



## The Role of GTF2H1 and SULF1 Gene Polymorphisms in T2DM

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### Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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### ABSTRACT

Genetic variations could be involved in the pathogenesis of diabetes. Type 2 diabetes (T2DM) accounts for 90% of all diabetes cases worldwide, however, the percentage is higher in the South Asian region. In this study, we observed the single nucleotide polymorphism (SNP) in *GTF2H1* and *SULF1* genes to find the association of smoking leading to T2DM. A total of 150 individuals (100 T2DM patients and 50 controls) were included in this study. Tetra ARMS-PCR was performed to study polymorphic genotyping. The data showed non-significant allelic associations of *GTF2H1* rs4150558 ( $P=0.389228$ ) and *SULF1* rs6990375 ( $P=0.45124$ ) confidence for smoking with T2DM occurrence. Both T2DM cases and controls were in Hardy–Weinberg equilibrium indicated the significant outcomes. The pooled odds ratios were calculated to evaluate the association between *GTF2H1* and *SULF1* polymorphisms and the risk of smoking, age, depression, energy-rich diet, obesity, and alcohol consumption adverse effects. Smoking was not found progressive risk factor of T2DM as compared to cholesterol level, depression, hormonal imbalance, healthy diet, or energy-rich diet. This study revealed that the irrational style of individuals of Southern Punjab brought a significant change in SNPs and is a greater risk for the progression of this T2DM. These molecular variants *GTF2H1* and *SULF1* could be used as genetic biomarkers to find the association of smoking with cancer but not with T2DM.

**Keywords:** SNPs; type 2 diabetes; smoking; genetic variation; genotyping.

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## 1. INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is referred to as an adult-onset of disease which is characterized by the ability of the body to resist excessive insulin concentration due to an imbalance of metabolic processes regulated by pancreatic secretions. Metabolic dysregulation of the  $\beta$  cells of islet of Langerhans causes insulin resistance that eventually leads to Polyuria, Hyperglycemia, and Polydipsia [1,2]. Pakistan accounts for 17.1 % of diabetes cases currently all over the country which comprises 90% of the cases of T2DM [3,4]. There are several factors including demographic, genetic, socioeconomic, and environmental which have a combined role in the elevation of the number of T2DM individuals [5,6]. However, the leading factors of T2DM include industrialization, low level of physical activity, elderly population, and elevated numbers of overweight and obese individuals. Males are more likely to be affected than females, and metropolitan regions are more likely to be affected than rural regions [7]. According to an estimate, approximately 366 million individuals will have T2DM by 2030 globally [8], who will belong to an age group of middle to late adult years. T2DM is a complex disorder caused by the unique combination of environmental factors and genes involved in the disease [9]. It is observed that obesity is the leading factor in 60% of the individuals that results in insulin resistance ultimately leading to T2DM. Additionally, T2DM occurrence is also due to a rise in cigarette smoking. Different studies have recognized nicotine as the main pharmacologically active component in cigarettes which is responsible for the incidence of T2DM [10].

In 2014, Surgeon General documented in his report that smokers have increased susceptibility of 30-40% to T2DM as compared to non-smokers which imply that public health awareness to end smoking should be emphasized to fight against the global diabetes epidemic [11]. According to World Health Organization (WHO), smoking can be avoided to lower the incidence rate of T2DM and further suggested to cease smoking for a healthy lifestyle [12]. Furthermore, several single nucleotide polymorphisms (SNPs) have been reported to involve in T2DM [13].

A protein-coding gene named General Transcription Factor IIH Subunit 1 having *GTF2H1* as its condensed is precisely located on the short arm of chromosome number 11 which

is recognized as 11p15.1. This gene has its place in the TFB2 family of genes. *GTF2H1* gene codes for a protein of 62 kDa size which in the form of a complex, have its role in gene transcription and DNA repair [14].

