SOCIO-DEMOGRAPHIC DETERMINANTS OF DIABETES AND PREDIABETES IN ALGERIAN ADULTS ACCORDING TO STEPWISE 2016-2017 SURVEY DATA

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Abstract: *Diabetes mellitus is one of the world's greatest public health concerns particularly in developing countries. The aim of this study is to examine the association of risk factors with diabetes and prediabetes in the adult population in Algeria. This is a cross-sectional descriptive study of adults aged between 18 and 69 years listed in the database of the STEPwise Algeria Survey conducted in 2016-2017, i. e. 7450 adults across the national territory. Using a multivariate logistic regression model, we assessed the role of different socio-demographic, economic, geographical and behavioural factors in the glycemic status of adults. The prevalence of diabetes and prediabetes was 14.3% and 8.2% respectively. The main factors associated with a significantly higher risk for prediabetes and diabetes were advanced age, south-eastern region, general obesity and hypertension. Other factors such as urban area of residence, marital status, low level of education, abdominal obesity, high cholesterol and heart attacks appear to be associated with diabetes only. These factors are often avoidable through preventive interventions based on early diagnosis, screening of at-risk subjects and therapeutic education, which can be beneficial for the Algerian population, by taking into consideration the socio-economic and cultural particularities of each health region and even of each patient.*

Keywords: diabetes mellitus, prediabetic state, determinant, adult , Algeria.

1. Introduction

The fight against non-communicable diseases and their risk factors is one of the major challenges of sustainable development in the 21st century. They have become an enormous health burden, particularly in low- and middle-income countries (World Health Organization [WHO] et al., 2014). Most Arab countries, including Algeria, are confronting a growing trend of non-communicable diseases as a result of economic, demographic and geographical transitions. Premature mortality from these diseases reaches 20% in 33% of Arab countries (Maamri and Ben El Mostafa, 2020).

Among the main chronic diseases is diabetes mellitus. It is a real global health threat that does not depend on socio-economic status and knows no borders. The main types of diabetes are type 1, type 2 and gestational diabetes. Type 2 diabetes is the most common form of diabetes (about 90% of cases) worldwide (International Diabetes Federation, 2011).

Currently, according to the International Diabetes Federation (IDF), there are an estimated 463 million people living with diabetes worldwide and this number is expected to rise to 578 million in 2030 and 700 million in 2045. 79.4% of them live in low- and middle-income countries according to estimates (IDF, 2019).

In the Middle East and North Africa region (MENA), 54.8 million adults aged 20-79 years will be living with diabetes in 2019, representing 12.8% of the regional population in this age group. 24.5 million of all persons with diabetes are unaware that they are living with diabetes (undiagnosed diabetes). It is estimated that the number of people living with diabetes in the region will increase by 38.8% by 2030 and 96.5% by 2045 (IDF, 2019). In addition, 35.5 million adults aged between 20 and 79, or 8.3% of the regional population in this age group, are prediabetics. The term "prediabetes" is often used to refer to people with glucose intolerance and/or impaired fasting glucose. This indicates a risk of future development of type 2 diabetes and diabetes-related complications (Nathan et al., 2007). Approximately 418,900 deaths in this region are due to diabetes and its complications in the 20-79 age group in 2019 (16.2% of all-cause mortality). About 53.3% of all these deaths occurred in people under 60 years of age. 86.7% of all diabetes-related deaths in the region occurred in middle-income countries (Meo et al., 2017; IDF, 2019).

Algeria is not exempt from this pandemic; the prevalence of this disease is constantly increasing. It increased from 2.1% in 1992 (Bezzaoucha, 1992) to 12.29% in 2005 (National Health Survey, 2005) and 14% in 2007 (Zaoui et al., 2007). Indeed, the demographic transition, which has affected Algeria for around half a century, has led to a decrease in infectious diseases and an increase in the incidence of chronic diseases such as diabetes. It should be noted that the phenomenon of "globalisation" over the last two decades, which has standardized lifestyles on a model favouring obesity and sedentary lifestyles, as well as longer life expectancy, have contributed to the proliferation of this disease (Belhadj, 2011).

To address this global health problem, the World Health Organization (WHO) and the United Nations (UN) have set global targets to encourage action to improve care and strengthen health systems. These measures include reducing premature deaths from non-communicable diseases (NCDs), including diabetes, by 30% until 2030, implementing national diabetes plans and achieving universal health coverage (WHO, 2018).

Risk factors such as high blood pressure, poor diet, smoking, obesity and physical inactivity are known to contribute to the growing trend of diabetes. On the other hand, diabetes education, support and a healthy lifestyle, combined with medication where appropriate, can effectively manage type 2 diabetes (Walker et al., 2014). However, several studies highlight action on the social determinants of health such as gender, economic status, education level, marital status, residence environment... which can reduce the burden of this disease (Gonzalez-Zacarias et al., 2016).

Few studies have focused on the analysis of the determinants related to diabetes and pre-diabetes in the overall population in Algeria. Most of the studies already carried out have been conducted at regional levels. Given that the Stepwises survey reports are limited to descriptive tables and the sociodemographic, economic, geographical and behavioural factors associated with the glycemic status of adults are not clearly identified ; the initiative was taken to examine the association of these factors with this phenomenon in order to provide information that can help the authorities to design appropriate prevention and control measures, and understand the determinants leading to an increase in the prevalence of diabetes in disparate regions of Algeria.

2. Materials and methods

2.1. Study design

This is a cross-sectional descriptive study of adults aged between 18 and 69 years listed in the database of the STEPwise Algeria Survey conducted in 2016-2017 by the Ministry of Health, Population and Hospital Reform - Directorate General for Prevention and Health Promotion, in collaboration with the National Institute of Public Health with the support of WHO HQ-Geneva and the WHO-Algeria representative office.

The "STEPwise" approach is a standardised tool developed and recommended by the WHO for the surveillance of risk factors for Non-Communicable Diseases and their morbidity and mortality (Riley et al., 2016).

The main objective of the STEPwise Algeria survey was to estimate the frequency of these factors on a representative sample of 7450 people, aged between 18 and 69 years, drawn at random, within households across the national territory (48 wilayas), taking into account geographical differences (coastline, highlands and southern region). Information on socio-demographic, behavioural and clinical characteristics was collected by using a three-step questionnaire. The first stage involves the collection of sociodemographic data and behavioural information, the second stage involves simple physical measurements (weight, height, waist and hip circumference), and the third stage is for biochemical testing (blood glucose testing) (Riley et al., 2016; Stepwise Algeria survey, 2016). A 3 stage cluster sampling design was used to produce representative data for this age group in Algeria. A sampling method where the target population is divided into clusters/groups and a subset of each cluster is selected instead of the entire cluster. The sampling modalities are described in detail in the survey report, which is available on the official WHO website (WHO, 2005; Stepwise Algeria survey, 2016). To obtain the survey database, the authors have systematically contacted and made a request on their official website (WHO microdata repository, 2016).

