greater odds of developing abnormal glucose tolerance (95% CI 1.3 - 3.1), but this risk disappeared in the adjusted analysis (95% CI 0.60 - 1.7). The unadjusted model for gender showed a statistically significant 40% increased odds of abnormal glucose tolerance in women than in men, with the adjusted model showing no change in those odds (95% CI 1.1 - 1.8). Hypertensive individuals had a statistically significant 2.6 times greater odds of developing abnormal glucose tolerance in the unadjusted model (95% CI 2.1 - 3.3), with the odds decreasing slightly to only 1.6 times greater in the adjusted model (95% CI 1.2 - 2.1). In regards to smoking, the unadjusted model showed no statistically significant change in the odds of having abnormal glucose tolerance with different smoking statuses. In the unadjusted model, the odds of glucose metabolism disorder was 1.7 (95% CI 1.2 - 2.4) and 1.6 (95% CI 1.0 - 2.3) times higher in low and moderate levels of physical activity respectively when compared with high levels of physical activity. This statistically significant result disappears after adjusting for covariates (95% CI 0.90 - 1.9 for low level physical activity; 0.80 - 1.8 for moderate level of physical activity). With respect to BMI, when compared to the reference of normal BMI, the odds of abnormal glucose were 1.3 (95% CI 0.10 - 0.80) and 2.2 (95% CI 1.7 - 2.9) times higher in overweight and obese categories respectively. Underweight status seems to be protective (OR 0.2, 95% CI 0.10 - 0.80). However, after adjustments for covariates, the only statistically significant increase in odds is seen among obese individuals by 80% (95% CI 1.3 - 2.4).

Table 2. Unadjusted and adjusted associations between variables and glucose metabolism disorders in Northern Colombia in 2014/2015

	Glucose Metabolism Disorder	
	Unadjusted OR[1] (95% CI[2])	**Adjusted OR (95% CI)**
Marital Status		
Single/Divorced/Separated/Widowed	0.8 (0.7-1.0)	1.0 (0.7-1.2)
Married/Free Union	Ref[3]	Ref
Age	1.04 (1.03-1.05)	1.03 (1.02-1.04)
Ethnicity		
Afro-Colombian	1.0 (0.7-1.3)	0.9 (0.7-1.2)
Indigenous/ROM	1.2 (0.6-2.2)	0.9 (0.5-1.8)
None	Ref	Ref

Level of education		
No school	2.0 (1.3-3.1)	1.0 (0.6-1.7)
Less than high school	1.5 (1.0-2.3)	0.9 (0.6-1.4)
High school	0.9 (0.6-1.4)	0.9 (0.5-1.3)
Above high school	Ref	Ref
Gender		
Women	1.4 (1.1-1.8)	1.4 (1.1-1.8)
Men	Ref	Ref
Hypertension		
Yes	2.6 (2.1-3.3)	1.6 (1.2-2.1)
No	Ref	Ref
Smoking		
Former	1.2 (0.8-1.6)	
Current	0.7 (0.5-1.2)	
Never	Ref	
Level of physical activity		
Low	1.7 (1.2-2.4)	1.3 (0.9-1.9)
Moderate	1.6 (1.0-2.3)	1.2 (0.8-1.8)
High	Ref	Ref
BMI		
Underweight (<18.5)	0.2 (0.1-0.8)	0.3 (0.1-1.0)
Overweight (25.0-29.9)	1.3 (1.0-1.7)	1.1 (0.8-1.5)
Obese (≥ 30.0)	2.2 (1.7-2.9)	1.8 (1.3-2.4)
Normal (18.5-24.9)	Ref	Ref

[1]Odds ratio, [2]Confidence interval, [3]Reference group.

4. Discussion

Our study showed no association between marital status and previously undetected abnormal glucose tolerance. Although the initial analysis showed a statistically significant 20% decrease in the odds of having abnormal glucose tolerance among single individuals compared to partnered individuals, this association disappeared after adjusting for covariates. Nevertheless, the same adjustment did not affect the significant increased odds of having abnormal glucose tolerance as a female individual. Similarly, those with hypertension also had a significantly increased likelihood of having abnormal glucose tolerance even after adjustment for covariates.