Heparin sulfate is an extracellular protein molecule that is coded by a protein molecule termed Sulfatase 1. The gene has its presence on the long arm of chromosome number 8 having a 13.2 position. The gene length ranges from 466,624 bp from pter to 69,660,915 bp from pter. Moreover, the *SULF1* gene comprises 194,292 nucleotides with 871 amino acids and is located on the plus strand of the DNA. In addition, the *SULF1* has a protein size of 101027 Da with  $Ca^{+2}$  as its cofactor which is crucial for its functioning. *SULF1* gene is a member of the Sulfatase family and helps in the separation of the 6-O-sulfate group. Golgi apparatus is responsible for the release of the enzyme encoded by the *SULF1* gene. However, the dysregulation of the *SULF1* gene causes various diseases such as Meromelia-Synostoses Syndrome. There are almost 11015 variants of *SULF1* which have been described in the literature. One of the variants of this gene namely rs112038488 SNP is involved in disease caused by the Hepatitis B virus. The SNP selected for this study is found to be linked with smoking [14]. Smoking is considered one of the risk factors for T2DM. Thus, this study investigates whether SNP related to smoking also contributes to T2DM progression.

This study aimed to investigate the correlation of *GTF2H1* and *SULF1* SNPs to find the association of smoking leading to T2DM in the Southern region of Punjab, Pakistan individuals.

## 2. MATERIALS AND METHODS

This study was carried out between 2016 and 2017 at the Institute of Molecular Biology and Biotechnology, Bahuddin Zakariya University Multan Pakistan. Blood samples were collected from the Nishtar Medical Hospital and Institute of Nuclear Medicine and Radiotherapy Multan followed by the genetic analysis to find the association of genetic variants with T2DM.

### 2.1 Clinical Data

The sample size of this study consisted of 150 subjects (100 patients as cases and 50 controls). All the subjects voluntarily participated and were investigated through the standard interviewer-

administered questionnaire for data collection regarding associated risk factors. In this study only pathologically known cases of T2DM of above 20 years of age along with new patients diagnosed for the first time by the Nishtar Hospital in Multan who were consented to provide blood samples for scientific research and consent to the publication of research results were included. Moreover, healthy people with no prior history of diabetes, cancer, or cardiovascular disease served as controls. Those with pathologically confirmed local vascular invasion, patients with various and complicated pathologies, patients with cancer or immunological disorders; and individuals with a history of surgery in the previous three years were all excluded.

## 2.2 Primers Designing and DNA Extraction

Primers of our genetic variants were designed from Tetra-ARMS (amplification refractory mutation system) primers software [15] (Table 1). DNA of all collected blood samples was extracted by the standard organic method. The extracted DNA is then quantified by UV- a visible spectrophotometer (Perkin Elmer Lambda 25).

## 2.3 Genotyping

The genotyping for the SNPs of *GTF2H1* (rs4150558) and *SULF1* (rs6990375) was done through the Tetra-primer ARMS PCR method. The PCR products were analyzed on 2% agarose gel. Alleles were identified by the presence or absence of specifically sized bands on gel electrophoresis. Two bands indicated heterozygous genotype, while one band showed a homozygous genotype among the individuals under investigation.

## 2.4 Statistical Analysis

The genotypic frequencies of *GTF2H1* (rs4150558) and *SULF1* (rs6990375) with T2DM were calculated. The allele frequency of the genetic variants of *GTF2H1* and *SULF1* was calculated from Hardy-Weinberg equilibrium for the wild-type allele and mutant type allele in both case and control subjects. Statistical analysis was done through the chi-square "Goodness of Fit" test with a degree of freedom (distribution of sample), via software of SPSS v22 to analyze all associated risk factors with our genetic variants and T2DM. The odds ratio (OR), its standard error, and 95% confidence intervals (CI) were

measured from the online MedCalc Odd Ratio Calculator. The probability value (*P*-value) was calculated from Social Sciences Statistics- an online calculator at significance level 0.05, using chi-square and degree of freedom.

## 3. RESULTS

### 3.1 Genotypic Analysis

Single nucleotide polymorphism of two genes *GTF2H1* and *SULF1* was investigated with the help of tetra arm PCR. The main objective of this study was to find out the relationship of selected SNPs with type 2 diabetes. PCR amplification of *SULF1* showed three bands (Fig. 1A) on gel electrophoresis. The size of bands, 207bp for mutant homozygous AA genotype, 253bp for wild type homozygous GG genotype, and one outer band with 411bp size, were observed. The presence of both bands represents heterozygosity of the genotype that is AG.