Ethical approval for this study was obtained from the committee of the National Council for Health Sciences Ethics - Ministry of Health, Population and Hospital Reform. A written consent was obtained from each participant prior to enrollment in the study. The aim of the survey, their rights and how confidentiality will be handled was explained to all participants as well as health benefits of the research for the community.

2.2. Definitions of variables

The subject was considered a person with diabetes if he had a capillary blood glucose level greater than or equal to 1.26g/l (newly diagnosed diabetes), or if he declared that he was diagnosed by health personnel as such (known diabetes). When capillary blood glucose levels were between 1.10 and 1.25 g/l, the subject is considered a person with prediabetes according to WHO international standards (IDF, 2019). This allowed us to divide the adults at last in three groups : Normal, prediabetes and diabetes.

In order to better identify the factors associated with prediabetes and diabetes, sociodemographic variables were selected from the database such as sex, age, level of education, professional status, socio-economic level expressed as monthly salary, residence environment (rural or urban), geographical area. Behavioural variables such as smoking, eating behaviour, physical inactivity and clinical variables such as general obesity, abdominal obesity, high blood pressure, high cholesterol and heart attacks.

The 48 wilayas registered were divided into five geographical regions according to the division adopted by the government in 1995. These are the regions: Centre, East, West, South-East and South-West (Brahmia, 2010).

A height/length measurement board and a portable scale were used to measure anthropometric parameters (weight and height) for each participant in order to calculate their body mass index (BMI) using standardised techniques by dividing weight in kilograms by the square of height in metres. A BMI below 18.5 was considered underweight, 18.5 to 24.9 normal weight, 25 to 29.9 overweight and over 29.9 was considered obese (WHO, 2018). Abdominal obesity has been defined by the WHO as a waist circumference of 94 cm or more in men and 80 cm or more in women (WHO, 2009).

Physical activity behaviour was assessed in three different aspects: work, transport and leisure. The activities are classified into two levels of intensity: vigorous and moderate. “Vigorous Intensity Activities” are activities that require a high level of physical effort and cause large increases in breathing or heart rate. “Moderate-intensity activities” are activities that require moderate physical effort and cause slight increases in breathing or heart rate. On this basis, an adult person should perform at least 150 minutes of moderate intensity work or 75 minutes of vigorous intensity work or 60 minutes of combined vigorous and moderate intensity work per week. If the reported physical activity did not meet the WHO recommendation, participants were classified as physically inactive (WHO, 2018).

Concerning the consumption of fruits and vegetables, two categories have been created. One category was created for those who reported consuming five or more servings of fruits and vegetables on a typical day, and the other for those who reported consuming less.

Blood pressure measurements were taken three times on the right arm of the survey participants in a sitting position, using digital automatic blood pressure monitor with a universal cuff. The mean of three measurements was taken for analysis. The measurements were taken after the participant had rested for 15 minutes, with three minutes of rest between the measurements. Raised blood pressure was defined as: systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg or where the participant is currently on antihypertensive medication (American Diabetes Association, 2014).

Laboratory tests were performed for total cholesterol and High-Density Lipoprotein cholesterol (HDL) using Cardiocheck PA blood meter and using a capillary drop of blood from their fingers. Raised cholesterol was defined as having raised fasting TC ≥200 mg/dl or currently on medication for raised cholesterol (Alberti et al., 2006).

For the subjective measurement of heart attacks, the following question was asked: "Have you ever had a heart attack?". On this basis, a dummy variable was created, which takes the value "yes" if the respondent answers " affirmatively to the question and "no" for the opposite.

For the socio-economic level, the monthly income reported by the respondent was used. The categories are based on the guaranteed national minimum wage (GNMW). This allowed us to divide individuals into four groups from the least wealthy to the wealthiest.

2.3. Statistical analysis

The statistical analysis was performed using SPSS version 25 statistical software (IBM Corp). The measurement of associations between individuals' diabetic status and its potential predictors were evaluated using logistic regression tests. From the bivariable logistic regression test model, only those variables having a significant association with the dependent variable were entered into the final multivariable regression model. The magnitude of the association was expressed as odds ratios (OR) with its 95% confidence interval. P values less than 0.05 were considered statistically significant. Multicollinearity between variables was assessed using the multicollinearity diagram (variance inflation factor and tolerance test). The final multivariate logistic regression model was found to be consistent with the results of the Hosmer-Lemeshow fit test.

3. Results

Among the 7,450 subjects aged 18 to 69, 6,989 were surveyed, i.e. a response rate of 93.8%, 3,082 men and 3,907 women, i.e. a sex ratio of 0.78. 883 adults were excluded from the study due to missed fasting blood glucose values. Thus, the study finally included 6106 adults, 2652 men (43.4%) and 3454 women (56.6%). The age group (30-44) represents the largest group in the sample with 39.0% followed by the group (45-59) estimated at 28.0%, the youngest group (18-29) with 21.0% and finally the oldest group with 11.9%. Table 1 summarises the socio-demographic, behavioural and clinical characteristics of the participants.

Table 1. Socio-demographic, geographical and behavioural characteristics of the study participants

Variables	Subjects	
	N	%
Sex		
male	2652	43.4
Female	3454	56.6
Age		
18-29	1283	21.0

30-44	2384	39.0
45-59	1712	28.0
60-69	727	11.9
Residence		
Urban	4085	66.9
Rural	2021	33.1
Geographical region		
north-centre	2135	34.9
north-west	1405	23.0
north-east	1962	32.1
South-west	202	3.3
south-east	401	6.7
Marital statut		
Single	1456	23.8
Married	4245	69.5
separated	174	2.9
Widowed	221	3.7
Education level		
Illiterate	968	15.8
Elementary	1040	17.0
Middle	1437	23.6
Secondary	1405	23.2
university	1240	20.3
Professionnel statut		
unemployed	1486	24.3
Government employee	1046	17.1
Non-government employee	642	10.5
Self-employed	698	11.5
Home maker	1785	29.2
Retired	449	7.3
Salary category		
GNMW and less	1093	28.6
+ 1 to 2 times GNMW	1496	39.2
+ 2 times to 4 times GNMW	888	23.3
+ 4 fois GNMW	340	8.9

Table 1. Socio-demographic, geographical and behavioural characteristics of the study participants (continued)

Variables	Subjects	
	N	%
BMI		
normal	1755	29.7
underweight	133	2.2
overweight	2542	43.0
obesity	1485	25.1
Abdominal obesity		
Yes	4049	68.5
No	1860	31.5
Blood pressure		
Yes	1989	32.8
No	4058	67.1
Hypercholesterolemia		
Yes	1568	25.8
No	4508	74.1
Heart attack		
Yes	385	6.3
No	5709	93.5

Tobacco consumption		
Current smoker	703	11.5
Ex-smoker	688	11.3
Non-smoking	4715	77.2
Consumption of fruits and vegetables		
Less than 5 potions	5054	84.9
5 potions and more	901	15.1
Physical activity		
- 150 min/week	1585	26.0
150 and more min/week	4521	74.0

BMI: Body Mass Index; GNMW: guaranteed national minimum wage; min: minute.