The results of our analyses differed from much of the current literature. Most studies showed marriage to be associated with lower rates of diabetes, suggesting that marriage may possibly serve as a protective health factor (Fukuda et al., 2013; Perkins et al., 2016; Kamon et al., 2008; Molloy et al., 2009; Cornelis et al., 2014; Badedi et al., 2016). Studies conducted by Fukuda et al. and Perkins et al., both also secondary data analyses, showed this association. Interestingly, Fukuda et al found that married men were less likely to have high fasting blood glucose - defined as having a level ≥126 mg/dl - while married women had a higher likelihood of having a high FBS. Their study evaluated various cardiovascular risk factors and not abnormal glucose tolerance alone, so the higher threshold of 126 mg/dl for the fasting blood glucose, as opposed to our threshold of 100 mg/dl, may have contributed to their differing results. When examining the differences between theirs and our study methodology, the increased odds of abnormal glucose tolerance among singles that they found may also be due to the specific exposure/outcomes assessed. Their study investigated associations between household expenditure (as a marker of socioeconomic status) and marital status with cardiovascular risk factors - namely obesity, hypertension, dyslipidemia, diabetes, presence of multiple risk factors, and current smoking. Perkins, for example, found that the odds of diabetes were higher in *widowed men* specifically, where our study did not separate singlehood into different categories. Additionally, the study population in their study was an Indian population, where widows are typically treated poorly as explained in their study, possibly accounting for poorer health outcomes (i.e. diabetes) (Perkins et al., 2016). Similar to our findings, two studies (Azimi-Nezhad et al., 2008; Rahmanian et al., 2016) found no association between marital status and abnormal glucose tolerance. Interestingly, both studies that found no associations were conducted in Iran. Azimi-Nezhad et al found no statistical difference on the prevalence of DM among married, single, divorced or widowed individuals from greater Khorasan province in northeast Iran (Azimi-Nezhad et al., 2008), while Rahmanian et al reported no statistically significant association was found between the odds of pre-diabetes and marital status among study subjects from Jahrom, Fars province in southern Iran (Rahmanian et al., 2016). Our study's methodology matched quite closely with these studies, possibly explaining our similar results.

In the development of glucose metabolism disorder and ultimately diabetes, stress has been a heavily studied source of abnormal glucose tolerance (Siddiqui et al., 2015). Cortisol levels increase when the body and mind are undergoing stress, which in turn results in increased blood glucose levels. Marital status may represent a source of social support that serves to decrease stress and thus decrease cortisol and blood glucose. Our finding of non-association may be explained by other sources of social support/stress reduction that are common among both exposure groups, such as family and friends as opposed to singular companions.

One interesting secondary finding in our study is that women had a forty percent greater odds of having AGT. This may be explained in part by the fact that in many Colombian households, traditional roles for men and women are still adhered to, especially in lower socioeconomic groups. Men often work to cover the family's expenses while women stay home to attend to household duties and take care of the children. This may lead to women having a lower level of physical activity compared to men and thus explain the increased prevalence of AGT amongst women in our study. Our study does indeed show a sequentially decreased odds of developing AGT with increased level of activity, although this association loses significance in the adjusted model. Another important finding is that hypertensive individuals are significantly more likely to have AGT both in unadjusted and adjusted models. Hypertension is a known comorbidity of glucose metabolism disorder.

One of the limitations of our study is that our study was a secondary data analysis of a cross-sectional survey, thus our ability to establish causality was not possible. Second, our population was largely homogeneous -- although based at various Colombian provinces, the locale that provided information for our study were largely from the lower socioeconomic class, thereby limiting its external validity as our results are only valid for that particular socio-economic subgroup. Third, the survey that was utilized for data collection in this study did not inquire about various other measures of socioeconomic status, such as income levels and household composition, which may have also been important covariates to address in the statistical analyses. And fourth, the data that was used for this study was self-reported via a written questionnaire, which introduces the possibility of response bias.

5. Conclusion

Our study fills a certain niche in healthcare research by looking at marital status, a very important socioeconomic factor which is otherwise not usually considered. The present finding of no significant association between marital status and abnormal glucose tolerance suggests that marital status may not play a very influential role in the prevalence of previously undetected abnormal glucose tolerance. Hence, it may not be necessary to screen for abnormal glucose tolerance in specific marital status groups. Future studies may seek to examine the different strata of singlehood within the northern Colombian population, such as divorced or widowed individuals and how they affects glucose tolerance. Additionally, an important dynamic to explore would be how marital *quality* plays a role in abnormal glucose tolerance and other health outcomes overall.

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Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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