*GTF2H1*, on amplification, resulted in three types of bands on gel electrophoresis. Homozygous TT genotype is represented by 283bp band and 317bp band showed homozygosity for AA genotype (Fig. 1B). Heterozygosity AT is represented by the presence of both bands.

### 3.2 Effect of Some Demographic Factors on the Phenotype

In this study, some T2DM related demographic factors were considered. In Table 2, the demographic data is shown for the 100 T2DM patients (cases) and 50 healthy individuals (controls).

In this study, we observed that 38% of the patients were males and 62% were females ( $P=0.000527$ ). 37% of individuals were found in the age group between 41 and 50 years suffering from T2DM. The statistical analysis was non-significant ( $P=0.053123$ ) for this variable. Another importantly associated risk factor for T2DM is weight. Our analysis revealed that 32% of affected individuals fall between the weight category of 71-80 kg. Thus, the increase in weight is found significantly associated ( $P=0.015995$ ) with T2DM. Another risk factor smoking has found a non-significant association with T2DM ( $P$ -value 0.190467).

The statistical significance value between these two groups ( $P=0.190467$ ) in smoking as a variable patient was present. Fatigue and family

history are two variables for which no evidence was observed in the control group of individuals, but 74% and 50% of patients were reported who suffer from fatigue and family history of T2DM, respectively. These two variables were significant ( $P=0.001609$ ) and ( $P=0.00001$ ) for fatigue and family history of T2DM, respectively. Alcohol is that variable taken under consideration in our study for which no single evidence was observed, neither a patient nor a control. So, these variables are constant for both groups. Fatigue has a significant effect ( $P=0.001609$ ) as well as cholesterol levels also show a significant effect ( $P=0.32727$ ). Family history shows a significant value ( $P=0.00001$ ) with type 2 diabetes. Hormonal imbalance in females also correlates with type 2 diabetes ( $P=0.00001$ ) which shows a significant effect. Depression is another risk factor for type 2 diabetes with a  $P$ -value of 0.00001. A healthy diet shows significant values in patients ( $P=0.00001$ ) respectively. Usage of insulin has been found to non-significant association with T2DM ( $P=8.955$ ).

### 3.3 Allelic Frequencies in Genes *SULF1* and *GTF2H1*

Allelic frequencies of gene *SULF1* rs6990375 in cases show the wild type 4% GG allele, 2% mutant AA, while heterozygosity with 94% is present in controls with chi-seq=12.909, Df=2 giving the value  $P=0.001573$ . In cases, the allelic frequencies of gene *SULF1* show the chi-seq significances=12.909 with the  $P$ -value=0.001573, showing 21% of wild allele GG, mutant allele AA 8%, and heterozygous GA allele 71% which is greater in cases than that of controls.

Gene *GTF2H1* rs4150558 shows the allelic frequency of TT wild allele 4% and AA mutant 2%, while allele AT shows the 94% allelic frequency with chi-seq= 4.014 and  $P$ -value= 0.45124 which is non-significant. Allelic frequencies for these 2 genes have shown in Table 3. Allelic frequency of these genes shows the association of different demographic factors with type 2 diabetes. Table 4 shows the stratification of T2DM associated Risk Factors and Genotypes.

## 4. DISCUSSION

Diabetes has many forms but among them, 90% of reported cases account for T2DM the most prevailing and common form [16]. T2DM diabetes has 25-80% chances of being heritable to the next generation of the affected person [17].

In the beginning, T2DM diabetes affects the action of insulin in peripheral tissues. Later on, it causes detrimental effects on insulin production due to dysfunction and loss of beta-cells which causes a problem in glucose breakdown and glucose ingestion [18]. Recently a sharp rise in reported T2DM cases has been observed globally and the major cause behind this peak is obesity, psychological issues like depression and anxiety, lack of physical activity, and intake of energy-rich food. Most of the time the poor functioning of different organs like the pancreas ( $\beta$  cells and  $\alpha$  cells), liver, skeletal muscle, and small intestine ultimately result in the development of T2DM [19]. Lifestyle is another key factor in the development of this deadly disease especially among the Asians as their diet is rich in fatty acids and they are not physically active. Factors, like higher intake of fatty acid rich diet, physical inactivity are related with T2DM in Asians.