The prevalence of diabetes mellitus in the study was estimated as 14.3%, of which 4.4% were newly diagnosed (30.53% of all diabetes) and 9.9% were previously diagnosed by health personnel (self-reported).The prevalence of prediabetes was estimated at 8.2%, while the prevalence of normoglycaemics was 77.6%. Details concerning the classification of the sample according to glycemic status are summarised in figure 1 (see Figure 1). **Figure 1. Flow chart of blood glucose status.**

The results of the multivariate logistic regression for prediabetes are presented in Table 2. After adjustment, the results show that the factors associated with prediabetes are mainly age, geographical region, weight status, hypertension and hypercholesterolemia. Indeed, the risk of having prediabetes increases two and a half times in the (45-59) age group (AOR=2.53; CI [1.66-4.00]; P<0.001), and more than four times in the (60-69) age group (AOR=4.14; CI [2.45-6.91]; P<0.001) compared to the younger age group (18-29). Adults living in the geographic region of the South-East have a risk of prediabetes estimated to be nearly five times higher than those in the North-Central region (AOR=4.80; CI [3.27-7.05]; P<0.001), whereas the North-East region appears to have less risk compared to the reference region (AOR=0.68; CI [0.50-0.92]; P<0.05).Obese people have a 1.38 higher risk of having prediabetes than normal people (AOR=1.38; CI [1.03-1.80]; P<0.05). On the other hand, hypertension and hypercholesterolemia in participants also appeared to increase the risk of prediabetes by 1.65 (CI [1.25-2.18]; P<0.001) and 1.45(CI [1.08-1.95]; P<0.05) respectively.

Table 2. Multiple logistic regression analysis of studied risk factors for prediabetes versus non-diabetes

Variable	Normal		Pre-diabetes		COR (95 CI)	AOR (95 CI)	P-Value
	N	%	N	%			
Sex							
male	2087	90.46	220	9.54	1		
Female	2649	90.47	279	9.53	1.01 (0.84,1.23)		NS
Age							
18-29	1146	93.63	78	6.37	1	1	
30-44	2016	91.89	178	8.11	1.23 (0.91,1.60)	1.46 (0.97,1.85)	NS
45-59	1176	88.42	154	11.58	1.81 (1.38,2.45)	2.53 (1.66,4.00)	<0.001
60-69	390	81.42	89	18.58	2.92(2.08,4.04)	4.14 (2.45,6.91)	<0.001
Residence							
Urban	3076	90.10	338	9.90	1		
Rural	1660	91.16	161	8.84	0.85 (0.68,1.01)		NS
Geographical region							
north-centre	1674	92.03	145	7.97	1	1	
north-west	1043	89.45	123	10.55	1.37(1.03,1.67)	1.28(0.97,1.58)	NS
north-east	1582	93.61	108	6.39	0.79(0.62,1.01)	0.68(0.50,0.92)	<0.05
South-west	168	93.85	11	6.15	0.63(0.27,1.07)	0.53(0.21,1.35)	NS

south-east	259	70.19	110	29.81	4.87(3.91,6.62)	4.80(3.27,7.05)	<0.001
Marital statut							
Single	1272	92.64	101	7.36	1	1	
Married	3225	90.18	351	9.82	1.42(1.12,1.83)	0.78(0.53,1.05)	NS
separated	110	84.62	20	15.38	2.05(1.15,3.50)	0.89(0.42,1.98)	NS
Widowed	123	85.42	21	14.58	1.78(1.03,3.07)	0.65(0.34,1.26)	NS
Education level							
Illiterate	682	90.45	72	9.55	1.04 (0.75,1.39)		NS
Elementary	751	88.56	97	11.44	1.26 (0.98,1.73)		NS
Middle	1136	91.91	100	8.09	0.90 (0.69,1.17)		NS
Secondary	1114	90.20	121	9.80	1.12 (0.87,1.45)		NS
University	1037	90.96	103	9.04	1		
Professionnel statut							
unemployed	1204	91.98	105	8.02	1	1	
Government employee	834	90.55	87	9.45	1.18 (0.85,1.66)	1.15(0.81,1.63)	NS
Non-government employee	545	94.29	33	5.71	0.62 (0.43,0.98)	0.69 (0.42,1.14)	NS
Self-employed	563	90.66	58	9.34	1.15 (0.81,1.62)	1.10(0.72,1.68)	NS
Home maker	1306	89.03	161	10.97	1.40 (1.07,1.81)	1.52(0.94,2.40)	NS
Retired	269	83.54	53	16.46	2.17 (1.51,3.12)	1.19(0.76,1.88)	NS

BMI: Body Mass Index; GNMW: guaranteed national minimum wage; CI: Confidence Interval; COR: crude odds ratio; AOR: Adjusted odds ratio; P-Value: signification; NS: not significant.

Table 2. Multiple logistic regression analysis of studied risk factors for prediabetes versus non-diabetes (continued)

Variable	Normal		Pre-diabetes		COR (95 CI)	AOR (95 CI)	P-Value
	N	%	N	%			
Salary category (GNMW)							
GNMW and less	859	90.52	90	9.48	1		
+ 1 to 2 times	1163	91.07	114	8.93	0.98 (0.70,1.36)		NS
+ 2 to 4 times	676	90.13	74	9.87	1.20 (0.83,1.67)		NS
+ 4 times	257	90.18	28	9.82	0.99 (0.60,1.63)		NS
BMI							
normal	1753	91.88	155	8.12	1	1	
underweight	173	92.51	14	7.49	0.77 (0.38,1.55)	0.96 (0.37,2.50)	NS
overweight	1587	90.27	171	9.73	1.30 (1.02,1.64)	1.17(0.88,1.55)	NS
obesity	1163	89.74	133	10.26	1.52 (1.17,1.98)	1.38(1.03,1.80)	<0.05
Abdominal obesity							
Yes	3010	90.20	327	9.80	1.21(0.96,1.49)		
No	1570	91.76	141	8.24	1		
Tobacco consumption							
Current smoker	580	93.10	43	6.90	0.75 (0.50,0.98)		NS
Ex-smoker	481	87.77	67	12.23	1.33(1.00,1.76)		
Non-smoking	3682	90.73	376	9.27	1		
Blood pressure							
Yes	1260	87.1	187	12.90	1.82(1.49,2.21)	1.65(1.25,2.18)	<0.001
No	3446	92.50	281	7.50	1	1	
Chotesterolemia							
Yes	1059	88.90	132	11.11	1.33 (1.08,1.65)	1.45(1.08,1.95)	<0.05
No	3684	91.50	344	8.50	1	1	

Heart attack					
Yes	251	89.01	31	10.99	0.78 (0.47,1.26)
No	4495	90.90	450	9.10	1
Consumption of fruits and vegetables					
Less than 5 potions	3927	90.80	398	9.20	1.16 (0.87,1.55)
5 potions and more	701	91.28	67	8.72	1
Physical activity					
- 150 min/week	1179	90.14	129	9.86	1.12 (0.92,1.36)
150 and more min/week	3568	91.14	347	8.86	1

BMI: Body Mass Index; GNMW: guaranteed national minimum wage; CI: Confidence Interval; COR: crude odds ratio; AOR: Adjusted odds ratio; P-Value: signification; NS: not significant.

