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Cluster Identification of Diabetic Risk Factors among Saudi Population

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Authors' contributions

This work was carried out in collaboration among all authors. Author AA carried out study. Authors AA, AA and SA contributed in study conceptualization, data curation and formal analysis. Author ER as consultant contributed in analyzing data. Authors SM contributed in data processing and analysis. Author AA funding acquisition, project administration and reviewing. Author SA contributed in study conceptualization, supervision and writing (review and editing) the manuscript. Author MA contributed in data analysis and editing the manuscript. All authors approved the paper.

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ABSTRACT

Aims: The aim of the study was to estimate the prevalence and risk factors of diabetes mellitus among adult population of Albaha region, Saudi Arabia and to identify the diabetic risk clusters among Saudi population using various cluster analysis techniques.
Study Design: Cross-sectional observation and Hierarchal cluster analyses.
Place and Duration of Study: The study was conducted in three different cities of the Albaha region, Saudi Arabia including Albaha, AlAqiq and Baljurashi among Saudi adults 15 years of age or above. The study was carried out from April 2019 to May 2019.
Methodology: The first part of the research was a random cross-sectional observational diabetic risk factors screening using a structured questionnaire among adult volunteers of the Albaha region. The second part constituted a multiple cluster analysis technique performed to identify the diabetic risk factors from 13 regions of Saudi Arabia, clustered into five main regions, using NCSS software.
Results: In the first part, the risk factors identified among non-diabetic participants showed a significant association with the development of diabetes mellitus, particularly physical inactivity (49.12%), hypertension (41.15%), and high body mass index (19.03%). Likewise, in 11.54% of diabetic patients, elevated body mass index (30.51%), hypertension (27.12%) and physical inactivity (55.93%), which could be associated with diabetic complications. In the second part, the three forms of cluster analyses (the agglomerate hierarchical cluster, clustered heat map and K means clustering analysis) identified physical inactivity and high body mass index as key risk factors which are connected to all other risk factors among the total of 213591 volunteers.
Conclusion: Increased prevalence of diabetes and risk of developing diabetes mellitus in the Kingdom require substantial education and training programs to counsel volunteers on all aspects of self-care. Our data provides a robust evidence to establish diabetic counseling through regular diabetes awareness program that can reduce the risk of developing diabetes mellitus.

Keywords: Albaha; cluster analysis; diabetes; physical inactivity; risk factors; Saudi Arabia; screening.

1. INTRODUCTION

There is an exponential rise in the prevalence of diabetes in the Middle East and North Africa (MENA) region, including Saudi Arabia. According to the International Diabetic Federation (IDF) report in 2019, around 463 million adults (20-79 years) were diagnosed with diabetes, and this will grow up to 700 million by 2045 globally. While in the MENA region, 55 million adults (20-79) live with diabetes in 2019 and this number is expected to grow to 108 million by 2045 [1]. Estimates of the prevalence of diabetes mellitus in Saudi Arabia indicate that the current prevalence is around 17 percent, with predictions that by 2030 it will plateau at more than 20 percent [2,3]. Linking diabetes with COVID-19 shows a greater chance of death associated with COVID-19 than people without diabetes. However, the probability of death for individuals younger than 40 years of either type 1 or type 2 diabetes is very low [4].

Lifestyle variables, including obesity and being overweight, lack of physical exercise, smoking, inadequate diet, stress and urbanization are critical for the development of type 2 diabetes (T2DM). The risk can be minimized to a greater extent through diet and lifestyle interventions [5]. Furthermore, diet is considered as an adjustable risk factor for T2DM. Studies have shown that a low-fiber diet with high glycemic index is favorably correlated with a greater risk of T2DM [6], and particular dietary fatty acids can influence insulin resistance and the risk of varying degrees of diabetes [7]. Total and saturated fat intake, independent of body mass index (BMI), is associated with an increased risk of T2DM, but higher linoleic acid intake has the opposite effect, especially among leaner and younger males [8]. Following BMI modification, previous weight shift, and alcohol and energy intake, repeated consumption of processed meat but no other meats may increase the risk of T2DM [8]. Soft drinks are also related to an elevated risk of T2DMM [9] and metabolic syndrome [10], since they are correlated specifically with BMI [11]. As a wide difference in information and attitude has been found, a good education and awareness program will improve patients ' knowledge and attitude.

The aim of the study was to estimate the prevalence and risk factors of diabetes among adult population of Albaha region, Saudi Arabia, and to identify the diabetic risk clusters among Saudi population using various cluster analyses techniques.

2. METHODOLOGY

2.1 Risk Factor Screening for Diabetes at Albaha region, Saudi Arabia

2.1.1 Study design duration and location

Firstly, this cross-sectional observational study was conducted in three different cities of the Albaha region, Saudi Arabia including Albaha, AlAqiq and Baljurashi among Saudi adults aged 15 years and above. The study was carried out from April 2019 to May 2019.

As per 2015 estimates, the Albaha region is the smallest region of the Kingdom of Saudi Arabia with a population of 466115 individuals.