In this study, we checked the correlation of two cancer-related SNPs *SULF1* rs6990375 and *GTF2H1* rs4150558 with T2DM by considering smoking as a risk factor. *SULF1* binds to heparin and acts as one of the major co-receptors for both growth factors and cytokines. *SULF1* play part in a feedback mechanism by adding a sulfate group to the heparin. There is another factor known as Heparin sulfate proteoglycan which is playing a vital role in HPV infections [20]. Adding a sulfate group to the heparin lowers the chances of HPV infections. Any mutation in a *SULF1* co-receptors results in the hindrance of feedback loop resulting in the failure of heparin cofactor binding against HPV infections ultimately resulting in the T2DM progression [21].

This study showed that homozygous mutant genotype GG of *SULF1* rs6990375 was greater in cases compared to controls homozygous ancestral genotype AA was 21% in cases and 2% in control and heterozygous genotype GA was 71% in cases. The allelic frequency of homozygous mutant allele G in our population is 43%. Our statistical analysis showed that *GTF2H1* rs4150558 homozygous ancestral genotype TT was 2% in controls compared to 15% in cases. The homozygous mutant genotype CC was 1% in both cases and controls. Our research work showed an association between *SULF1* and *GTF2H1* with some of the risk factors of diabetes. There are some demographic factors like age and gender which are also important considerations in T2DM progression. Most of the T2DM patients were

from the age group 41-50 years. The statistical analysis was non-significant ( $P=0.053123$ ) for this variable. The increase in weight was found significantly ( $P=0.015995$ ) associated with T2DM. Smoking, cholesterol, fatigue, Family history, hormonal imbalance, depression, diet, and insulin are some other important risk factors involved in the progression of T2DM [22-26]. These factors are normally exploiting our lifestyle as humans encounter them in daily life. Smoking was found to have a non-significant ( $P$ -value 0.190467) association with T2DM. However, some previous studies found smoking as a risk factor for T2DM [27,28].

Two variables showed significant ( $P=0.001609$ ,  $P=0.00001$ ) association i.e., fatigue and family

history of T2DM, respectively. Alcohol is a variable for which no single evidence was observed, neither in a patient nor a control. So, these variables were constant for both groups. Cholesterol levels showed a non-significant effect ( $P=0.32727$ ). Hormonal imbalance in females also correlates with type 2 diabetes ( $P=0.00001$ ). Depression is another risk factor for type 2 diabetes with a  $P$ -value of 0.00001. A healthy diet shows significant values in patients ( $P=0.00001$ ) respectively. Usage of insulin has been found to have a non-significant association with T2DM ( $P=8.955$ ). While previous studies have shown a significant association of insulin as a major risk factor of T2DM because insulin deficiency or insulin resistance leads to abnormal absorption of glucose [29,30].