The factors associated with diabetes mellitus according to the multivariate logistic regression results presented in Table 3 are age, area of residence, geographical region, marital status, education level, weight status, abdominal obesity, smoking, hypertension, hypercholesterolaemia and heart attacks. The analysis revealed that the risk of developing diabetes in adults increased by 1.56 times in the (30-44) age group (AOR=1.56; CI [1.11-2. 13]; P<0.05), almost five times in the (45-59) age group (AOR=4.82; CI [3.45-6.29]; P<0.001), and 8.53 times in the (60-69) age group (AOR=8.53; CI [5.92-12.24]; P<0.001) compared to the (18-29) age group. People living in rural areas are less likely to have diabetes compared to those living in urban areas with (AOR=0.62; [0.52-0.74]; P<0.001).Similar to prediabetes, the risk of diabetes appears to be increased in the South-East region by 2.81 times compared to the North-Central region (AOR=2.81; CI [2.12-3.74]; P<0.001).The risks of having diabetes among married, separated and widowed people are respectively 1.63 (CI [1.23-2.16]; P<0.01), 2.72 (CI [1.71-4.31]; P<0.001) and 2.13 (CI [1.42-3.22]; P<0.001) higher than that of single people. Regarding the level of education, those with middle and secondary level seem to have a higher risk of diabetes than those with university education (AOR=1.43; CI [1.08-1.88]; P<0.05); (AOR=1.41; CI [1.07-1.85]; P<0.05). The results also showed that general obesity and abdominal obesity can increase the risk of developing diabetes by 1.73 (CI [1.19-3.39]; P<0.05) and 1.51 (CI [1.05-2.18]; P<0.05) times respectively. Adults with co-morbidity such as hypertension had a 3.34 times greater risk of having diabetes (CI [2.69-4.14]; P<0.001), those with hypercholesterolemia had a 2.1 times greater risk (CI [1.66-2.64]; P<0.01), and those who reported having had a heart attack had a 1.5 (CI [1.06-2.10]; P<0.05) times greater risk of having diabetes than their peers. Concerning smoking, it appears that ex-smokers have a two times greater risk than non-smokers of developing diabetes (AOR=2.02; CI [1.56-2.60]; P<0.001).Thus, none of the factors such as gender, employment status, salary, fruit and vegetable consumption and physical activity seem to influence the risk of developing diabetes.

Table 3. Multiple logistic regression analysis of studied risk factors for diabetes versus non-diabetes

Variable	Normal		Diabetes		COR (95 CI)	AOR (95 CI)	P-Value
	N	%	N	%			
Sex							
Male	2087	85.81	345	14.19	1	1	
Female	2649	83.43	526	16.57	1.20 (1.04,1.39)	1.05 (0.82,1.35)	NS
Age							
18-29	1146	95.10	59	4.90	1	1	
30-44	2016	91.39	190	8.61	1.82 (1.34,2.45)	1.56 (1.11,2.13)	<0.05
45-59	1176	75.87	374	24.13	6.28 (4.76,8.36)	4.82 (3.45,6.29)	<0.001

60-69	390	61.13	248	38.87	12.20(9.00,16.56)	8.53 (5.92,12.2)	<0.001
Residence							
Urban	3076	82.09	671	17.91	1	1	
Rural	1660	89.25	200	10.75	0.55(0.46,0.65)	0.62 (0.5,0.74)	<0.001
Geographical region							
north-centre	1674	85.06	294	14.94	1	1	
north-west	1043	83.44	207	16.56	1.13(0.93,1.37)	1.22(0.99,1.50)	NS
north-east	1582	86.31	251	13.69	0.96(0.80,1.09)	0.97(0.80,1.18)	NS
South-west	168	88.42	22	11.58	0.73(0.42,1.18)	1.08(0.62,1.62)	NS
south-east	259	70.38	109	29.62	2.38(1.84,3.07)	2.81(2.12,3.74)	<0.001
Marital statut							
Single	1272	94.01	81	5.99	1	1	
Married	3225	82.67	676	17.33	3.30(2.67,4.23)	1.63(1.23,2.16)	<0.01
separated	110	70.51	46	29.49	6.41(4.26,9.66)	2.72(1.71,4.31)	<0.001
Widowed	123	60.89	79	39.11	9.80(6.87,13.98)	2.13(1.42,3.22)	<0.001
Education level							
Illiterate	682	76.29	212	23.71	2.97 (2.32,3.80)	1.43(1.08,1.88)	<0.05
Elementary	751	80.58	181	19.42	2.31(1.80,2.97)	1.41(1.07,1.85)	<0.05
Middle	1136	85.22	197	14.78	1.65(1.25,2.05)	1.14 (0.83,1.5)	NS
Secondary	1114	85.96	182	14.04	1.55(1.20,2.00)	1.18(0.88,1.59)	NS
university	1037	90.49	109	9.51	1	1	
Professionnel statut							
unemployed	1204	88.59	155	11.41	1	1	
Government employee	834	86.42	131	13.58	1.16(0.90,1.49)	0.97(0.71,1.32)	NS
Non-government employee	545	90.98	54	9.02	0.83 (0.60,1.16)	0.76 (0.52,1.1)	NS
Self-employed	563	87.69	79	12.31	1.13(0.85,1.50)	0.87(0.62,1.24)	NS
Home maker	1306	79.54	336	20.46	2.11(1.72,2.60)	1.22(0.97,1.55)	NS
Retired	269	67.93	127	32.07	3.55(2.72,4.63)	1.12(0.80,1.58)	NS

BMI: Body Mass Index; GNMW: guaranteed national minimum wage; CI: Confidence Interval; COR: crude odds ratio; AOR: Adjusted odds ratio; P-Value: signification; NS: not significant.

