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ORIGINAL ARTICLE

Nutrition, Metabolism, and Prevention of NCDs

Hypertension in Moroccan adults: sociodemographic, lifestyle, and dietary risk factors

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ABSTRACT

Background: Hypertension constitutes a principal etiological factor in cardiovascular morbidity and premature mortality worldwide, however, the epidemiological profile of its risk determinants within the Moroccan population remains inadequately characterized.

Aims: This investigation aimed to estimate the prevalence of prehypertension and hypertension and elucidate their association with various sociodemographic, behavioral, and metabolic factors among adult Moroccans.

Patients and Methods: Data were derived from the inaugural nationwide cross-sectional survey on non-communicable diseases risk factors, conducted between 2017 and 2018. Data collection adhered to the World Health Organization's STEPwise approach to surveillance (STEPS). The analytical cohort comprised 4580 adults, aged 18 years and above.

Results: The observed prevalence rates for prehypertension and hypertension were 42.4% and 34.5%, respectively. Individuals aged 45 years or older demonstrated a significantly elevated propensity for both prehypertension and hypertension relative to younger cohorts. Participants with university-level education exhibited a statistically significant elevated risk of hypertension compared to those with lower educational attainment. Overweight and obese individuals presented a significantly increased risk for both prehypertension and hypertension than their non-overweight peers (Adjusted Odds Ratio [AOR] = 1.83; 95% Confidence Interval [CI]: 1.58–2.13; $p < 0.001$; and AOR=3.06; 95% CI: 2.60–3 .60; $p < 0.001$, respectively). Hyperglycemia and dyslipidemia were associated with higher odds of hypertension, albeit marginally (AOR = 1.19; 95% CI: 0.99–1.41; $p = 0.055$; and AOR = 1.16; 95% CI: 0.99–1.37; $p = 0.069$, respectively). Current tobacco smokers exhibited a significantly higher risk of hypertension than non-smokers (AOR = 1.47; 95% CI: 1.09–1.98; $p = 0.013$).

Conclusions: The prevalence of prehypertension and hypertension was substantial within the studied population. Advanced age, elevated educational attainment, obesity, hyperglycemia, dyslipidemia, and tobacco smoking were associated with an elevated risk of both prehypertension and hypertension. Consequently, the implementation of urgent public health interventions is imperative to address the health burden associated with hypertension and to prevent the progression of prehypertension to hypertension and subsequent cardiovascular diseases.

Keywords: Age, Dyslipidemia, Education level, Hyperglycemia, Hypertension, Obesity, Overweight, Prehypertension.

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1 INTRODUCTION

Hypertension is a major public health problem worldwide and it plays an important role in the initiation and progression of many diseases. Hypertension is one of the leading causes of various cardiovascular diseases, including myocardial infarction, stroke, heart failure, and subsequent death (Forget *et al.*, 2016; Liu *et al.*, 2021; Mills *et al.*, 2016).

Globally, an estimated 1.28 billion adults aged 30–79 years suffer from hypertension, most of them (two-thirds) living in low- and middle-income countries, and this number is set to rise in the coming years. During the past decades, the prevalence of hypertension remained unchanged or decreased in developed countries, whereas it has been increasing in developing countries (Kearney *et al.*, 2005; Mills *et al.*, 2016). For instance, in Morocco, recent studies showed a high prevalence of hypertension in some regions, ranging from 17.62% in the eastern region (Berkane and Nador) and 35.5% in Khouribga region (El Hendaoui *et al.*, 2023; Mharchi and Maamri, 2024; Mouzouni *et al.*, 2021). Thus,

this study aimed to provide data on the magnitude of hypertension and associated risk factors in a large sample of the Moroccan population and underscore the need for public health interventions to treat this disease and prevent its devastating consequences.

Hypertension, a preventable illness condition, is associated with various unhealthy lifestyle behaviors (physical inactivity, tobacco smoking, and alcohol consumption), demographic factors (age, sex, place of residence), socioeconomic factors (education level, income, health disparities), and unhealthy diet (high in salt and saturated fats) (Ghose *et al.*, 2018). Risk factors' prevalence and the strength of relationships between risk factors and hypertension are well described in high-income countries, however, information for middle- and low-income countries is scarce. The World Health Organization's (WHO) STEPwise approach to surveillance also makes it easier to get comparable data on risk factor prevalence across countries but does not investigate their association with health outcomes (Riley *et al.*, 2016).

Furthermore, despite the rising prevalence of hypertension, the proportions of hypertension awareness, treatment, and blood pressure control are low, particularly in low- and middle-income countries (Mills *et al.*, 2020). For instance, less than 10% of hypertensive individuals in Ghana and South Africa had access to efficient therapy, according to recent WHO data (Lloyd-Sherlock *et al.*, 2014). The rates of therapy in the majority of Western nations also had between 50 and 80% (Joffres *et al.*, 2013), whereas emerging nations had far lower rates, such as Indonesia's 25 % (Hussain *et al.*, 2016). Therefore, hypertension prevalence has been higher among adults in low- and middle-income countries than in high-income countries. Differences in regional hypertension rates may be attributed to disparities in healthcare access and variations in risk factors, including high sodium intake, low potassium intake, obesity, alcohol consumption, physical inactivity, and unhealthy diets (Mills *et al.*, 2020).

