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Type 2 Diabetes Mellitus and Family History: A Case Control Study

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Abstract Diabetes is a multifaceted metabolic disorder marked by chronically high levels of glucose in the bloodstream. Family history is a significant risk factor for developing type 2 diabetes (T2D). The objectives of our study were to assess the association between maternal and paternal diabetes and risk of type 2 diabetes mellitus and to determine the sociodemographic characteristics associated with type 2 diabetes mellitus among the adults in the United Arab Emirates (UAE). A case control study was conducted among 141 adults (47 cases and 94 controls) by means of a validated, self-administered questionnaire in both English and Arabic languages distributed in printed format. Cases can be defined as participants with type 2 diabetes mellitus and controls can be defined as participants without type 2 diabetes mellitus. The study setting was a tertiary hospital in Ajman, UAE and the duration of the study was six months. Permission was obtained from IRB before conducting the research. SPSS Version 28 was used to analyze the data. Chi-square test was used to test the association between the variables, and significant factors were further analyzed using binary logistic regression. The estimated risk of diagnosis of T2D increases by almost 5 fold if there is a positive family history of T2D, OR=4.79 (2.08-11.02). It was also noted that subjects having a positive family history of mothers with gestational diabetes are OR=2.5 (1.04-6.41) times more prone to developing T2D. It has been implicated that maternal history of T2D has a higher likelihood of being passed on to the next generation. Additionally, age, gender and marital status have been found to be risk factors in the development of T2D. The study revealed that family history is a strong independent risk factor for T2D. Among history of other chronic illnesses in the family, history of gestational diabetes remains a significant risk factor for T2D. Additionally, among the sociodemographic variables, age, gender and marital status were found to be significant risk factors.

Keywords Type 2 Diabetes Mellitus, Family History, Gestational Diabetes, Sociodemographic Characteristics

1. Introduction

Diabetes is a chronic condition where the body can't properly regulate blood sugar levels. This occurs either due to the immune system attacking the insulin-producing cells in the pancreas (type 1 diabetes), or because the body doesn't respond properly to insulin (type 2 diabetes). Both types result in high blood sugar levels [1]. T2D is the most widespread form of diabetes, affecting over 90% of diabetic individuals globally. While typically associated with middle to late adulthood, T2D can also manifest in children. Both type 1 and type 2 diabetes lead to heightened blood sugar levels and share complications associated with hyperglycemia, but T2D is more prevalent. The incidence of diabetes mellitus diagnoses has surged

dramatically over the past thirty years, now ranking as the ninth leading cause of death. Zheng et al. [2] highlighted Asia's notable role in the expanding global prevalence of T2D, particularly focusing on China and India as the main epicenters. Although genetic factors do influence one's susceptibility to T2D, the widespread epidemic is largely fueled by poor dietary choices and insufficient physical activity on a global scale. Berumen et al. [3] revealed that genes and parental history play a greater role than obesity in T2D. Alawadi et al. [4] found that the prevalence of diabetes among UAE nationals in Dubai was 19%, compared to 14.7% among expatriates. The overall diabetes prevalence in Dubai was 15.2%. Undiagnosed diabetes was 10% for UAE nationals and 10.9% for expats. Among individuals without a family history of diabetes, the overall prevalence was 13.9%, whereas for those with a family history, it was 52.7%. Conversely, this association was reversed for pre-diabetes.

Family history of a disease highlights the influence of shared environmental and behavioral factors, along with genetic interactions. This familial clustering is evident in many complex conditions, making family history a significant independent risk factor for prevalent chronic diseases like cardiovascular disease, cancer, and T2D. Recent research indicates a strong link between type 2 diabetes mellitus and maternal and paternal diabetes [5,6]. Abbasi et al. [5] revealed that in certain populations, the transmission of family history of type 2 diabetes to the next generation was more pronounced through maternal rather than paternal inheritance. The slightly elevated risk associated with maternal diabetes, as opposed to paternal diabetes, was attributed to a greater influence of dietary choices, lifestyle factors, and body weight. Family history is often included in screening tools designed to identify individuals at risk of diabetes or those who may have undiagnosed diabetes. Screening is crucial because diabetes often has a prolonged asymptomatic phase, which includes impaired fasting glucose, impaired glucose tolerance, and early diabetes stages. As diabetes presents a significant public health challenge due to its high prevalence, research indicates that early detection of impaired glucose metabolism (prediabetes) can potentially delay or prevent the onset of the disease and its associated complications [7]. Recent surveys indicate that a large majority of US adults can recognize T2D among their first-degree relatives, with slightly lower awareness for second-degree relatives [8]. Recognizing a family history of diabetes allows for earlier detection and intervention, potentially delaying or preventing the onset of the disease. This information enables personalized care and motivates patients to adopt preventive measures and adhere to screening recommendations.