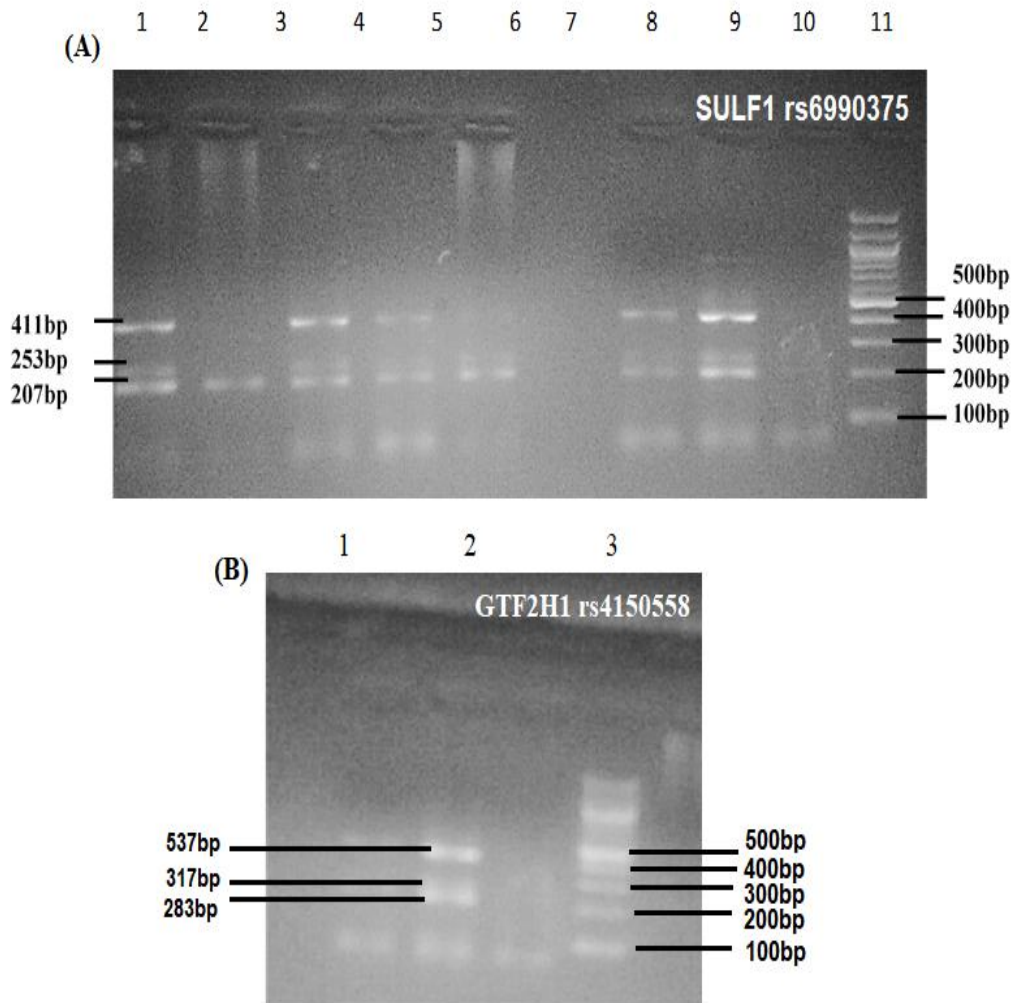


Fig. 1. PCR amplified bands indicated homozygosity and heterozygosity (A) *SULF1* gene (B) *GTF2H1* gene

**Table 1. Sequence, product magnitude and annealing temperature of designed primers**

DNA segment Name	*SNP No.	Primer	Primer sequence	Product size	Annealing temperature (°C)
GTF2H1	4150558	Inner-forward-primer(T-allele)	TGTATAAGAATATAACTGAGGAAAATAAGTT 401	T-allele 283	61
		Inner-forward-primer(A-allele)	TTTATAACAATACTTATATGCTAATGAGTATTACTT401	A-allele 317	
		Outer-forward-primer (5'-3')	AGAAATTAGCATGTGAAGTGTTAAAT 144	Outer forward 537	
		Outer-reverse-primer (5'-3')	CTAAGAGAGAAAAAAGATGAAGAA 627	Outer reverse 627	
SULF1	6990375	Forward inner primer (A-allele)	GTCACAGCACCTAGAAGGCATCA 401	A-allele 253	58
		Reverse inner primer (G-allele)	TAATCAGAGGAGAGTGAAGAGGATGC 401	G-allele 207	
		Forward outer primer (5' - 3')	TGGAAAGGACATTTTTGAAGATCAA 244	Outer forward 411	
		Forward outer primer (5' - 3')	GCCTTTCTTTCTACTCTTGGCAGATAGT 603	Outer reverse 603	