In an additional effort to monitor Morocco's progress in addressing non-communicable diseases (NCDs), the Ministry of Health and Social Protection conducted in 2017-2018 a nationwide cross-sectional survey examining several NCDs and their risk factors. In this paper, only data related to blood pressure were presented and discussed. Our main objective was to investigate the association of prehypertension and hypertension with sociodemographic factors, lifestyle behaviors, and metabolic factors (obesity, hyperglycemia, and dyslipidemia) among adults aged 18 years or older.

2 METHODS

2.1 Study design and data source

This paper reports data derived from a nationwide STEPS survey on risk factors for non-communicable diseases conducted by the Moroccan Ministry of Health and Social Protection between 2017–2018. This cross-sectional investigation employed a multi-stage, stratified, and geographically clustered sampling design to obtain a nationally representative sample of Moroccan adults aged 18 years and above (N = 4580), selected through a process of randomization. The sample size was determined based on the 2014 General Population Census, to ensure national representativeness, yielding an overall response rate of 89%. A comprehensive quality control system was implemented to monitor the data collection process, laboratory analysis, and data reliability. Further details regarding the sample determination methodology and quality control are provided elsewhere (Ministère de la Santé, 2019).

2.2 Data collection

Trained investigators collected data employing the three standardized "steps" of the World Health Organization's (WHO) STEPwise approach to surveillance (STEPS) methodology (Riley *et al.*, 2016):

Step 1: Demographic and behavioral data

Employing a standardized questionnaire developed by the WHO, trained interviewers collected data pertaining to socio-demographic and lifestyle behaviors. These included age, marital status, education level, place of residence, tobacco and alcohol consumption, vegetable and fruit intake, and level of physical activity. Participants were classified as physically active or inactive based on the WHO's guidelines for total moderate-to-vigorous intensity physical activity (WHO, 2019). The adequacy of participants' fruit and vegetable consumption was assessed against the WHO dietary recommendations (WHO, 2023), which advocate a minimum daily intake of 400 grams (equivalent to five servings, comprising two servings of fruits and three servings of vegetables), with a standard serving size defined as 80 grams.

Step 2: Physical measurements

Physical measurements were carried out at the participants' residences following standardized protocols and utilizing calibrated equipment, with findings digitally recorded on mobile tablets. Regarding anthropometric measurements, a portable stadiometer (Seca, Germany) calibrated to a precision of 0.1 cm within a range of 200 ± 0.1 cm, was used for height measurement in adults. Body weight was measured to the nearest 0.1 kg using a digital scale (Seca,

Germany; 150 ± 0.1 kg). Waist circumference (WC) was measured horizontally to the nearest 0.1 cm using a non-stretchable measuring tape. Body mass index (BMI) was calculated as the ratio of weight in kilograms to the square of height in meters (kg/m²). Participants' weight status was categorized as normal (18.5 kg/m² ≤ BMI < 25 kg/m²), overweight (25 kg/m² ≤ BMI < 30 kg/m²), and obese (BMI ≥ 30 kg/m²) according to the WHO criteria (WHO, 2018). Abdominal obesity was defined as WC exceeding 94 cm for men and 80 cm for women (Alberti *et al.*, 2009).

Blood pressure classification adhered to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7) guidelines (Lenfant *et al.*, 2003). Individuals were classified as hypertensive if they self-reported a physician-diagnosed hypertension with a prescription for antihypertensive medication, and/or reported a prior diagnosis of hypertension by a healthcare professional, and/or exhibited survey-measured systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg. Prehypertension was defined as the absence of antihypertensive medication use with an SBP of 120-139 mmHg and/or a DBP of 80–89 mmHg. Normal blood pressure was defined as an SBP ≤ 120 mmHg and a DBP ≤ 80 mmHg without antihypertensive medication. During blood pressure measurement, participants remained seated with legs uncrossed, and three consecutive measurements were taken with the cuff appropriately positioned around the arm. The arithmetic mean of these three readings was used to determine the participant's blood pressure.

Step 3: Biochemical measurements

This phase involved the measurement of fasting plasma glucose (FPG), total cholesterol, HDL-cholesterol, and triglycerides. Following a 12–hour overnight fast, venous blood samples were collected for biochemical analysis. All blood samples were promptly centrifuged to separate the serum and subsequently transported under cold chain conditions to the Reference Laboratory of the Joint Research Unit in Nutrition and Food, Regional Designed Center of Nutrition (AFRA/IAEA), Ibn Tofail University-CNESTEN, Rabat.

The FPG values were interpreted according to the WHO guidelines for the diagnosis of diabetes and prediabetes (WHO, 2006). Participants with a self-reported history of physician-diagnosed diabetes and a prescription for antidiabetic medication, as well as those with documented survey-measured FPG values exceeding 7 mmol/L (126 mg/dL) and/or a prior diagnosis of diabetes, were classified as diabetic. Prediabetic individuals were defined as those with survey-measured FPG values ranging from 6.1 to 6.9 mmol/L (110 to 125 mg/dL). A distinction between type 1 and type 2 diabetes was not considered in this study.