This study was designed to assess whether family history of T2D is an independent risk factor for T2D. Our aim was to assess the association of maternal and paternal diabetes with the risk of type 2 diabetes and to determine the sociodemographic characteristics of type 2 diabetes mellitus in vulnerable and diseased individuals.

2. Materials and Methods

Study Design

The research design was a case control study conducted among adults residing in the UAE. The inclusion criterion for cases was adults above 18 years of age who were diagnosed with type 2 diabetes. The inclusion criterion for controls was those who did not have type 2 diabetes. The exclusion criteria were subjects with active hematological disease, positive Hepatitis B/ hepatitis C serology, positive HIV serology, active neuropsychiatric disease and subjects who did not give informed consent.

Study Setting

The study setting was a Tertiary care hospital in Ajman, and the duration of the study was six months. The period of data collection was from July 2021 to December 2021.

Participants

The inclusion criterion for cases was adults above 18 years of age who were diagnosed with type 2 diabetes. The inclusion criterion for controls was those who did not have type 2 diabetes. The exclusion criteria were subjects with active hematological disease, positive Hepatitis B/ hepatitis C serology, positive HIV serology, active neuropsychiatric disease and subjects who did not give informed consent.

Cases were collected from a tertiary hospital in Ajman, UAE. Cases can be defined as participants with type 2 diabetes and controls can be defined as participants without type 2 diabetes mellitus. Controls were collected from the general population in Ajman, UAE.

Variables

The variables that we considered were age, gender, marital status, nationality, occupation, status of family history of diabetes, association of other chronic illnesses in the family with T2D, and lifestyle factors such as dietary intake, physical activity and Cigarette smoking.

A self-administered questionnaire was formulated after a thorough review of literature of similar studies and validated by three experts in the field. The questionnaire was given out as printed forms. Participants were chosen via convenience sampling. 171 forms were printed, of which 141 forms were in English language and 30 in Arabic language. 5 responses were invalid as the age exceeded the inclusion criteria.

Sample Size

The calculated sample size was 141 (47 cases and 94 controls). Hu Z et al. [9] found that the exposure rate of family history of Type 2 diabetes in the control group was 10.8 &, and the reported odds ratio was 3.69. Therefore, the sample size was calculated using the formula,

$$(n = \left(\frac{r+1}{r}\right)\frac{\left(\underline{p}\right)\left(1-\underline{p}\right)\left(Z_{\beta}+Z_{\alpha 2}\right)^{2}}{(p_1-p_2)^2})$$

With 95% confidence interval, a power of 80%, and the ratio of controls to cases as 2:1, a pilot study was conducted among a small group of adults (~5) to ensure that the protocols of the research met the needs of the study.

Statistical Methods

SPSS Version 26 was used to analyze the data. Descriptive and inferential statistics were used. Chi-square test was used to test the association between the variables, and significant associations were further analyzed using binary logistic regression. Tables and graphs have been used to present the data. Statistical significance was taken as $p < 0.05$, and the confidence interval for the adjusted odds ratio (AOR) was taken as 95%. There was only a minor percentage of missing, which would barely affect the results. The research was conducted ethically, confidentiality and anonymity were maintained, and an informed consent was taken from the participants. IRB permission was obtained before conducting the research. After receiving ethical approval from the IRB, permission was granted by hospitals and universities. Following this, responses were collected and analyzed using various statistical tests.