Table 3. Multiple logistic regression analysis of studied risk factors for diabetes versus non-diabetes (continued)

Variable	Normal		Diabetes		COR (95 CI)	AOR (95 CI)	P-Value
	N	%	N	%			
Salary category (GNMW)							
GNMW and less	859	86.07	139	13.93	1		
+ 1 to 2 times	1163	85.45	198	14.55	1.069(0.85,1.35)		
+ 2 to 4 times	676	84.39	125	15.61	1.126(0.87,1.46)		
+ 4 times GNMW	257	83.17	52	16.83	1.229(0.87,1.73)		
BMI							
normal	1753	91.49	215	8.51	1	1	
underweight	173	96.11	11	3.89	0.55 (0.26,1.19)	1.88(0.59,6.38)	NS
overweight	1587	80.85	329	19.15	1.75 (1.44,2.13)	1.42(0.98,2.06)	NS
obesity	1163	79.55	307	20.45	2.53 (2.06,3.11)	1.73(1.19,3.39)	<0.05
Abdominal obesity							
Yes	3010	81.15	699	18.85	2.30 (1.91,2.75)	1.51 (1.1,2.18)	<0.05

No	1570	90.75	160	9.25	1	1	
Tobacco consumption							
Current smoker	580	91.19	56	8.81	0.54 (0.39,0.75)	1.21 (0.87,1.7)	NS
Ex-smoker	481	76.23	150	23.77	1.60 (1.30,1.95)	2.02 (1.56,2.6)	<0.001
Non-smoking	3682	84.47	677	15.53	1	1	
Blood pressure							
Yes	1260	69.90	542	30.10	4.48 (3.85,5.20)	3.34(2.69,4.14)	<0.001
No	3446	91.20	331	8.80	1	1	
Chotesterolemia							
Yes	1059	73.7	377	26.30	2.73 (2.34,3.17)	2.09(1.66,2.64)	<0.001
No	3684	88.50	480	11.50	1	1	
Heart attack							
Yes	251	70.70	104	29.30	2.36 (1.86,2.99)	1.49(1.06,2.10)	<0.05
No	4495	85.47	764	14.53	1	1	
Consumption of fruits and vegetables							
Less than 5 potions	3927	84.34	729	15.66	0.93 (0.76,1.14)		
5 potions and more	701	84.36	130	15.64	1		
Physical activity							
- 150 min/week	1179	80.98	277	19.02	1.42 (1.22,1.66)	1.09(0.85,1.39)	NS
150 and more min/week	3568	85.48	606	14.52	1	1	

BMI: Body Mass Index; GNMW: guaranteed national minimum wage; CI: Confidence Interval; COR: crude odds ratio; AOR: Adjusted odds ratio; P-Value: signification; NS: not significant.

4. Discussion

This study was conducted on a representative sample of 6106 adults using data from the national Stepwise survey 2016-2017. It allowed describing the socio-demographic determinants associated with the prevalence of diabetes and prediabetes in Algeria. The results indicated that 14.3 of the population had diabetes of which 4.4 were newly diagnosed (30.53 of all diabetes). This proportion is higher than in some previous studies. In 1992, a survey carried out in Algiers on 9384 inhabitants found a prevalence of known diabetes of 2.1 (Bezzaoucha, 1992). In 2003, the Stepwise survey conducted on 4050 people in two geographical areas, the East (Setif) and the West (Mostaganem) found an overall prevalence of 8.9 (Stepwise Algeria survey, 2003). In 2006, a survey conducted on a sample of 7656 individuals in Tlemcen found a prevalence of type 2 diabetes equal to 10.5 (Zaoui et al., 2007). On the other hand, 7.04 and 7.2 are respectively the rates of diabetes found by the international diabetes federation in 2011 and 2019 (IDF, 2019; IDF, 2011). The prevalence of diabetes found in results is also higher than the world prevalence which is about 9.3, the African region (3.9) and the MENA region (12.8) (IDF, 2019). It is also higher than the rate found in Morocco (12.4) (Chetoui et al., 2018), Kuwait (13.42) (Nikoloski, 2020), Indonesia (13.0) (Idris et al., 2013) and comparable to Iran's rate which is 14.1 (Mirzaei et al., 2020). However, it remains lower than found in Tunisia (15.1) (Maoui et al., 2019), Egypt (24.9) (Assad-khalil et al., 2018), Sudan (22.1) (IDF, 2019), Libya (18.8) (Meo et al., 2017) and China (15.5) (Liu et al., 2020).

About 5-10 of people with prediabetes develop diabetes each year, although the conversion rate varies depending on population characteristics and the definition of prediabetes (Nathan et al., 2007). The results showed an estimated prevalence of prediabetes of 8.2. This prevalence is higher than the world prevalence reported by IDF which is 7.5, and comparable to that of the MENA region which is 8.3 (IDF, 2019). Meanwhile, it is lower than that of Africa (9.0) (IDF, 2019), Blida (Central Algeria) (10.6) (Bachir-cherif et al., 2018), Oran (11.6) (Houti et al., 2016), Egypt (13.1) (WHO, 2018) and Iran (20.7) (Mirzaei et al., 2016).

30.53 of adults living with diabetes in the study did not know they had diabetes. Although this prevalence remains lower than the global prevalence which is reported by the IDF at 50.1, that of Africa (59.7) and the MENA region which is estimated at 44.7 (IDF, 2019), This figure is still alarming. If these adults were not included in this survey, it means that these cases of diabetes may run a higher risk of complications, which would be too late to reverse, causing more frequent use of care and higher costs. Therefore, early and rapid detection is essential for better detection of diabetes.

Nevertheless, all these comparisons should be interpreted with caution, given the variance in design, sampling, target population (general or hospital, etc.), inclusion age, definition of diabetes and undiagnosed cases, which makes direct comparisons more difficult.

The results showed that the prevalence of diabetes and prediabetes found in this survey are associated with several factors. The difference of this prevalence in both sexes has been investigated in several studies. Some have found that the rate of prediabetes and diabetes is higher in women (Chentli et al., 2014; Idris et al.,2017; Maoui et al., 2019) explaining this difference by the hormonal profile of women which is considered as a factor leading to obesity. While others have found that this rate is in favour of men (Belkacem and Semrouni, 2018; Eltom et al., 2018). Navarro and al explained in their study in 2015 that testosterone deficiency leads to metabolic dysfunction and predisposes to diabetes in older men (Navarro et al., 2015). In the results, although the proportion of diabetes in women is relatively higher than men, multiple regression showed that the prevalence of the two glycaemic states are comparable in both sexes. These results are in line with several studies (Belmokhtar et al., 2011; Liu et al., 2020;).