The classification of each participant's lipid profile was based on the criteria outlined in the European guidelines on cardiovascular disease prevention in clinical practice (Lenfant *et al.*, 2003): i) high total cholesterol (≥ 5 mmol/L or ~190 mg/dL); ii) high triglycerides (≥ 150 mg/dL or 1.7 mmol/L); and iii) low HDL-cholesterol (man, 0.40 mg/dL or 1.03 mmol/L; woman, 0.50 mg/dL or 1.29 mmol/L); and ii) high LDL–cholesterol (≥115 mg/dL or 3.0 mmol/L), calculated using the following formula: LDL-cholesterol = Total cholesterol – HDL-cholesterol – Triglycerides /5 (g/L). The presence of at least one of these four lipid abnormalities constituted the definition of dyslipidemia (De Backer *et al.*, 2003).

2.3 Ethical consideration

Ethical approval for this survey was granted by the Biomedical Research Ethics Committee of the Faculty of Medicine and Pharmacy in Rabat, Morocco. Prior to data collection, comprehensive information regarding the research objectives and methodological procedures was provided to all invited participants, and written informed consent was obtained from each individual involved in the survey.

2.4 Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software (version 20.0; IBM Corp, Armonk, NY, USA). Descriptive statistics were employed to express results as proportions with corresponding 95% confidence intervals. The Chi-square test (χ^2) was utilized to examine the association between blood pressure status and the studied variables. Furthermore, multinomial logistic regression analysis was carried out to determine potential risk factors for prehypertension and hypertension, based on *p*–values and adjusted odds ratios (AORs) along with 95% confidence intervals. A *p*–value < 0.05 was considered indicative of statistical significance.

3 RESULTS

3.1 Characteristics of the study participants

A total of 4580 adults were included in the final data analysis. The sociodemographic characteristics of the study population are presented in Table 1. The majority of the surveyed participants were female (65.0%), with a substantial proportion (74%) aged between 30 and 69 years. Geographically, 60.3% of the participants resided in urban areas. Regarding educational attainment, the largest segment of the study population (72.8%) had either no formal schooling or only primary school education. In terms of

Table 1. Sociodemographic characteristics of the study population

	n	%	95% CI
Sex			
Female	1604	35.0	33.6–36.4
Male	2976	65.0	63.6–66.4
Age groups (years)			
18–2 9	801	17.5	16.4–18.6
30–44	1457	31.8	30.5–33.1
45–59	1316	28.7	27.4–30.0
60–69	617	13.5	12.6–14.5
≥ 70	389	8.5	7.7–9.4
Place of residence			
Rural	1818	39.7	38.2–41.1
Urban	2762	60.3	58.9–61.8
Education levels			
No formal school	2392	52.2	50.7–53.7
Primary school	948	20.6	19.4–21.8
Middle school	541	11.8	10.9–12.8
High school	367	8.0	7.2–8.8
University	332	7.2	6.5–8.0
Marital status			
Single	634	13.8	12.8–14.9
Married	3363	73.4	72.2–74.7
Separated/divorced	135	2.9	2.4–3.4

Note: CI: Confidence Interval

marital status, 73.4% of the individuals were married, whereas the remaining participants were single (13.8%), widowed (9.8%), or separated/divorced (2.9%).

3.2 Risk factors

The prevalence of prehypertension and hypertension within the study population was 42.4% and 34.5%, respectively (Table 2). Statistically significant associations were observed between blood pressure status and each of the following variables: age group (χ^2, p = 0.005), weight status (χ^2, p < 0.001), abdominal obesity (χ^2, p < 0.001), and smoking status (χ^2, p = 0.041).

Multinomial logistic regression analysis revealed that individuals in the age group 45–59 years, 60–69 years, and ≥ 70 years exhibited a significantly higher likelihood of having both prehypertension and hypertension compared to those aged 18–29 years. In comparison to adults with no formal schooling, individuals who had completed primary school education demonstrated a significantly lower odds ratio for hypertension (AOR = 0.78; 95% CI: 10.64-0.96; p = 0.017), while those with a university-level education level exhibited significantly elevated odds of being hypertensive (AOR = 1.41; 95% CI: 1.02–1.95; p = 0.035). Overweight or obese individuals presented a significantly increased risk for both prehypertension and hypertension than their non-overweight peers (AOR = 1.83; 95% CI:1.58–2.13; p < 0.001; and AOR = 3.06; 95% CI: 2.60–3.60; p < 0.001, respectively). Similarly, participants with abdominal obesity were significantly more likely to experience prehypertension (AOR = 1.43; 95% CI: 1.22–1.67; p < 0.001) and hypertension (AOR = 2.74; 95% CI: 2.30–3.27; p < 0.001) compared to those without abdominal obesity. While not reaching conventional statistical significance, individuals with hyperglycemia (AOR = 1.19; 95% CI: 0.99–1.41; p = 0.055) and dyslipidemia (AOR = 1.16; 95% CI: 0.99–1.37; p = 0.069) exhibited a trend towards higher odds of hypertension. Current smokers also demonstrated a significantly elevated risk for hypertension compared to individuals who had never smoked (AOR = 1.47; 95% CI: 1.09–1.98; p = 0.013) (Table 3).

4 Discussion

The findings of this study revealed a prehypertension prevalence of 42.4% and a hypertension prevalence of 34.5% among the Moroccan adult participants. Our estimated hypertension prevalence is lower than recent reports from certain North African countries, such as Tunisia (47.4%) (Boujnah *et al.*, 2018) and Algeria (36.9%) (Bachir Cherif *et al.*, 2017). However, it is comparatively higher than the 33.6% prevalence reported in a study conducted by the Moroccan Ministry of Health in 2000 (Tazi *et al.*, 2003). Furthermore, the proportion of individuals with hypertension in our study population exceeds the average rates observed in the WHO African and Americas regions (27% and 18%, respectively) (WHO, 2021), yet remains significantly lower than prevalence reported in some European countries, such as Sweden (38%), the UK (42%), Spain (47%), and Germany (55%) (Cifkova *et al.*, 2016).