3. Results

When the sociodemographic characteristics were compared with the development of Type 2 Diabetes (T2D), we found that the cases 36(76.6) were above the age of 40. In the age group 25-40, 11(23.4) were cases and 36(38.2) were controls. Lastly, there were no cases under the age of 25. The p-value was found to be significant. The results showed that the cases had a higher proportion of males with 29(61.7) compared to 40 (42.6) in the control group. Conversely, the control group had a higher proportion of females with 54(57.4) compared to 18(38.3) in the cases. The results were significant as the P value was 0.032, making males more likely to develop T2D. Marital status was noted to be a factor as well. Most of the cases 46(97.9) fall under the married category compared to the controls 39(41.5), and the p value was very significant as it was calculated to be less than <0.001. A strong association was observed for the development of T2D with family history as 38 (80.9) of our cases had a positive family history whereas only 9(19.1) of the cases did not have a family history. More than half of the controls 50(53.2) did not have a family history of T2D. The P value was statistically significant as it was less than 0.001. We particularly noted that positive family history of mothers 29(61.7) and siblings 14(29.8) was also statistically significant as the p value was also less than 0.001. However, inverse association was observed in grandparents with T2D as grandparents with T2D were observed more in the controls 21(22.3) than cases 8(17.0). We found that among other illnesses associated with T2D, only the positive maternal history of gestational diabetes was significant. Maternal history of gestational diabetes was observed more in cases 12(25.5) than controls 11(11.7), and the p value was found to be 0.036 which is statistically significant (Table 1).

The results of binary logistic regression analysis without adjusting the odds ratio (table 2) found gender, age, marital status, family history and maternal history of gestational diabetes to be significant risk factors for the onset of type 2 diabetes mellitus. It was observed that the odds of developing T2D in males were 2.17(1.06-4.45) times more in comparison to females. The odds of getting diagnosed with T2D in people aged over 40 were 1.21(1.14-1.29) times in comparison to persons aged 40 and below, portraying age as a pivotal contributing factor in T2D risk assessment. In a parallel analysis, distinct risk factors for developing T2D were observed. Marital status played a significant role, with married individuals exhibiting a markedly higher risk specifically, 64.87 times elevated odds of acquiring T2D compared to their single or divorced counterparts. Individuals with family history of T2D faced a notable risk, being 4.8 times more likely to develop the disease than those without such a familial background. Maternal health factors were also examined, revealing that individuals born to mothers with gestational diabetes had a 2.58 times higher likelihood of developing T2D than those born to mothers without gestational diabetes. However, upon adjustment of the odds ratios and binary logistic regression analysis (Table 3), the analysis indicated that only family history and age retained significance as discernible risk factors.

Table 1. Association of sociodemographic characteristics and family history with T2D

Variable			Cases	Controls	P-value
Age group	Below 25		0 (0)	51 (54.2)	**<0.001**
	25-40		11 (23.4)	36 (38.2)	
	Above 40		36 (76.6)	7 (7.6)	
Gender	Male		29 (61.7)	40 (42.6)	**0.032**
	Female		18 (38.3)	54 (57.4)	
Marital status	Unmarried		1 (2.1)	55 (58.5)	**<0.001**
	Married		46 (97.9)	39 (41.5)	
Occupation	Employed		30 (63.8)	53 (56.3)	0.243
	Unemployed		12 (25.5)	34 (36.1)	
Status of family history of diabetes	Family history of diabetes		38 (80.9)	44 (46.8)	<0.001
	No family history of diabetes		9 (19.1)	50 (53.2)	
Family members and history of T2D	Father	Yes	21(44.7)	17(18.1)	0.093
		No	17(36.2)	29(30.9)	
	Mother	Yes	29(61.7)	17(18.1)	<0.001
		No	9(19.1)	29(30.9)	
	Siblings	Yes	14(29.8)	0(0.0)	<0.001
		No	24(51.1)	46(49.0)	
	Grandparents	Yes	8(17.0)	21(22.3)	0.018
		No	30(63.8)	25(26.6)	
Presence of family history of chronic illnesses	Coronary heart disease	Yes	11(23.4)	24(25.5)	0.783
		No	36(76.6)	70(74.5)	
	High blood pressure	Yes	21(44.7)	61(64.9)	0.389
		No	27(57.4)	61(64.9)	
	High cholesterol	Yes	23(49.0)	43(45.7)	0.720
		No	24(51.1)	51(54.3)	
	Mother with GDM	Yes	12(25.5)	11(11.7)	0.036
		No	35(74.5)	83(88.3)	
	Dyslipidemia	Yes	1(2.1)	6(6.4)	-
		No	46(97.9)	88(93.6)	
	Chronic Kidney Disease	Yes	3(6.4)	10(10.6)	-
		No	44(93.6)	84(89.4)	
	Others	Yes	1(2.1)	3(3.2)	-
		No	46(97.9)	91(96.8)	
	Total		47	94	141