The prevalence of prediabetes and diabetes increases significantly with age. These results are consistent with reports from studies in Algeria (Houti et al., 2016; Bachir-Cherif et al., 2018), North Africa (Chetoui et al., 2018; Maoui et al., 2019) and worldwide (Eltom et al., 2018; Endris et al., 2019; Mirzari et al., 2020). Indeed, we note an ageing of the population in Algeria and everywhere in the world expressed by an increase in life expectancy which explains the high proportion of diabetes on one hand. On the other hand, some authors argue that in elderly people there is a decrease in insulin secretion and an increase in insulin resistance (Rcette et al., 2006; Endris et al., 2019;).

The high risk of diabetes prevalence in urban areas observed in the results is in agreement with the results of many studies (Animaw and Seyoum, 2017; Chetoui et al., 2018; Maoui et al., 2019). Most consider that this is probably due to the living conditions in these areas, where access to fast food, ready-made and frozen food rich in fat and energy is easier, not forgetting the availability of transport creating a sedentary environment. In contrast to rural areas, where people often have higher levels of physical activity due to the intense agricultural activities that are usually their main occupation.

The direct reasons of the positive association between prediabetes and diabetes with the South East region are unknown, but it is thought that it is probably due to the living conditions in this environment, such as poor potable water supply, accessibility of sanitary structures, lack of specialized medical coverage as well as the lack of various facilities found in the northern regions. In addition, variations in the level of urbanization and socio-economic status of specific sub-populations as well as differences in lifestyle and eating habits between the southern and northern regions of Algeria could be responsible for this difference. But as it is only speculation, it may be an incentive for further research (Maoui et al., 2019).

The association between diabetes and married, separated and widowed status observed in the results is found in several studies (Belmokhtar et al., 2011; Assad-Khalil et al., 2018). These studies argue that the socio-economic level decreases when the family grows. At the same time, several other studies highlight the protective effect of marriage compared to the situation of single or separated people (Idris et al., 2017; Yaghoubi et al., 2020).

Being married can provide diabetic patients with social support that can help reduce the stress due to affection between couples. Contrary to separated or single people who are prone to negative effects and depression due to their experiences (Yaghoubi et al., 2020).

The effect of education level on the prevalence of diabetes is highly controversial. It is true that educational level is one of several factors that determines a person's behavior. As it is linked to access and use of health services, it also influences families' choices about diet, personal care and disease prevention. In our results we found an association between diabetes and low level of education, a finding found in several studies (Belmokhtar et al., 2011; Assad-Khalil et al., 2018; Endris et al., 2019; Nikoloski, 2020). However, having a high level of education does not necessarily mean having knowledge of nutrition and dietetics, as several studies have found a positive relationship between diabetes and high education (Swasey et al., 2020; Seiglie et al., 2020).

In the study, socio-economic level and occupation of participants did not emerge as factors favoring the development of diabetes. These results corroborate the findings of several studies (Animaw and Seyoum, 2017; Idris et al., 2017; Maoui et al., 2019). The association of general and abdominal obesity with the high prevalence of diabetes observed in the results is in line with the results found in the literature in Algeria (Belmokhtar et al., 2011; Belkacem and Semrouni, 2018; Maoui et al., 2019) and worldwide (Endris et al., 2019; Lui et al., 2020; Swasey et al., 2020; Seiglie et al., 2020). This association is often found in females (Chetoui et al., 2018; Assad-Khalil et al., 2018; Mirzaei et al., 2020), usually due to their hormonal profiles, or, as some authors have explained, this may be considered in some regions as a cultural determinant of female beauty (Maoui et al., 2019; Chentli et al., 2020). The strong association of obesity with diabetes has imposed a new term to describe this linkage, which is "Diabesity". Obesity is capable of inducing or worsening insulin resistance and can also cause a range of metabolic syndrome and cardiovascular disease manifestations (Navarro et al., 2015).

Like many previous studies, hypertension and hypercholesterolaemia has been found to be associated with prediabetes and diabetes (Belmokhtar et al., 2011; Endris et al., 2019; Yu et al., 2020). The same results have been observed for hypercholesterolaemia, which corroborates several reports (Assad-Khalil et al., 2018; Endris et al., 2019; Lui et al., 2020), as well as heart attacks (Hills et al., 2018; Yaghoubi et al., 2020). This situation of comorbidity has often been attributed in part to poor adherence and long-standing diabetes.

The results showed a higher prevalence of diabetes in ex- smokers compared to current smokers, It should be noted that, according to some authors, smoking cessation can lead to weight gain and an increased risk of obesity which can lead to the development of diabetes (Maier et al., 2014). Although several studies have indicated that poor diet and lack of physical activity increase the risk of diabetes (Assad-Khalil et al., 2018; Nikoloski, 2020; Liu et al., 2020), the study did not show a significant association between these factors and the prevalence of glycemic status. Urbanization, mechanization of work and transport lead to an increasing sedentarisation resulting in a change in lifestyle with a strong increase of inactivity. For diabetes, reduced physical activity is responsible for a decrease in glucose uptake by the muscles and an increase in insulin resistance (Maamri and Benelmostafa, 2020). The non-association between glycemic status and daily portions of fruits and vegetables observed in the results can be explained by the Mediterranean diet which is described by several authors as beneficial in the management of type 2 diabetes and helps to improve blood sugar and cholesterol levels in metabolic syndrome and in the prevention of diabetes (O'Connor et al., 2020).

4.1. Limitations

It should be noted that this study has several limitations. First, the definition of biochemical diabetes in this survey was limited to a single glucose measurement. In addition, the real prevalence of diabetes may be imprecise either because of under- or over-reporting resulting from self-reporting of diabetes, or because of the use of capillary readings, which remain less accurate than other laboratory methods requiring sample dilution. The data collected on diabetes do not distinguish between different types of diabetes. Considering that type 1 diabetes and other types of diabetes generally account for 5 of the total adult population with diabetes, this may suggest that the associations observed in the analysis are more pertinent to type 2 diabetes. In addition, HbA1c data (glycated haemoglobin) that are needed to correctly estimate diabetes prevalence and adherence were unavailable. Another limitation was that the study did not include people over 69 years of age, which may bias the overall prevalence of diabetes in the population. Finally, the variables examined in this study can only explain part of the determinants of diabetes mellitus, which is a complex disease to understand. Other socio-anthropological factors, more contextualized, can help us to better understand and define this phenomenon, without forgetting the genetic predispositions that have not been studied in this study.

5. Conclusion

Older age, Southeast region, general obesity, and hypertension appear to be related to the prevalence of prediabetes, while in addition to the factors mentioned above, urban area of residence, marital status, low level of education, abdominal obesity, hypercholesterolemia, and heart attacks seem to be related to diabetes. These factors are often preventable by preventive interventions based on early diagnosis through screening of at-risk individuals and therapeutic education, which may be more beneficial by considering the socio-economic and cultural particularities of each health region and even of each patient. These results should help measure progress towards the goals of the new 2030 Agenda for Sustainable Development, and will be very useful for the development, monitoring and evaluation of population policies and health programs, particularly prevention programs, which would help reduce the incidence of diabetes.