**Table 2. Risk factors of T2DM occurrence in Southern region of Punjab, Pakistan**

Factors	Category	Controls (N=50)	Cases (N=100)	Chi-sq	Df	P-value																																																																										
Gender	Male	68%	38%	12.019	1	0.000527																																																																										
	Female	32%	62%				Age in Years	20-30	10%	8%	10.913	5	0.053132	31-40	20%	26%	41-50	36%	45%	51-60	34%	21%	Weight (kg)	40-50	4%	3%	12.612	6	0.015995	61-60	24%	11%	61-70	40%	23%	71-80	24%	34%	81-90	6%	24%	91-100	2%	5%	Smokers	No	94%	87%	1.714	1	0.190467	Yes	6%	13%	Fatigue	No	52%	26%	9.949	1	0.001609	Yes	48%	74%	Cholesterol	No	92%	78%	4.56	1	0.32727	Yes	8%	22%	Family history	NO	96%	50%	31.142	1
Age in Years	20-30	10%	8%	10.913	5	0.053132																																																																										
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	51-60	34%	21%				Weight (kg)	40-50	4%	3%	12.612	6	0.015995	61-60	24%	11%	61-70	40%	23%	71-80	24%	34%		81-90	6%	24%				91-100	2%	5%	Smokers	No	94%	87%	1.714	1	0.190467	Yes	6%	13%	Fatigue	No	52%	26%	9.949	1	0.001609	Yes	48%	74%	Cholesterol	No	92%	78%	4.56	1	0.32727	Yes	8%	22%	Family history	NO	96%	50%	31.142	1	0.00001	Yes	4%	50%								
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Factors	Category	Controls (N=50)	Cases (N=100)	Chi-sq	Df	P-value
Hormonal Imbalance	No	70%	13%	49.770	1	0.00001
	Yes	30%	87%			
Depression	No	100%	45%	43.421	1	0.00001
	Yes	0%	55%			
Healthy diet	No	99%	31%	60.121	1	0.00001
	Yes	1%	69%			
Insulin	No	100%	84%	8.955	1	8.955
	Yes	0%	16%			

Table 3. Allelic frequencies of genes in the Southern region of Punjab, Pakistan

SULF1 gene rs6990375						
Genotype	GG	AA	GA	A freq.	G freq.	Significance
Control	2 (0.04)	1 (0.02)	47 (0.94)	0.51%	0.49%	Chi-seq=12.909 Df=2 P=0.001573
Patients	21 (0.21)	8 (0.8)	71 (0.71)	0.565%	0.435%	
GTF2H1 gene rs4150558						
Genotype	TT	AA	AT	A freq.	T freq.	Significance
Control	2 (0.04)	1 (0.02)	47 (0.94)	0.51%	0.49%	Chi-seq=4.014 Df=1 P=0.45124
Patients	15 (0.15)	1 (0.01)	84 (0.84)	0.57%	0.43%	

Table 4. Stratification of T2DM associated Risk Factors and Genotypes

Genotype	Smokers				Nonsmokers			
	Controls	Cases	Chi seq.	P value	Controls	Cases	Chi seq.	P value
SULF1 Genotype								
GG	1	9	1.887	0.389228 <sup>N.S</sup>	1	61	69.3167	0.00001 <sup>***</sup>
AA	1	1			1	8		
GA	1	3			46	18		
GTF2H1 Genotype								
TT	1	3	1.143	0.45124 <sup>N.S</sup>	1	11	1.143	0.45124 <sup>N.S</sup>
AA	0	0			0	1		
AT	2	10			46	75		

Genotype	Cholesterol				Non-Cholesterol			
	Controls	Cases	Chi seq.	P value	Controls	Cases	Chi seq.	P value
SULF1 Genotype								
GG	1	2	Cannot be calculated	Cannot be calculated	2	53	Cannot be calculated	Cannot be calculated
AA	0	0			0	6		
AG	3	20			44	18		
GTF2H1 Genotype							1.218	0.32727 <sup>N.S</sup>
TT	1	2	Cannot be calculated	Cannot be calculated	1	12		
AA	0	0			0	1		
AT	3	20			45	65		
Genotype	Healthy diet				Non-Healthy diet			
	Controls	Cases	Chi seq.	P value	Controls	Cases	Chi seq.	P value
SULF1 Genotype								
GG	0	49	Cannot be calculated	Cannot be calculated	21	2	43.5484	0.00001 <sup>***</sup>
AA	0	60			3	1		
AG	1	14			7	46		
GTF2H1 Genotype								
TT	0	12	Cannot be calculated	Cannot be calculated	2	2	2.664	0.210 <sup>N.S</sup>
AA	0	1			0	0		
AT	1	56			47	29		
Genotype	Depression				No-depression			
	Controls	Cases	Chi seq.	P value	Controls	Cases	Chi seq.	P value
SULF1 Genotype								
GG	0	39	Cannot be calculated	Cannot be calculated	2	31		0.0001 <sup>**</sup>
AA	0	5			0	4	38.4231	
AG	0	12			48	9		
GTF2H1 Genotype								
TT	0	4	Cannot be calculated	Cannot be calculated	2	10		0.373 <sup>N.S</sup>
AA	0	0			0	1	2.704	
AT	0	41			48	44		