Table 2. Logistic regression of unadjusted odds ratio

Variables		OR	CI	P-value
Gender	Female (R)	1		
	Male	2.17	1.06-4.45	**0.033**
Age	40 & below (R)	1		
	Above 40	1.21	1.14-1.29	**0.000**
Marital status	Unmarried & divorced (R)	1		
	Married	64.87	8.57-490.59	**<0.001**
Family history of T2D	Yes	4.79	2.08-11.02	**<0.001**
	No (R)	1		
Mother with gestational diabetes	Yes	2.58	1.04-6.41	**0.040**
	No (R)	1		

Table 3. Logistic regression of adjusted odds ratio

Variables		OR	CI	P-value
Family with T2D	Yes	23.64	3.44-162.406	**0.001**
	No (R)	1		
Age	40 & below (R)	1		**0.000**
	Above 40	1.24	1.12-1.38	

4. Discussion

According to our research study, having a positive family history of T2D, the estimated probability of being diagnosed with the disease increases by nearly five-fold, OR=4.79 (2.08-11.02). It was also shown that the odds of developing T2D were OR=2.58 (1.04-6.41) times higher in people with a positive family history of mothers with gestational diabetes. It has been implicated that maternal history of T2D has a higher likelihood of being passed on to the next generation. Age, gender, and marital status have also been identified as risk factors for T2D development. Moreover, the confounding variables such as dietary intake, physical activity and cigarette smoking were not found to be significant in our study.

4.1. Sociodemographic Characteristics

The study found that between groups of 18 to 60, the age group above 40 years was highly affected by type 2 diabetes mellitus, as our analysis shows that people above 40 years of age are 1.21 (1.06-4.45) times more likely to develop the disease in comparison to people aged 40 and below among both cases and controls. The changes that happen with aging are hastened with DM causing lower life expectancy. In fact, it has been shown that adults aged 55 to 64 years who had DM experienced a life expectancy reduction of up to 8 years [10]. A recent study showed that patients with diabetes from childhood and adolescence have a higher chance of developing comorbidities among those with T2D compared with T1D [11]. A population based study done in the United States also revealed that T2D is more prevalent in older age groups [12]. Thus, there is a significant link between age and T2D onset [13,15]. Thomas et al. [14] also revealed that Diabetes type 1 was diagnosed in individuals aged over 30 years. Overall, the observed association between gender and T2D demonstrated that 29 (61.7) males are affected compared to females 18 (38.3). Furthermore, our study shows males have 2.17 (1.06-4.45) times more risk for developing T2D in comparison to the females. This study [16] explores the different hormonal variations, genetics, lifestyle and environment. Several studies have results that correspond to our results which indicate that T2D is more prevalent in men [12,15,16]. Additionally, Doubova et al. [17] contributed that a later onset of diabetes, along with severe sudden complications, long-term microvascular and macrovascular issues, and additional health conditions, elevates the likelihood of requiring emergency room visits and hospitalization. In another study Hajian-Tilaki. et al. [18], found that women tend to report lower Health-Related Quality of Life (HRQoL) scores compared to men across various measured aspects, the reason being that women may be more likely to report health issues, potentially leading to the perception of poorer HRQoL. Adjusting for sociodemographic factors somewhat reduced the gender differences in HRQoL, although the adjusted effect was still greater than that reported in the US

population. While the study provides valuable insights into gender differences in HRQoL, further research is warranted to explore additional contributing factors and longitudinal changes over time.