2.1.2 Sample size and sampling technique

Five hundred and eleven participants took part in the study. Cluster random sampling approach was adopted to sample the subjects covering Albaha region at different locations such as malls and banks. General public, both male and female with age of 15 years and above, and willing to voluntarily participate were included in the study. Based on the population size of 20000 for people of age group 15 to 74 years, confidence level of 95%, margin of error 5%, and response distribution of 50%, the minimum effective sample size calculated for this study was 377. The sample size for this study was calculated by using Raosoft sample size calculator [http://www.raosoft.com/samplesize.html].

$$n = Z^2 P (1-P) / d^2$$

Where,

n = required sample size, P = disease prevalence Z = confidence level, d = margin of error. Additionally, sampling errors of approximately 1.356 were expected using a cluster sampling technique. Therefore, the final sample size was multiplied by 1.356 (377 × 1.356) equaling 511.

2.1.3 Data collection

Data was collected by trained pharmacists. The data collectors used a questionnaire that included demographic data, family history, smoking and Qat habits, assessment of blood pressure and BMI, physical exercise. On an average, each of the interviews took about 20-30 minutes. Prior to beginning the survey, data collectors were trained for data collection. Height and weight were estimated using standardized methods, and the National Heart, Lung, and Blood Institute (NIH) USA table was used to measure the BMI. Random blood sugar level and blood pressure assessment were carried out according to the World Health Organization (WHO) standard guidelines by qualified practitioners [12].

2.2 Agglomerate Hierarchical Cluster Analysis for Identifying National Diabetic Risk Factors

Secondly, we collected all the articles published until December 2020 that reported risk factors for diabetes like gender, age, smoking, family history of diabetes, physical inactivity, BMI, hypertension, metabolic syndrome in normal volunteers from thirteen region of Saudi Arabia. Thirteen regions were clustered into five regions: Central region - Riyadh [13,14], Eastern region - Dammam and related cities [15], Northern region-Qassim [16], Tabuk [17], Hail [18], Arar [19], Aljouf [20], Southern region - Jazan [3], Albaha and Western region - Makkah [21], Jeddah [22], Madinah [23]. Studies that only considering physical inactivity and smoking risk factors, and risk factors in diabetic patients, were excluded. Some cities in the Asir region, such as Abha and Najran, did not report any publications relating to risk factors screening in normal volunteers among thirteen regions. An agglomerative hierarchical cluster analysis with Euclidean distance Group average (Unweighted pair group) centroid method was used to determine the groupings between the different variables. In order to determine the association between risk factors for developing diabetes in healthy volunteers, first hierarchical clustering was performed and secondly to determine the region that is most at risk of developing diabetes using the cluster heat map. Third comparative risk factors clusters among the various regions were identified using K means analysis.

2.3 Statistical Analysis

The overall prevalence of DM among volunteers and parameters for risk for diabetes, was calculated as percent and 95 percent confidence interval (CI). Chi-square test was used to identify the association between risk for diabetes and the independent variables. Gender, age group, marital status, family income, educational attainment, occupation, family history, BMI, Khat chewing, smoking, hypertension, daily exercise and work involved physical activity included in the model as independent variables using GraphPad Prism 5.01, Software Inc., San Deigo, CA, USA. All statistical tests were two-sided; and a level of P < 0.05 was used to indicate statistical significance. Whereas an agglomerative hierarchical cluster analyses with Euclidean distance Group average (Unweighted pair group) centroid method, clustered heat map and K means cluster analyses were used to determine the groupings between the different variables by using software NCSS 2020 Statistical Software (2020). NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/ncss.

3. RESULTS

3.1 Risk Factors Screening for Diabetes at Albaha Region, Saudi Arabia

Five hundred and eleven individuals including 96.28% (n=492) males and 3.71% (n=19) females were screened for risk for diabetes in this study (Table 1). The distribution of age of sample participants indicates that 65.95 percent were in the age range (15-39) years, 20.94 percent in the age group (40-49) years. About 74.56 percent of the participants were married in a single marriage, compared with just 1.57 percent who were married in a polygamy arrangement, while 21.14 percent were single participants. Nearly 33.66 percent of respondents had a monthly family income of less than 3000 Saudi Riyal (SR). Illiterate individuals were 0.2 percent, while 22.2 percent participants of those who finished secondary school. 22.15 percent are employed by government institutions, compared to 49.11 percent in the private sector (Table 1). The prevalence rates of diabetic and non-diabetic among the screened population were 11.54 percent and 88.45 percent respectively. The study characteristics of the participants in the non-diabetic and diabetic studies are shown in Table 1.