Growing evidence indicates that hypertension prevalence varies across regions, countries, and socioeconomic strata. Ethnic origin may play a key role in the prevalence of hypertension in certain geographical areas. For instance, epidemiological studies have demonstrated a higher prevalence of hypertension among African American individuals compared to those originating from continental Africa (Ortega *et al.*, 2015). Moreover, substantial variations in hypertension prevalence have been observed both between and within Arab countries (Tailakh *et al.*, 2014), with national studies reporting rates ranging from 20.1% in Syria to 41.5% in the Sultanate of Oman (Abd El-Aty *et al.*, 2015; Khdour *et al.*, 2013; Matar *et al.*, 2015). These disparities may be attributable to differences in socioeconomic conditions, healthcare systems, dietary and lifestyle behaviors, or environmental factors that contribute to the observed variability in hypertension prevalence.

Table 2. Prevalence of prehypertension and hypertension across sociodemographic categories, lifestyle and health variables in Moroccan adults

Variables	Normal blood pressure		Prehypertension		Hypertension		*p*-value*
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	
Total	1057	23.1 (21.8-24.3)	1941	42.4 (40.9-43.8)	1582	34.5 (33.3-35.9)	-
Sex							
Female	361	22.5(20.4-24.5)	688	42.9(40.6-45.3)	555	34.6(32.4-36.8)	0.676
Male	696	23.4(21.9-25.0)	1253	42.1(40.4-43.9)	1027	34.5(32.9-36.3)	
Age groups (years)							
18-29	204	25.5(22.7-28.7)	341	42.6(39.1-45.9)	256	32.0(29.0-35.2)	0.005
30-44	350	24.0(22.0-26.3)	642	44.1(41.5-46.4)	465	31.9(29.6-34.2)	
45-59	294	22.3(20.2-24.9)	561	42.6(40.0-45.4)	461	35.0(32.4-37.5)	
60-69	122	19.8(17.0-23.0)	242	39.2(35.3-42.8)	253	41.0(37.4-44.7)	
> 70	87	22.4(18.5-26.7)	155	39.8(35.2-44.7)	147	37.8(32.9-42.4)	
Place of residence							
Rural	415	22.8(21.0-24.7)	762	41.9(39.7-44.1)	641	35.3(33.2-37.3)	0.710
Urban	642	23.2(21.7-24.8)	1179	42.7(41.0-44.6)	941	34.1(32.2-35.9)	
Education levels							
No formal school	545	22.8(21.1-24.4)	1007	42.1(40.1-44.1)	841	35.1(33.2-37.0)	0.095
Primary school	244	25.8(22.9-28.4)	407	43.0(39.9-46.5)	295	31.2(27.9-34.0)	
Middle school	128	23.6(20.1-27.1)	232	42.8(38.7-46.9)	182	33.6(29.5-37.5)	
High school	79	21.5(17.4-26.4)	157	42.8(37.6-48.0)	131	35.7(30.8-40.3)	
University	61	18.4(14.5-22.6)	138	41.6(36.4-46.7)	133	40.1(34.6-45.5)	
Marital status							
Single	140	22.1(18.6-25.6)	267	42.1(38.2-46.4)	227	35.8(32.0-39.6)	0.245
Married	795	23.6(22.2-25.1)	1444	42.9(41.3-44.4)	1128	33.5(31.9-35.0)	
Separated/divorced	29	22.1(15.3-29.8)	52	39.7(31.3-48.1)	50	38.2(29.8-46.6)	
Widowed	93	20.8(17.0-24.6)	178	39.7(35.0-44.2)	177	39.5(35.5-43.8)	
Weight status							
Not overweight	588	32.0(30.0-34.0)	788	42.9(40.7-45.2)	460	25.1(23.0-27.0)	<0.001
Overweight/obese	469	17.1(15.7-18.5)	1153	42.0(40.2-43.8)	1122	40.9(39.1-42.7)	
Abdominal obesity							
No	424	31.3(28.9-33.8)	620	45.8(43.0-48.3)	311	23.0(20.7-25.2)	<0.001
Yes	627	19.6(18.2-20.9)	1308	40.9(39.2-42.8)	1262	39.5(37.8-41.2)	
Dyslipidemia							
No	381	24.5(22.5-26.6)	656	42.2(39.7-44.8)	516	33.2(30.8-35.5)	0.183
Yes	676	22.3(20.9-23.8)	1285	42.5(40.8-44.2)	1066	35.2(33.4-36.9)	
Physical activity levels							
Active	826	23.0(21.6-24.5)	1531	42.7(41.1-44.2)	1231	34.3(32.8-35.9)	0.736
Inactive	231	23.3(20.7-25.8)	410	41.3(38.4-44.2)	351	35.4(32.3-38.5)	
Fruit and vegetable consumption							
Sufficient	378	21.8(20.1-23.7)	737	42.6(40.2-44.8)	616	35.6(33.4-37.8)	0.251
Insufficient	679	23.8(22.3-25.3)	1204	42.3(40.5-44.2)	966	33.9(32.2-35.7)	
Alcohol consumption							
No	1008	23.2(22.0-24.5)	1845	42.4(41.0-43.8)	1495	34.4(33.0-35.7)	0.583
Yes	49	21.1(16.4-26.3)	96	41.4(35.3-47.4)	87	37.5(31.5-44.0)	
Smoking status							
Never	904	23.2(21.9-24.5)	1662	42.6(40.9-44.2)	1333	34.2(32.8-35.8)	0.041
Former	86	26.1(21.0-30.7)	139	42.2(36.5-47.7)	104	31.6(26.7-36.8)	
Current	67	19.0 (14.8-23.0)	140	39.8 (35.2-44.9)	145	41.2 (35.8-46.3)	