As it was observed in our study, individuals who are married have 64.87 times more risk for developing T2D compared to the ones who are unmarried or divorced. In this population-based study, we found that marital status was found to be a risk factor for the onset of type 2 diabetes mellitus. Ramezankhani et al. [19] state that the relationship between marital status and health outcomes (i.e. risk of T2D) varied by gender. Rahmanian et al. [20] observed that there was no significant difference in the prevalence of diabetes mellitus between the married and other subgroups. de Olivera et al. [21] state that marital status seems to be a predictor of T2D incidence and preventive programs should be implemented to identify and modify the underlying factors.

4.2. Family History

The case-control study underscores the significance of family history (FH) as a crucial risk factor for the development of T2D. Our study showed that individuals with a family history of T2D are 4.78 times more likely to develop T2D compared to those without such a history (CI: 2.088-11.024). This aligns with prior research findings, emphasizing the pivotal role of family history in T2D development. Notably, 80.9% of the cases in our study had a positive family history of T2D, reinforcing the prominence of this factor. Comparisons with other studies strengthen our findings. Scott et al. [22] state that biparental history of T2D conferred a 5-fold increased risk. Additionally, our findings align with studies highlighting T2D history as the most significant risk factor compared to other diseases. This consistency across studies supports the robustness of our research outcomes [22-27].

Our study further delves into specific family members' history, identifying mothers, siblings, and grandparents as high-risk contributors. A substantial 76% of cases had a positive maternal history, 36.8% had a positive sibling history, and 21.1% had a positive grandparent history of T2D. These findings echo several studies emphasizing the high risk associated with sibling and parental history of T2D [27,28]. Maternal inheritance of T2D emerges as particularly significant, consistent with numerous studies reinforcing its importance as a primary risk factor [28,30,31]. Although Papazafiropoulou et al. [25] state that biparental history is associated with a 2-4 increased risk of developing T2D, it was found that the likelihood of the next generation developing T2D was more associated with a diabetic mother than a diabetic father. In comparison, Parkkola et al. [26] found that children with T2D had a greater chance of developing T2D if there was a positive paternal family history. Compared to type 1 diabetes, T2D usually demonstrates a stronger familial association [29]. The collective evidence supports the notion that T2D is closely linked to maternal history, aligning with existing research literature.

The study also explores the association between T2D and other chronic illnesses within the family. Notably, only a positive family history of gestational diabetes mellitus (GDM) was found to be statistically significant. Participants with a positive family history of a mother with GDM were 2.5 times more likely to develop T2D. This aligns with a wealth of literature suggesting a positive association between maternal hyperglycemia, including GDM, and various health issues in offspring, including T2D [32-33]. Our findings resonate with studies documenting an increased risk of T2D among women with GDM, indicating a consistent trend across diverse populations. In our study, 4.2% of participants had gestational diabetes, a pattern mirrored in other research. On average, the risk of developing T2D is 7.4 times greater for women with GDM compared to those without, emphasizing the enduring impact of maternal hyperglycemia on offspring health [32-34].

4.3. Limitation

The aim of this study was to investigate the significance of family history as a risk factor for the development of T2D. However, several limitations affected our investigation. Language bias emerged as the most significant flaw. We found that the majority of participants who visited the hospital were of Arab nationality, creating a linguistic barrier due to the limited number of questionnaires available in Arabic. Additionally, the COVID-19 pandemic significantly impacted data collection. The number of patients visiting the hospital was lower than usual, prolonging the data collection period. The rising cases of the COVID-19 Omicron variant further restricted our ability to visit other hospitals, limiting the diversity of our cohort. Despite these challenges, our findings underscore the crucial role of family history in the development of T2D, aligning with existing research and reinforcing the importance of considering familial risk factors in clinical assessments.