Male volunteers were more among non-diabetic and diabetic, 441 and 51 respectively. The age-specific prevalence rate indicated a general rise in middle-aged DM, with a substantial variation between the multiple age groups. In the age group, the highest prevalence was observed in (15-39; 40-49) years 38.98 percent (95% CI; 27.5-51.7); 37.29 (95% CI; 26.08-50.05), while the lowest prevalence in the age group 60+ was recorded as 8.47 percent (95% CI; 3.67-18.35) respectively. The prevalence of DM by 67.80 percent of married respondents according to marital status (95% CI; 55.1-78.3), followed by single participants 25.42 percent and married in polygamy 1.69 percent. According to financial status, 25.42 percent of people with a monthly salary below 3000 SR were diabetic patients (95% CI; 16.06-37.8). According to the educational and occupational status, 37.29 percent (95% CI; 26.08-50.05) were university graduate and 50.85 percent (95% CI; 38.44-63.16) with private jobs respectively were diabetic patient. It was observed that the average prevalence of DM among study participants was 11.54 percent (95% CI; 9.06-14.61). The table further showed that there is a substantial variation between the incidence of DM by gender, marital status, and between patients by profession and monthly family income. Characteristics of non-diabetic and diabetic study participants are shown Table 2.

Table 3 shows that the association between risk factors for developing diabetes and diabetic complication in non-diabetic and diabetic patients respectively. According to the table, the body mass index of the individual, age, family history of diabetes, and regular exercise and physical function involved indicated a substantial correlation with the progression of diabetes. Among non-diabetics, 43.17 percent (95% CI; 38.65-47.75) had family history, 19.03 percent (95% CI; 15.67-22.90) had higher BMI, 9.21 percent & 30.99 percent had khat and tobacco usage respectively, 41.15 percent had hypertension with 49.12 percent and 40.84 percent of no daily exercise and physical activity. These volunteers with above characteristic are at higher risk for possible developing diabetes. The risk of DM increases ten times with age greater than 40 years, although the family history of DM increases the risk three times. Obesity raises the risk of DM twice, although the risk is decreased twice by daily exercise. In diabetic patients, 57.63 percent (95% CI; 44.93-69.39) had family history, 30.51 percent (95 %CI; 20.2-43.1) had higher BMI, 7 percent and 14 percent habitat at to khat usage and smoking respectively, 27.12 percent had hypertension, 55.93 percent and 45.76 percent had no daily exercise and physical activity respectively. Family history, BMI related with diet and low physical activity, smoking in patients with diabetes have a greater risk of developing diabetic complications.

Table 1. Some selected characteristics of the participants of Albaha region (n=511)

Characteristics	Number of participants	Percentage	95 % CI
Gender			
Male	492.0	96.28	94.27-97.61
Female	19.0	3.72	2.39-5.73
Age group			
15 -39	337.0	65.95	61.74-69.93
40 -49	107.0	20.94	17.63-24.68
50 - 59	44.0	8.61	64.8-113.6
60 and above	23.0	4.50	3.02-6.66
Married Status			
Single	108.0	21.14	17.82-24.88
Married	381.0	74.56	70.61-78.14
Married in polygamy	8.0	1.57	0.80-3.06
Not known	14.0	2.74	1.64-4.55
Family Income (SR)			
< 3000	172	33.66	29.70-37.87
3000-4900	105	20.50	17.27-24.26
5000-6900	75	14.59	7.67-12.89
7000-9999	51	9.94	7.58-12.79
10000 and above	79	15.42	12.58-18.85
Not known	30	5.87	4.14-8.26
Diabetic	59	11.55	9.06-14.61
Non diabetic	452	88.45	85.39-90.94
Family history			
Yes	229	44.84	40.56-49.15
No	261	51.07	46.75-55.39
Not known	21	4.09	2.70-6.20
Education			
Illiterate	1	0.20	0.03-1.11
Incomplete School	10	1.92	0.94-3.35
Primary	33	6.49	4.51-8.79
Intermediate	57	11.08	8.62-14.10
Secondary	114	22.22	18.92-26.16
University	271	53.06	49.00-57.66
Not known	26	5.04	3.53-7.42
Occupation			
Government	113	22.15	18.73-25.91
Private	251	49.11	44.81-53.44
Student	79	15.48	12.58 -18.85
Retired	21	4.03	2.70-6.20
Unemployed	26	5.15	3.50-7.35
Housewife	4	0.77	0.30-2.00
Not known	17	3.31	2.09-5.26