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Ethics approval and consent to participate

The World Health Organization noted in its report that the ethical approval was validated by the relevant Algerian authorities and informed consent was obtained from every survey participant before conducting the interviews

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Author Contributions

Adel Sidi-Yakhlef was in charge of conceptualization and formal analysis. Abdellatif Moussouni was in charge of methodology. Meryem Boukhelif and Houari Hamdaoui contributed to writing of the first draft of the paper. Amaria Metri-Aouar provided a critical review of the data analysis and manuscript. All authors reviewed drafts of the manuscript, provided suggestions for refinement and provided approval for the version to be published.

Availability of data

The data supporting the findings of this study are available on request to the following address: https://extranet.who.int/ncdsmicrodata/index.php/catalog/91

References:

1. Alberti, KG.; Zimmet, P.; Shaw, J. (2006). Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med. 23(5):469-480. doi:10.1111/j.1464-5491.2006.01858.x American Diabetes Association. Standards of medical care in diabetes. Diabetes Care 2014: 37(Suppl 1): S14–S80
2. Animaw, W.; Seyoum, Y. (2017). Increasing prevalence of diabetes mellitus in a developing country and its related factors. Schooling CM, editor. PLoS ONE. 7;12(11):e0187670.
3. Assaad Khalil, SH.; Megallaa, MH.; Rohoma, KH.; Ismael, H.; AbouSeif, M.; Kharboush, I. (2018). Prevalence of type 2 diabetes mellitus in a sample of the adult population of Alexandria, Egypt. DiabetesResearch and Clinical Practice. 144:63–73.
4. BachirCherif, A.; Bennouar, S.; Bouamra, A.; Taleb, A.; Hamida, F.; Temmar, M. (2018). Prevalence of diabetes and dyslipidemia in hypertensive patients in the area of Blida (Algeria). Annales de Cardiologie et d'Angéiologie. 67(3):198–203.
5. Belhadj, M. (2011). Le diabète en Algérie. Médecine des Maladies Métaboliques.5(4):5–6. doi:10.1016/s1957-2557(11)70061-x
6. Belkacem, S. ; Semrouni, M. (2018). Les facteurs de risque du diabète sucré chez une population à haut risque. Annales d'Endocrinologie. 1;79(4):483.
7. Belmokhtar, F.; Belmokhtar, R.; Charef, M. (2011). Risk Factors Associated With Type 2 Diabetes Mellitus in West Region of Algeria, Maghnia. J Diabetes Metab [Internet]. [cited 2021 Jan 25];02(05). Available from: https://www.omicsonline.org/risk-factors-associated-with-type-2-diabetes-mellitus-in-west-region-of-algeria-maghnia-2155-6156.1000148.php?aid=2026.
8. Brahamia, B. (2010). Économie de santé, évolution et tendance des systèmes de santé. Edition Bahaeddine, Constantine. P.363.
9. Bezzaoucha, A (1992). Le diabète sucré connu à Alger : fréquence et conséquences. Diabète Metab (Paris) ;18:229-35.
10. Chentli, F.; Azzoug, S.; Meskine, D.; El Gradechi, A .(2014). Gender discrimination for women with diabetes mellitus in Algeria. Indian J Endocrinol Metab. 18(6):804-10. doi: 10.4103/2230-8210.141351. PMID: 25364674; PMCID: PMC4192985.
11. Chetoui, A.; Kaoutar, K.; Kardoudi, AE.; Boutahar, K.; Chigr, F.; Najimi, M. (2018). Epidemiology of diabetes in Morocco: review of data, analysis and perspectives. 9(12):8.
12. Eltom, MA.; Babiker Mohamed, AH.; Elrayah-Eliadarous, H.; Yassin, K.; Noor, SK.; Elmadhoun, WM. (2018). Increasing prevalence of type 2 diabetes mellitus and impact of ethnicity in north Sudan. Diabetes Research and Clinical Practice. 136:93–9.
13. Endris, T.; Worede, A.; Asmelash, D. (2019). Prevalence of Diabetes Mellitus, Prediabetes and Its Associated Factors in Dessie Town, Northeast Ethiopia: A Community-Based Study. DMSO. 12:2799–809.
14. Enquête Stepwise Algérie 2016-2017 : Meilleure connaissance du profils de santé des Algériens pour les facteurs de risques des maladies non transmissibles [Internet]. Regional Office for Africa. [cited 2021 Feb 11]. Available from: https://www.afro.who.int/fr/media-centre/events/enquete-stepwise-algerie-2016-2017-meilleure-connaissance-du-profil-de-sante.
15. Gonzalez-Zacarias, AA. ; Mavarez-Martinez, A. ; Arias-Morales, CE. ; Stoicea, N. ; Rogers, B. (2016). Impact of Demographic, Socioeconomic, and Psychological Factors on Glycemic Self-Management in Adults with Type 2 Diabetes Mellitus. Front Public Health [Internet]. [cited 2021 Feb 22];4. Available from: http://journal.frontiersin.org/Article/10.3389/fpubh.2016.00195/abstract