5. Conclusions

Our study results indicated several key risk factors for T2D. We found that participants over the age of 40 and males were more likely to develop the disease. Furthermore, positive family history was one of the most significant aspects which influenced development of T2D with maternal family history having the strongest disposition. Additionally, we found that family history of gestational diabetes was a contributing factor as well. To prevent T2D, we recommend that lifestyle changes such as exercise and a balanced diet should be implemented in daily life. Furthermore, awareness of the risk factors that can contribute to T2D should be taught at an early age so

appropriate intervention measures can be taken. Screening people with risk factors ensures early intervention. Finally, once diagnosed with T2D, it is imperative that patients have routine checkups and regularly monitor other comorbidities such as blood pressure and blood lipid levels.

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REFERENCES

[1] Ndisang, J. F., Vannacci, A., & Rastogi, S. "Insulin Resistance, Type 1 and Type 2 Diabetes, and Related Complications." Journal of diabetes research, vol. 2017, 2017. DOI: 10.1155/2017/1478294

[2] Zheng Y, Ley SH, Hu FB. "Global aetiology and epidemiology of type 2 diabetes mellitus and its complications." Nature Reviews Endocrinology, vol. 14, no. 2, pp. 88-98, 2017. DOI: 10.1038/nrendo.2017.151

[3] Berumen J, Orozco L, Betancourt-Cravioto M, Gallardo H, Zulueta M, Mendizabal L, et al. "Influence of obesity, parental history of diabetes, and genes in type 2 diabetes: A case-control study." Scientific reports, vol. 9, no. 1, pp. 2748, 2019. DOI: 10.1038/s41598-019-39145

[4] Alawadi F, Hassanein M, Suliman E, Hussain HY, Mamdouh H, Ibrahim G, et al. "The Prevalence of Diabetes and Pre-Diabetes among the Dubai Population: Findings from Dubai Household Health Surveys, 2014 and 2017." Dubai Diabetes and Endocrinology Journal, vol. 26, no. 2, pp. 78-84, 2020. DOI: 10.1159/000508833

[5] Abbasi A, Corpeleijn E, Schouw YT, Stolk RP, Spijkerman AM, van der A DL, et al. "Maternal and paternal transmission of type 2 diabetes: influence of diet, lifestyle and adiposity." Journal of Internal Medicine, vol. 270, no. 4, pp. 388-96, 2011. DOI: 10.1111/j.1365-2796.2011.02347

[6] Chiu H, Lee M-Y, Wu P-Y, Huang J-C, Chen S-C, Chang J-M. "Comparison of the effects of sibling and parental history of type 2 diabetes on metabolic syndrome." Scientific reports, vol. 10, no. 1, pp. 22131, 2020. DOI: 10.1038/s41598-020-79382

[7] Valdez R. "Detecting Undiagnosed Type 2 Diabetes: Family History as a Risk Factor and Screening Tool." Journal of Diabetes Science and Technology, vol. 3, no. 4, pp. 722-726, 2009. DOI: 10.1177/193229680900300417

[8] Hariri S, Yoon PW, Qureshi N, Valdez R, Scheuner MT, Khoury MJ. "Family history of type 2 diabetes: A population-based screening tool for prevention?" Genetics in Medicine, vol. 8, no. 2, pp. 102-108, 2006. DOI: 10.1097/01.gim.0000200949.52795.df.

[9] Hu Z, Zhu X, Kaminga AC, Xu H. "Associated risk factors and their interactions with type 2 diabetes among the elderly with prediabetes in rural areas of Yiyang City: A nested case–control study." Medicine, vol. 98, no. 44, pp. 17736, 2019. DOI: 10.1097/MD.0000000000017736

[10] Pinchevsky Y., Butkow N., Raal F.J., Chirwa T., Rothberg A., "Demographic and Clinical Factors Associated with Development of Type 2 Diabetes: A Review of the Literature." International Journal of General Medicine, vol. 13, pp. 121-129, 2020, DOI: 10.2147/IJGM.S226010

[11] Dabelea D., Stafford J.M., "Association of Type 1 Diabetes vs Type 2 Diabetes Diagnosed During Childhood and Adolescence With Complications During Teenage Years and Young Adulthood." JAMA, vol. 317, no. 8, pp. 825-835, 2017, DOI: 10.1001/jama.2017.0686