3.2 Agglomerate Hierarchical Cluster Analysis of Identifying National Diabetic Risk Factors

A total of 14 publications were reported for diabetic risk factors screening in 213591 non-diabetic volunteers from 13 regions of Saudi Arabia. Various risk factors like gender, age, smoking, family history, physical inactivity, BMI risk, hypertension and metabolic syndrome have been reported. An agglomerate hierarchical cluster analysis demonstrates the relative proximities of each tested variable in the dendrogram (Fig. 1). The dendrogram identifies the tests that trend together; the most distal branch points reveal those tests that are most closely associated. The cluster identifies relation between risk factors and diabetes in total volunteers and are assigned to clusters based solely on risk factors, a total of three clusters of subjects emerges. Cluster 1 (male, physical inactivity) with largest Euclidean distance indicating highest risk, followed by cluster 2 (female and BMI risk), cluster 3 (age >60, 50-59, smoking, metabolic syndrome, hypertension and 40-49 age) The Euclidean distance was in following order cluster 1 > cluster 2 > cluster 3. Cluster 1 and cluster 2 being higher risk factor and linked to all other risk factors. In cluster 1 and 2 apart from gender, BMI risk and physical inactivity being the most higher risk factors for diabetes and its linked other risk factors. In Fig. 2 represents cluster heat map defining diabetic risk factors in five major region that identified region with most of the risk factors. Two clusters, cluster 1 (western region and eastern region) and cluster 2 (southern region, northern region and central region), and sub-cluster (northern and southern region) were identified. Following risk factors such as male sex, physical inactivity in all regions, family history in the western region, BMI risk factors in the Eastern region are identified as prominent risk factors for developing diabetes. In Fig. 3, K mean clusters are shown, clusters of risk factors are compared between various regions, in Fig. 3 A, B, C, D, E, F, G, H and I the cluster of physical inactivity and BMI risk being more prominent is all regions. Again, demonstrating in all three-cluster analysis technique, physical inactivity and BMI risk being the highest risk factors in Saudi Arabia and it is linked to other diabetic risk factor clusters.

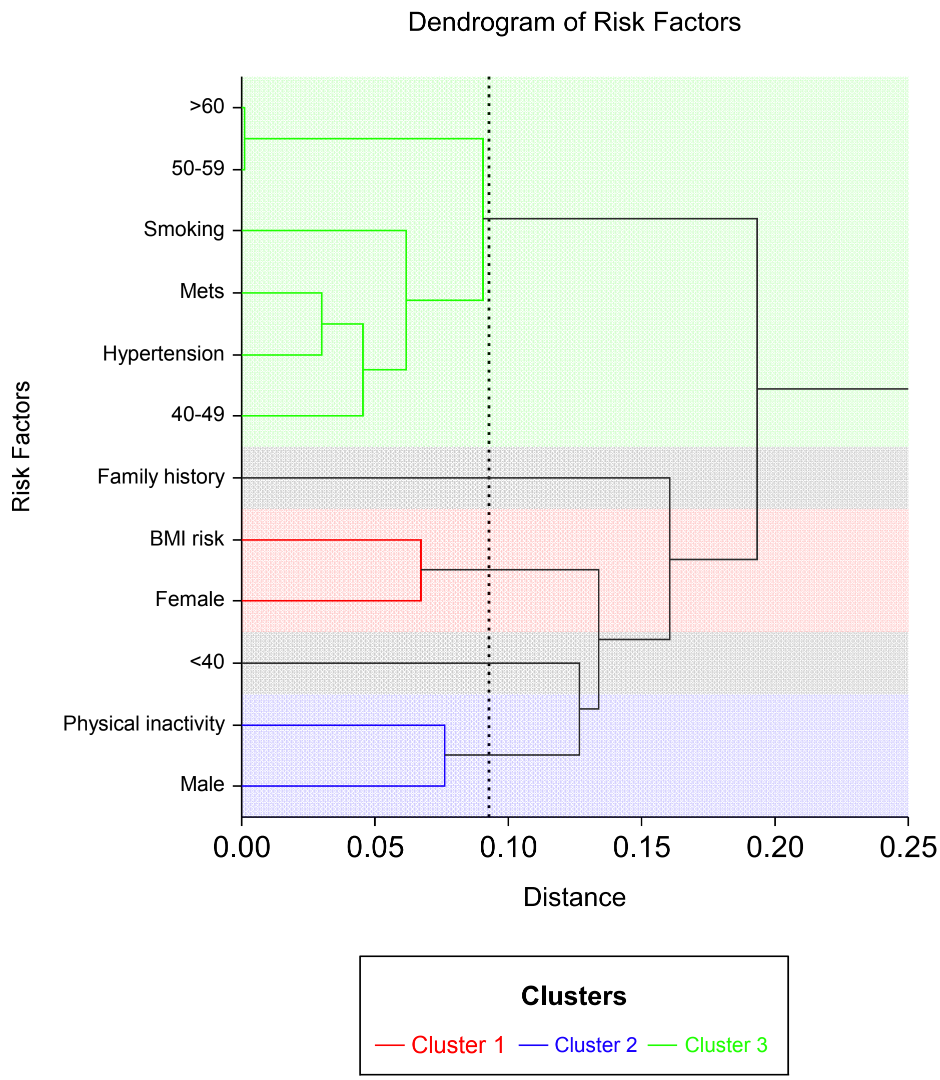


Fig. 1. Hierarchical cluster dendrogram of diabetic risk factors in various regions of Saudi Arabia

Table 2. Some selected characteristics of non-diabetic and diabetic study participants of Albaha Region (n=511)