Note: CI: Confidence Interval

While prior research has suggested a relatively higher risk of hypertension among men compared to women, irrespective of race, ethnicity, and country of origin (Bays *et al.*, 2022; WHO, 2017), our results did not reveal a statistically significant sex difference in hypertension prevalence.

Although sex-specific differences may still exist within particular age cohorts or geographical regions, the absence of significant sex differences in our study could be attributed to factors such as population aging, lifestyle patterns, and broader shifts in health conditions such as obesity and diabetes mellitus. Moreover, it has been reported that the increasing prevalence in hypertension in women could be attributed to their age, hormonal fluctuations, multiparity, and lower engagement in physical activity or sports (Sandberg *et al.*, 2012). Our findings highlight the necessity for further research to elucidate the factors contributing to the convergence of blood pressure levels between sexes.

Table 3. Association of sociodemographic, behavioral, and metabolic factors with prehypertension and hypertension among Moroccan adults

Variables	Prehypertension			Hypertension		
	AOR*	95% CI*	*p*-value	AOR*	95%CI*	*p*-value
Sex						
Female	Ref.		Ref.			
Male	1.06	0.90-1.24	0.460	1.04	0.88-1.23	0.623
Age groups (years)						
18-29	Ref.	Ref.				
30-44	1.09	0.88-1.36	0.401	1.06	0.84-1.33	0.627
45-59	1.14	0.91-1.43	0.246	1.25	0.99-1.58	0.063
60-69	1.19	0.89-1.57	0.228	1.65	1.24-2.19	0.001
> 70	1.07	0.78-1.46	0.691	1.35	0.96-1.86	0.071
Place of residence						
Rural	Ref.		Ref.			
Urban	1.00	0.86-1.17	0.997	0.95	0.81-1.11	0.504
Education levels						
No formal school	Ref.		Ref.			
Primary school	0.90	0.75-1.09	0.291	0.78	0.64-0.96	0.017
Middle school	0.98	0.77-1.25	0.875	0.92	0.72-1.18	0.522
High school	1.08	0.81-1.44	0.622	1.07	0.79-1.45	0.638
University	1.22	0.89-1.68	0.213	1.41	1.02-1.95	0.035
Marital status						
Single	Ref.			Ref.		
Married	0.95	0.76-1.19	0.667	0.86	0.70-1.10	0.254
Separated/divorced	0.94	0.57-1.55	0.808	1.06	0.64-1.76	0.811
Widowed	1.00	0.73-1.39	0.983	1.17	0.85-1.63	0.338
Weight status						
Non-overweight	Ref.			Ref.		
Overweight/Obese	1.83	1.58-2.13	<0.001	3.06	2.60-3.60	<0.001
Abdominal obesity						
No	Ref.			Ref.		
Yes	1.43	1.22-1.67	<0.001	2.74	2.30-3.27	<0.001
Hyperglycemia						
No	Ref.			Ref.		
Yes	1.02	0.86-1.21	0.823	1.19	0.99-1.41	0.055
Dyslipidemia						
No	Ref.			Ref.		
Yes	1.10	0.94-1.29	0.216	1.16	0.99-1.37	0.069
Physical activity levels						
Active	Ref.			Ref.		
Inactive	0.96	0.79-1.15	0.641	1.02	0.85-1.23	0.840
Fruit and vegetable consumption						
Sufficient	Ref.			Ref.		
Insufficient	0.91	0.78-1.06	0.232	0.87	0.74-1.03	0.099
Alcohol consumption						
No	Ref.			Ref.		
Yes	1.07	0.75-1.52	0.705	1.19	0.84-1.71	0.326
Smoking status						
Never	Ref.			Ref.		
Past	0.88	0.66-1.16	0.369	0.82	0.61-1.11	0.192
Current	1.14	0.84-1.54	0.406	1.47	1.09-1.98	0.013

Note: * Adjusted Odds Ratio (AOR) and 95% confidence interval (95%CI) for prehypertension and hypertension using multinomial logistic regression analysis.

In our study population, a significant association was observed between blood pressure status and age group. Individuals aged 45–59 years and those aged 60 years or older exhibited a significantly higher likelihood of having both prehypertension and hypertension compared to individuals 18–29 years. These results corroborate findings from other investigations that have identified age as a significant risk factor for hypertension (Tailakh *et al.*, 2014). Of particular concern is the finding that elevated hypertension prevalence was not high only among older adults but was also notable among young adults aged 18–29 years and those aged 30–44 years (38.2% and 40.8%, respectively). These results emphasize the importance of investigating the effects of various risk factors, including alterations in dietary and lifestyle patterns, that may ultimately elucidate the increasing prevalence of hypertension, particularly among younger individuals. Identifying key contributing factors could provide valuable insight for the development of preventive measures aimed at slowing or reversing this concerning trend.