[12] Xu G., Liu B., Sun Y., Du Y., Snetselaar L.G., Hu F.B., et al., "Prevalence of diagnosed type 1 and type 2 diabetes among US adults in 2016 and 2017: Population Based Study." BMJ, vol. 362:k1497, 2018, DOI: 10.1136/bmj.k1497

[13] Sreedharan J., Muttappallymyalil J., al Sharbatti S., Hassoun S., Safadi R., Abderahman I., et al., "Incidence of Type 2 Diabetes Mellitus among Emirati Residents in Ajman, United Arab Emirates." Korean Journal of Family Medicine, vol. 36, no. 5, pp. 253-257, 2015, DOI: 10.4082/kjfm.2015.36.5.253

[14] Thomas, N. J., Lynam, A. L., Hill, A. V., Weedon, M. N., Shields, B. M., Oram, R. A., McDonald, T. J., Hattersley, A.T., Jones, A. G., "Type 1 diabetes defined by severe insulin deficiency occurs after 30 years of age and is commonly treated as type 2 diabetes", Diabetologia, vol. 62, pp. 1167-1172, 2019. DOI: 10.1007/s00125-019-4863-8

[15] Cowie C.C., Casagrande S.S., Menke A, Cissell M. A., Eberhardt M.S., Meigs J.B., et al., "Sociodemographic Characteristics of Persons With Diabetes." in Diabetes in America, 3rd ed, NIDDK, 2018, pp. 1-67.

[16] Kautzky-Willer A., Harreiter J., Pacini G., "Sex and Gender Differences in Risk, Pathophysiology and Complications of Type 2 Diabetes Mellitus." Endocrine reviews, vol. 37, no. 3, pp. 278-316, 2016, DOI: 10.1210/er.2015-1137

[17] Doubova, S. V., Ferreira-Hermosillo A., Pérez-Cuevas, R., Barsoe C., Gryzbowski-Gainza E., Valencia, J. E., "Socio-demographic and clinical characteristics of type 1 diabetes patients associated with emergency room visits and hospitalizations in Mexico." BMC Health Services Research, vol. 18, no. 1, pp. 602, 2018. DOI: 10.1186/s12913-018-3412-3

[18] Hajian-Tilaki K., Heidari B., Hajian-Tilaki A., "Are Gender Differences in Health-related Quality of Life Attributable to Sociodemographic Characteristics and Chronic Disease Conditions in Elderly People?", International Journal of Preventive Medicine, vol. 8, no. 95, 2017, DOI: 10.4103/ijpvm.IJPVM_197_16

[19] Ramezankhani A, Azizi F, Hadaegh F. "Associations of marital status with diabetes, hypertension, cardiovascular disease and all-cause mortality: A long term follow-up study." *PloS one*, vol. 14, no. 4, pp. e0215593, 2019. DOI: 10.1371/journal.pone.0215593

[20] Rahmanian, Karamatollah et al. "Relation of type 2 diabetes mellitus with gender, education, and marital status in an Iranian urban population." Reports of biochemistry &

molecular biology, vol. 1, no. 2, pp. 64-68, 2013. https://pubmed.ncbi.nlm.nih.gov/26989710/

[21] De Oliveira CM, Viater Tureck L, Alvares D, Liu C, Horimoto ARVR, Balcells M, et al. "Relationship between marital status and incidence of type 2 diabetes mellitus in a Brazilian rural population: The Baependi Heart Study." *PloS one*, vol. 15, no. 7, pp. e0236359, 2020. DOI: 10.1371/journal.pone.0236869

[22] InterAct Consortium, Scott RA, Langenberg C, Sharp SJ, Franks PW, Rolandsson O, et al. "The link between family history and risk of type 2 diabetes is not explained by anthropometric, lifestyle or genetic risk factors: the EPIC-InterAct study." *Diabetologia*, vol. 56, no. 1, pp. 60–69, 2013. DOI: 10.1007/s00125-012-2715-x

[23] Tsenkova VK, Karlamangla AS, Ryff CD. "Parental history of diabetes, positive affect, and diabetes risk in adults: Findings from MIDUS." *Ann Behav Med*, vol. 50, no. 6, pp. 836–843, 2016. DOI: 10.1007/s12160-016-9810-z