Characteristics	Non-diabetic	Percent	95% CI	Diabetic	Percent	95% CI	P value
Gender							
Male	441	97.57	95.70 – 98.64	51	86.44	71.4 - 92.9	<0.001
Female	11	2.43	1.8 - 4.5	8	13.56	7.03 - 24.5	
Age group							
15 - 39	314	69.47	65.07 - 73.54	23	38.98	27.5 - 51.7	
40 - 49	85	18.81	15.4 - 22.6	22	37.29	26.08 - 50.05	
50 - 59	35	7.74	5.6 - 10.5	9	15.25	8.2 - 26.5	<0.001
60 and above	18	3.98	2.5 - 6.6	5	8.47	3.67 - 18.35	
Married Status							
Single	93	20.58	17.1 - 24.5	15	25.42	16.06 - 37.8	
Married	341	75.44	71.2 - 79.18	40	67.80	55.1 - 78.3	
Married in polygamy	7	1.55	0.7 - 3.1	1	1.69	0.3 - 9.0	0.505
Not known	11	2.43	1.8 - 4.5	3	5.08	1.7 - 13.9	
Family Income							
< 3000	157	34.73	30.4 - 39.2	15	25.42	16.06 - 37.8	
3000-4900	87	19.20	15.8 - 23.14	18	30.51	20.2 - 43.1	
5000-6900	67	14.72	11.8 - 18.3	8	13.56	7.03 - 25.54	0.232
7000-9999	44	9.69	7.3 - 12.8	7	11.86	5.87 - 22.52	
10000 and above	73	16.11	13.05 - 19.8	6	10.17	4.74 - 20.46	
Not known	25	5.53	3.7 - 8.04	5	8.47	3.67 - 18.35	
Education							
Illiterate	1	0.22	0.04 – 1.24	2	3.39	0.93 - 11.54	
Incomplete School	7	1.51	0.75 - 3.16	3	5.08	1.7 - 13.9	
Primary	27	6.01	4.14 - 8.55	6	10.17	4.74 - 20.46	
Intermediate	50	10.98	8.49 - 14.29	7	11.86	5.87 - 22.52	0.005
Secondary	97	21.35	17.92 - 25.48	17	28.81	2.67 - 16.18	
University	249	55.12	50.48 - 59.61	22	37.29	26.08 - 50.05	
Not known	22	4.87	3.21 - 7.26	2	3.39	0.93 - 11.54	
Occupation							
Government	99	21.95	18.34 - 25.94	14	23.73	14.69 - 35.97	
Private	221	48.88	44.31 - 53.49	30	50.85	38.44 - 63.16	
Student	75	16.62	13.45 - 20.30	4	6.78	2.67 - 16.18	

Characteristics	Non-diabetic	Percent	95% CI	Diabetic	Percent	95% CI	P value
Retired	15	3.22	2.02 - 5.40	6	10.17	4.74 - 20.46	0.108
Unemployed	24	5.38	3.5 - 7.70	2	3.39	18.84 - 41.38	
Housewife	3	0.64	0.23 - 1.93	1	1.69	1.7 - 13.9	
Not known	15	3.30	2.02 - 5.40	2	3.39	16.06 - 37.8	

Table 3. Screened risk factors at Albaha region (n=511)

Risk Factors	Non-Diabetic	Percent	95 % CI	Diabetic	Percent	95 % CI	P value
Family History							
Yes	195	43.17	38.65 - 47.75	34	57.63	44.93 - 69.39	
No	237	52.42	47.83 - 57.00	24	40.68	29.09 - 53.41	0.0906
Not known	20	4.41	2.88 - 6.74	1	1.69	0.3 - 9.0	
BMI							
BMI < 30	366	80.97	77.10 - 84.33	41	69.49	56.85 - 79.75	
BMI > 30	86	19.03	15.67 - 22.90	18	30.51	20.2 - 43.1	0.0394
Khat							
Yes	42	9.21	6.95 - 12.32	7	11.86	5.87 - 22.52	
No	359	79.52	75.46 - 82.90	51	86.44	71.4 - 92.9	0.0674
Not known	51	11.26	8.69 - 14.53	1	1.69	0.3 - 9.0	
Tobacco							
Yes	140	30.99	26.89 - 35.38	14	23.73	14.69 - 35.97	
No	297	65.71	61.22 - 69.94	43	72.88	60.40 - 82.56	0.5186
Not known	15	3.30	2.02 - 5.40	2	3.39	0.93 - 11.54	
Hypertension							
Absent	266	58.85	54.26 - 63.29	43	72.88	60.40 - 82.56	
Present	186	41.15	36.71 - 45.74	16	27.12	17.44 - 39.60	0.0381
Exercise daily							
Yes	214	47.35	42.78 - 51.95	25	42.37	30.61 - 55.07	
No	222	49.12	44.53 - 53.71	33	55.93	43.29 - 67.85	0.5231
Not known	16	3.52	2.19 - 5.67	1	1.69	0.3 - 9.0	
Work involved physical activity							
Yes	253	55.86	51.37 - 60.48	27	45.76	33.70 - 58.34	
No	185	40.84	36.49 - 45.52	31	52.54	40.04 - 64.73	0.2120
Not known	15	3.30	2.02 - 5.40	1	1.69	0.3 - 9.0	