Highly Significant at  $p < 0.005 = ***$ ; Moderately Significant at  $p < 0.05 = **$ ; Non-significant (NS)



In this research, we make an effort to relate the impacts of demographic factors with two important cancer genes *SULF1* rs6990375 and *GTF2H1* rs4150558. The results of the research were not according to the presumptions. Smoking was presupposed to be the major leading factor for the development of the T2DM, but the outcome of the research is quite contentious which indicates that smoking was not the top cause of T2DM despite that other causative factors are strongly associated with the progression of this disease including cholesterol, physical inactivity, psychological disorders, family history, age, gender, and hormonal issues. There are other contributory factors to T2DM like fuzzy vision, use of insulin, weakness excessive exercise, and urination. Most young females develop this disease due to their unhealthy lifestyle, excessive use of alcohol, physical inactivity, obesity, and nutrient-deficient poor diet. Obese people are at higher risk of developing T2DM. The research indicated that T2DM is genetic sometimes as a study on family history indicated the association of several genes with the onset of T2DM. The sole purpose of the research was to associate and relate the cancer genes *SULF1* and *GTF2H1* with smoking and T2DM, but the results deviate from the expected outcome. The deviation in the result is attributed to factors like ethical, geographical variations; these factors are associated with the ultimate variation in gene allelic frequencies in the local population. Tentative research is recommended by enhancing the population and sampling size to further build up a strong association between genetic and demographic factors with T2DM.

## 5. CONCLUSION

*GTF2H1* and *SULF1* genetic polymorphic variants due to smoking risk factors were not associated with T2DM in the Southern region of Punjab, Pakistan. Some demographic factors are significantly associated with these genes which lead to T2DM.

## CONSENT AND ETHICAL APPROVAL

Ethical approval for this study was granted by the "Institutional Review Board" (IRB) of "Institute of Molecular Biology and Biotechnology", BZU Multan. All patients and volunteers signed the consent for the donation of blood.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Bangalore S, Kumar S, Lobach I, Messerli FH. Blood pressure targets in subjects with type 2 diabetes mellitus/impaired fasting glucose: observations from traditional and bayesian random-effects meta-analyses of randomized trials. *Circulation*. 2011;123(24):2799-810.
2. McCarthy MI, Zeggini E. Genome-wide association scans for Type 2 diabetes: New insights into biology and therapy. *Trends Pharmacol Sci*. 2007;28(12):598-601.
3. Aamir AH, Ul-Haq Z, Mahar SA, Qureshi FM, Ahmad I, Jawa A, et al. Diabetes Prevalence Survey of Pakistan (DPS-PAK): prevalence of type 2 diabetes mellitus and prediabetes using HbA1c: a population-based survey from Pakistan. *BMJ open*. 2019;9(2):e025300.
4. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. *Diabetes Res Clin Pract*. 2019;157:107843.
5. Dendup T, Feng X, Clingan S, Astell-Burt T. Environmental risk factors for developing type 2 diabetes mellitus: a systematic review. *International journal of environmental research and public health*. 2018;15(1):78.
6. Gonzalez-Zacarias AA, Mavarez-Martinez A, Arias-Morales CE, Stoicea N, Rogers B. Impact of demographic, socioeconomic, and psychological factors on glycemic self-management in adults with type 2 diabetes mellitus. *Frontiers in public health*. 2016;4:195.
7. Meo SA, Zia I, Bukhari IA, Arain SA. Type 2 diabetes mellitus in Pakistan: Current prevalence and future forecast. *JPMA The Journal of the Pakistan Medical Association*. 2016;66(12):1637-42.
8. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes care*. 2004;27(5):1047-53.
9. Jafar-Mohammadi B, McCarthy MI. Genetics of type 2 diabetes mellitus and obesity—a review. *Ann Med*. 2008;40(1):2-10.
10. Xie X-t, Liu Q, Wu J, Wakui M. Impact of cigarette smoking in type 2 diabetes