The prevalence of hypertension tended to be slightly higher among people residing in rural areas compared to those in urban areas (36.3% vs. 33.4%), although this difference did not reach statistical significance. The absence of a significant difference in hypertension prevalence between rural and urban areas may be attributed to a combination of several factors, including urbanization and socioeconomic changes, evolving lifestyle behaviors, and an aging population, that are exhibiting increasing similarity across both environments in Morocco. While our findings did not attain a statistical significance, they align with those the results of some previous studies (Daştan *et al.*, 2017). For instance, a large multinational study of 153,996 adults aged 35–70 years from 628 communities (348 urban and 280 rural) across 17 countries on five continents, reported a significantly higher prevalence of hypertension in rural areas compared to urban areas (Chow *et al.*, 2013). This observation may be related to a lack of awareness and control of elevated blood pressure, as well as changes in lifestyle behaviors such as physical inactivity, excessive dietary sodium, and fat intake associated with an increasing trend in overweight and obesity prevalence in rural settings compared with urban ones.

Contrary to some previous studies (Leng *et al.*, 2015), our results indicated that individuals with a higher level of education (university) had significantly higher risks for both prehypertension and hypertension compared to those with no formal schooling. Similarly, adults with a high school education level exhibited relatively higher odds of having prehypertension and hypertension than less educated individuals. This association may be mediated by increased socioeconomic status, a factor that was not assessed in the current study. Thus, our data underscores the necessity for public health initiatives focusing on raising awareness regarding prehypertension, hypertension, and associated risk factors across all population groups, irrespective of education level.

Despite the absence of a statistically significant association between marital status and blood pressure status, married individuals exhibited a slightly lower risk of hypertension compared to unmarried individuals, while widowed individuals presented relatively higher odds of having the condition. Our results are consistent with previous studies identifying being never married as a significant risk factor for hypertension (Ramezankhani *et al.*, 2019); however, they are inconsistent with another study that reported higher odds of hypertension among married subjects compared to unmarried subjects (Singh *et al.*, 2017). These divergent findings highlight the clear need for additional research to establish causal relationships between marital status and hypertension across various regions, countries, and socioeconomic groups.

We observed that both overall overweight/obesity and abdominal obesity were associated with significantly higher odds of prehypertension and hypertension. These findings are consistent with previous studies indicating that increased body mass index and waist circumference are robust predictors of hypertension (Li *et al.*, 2010). Consequently, primary care physicians should prioritize the assessment of BMI in their hypertensive patients and strongly encourage weight reduction strategies. Furthermore, public health interventions designed to promote the maintenance of healthy body weight through regular physical activity and appropriate energy intake may be effective in the primary and secondary prevention of hypertension.

The current study revealed associations of borderline statistical significance between hypertension and both hyperglycemia (AOR = 1.19; 95% CI: 0.99–1.41; $p = 0.055$) and dyslipidemia (AOR = 1.16; 95% CI: 0.99–1.37; $p = 0.069$). While the cross-sectional design of this observational study prevents the establishment of causality, our findings align with previous research suggesting a potential link between elevated blood glucose levels and dyslipidemia with an increased risk of hypertension (Kuwabara *et al.*, 2019; Otsuka *et al.*, 2016). These observations underscore the importance of preventing and controlling hyperglycemia and dyslipidemia as potential risk factors for hypertension, particularly among vulnerable groups such as individuals with obesity and older adults.

Although prior studies have reported associations between physical inactivity and insufficient fruit and vegetable consumption with an increased risk of hypertension (Gamage *et al.*, 2021; Liu *et al.*, 2018), we did not observe such an association in this study. The underlying reasons for the lack of relationships of physical activity level and fruit and

vegetable intake with blood pressure status remain unclear and require further studies. We hypothesize that participants, upon being diagnosed with prehypertension or hypertension, or identified as having other risk factors such as overweight or obesity, may have adopted more regular physical activity and healthier dietary habits based on medical advice, potentially obscuring baseline associations. Additionally, the accuracy of self-reported data on physical activity and dietary intake such may be influenced by factors such as sex and BMI (Quinlan *et al.*, 2021; Wehling and Lusher, 2019).

Alcohol consumption did not demonstrate a statistically significant association with blood pressure status; however, alcohol users exhibited marginally increased odds of both prehypertension and hypertension (AOR = 1.07; 95% CI: 0.75–1.52, and AOR = 1.19; 95% CI: 0.84–1.71, respectively). While this trend is consistent with other studies suggesting a relationship between alcohol consumption and elevated hypertension risk (Kuwabara *et al.*, 2019; Otsuka *et al.*, 2016), its interpretation requires caution given that the study population was predominantly Muslims, a group for whom alcohol consumption is proscribed and whose reporting of such behavior may be subject to social desirability bias..

Current smokers showed significantly higher odds of being hypertensive compared to individuals who had never smoked (AOR = 1.47; 95% CI: 1.09–1.98; p = 0.013). Our results are consistent with existing literature identifying smoking as a risk factor for hypertension (Singh *et al.*, 2017). However, the cross-sectional nature of our study prevents the determination of the direction of causality between smoking and hypertension. Moreover, a recent study reported an inconsistent relationship between smoking and hypertension (Sohn *et al.*, 2018), highlighting the need for further research to elucidate the basis of the observed associations within our study population.