Table 4. Risk factors from various regions of Saudi Arabia from published literature

Study Area	Central region	Eastern region	Northern region	Southern region	Western region	Total
Reference	[13,14,24]	[15,24]	[16,17,18,19,20,24]	[3,24]	[21,22,23,24]	
Study population	1711	198314	1967	2575	9024	213591
Risk factors	%	%	%	%	%	Average
Male	67	47	58	86	42	60
Female	33	53	42	14	58	40
<40	45	15	60	68	70	51
40-49	46	32	19	17	16	26
50-59	6	27	10	9	8	12
≥60	3	25	11	6	6	10
Smoking	50	17	38	52	0	31
Family history	0	51	40	40	83	43
Physical inactivity	58	74	66	58	59	63
BMI risk	58	79	48	20	48	51
Hypertension	15	15	29	24	18	21
MetS	34	25	40	25	25	30

MetS: Metabolic Syndrome

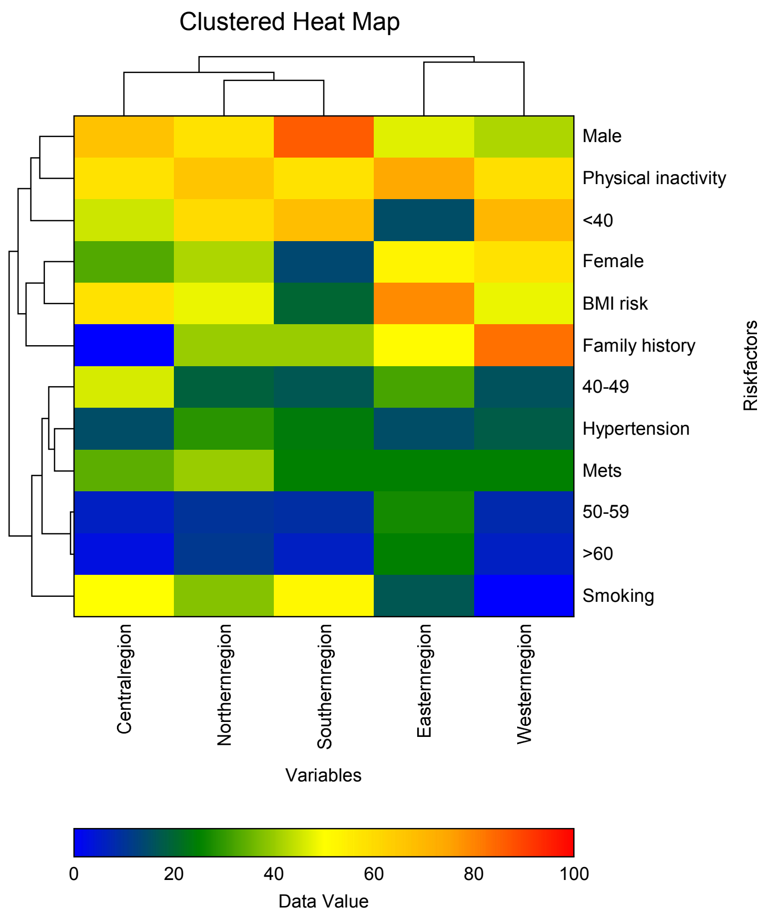
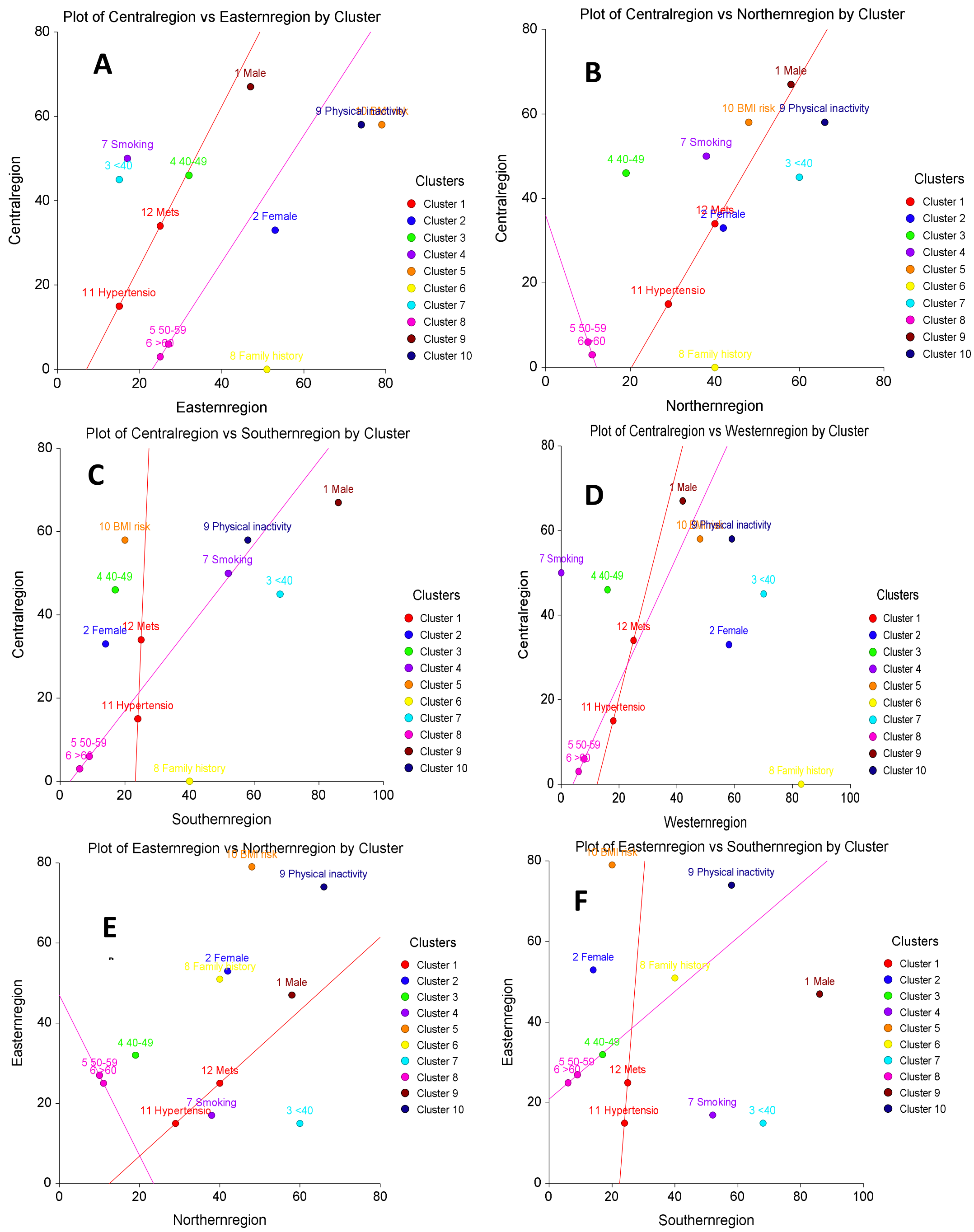