- development. *Acta Pharmacol Sin.* 2009;30(6):784-7.
11. Health UDo, Services H. The health consequences of smoking—50 years of progress: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease; 2014.
  12. Organization WH. Global Report on Diabetes 2016 [cited 2021 24 April]. Available:<http://www.who.int/diabetes/global-report/en/>.
  13. Saxena R, Voight BF, Lyssenko V, Burtt NP, de Bakker PI, Chen H, et al. Genome-wide association analysis identifies loci for type 2 diabetes and triglyceride levels. *Science.* 2007;316(5829):1331-6.
  14. Wang J, Kumar S, Chang S-F. Sequential projection learning for hashing with compact codes;2010.
  15. Collins A, Ke X. Primer1: primer design web service for tetra-primer ARMS-PCR. *The Open Bioinformatics Journal.* 2012; 6:55-8.
  16. de Vegt F, Dekker JM, Jager A, Hienkens E, Kostense PJ, Stehouwer CD, et al. Relation of impaired fasting and postload glucose with incident type 2 diabetes in a Dutch population: The Hoorn Study. *Jama.* 2001;285(16):2109-13.
  17. Prasad RB, Groop L. Genetics of type 2 diabetes—pitfalls and possibilities. *Genes.* 2015;6(1):87-123.
  18. Järigen P, Dietrich A, Herling AW, Hammes H-P, Wohlfart P. The role of insulin resistance in experimental diabetic retinopathy—Genetic and molecular aspects. *PloS one.* 2017;12(6):e0178658.
  19. Chatterjee S, Khunti K, Davies MJ. Type 2 diabetes. *The Lancet*; 2017.
  20. Wang SS, Gonzalez P, Yu K, Porras C, Li Q, Safaeian M, et al. Common genetic variants and risk for HPV persistence and progression to cervical cancer. *PloS one.* 2010;5(1):e8667.
  21. Mahtal N, Lenoir O, Tharaux P-L. Glomerular Endothelial Cell Crosstalk With Podocytes in Diabetic Kidney Disease. *Frontiers in Medicine.* 2021;8:334.
  22. Golden SH, Williams JE, Ford DE, Yeh H-C, Sanford CP, Nieto FJ, et al. Depressive symptoms and the risk of type 2 diabetes: the Atherosclerosis Risk in Communities study. *Diabetes care.* 2004;27(2):429-35.
  23. Cosgrove MP, Sargeant LA, Griffin SJ. Does depression increase the risk of developing type 2 diabetes? *Occupational medicine.* 2008;58(1):7-14.
  24. Singh R, Teel C, Sabus C, McGinnis P, Kluding P. Fatigue in type 2 diabetes: impact on quality of life and predictors. *PLoS One.* 2016;11(11):e0165652.
  25. Valdez R. Detecting undiagnosed type 2 diabetes: family history as a risk factor and screening tool. *Journal of diabetes science and technology.* 2009;3(4):722-6.
  26. Joung KH, Jeong J-W, Ku BJ. The association between type 2 diabetes mellitus and women cancer: the epidemiological evidences and putative mechanisms. *BioMed research International.* 2015;2015.
  27. Xie X-t, Liu Q, Wu J, Wakui M. Impact of cigarette smoking in type 2 diabetes development. *Acta Pharmacologica Sinica.* 2009;30(6):784-7.
  28. Yeh H-C, Duncan BB, Schmidt MI, Wang N-Y, Brancati FL. Smoking, smoking cessation, and risk for type 2 diabetes mellitus: a cohort study. *Annals of internal medicine.* 2010;152(1):10-7.
  29. Reaven GM. Relationships among insulin resistance, type 2 diabetes, essential hypertension, and cardiovascular disease: similarities and differences. *The Journal of Clinical Hypertension.* 2011;13(4):238-43.
  30. Patel TP, Rawal K, Bagchi AK, Akolkar G, Bernardes N, da Silva Dias D, et al. Insulin resistance: an additional risk factor in the pathogenesis of cardiovascular disease in type 2 diabetes. *Heart failure reviews.* 2016;21(1):11-23.

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