Strengths and limitations

The principal strengths of this study include the application of the WHO STEPwise approach's standardized methodology for data collection and the large sample size, which enhances the reliability of the prevalence estimates. However, several limitations warrant consideration. Firstly, the cross-sectional design limits the ability to establish causal relationships between the reported associations. Secondly, the relatively low proportions of mal participants, individuals in the younger (18–29) and older (> 70) age groups, and residents of rural areas may limit precision of sex-, age-, and residence- specific analyses. Thirdly, missing data regarding participants' dietary habits and household socioeconomic status constrained our capacity to explore their potential relationships with hypertension. Finally, information bias may have arisen from the self-reported nature of data on demographic and lifestyle risk factors, such as smoking, alcohol consumption, dietary intake, and physical activity.

5 Conclusions

Our results indicate a high prevalence of prehypertension and hypertension among the studied Moroccan adult population. Increased age (≥ 45 years), higher educational attainment, general and abdominal obesity, hyperglycemia, dyslipidemia, and current smoking were associated with a greater risk for prehypertension and hypertension. These results underscore the urgent necessity for effective interventions aimed at the prevention and control of hypertension, including awareness campaigns, the promotion of weight management, regular physical activity, healthy dietary practices, and the reduction of tobacco smoking.

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References

Abd El-Aty, M. A., Meky, F. A., Morsi, M. M., Al-Lawati, J. A., & El Sayed, M. K. (2015). Hypertension in the adult Omani population. *Journal of the Egyptian Public Health Association*, *90*(3), 125–132. https://doi.org/10.1097/01.epx.0000470547.32952.cf [Crossref] [PubMed] [Google Scholar] [Publisher]

Alberti, K. G., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., Fruchart, J. C., James, W. P., Loria, C. M., Smith, S. C., Jr, International Diabetes Federation Task Force on Epidemiology and Prevention, National Heart, Lung, and Blood Institute, American Heart Association, World Heart Federation,

International Atherosclerosis Society, & International Association for the Study of Obesity (2009). Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation*, *120*(16), 1640–1645. https://doi.org/10.1161/CIRCULATIONAHA.109.192644 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bachir Cherif, A., Bouamra, A., Taleb, A., Nedjar, R., Bouraghda, A., Hamida, F., Temmar, M., & Bouafia, M. T. (2017). Differences in prevalence, treatment and control rates of hypertension between male and female in the area of Blida (Algeria). *Annales de Cardiologie et d'Angeiologie*, *66*(3), 123–129. https://doi.org/10.1016/j.ancard.2017.04.009 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bays, H. E., Kulkarni, A., German, C., Satish, P., Iluyomade, A., Dudum, R., Thakkar, A., Rifai, M. A., Mehta, A., Thobani, A., Al-Saiegh, Y., Nelson, A. J., Sheth, S., & Toth, P. P. (2022). Ten things to know about ten cardiovascular disease risk factors - 2022. *American Journal of Preventive Cardiology*, *10*, 100342. https://doi.org/10.1016/j.ajpc.2022.100342 [Crossref] [PubMed] [Google Scholar] [Publisher]

Boujnah, R., Nazek, L., Maalej, M., Achhab, Y. E., & Nejjari, C. (2018). Hypertension in Tunisian adults attending primary care physicians (ETHNA-Tunisia). *Indian Heart Journal*, *70*(4), 544–547. https://doi.org/10.1016/j.ihj.2017.11.005 [Crossref] [PubMed] [Google Scholar] [Publisher]

Chow, C. K., Teo, K. K., Rangarajan, S., Islam, S., Gupta, R., Avezum, A., Bahonar, A., Chifamba, J., Dagenais, G., Diaz, R., Kazmi, K., Lanas, F., Wei, L., Lopez-Jaramillo, P., Fanghong, L., Ismail, N. H., Puoane, T., Rosengren, A., Szuba, A., Temizhan, A., … PURE (Prospective Urban Rural Epidemiology) Study investigators (2013). Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. *JAMA*, *310*(9), 959–968. https://doi.org/10.1001/jama.2013.184182 [Crossref] [PubMed] [Google Scholar] [Publisher]

Cifkova, R., Fodor, G., & Wohlfahrt, P. (2016). Changes in Hypertension Prevalence, Awareness, Treatment, and Control in High-, Middle-, and Low-Income Countries: An Update. *Current Hypertension Reports*, *18*(8), 62. https://doi.org/10.1007/s11906-016-0669-y [Crossref] [PubMed] [Google Scholar] [Publisher]

Daştan, İ., Erem, A., & Çetinkaya, V. (2017). Urban and rural differences in hypertension risk factors in Turkey. *Anatolian Journal of Cardiology*, *18*(1), 39–47. https://doi.org/10.14744/AnatolJCardiol.2017.7452 [Crossref] [PubMed] [Google Scholar] [Publisher]

De Backer, G., Ambrosioni, E., Borch-Johnsen, K., Brotons, C., Cifkova, R., Dallongeville, J., Ebrahim, S., Faergeman, O., Graham, I., Mancia, G., Manger Cats, V., Orth-Gomér, K., Perk, J., Pyörälä, K., Rodicio, J. L., Sans, S., Sansoy, V., Sechtem, U., Silber, S., Thomsen, T., … Third Joint Task Force of European and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (2003). European guidelines on cardiovascular disease prevention in clinical practice. Third Joint Task Force of European and Other Societies on Cardiovascular Disease Prevention in Clinical Practice. *European Heart Journal*, *24*(17), 1601–1610. https://doi.org/10.1016/s0195-668x(03)00347-6 [Crossref] [PubMed] [Google Scholar] [Publisher]