Fig. 2. Cluster heat map of diabetic risk factors in various regions of Saudi Arabia

4. DISCUSSION

Although other survey-based studies are reported on diabetes, screening for prevalence and risk factors is not reported. The focus of this study was to create awareness among obese, hypertensive and physically inactive participants, and additionally to report prevalence rate. As per the 2015 census, the province of Albaha had a population of 466115, but according to new World Population data estimates, Albaha accounted for 1.5 percent of the total population of Saudi Arabia. The prevalence of diabetes from our sample was 11.54 percent, which is lower than the national average, this number can vary because screening was conducted at malls and



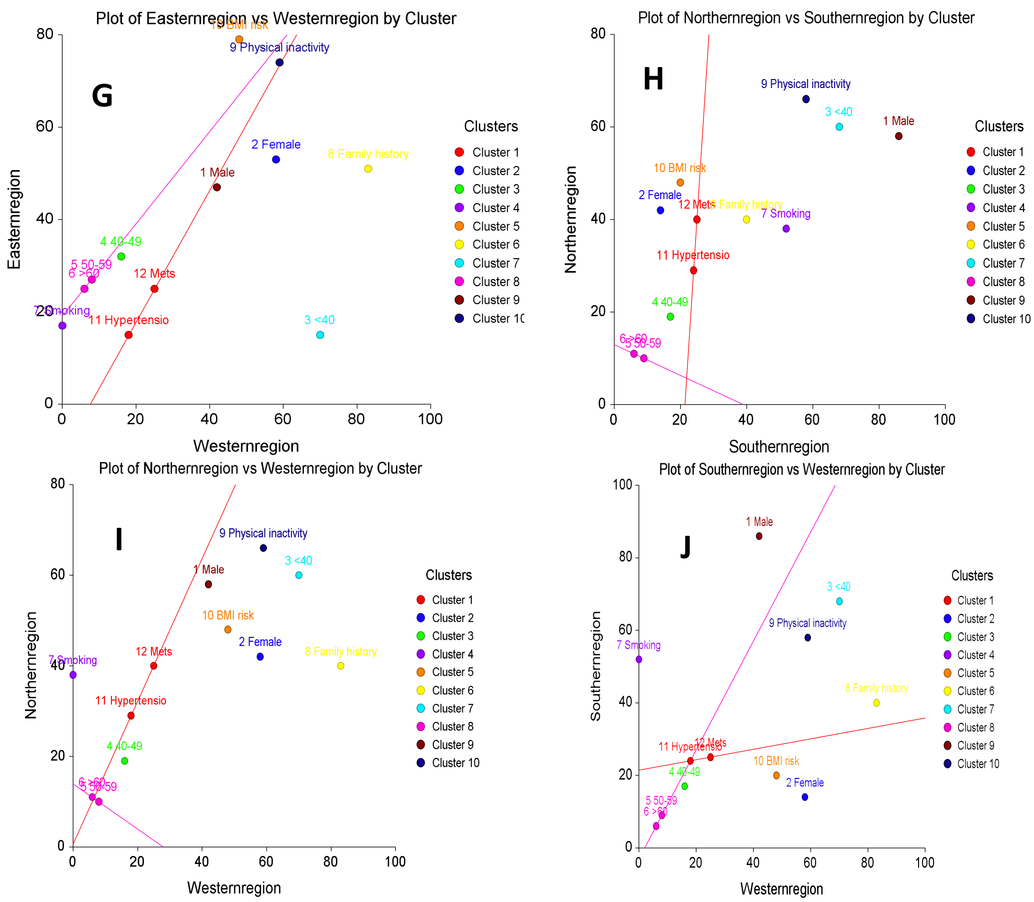


Fig. 3. K means Cluster of risk factors for diabetes between different comparative regions of Saudi Arabia

banks with 511 volunteers. If the mapping cluster survey design of the World Health Organization (EPI) is applied, then the prevalence rate in Albaha might be higher. According to International Diabetes Federation, the prevalence rate of diabetes in Saudi Arabia in 2019 was 18.3 percent for the age group 20-79 years [1]. In 2016, in Jeddah province, Bahijri et al studied for diabetes and prediabetes by mapping cluster design based on World Population as standard and found that the prevalence was 18.3 percent for DM and 11.9 percent for prediabetes [25]. In our study, the higher percentage of the age group for non-diabetics was 15-39, whereas 15-39 and 40-49 for diabetics, since more middle-aged people visit malls and banks. The distribution of screening volunteers was comparable to other studies performed in other regions of Saudi Arabia for both diabetic and non-diabetic volunteers, married with average income with university education with private jobs as reported at Al-Kharj region by Aldossari et al, Eastern province by Al Bagli et al, Riyadh region by Hadlaq et al [14,15,26]. The prevalence of obesity among adults in KSA in 2016 was 35.4 percent, also one of the highest in the MENA region. The prevalence of hypertension among adults in KSA in 2015 was also one of the highest in the GCC region, at 23.3 percent [1]. The link between diabetes mellitus and obesity is well known and has been reported, nationally and internationally, in many other surveys. In a global study involving forty-nine developing countries indicated that overweight (BMI) and obesity (BMI > 30 kg⁄m2) were substantially correlated for developing diabetes than in normal weight individual [27]. The prevalence of DM is higher among individuals with a history of diabetes in their families and is associated independently. A correlation between diabetes and physical inactivity was further recorded in the study. The level of physical inactivity can affect prevalence by its association with other factors such as obesity and hypertension [28]. When interpreting the outcomes of the current research, some limitations should be taken into account. The current study is focused on cross-sectional results, so with caution it should be interpreted as associating diabetes with other independent variables. The gender composition of research participants was prejudice against males, and this may influence the approximate prevalence of DM in this study, which may explain why the prevalence of DM among women was much lower than at national level.