16. Hills, AP.; Arena, R.; Khunti, K.; Yajnik, CS.; Jayawardena, R.; Henry, CJ. (2018). Epidemiology and determinants of type 2 diabetes in south Asia. The Lancet Diabetes & Endocrinology. 1;6(12):966–78.
17. Houti, L.; Ouhaibi-Djellouli, H.; Hamani-Medjaoui, I.; Lardjam-Hetraf, S.; Goumidi, L.; Mediene-Benchekor, S .(2016). CA-082: Épidémiologie du diabète de type 2 et ses facteurs de risque dans la population adulte oranaise (Étude ISOR). Diabetes&Metabolism. 42:A57.
18. Idris, H.; Hasyim, H.; Utama, F. (2017). Analysis of Diabetes Mellitus Determinants in Indonesia: A Study from the Indonesian Basic Health Research 2013. Acta Med Indones. 49(4):8.
19. International Diabetes Federation (IDF). (2011). IDF diabetes atlas, 5th edition [Internet]. Availablefrom www.diabetesatlas.org/. accessed March 2020.
20. International Diabetes Federation (IDF). (2019). IDF diabetes atlas, 8th edition [Internet]. Availablefrom www.diabetesatlas.org/. accessed March 2020.
21. Liu, C.; Li, X.; Lin, M.; Zheng, L.; Chen, X. (2020). A cross-sectional study on diabetes epidemiology among people aged 40 years and above in Shenyang, China. Sci Rep. 10(1):17742.
22. Maamri, A.; Ben El Mostafa, S. (2020). The Environmental Health Role in Reducing Non Communicable Diseases Through a Healthy Lifestyle. In: Boutayeb A. (eds) Disease Prevention and Health Promotion in Developing Countries. Springer, Cham. 2020. Pp. 39-59. https://doi.org/10.1007/978-3-030-34702-4_4
23. Maier, W. ; Scheidt-Nave, C. ; Holle, R. ; Kroll, LE. ; Lampert, T. ; Du, Y. ; Heidemann, C. ; Mielck, A. (2014). Area level deprivation is an independent determinant of prevalent type 2 diabetes and obesity at the national level in Germany. Results from the National Telephone Health Interview Surveys 'German Health Update' GEDA 2009 and 2010. PLoS One. 27;9(2):e89661. doi: 10.1371/journal.pone.0089661. PMID: 24586945; PMCID: PMC3937320.
24. Maoui, A.; Bouzid, K.; Abdelaziz, AB.; Abdelaziz, AB. (2019). Epidémiologie du Diabète de Type 2 au Grand Maghreb. Exemple de la Tunisie. Revue systématique de la littérature. Epidemiology of Type 2 Diabetes in the Greater Maghreb. Example of Tunisia. Systematic review of the literature. La Tunisie Médicale. 97:10
25. Meo, SA.; Usmani, AM.; Qalbani, E .(2017). Prevalence of type 2 diabetes in the Arab world: impact of GDP and energy consumption. Eur Rev Med Pharmacol Sci. 21(6):1303-1312.
26. Mirzaei, M.; Rahmaninan, M.; Mirzaei, M.; Nadjarzadeh, A.; Dehghanitafti, AA. (2020). Epidemiology of diabetes mellitus, pre-diabetes, undiagnosed and uncontrolled diabetes in Central Iran: results from Yazd health study. BMC Public Health. 20(1):166.
27. Nathan, DM.; Davidson, MB.; DeFronzo, RA. (2007). Impaired fasting gluco se and impaired glucose tolerance: implications for care. Diabetes Care. 30:753–9. [PubMed: 17327355])
28. National Institute of Public Health (2005). Project TAHINA (Epidemiological transition and health impact in North Africa). National Health Survey 2005 (Contract N° IC A3-CT-2002-10011)
29. Navarro, G. ; Allard, C. ; Xu, W. ; Mauvais-Jarvis, F. (2015). The role of androgens in metabolism, obesity, and diabetes in males and females. Obesity (Silver Spring). 23(4):713-9. doi: 10.1002/oby.21033. Epub 2015 Mar 6. PMID: 25755205; PMCID: PMC4380643.
30. Nikoloski, Z. (2020). Determinants of diabetes in Kuwait: evidence from the World Health Survey [Internet]. London, UK: LSE Middle East Centre; [cited 2021 Jan 17]. Available from: http://www.lse.ac.uk/middle-east-centre/publications
31. O'Connor, LE.; Hu, EA.; Steffen, LM.; Selvin, E.; Rebholz, CM. (2020). Adherence to a Mediterranean-style eating pattern and risk of diabetes in a U.S. prospective cohort study. Nutr Diabetes. 10(1):8.
32. Racette, SB.; Evans, EM.; Weiss, EP.; Hagberg, JM.; Holloszy, JO. (2006). Abdominal Adiposity Is a Stronger Predictor of Insulin Resistance Than Fitness Among 50-95 Year Olds. Diabetes Care. 1;29(3):673–8.

33. Riley, L.; Guthold, R.; Cowan, M.; Savin, S.; Bhatti, L.; Armstrong, T. (2016). The World Health Organization STEPwise Approach to Noncommunicable Disease Risk-Factor Surveillance: Methods, Challenges, and Opportunities. Am J Public Health. 106(1):74–8.
34. Seiglie, JA. ; Marcus, M-E. ; Ebert, C. ; Prodromidis, N. ; Geldsetzer, P. ; Theilmann, M. (2020). Diabetes Prevalence and Its Relationship With Education, Wealth, and BMI in 29 Low- and Middle-Income Countries. Dia Care. 43(4):767–75.
35. Step Wise Approach Report - WHO, Algeria. (2004). Measurement of risk factors for non-communicable diseases in two pilot areas (Step Wise Approach), Algeria 2003. République Algérienne Démocratique et Populaire. Ministère de la Santé, de la Population et de la Réforme Hospitalère. Direction de la Prévention, Alger 2004.
36. Swasey, KK.; Gupta, RD.; Nayeem, J.; Kibria, GMA. (2020). Determinants of diabetes in Bangladesh using two approaches: an analysis of the Demographic and Health Survey 2011. J Biosoc Sci. 52(4):585–95.
37. [dataset] The WHO NCD microdata repository. Algeria - STEPwise Survey for Non Communicable Diseases Risk Factors (STEPS) 2016, Ref. DZA_2016_STEPS_v01_M. Dataset downloaded from [https://extranet.who.int/ncdsmicrodata/index.php/catalog/91] on [2021 Feb 14]
38. Walker, RJ.; Gebregziabher, M.; Martin-Harris, B.; Egede, LE. (2014). Independent effects of socioeconomic and psychological social determinants of health on self-care and outcomes in Type 2 diabetes. Gen Hosp Psychiatry 36(6):662–8. doi:10.1016/j.genhosppsych.2014.06.011
39. World Health Organization. (2005). WHO steps surveillance manual: the WHO stepwise approach to chronic disease risk factor surveillance. Geneva: WHO; 2005.
40. World Health Organization. (2009). Global health risks: mortality and burden of disease attributable to selected major risks. Geneva: World Health Organization; 2009
41. World Health Organization. (2014). Global Status Report on Noncommunicable Diseases 2014. WHO: Geneva, Switzerland, 2014.
42. World Health Organization. (2018). Global Strategy on Diet, Physical Activity and Health: World Health Organization; https://www.who.int/dietphysicalactivity/pa/en/.
43. Yaghoubi, M.; Mansell, K.; Vatanparast, H.; Steeves, M.; Zeng, W.; Farag, M. (2020). Prevalence of Type 1 and Type 2 Diabetes-Related Complications and Their Association With Determinants Identified in Canada's Survey on Living With Chronic Diseases—Diabetes Component. Canadian Journal of Diabetes. 1;44(4):304-311.e3.
44. Yu, X. ; Duan, F. ; Lin, D. ; Li, H. ; Zhang, J. ; Wang, Q. (2020). Prevalence of Diabetes, Prediabetes, and Associated Factors in an Adult Chinese Population: Baseline of a Prediabetes Cohort Study. Bolanowski M, editor. International Journal of Endocrinology. 24;2020:8892176.
45. Zaoui, S. ; Biémont, C. ; Meguenni, K. (2007). Approche épidémiologique du diabète en milieux urbain et rural dans la région de Tlemcen (Ouest algérien). Santé ;17 :15-21.