[24] Vornanen M, Konttinen H, Kääriäinen H, Männistö S, Salomaa V, Perola M, et al. "Family history and perceived risk of diabetes, cardiovascular disease, cancer, and depression." *Prev Med*, vol. 90, pp. 177–183, 2016. DOI: 10.1016/j.ypmed.2016.06.027

[25] Papazafiropoulou AK, Papanas N, Melidonis A, Maltezos E. "Family history of type 2 diabetes: Does having a diabetic parent increase the risk?" *Current Diabetes Reviews*, vol. 13, no. 1, pp. 19–25, 2017. DOI: 10.2174/1573399812666151102150114

[26] Parkkola A, Turtinen M, Härkönen T, Ilonen J, Knip M, Finnish Pediatric Diabetes Register. "Family history of type 2 diabetes and characteristics of children with newly diagnosed type 1 diabetes." *Diabetologia*, vol. 64, no. 3, pp. 581–590, 2021. DOI: 10.1007/s00125-020-05342-x

[27] Xiong X., Wei L., Xiao Y., Han Y., Yang J., Zhao H., Yang M., Sun L., "Effects of family history of diabetes on pancreatic β-cell function and diabetic ketoacidosis in newly diagnosed patients with type 2 diabetes: a cross-sectional study in China." BMJ Open, vol. 11, no. 1, 2022. DOI: 10.1136/bmjopen-2020-041072

[28] Chiu H., Lee M.Y., Wu P.Y., Huang J.C., Chen S.C., Chang J.M., "Comparison of the effects of sibling and parental history of type 2 diabetes on metabolic syndrome." *Sci Rep*, vol. 10, no. 1, 2020. DOI: 10.1038/s41598-020-79382-z

[29] Walkey HC, Kaur A, Bravis V, Godsland IF, Misra S, Williams AJK, Bingley PJ, Dunger DB, Oliver N, Johnston DG. "Rationale and protocol for the After Diabetes Diagnosis REsearch Support System (ADDRESS): an incident and high risk type 1 diabetes UK cohort study." *BMJ Open*, vol. 7, no. 7, pp. e013956, 2017. DOI: 10.1136/bmjopen-2016-013956

[30] Wang, C., et al. "Association between Parental History of Diabetes and the Incidence of Type 2 Diabetes Mellitus Differs According to the Sex of the Parent and Offspring's Body Weight: A Finding from a Japanese Worksite-based Cohort Study." *Preventive Medicine*, vol. 81, pp. 49–53, 2015. DOI: 10.1016/j.ypmed.2015.07.021.

[31] Asaki, K., Yoshida, A., Ohta, H., Aizawa, Y., Kojima, A., Chiba, H., et al. "Maternal and paternal family history of type 2 diabetes differently influence lipid parameters in young nondiabetic Japanese women." E*nvironmental Health and Preventive Medicine*, vol. 18, no. 2, pp. 104–109, 2013. DOI: 10.1007/s12199-012-0296-4

[32] Lawlor, D. A., Lichtenstein, P., & Långström, N. "Association of maternal diabetes mellitus in pregnancy with offspring adiposity into early adulthood: sibling study in a prospective cohort of 280,866 men from 248,293 families." *Circulation*, vol. 123, no. 3, pp. 258-265, 2011. DOI: 10.1161/CIRCULATIONAHA.110.980169

[33] Chen, Q., Francis, E., Hu, G., and Chen, L. "Metabolomic Profiling of Women with Gestational Diabetes Mellitus and Their Offspring: Review of Metabolomics Studies." *Journal of Diabetes and Its Complications*, vol. 32, no. 5, pp. 512-523, 2018. DOI: 10.1016/j.jdiacomp.2018.01.007.

[34] Johns, Emma C et al. "Gestational Diabetes Mellitus: Mechanisms, Treatment, and Complications." *Trends in endocrinology and metabolism: TEM* vol. 29, no.11, pp. 743-754, 2018. DOI: 10.1016/j.tem.2018.09.004