The major cluster identified was physical inactivity and BMI risk that was linked all other risk factors. In several trials, the association between physical inactivity as a risk factor for type 2 diabetes has been tested. Unfortunately, there is a lack of physical activity among the Saudi population [29]. For instance, AlQuaiz and Tayel (2009) conducted a cross-sectional analysis at King Khalid University Hospital (KKUH) in Riyadh city on 450 Saudi participants and documented a prevalence of physical inactivity of 82 percent among participants. They also stressed that 88 percent of women were more physically inactive than 72 percent of males [30]. The third cluster with age, smoking, male, hypertension and metabolic syndrome. Family history is an important risk factor which is not clustered in our findings. Poor lifestyle habits have been dramatically related to metabolic syndrome. Physical inactivity is directly and inversely related to metabolic syndrome, which lowers with weight loss and daily physical activity [24]. In some trials, metabolic syndrome has been strongly linked with smoking. Tobacco use has been involved in insulin resistance pathogenesis, as smoking acutely impairs insulin action and causes insulin resistance [31,32].

This study was carried out at selected locations only, e.g., malls and banks whereas, healthcare centers could not be covered which would have noticeable implications. This was the main limitation of the study.

5. CONCLUSION

The prevalence of DM is 11.54 percent in the Albaha area. In Saudi population, the physical inactivity and high BMI risk factors are identified, and they are linked to other factors which are likely to develop diabetes. The increased incidence of diabetes calls for immediate efforts to encourage prevention and health promotion, which are interventions intended to minimize the burden of diabetes. Modification of the life style and awareness on obesity and physical inactivity are encouraged to be made available to the public to mitigate the risk of developing diabetes.

CONSENT AND ETHICAL APPROVAL

The study was reviewed and approved by the Ethics Committee of Faculty of Clinical Pharmacy, Albaha University. Participation was voluntary and verbal consent was acquired from all of the participants. Confidentiality of all the participants was maintained as no names were mentioned in the questionnaires, participants were told that they have the complete freedom to quit the study at any time.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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