El Hendaoui, H., Mziwira, M., & Belahsen, R. (2023). Prevalence of obesity and hypertension in the region of Khouribga (Morocco): Effects of socio-demographic and lifestyle factors. *E3S Web of Conferences*, *452*, 07008. https://doi.org/10.1051/e3sconf/202345207008 [Crossref] [Google Scholar] [Publisher]

Forget, P. (2016). Faculty Opinions recommendation of Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015 [Data set]. In *Faculty Opinions – Post-Publication Peer Review of the Biomedical Literature*. Faculty Opinions Ltd. https://doi.org/10.3410/f.726827339.793524296 [Crossref] [Google Scholar] [Publisher]

Gamage, A. U., & Seneviratne, R. A. (2021). Physical inactivity, and its association with hypertension among employees in the district of Colombo. *BMC Public Health*, *21*(1), 2186. https://doi.org/10.1186/s12889-021-12013-y [Crossref] [PubMed] [Google Scholar] [Publisher]

Ghose, B., & Yaya, S. (2018). Blood pressure-controlling behavior in relation to educational level and economic status among hypertensive women in Ghana. *Family Medicine and Community Health*, *6*(3), 115–123.

https://doi.org/10.15212/fmch.2018.0112 [Crossref] [Google Scholar] [Publisher]

Hussain, M. A., Al Mamun, A., Peters, S. A., Woodward, M., & Huxley, R. R. (2016). The Burden of Cardiovascular Disease Attributable to Major Modifiable Risk Factors in Indonesia. *Journal of Epidemiology*, *26*(10), 515–521. https://doi.org/10.2188/jea.JE20150178 [Crossref] [PubMed] [Google Scholar] [Publisher]

Joffres, M., Falaschetti, E., Gillespie, C., Robitaille, C., Loustalot, F., Poulter, N., McAlister, F. A., Johansen, H., Baclic, O., & Campbell, N. (2013). Hypertension prevalence, awareness, treatment and control in national surveys from England, the USA and Canada, and correlation with stroke and ischaemic heart disease mortality: a cross-sectional study. *BMJ Open*, *3*(8), e003423. https://doi.org/10.1136/bmjopen-2013-003423 [Crossref] [PubMed] [Google Scholar] [Publisher]

Kearney, P. M., Whelton, M., Reynolds, K., Muntner, P., Whelton, P. K., & He, J. (2005). Global burden of hypertension: analysis of worldwide data. *Lancet (London, England)*, *365*(9455), 217–223. https://doi.org/10.1016/S0140-6736(05)17741-1 [Crossref] [PubMed] [Google Scholar] [Publisher]

Khdour, M. R., Hallak, H. O., Shaeen, M., Jarab, A. S., & Al-Shahed, Q. N. (2013). Prevalence, awareness, treatment and control of hypertension in the Palestinian population. *Journal of Human Hypertension, 27*(10), 623–628. https://doi.org/10.1038/jhh.2013.26 [Crossref] [PubMed] [Google Scholar] [Publisher]

Kuwabara, M., & Hisatome, I. (2019). The Relationship Between Fasting Blood Glucose and Hypertension. *American Journal of Hypertension*, *32*(12), 1143–1145. https://doi.org/10.1093/ajh/hpz147 [Crossref] [PubMed] [Google Scholar] [Publisher]

Lenfant, C., Chobanian, A. V., Jones, D. W., Roccella, E. J., & Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (2003). Seventh report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7): resetting the hypertension sails. *Hypertension (Dallas, Tex.: 1979)*, *41*(6), 1178–1179. https://doi.org/10.1161/01.HYP.0000075790.33892.AE [Crossref] [PubMed] [Google Scholar] [Publisher]

Leng, B., Jin, Y., Li, G., Chen, L., & Jin, N. (2015). Socioeconomic status and hypertension: a meta-analysis. *Journal of hypertension*, *33*(2), 221–229. https://doi.org/10.1097/HJH.0000000000000428 [Crossref] [PubMed] [Google Scholar] [Publisher]

Li, H., Meng, Q., Sun, X., Salter, A., Briggs, N. E., & Hiller, J. E. (2010). Prevalence, awareness, treatment, and control of hypertension in rural China: results from Shandong Province. *Journal of Hypertension*, *28*(3), 432–438. https://doi.org/10.1097/HJH.0b013e328334b39e [Crossref] [PubMed] [Google Scholar] [Publisher]

Liu, J., Bu, X., Wei, L., Wang, X., Lai, L., Dong, C., Ma, A., & Wang, T. (2021). Global burden of cardiovascular diseases attributable to hypertension in young adults from 1990 to 2019. *Journal of Hypertension*, *39*(12), 2488–2496. https://doi.org/10.1097/HJH.0000000000002958 [Crossref] [PubMed] [Google Scholar] [Publisher]

Liu, M. W., Yu, H. J., Yuan, S., Song, Y., Tang, B. W., Cao, Z. K., Yang, X. H., Towne, S. D., Jr, & He, Q. Q. (2018). Association between fruit and vegetable intake and the risk of hypertension among Chinese adults: a longitudinal study. *European Journal of Nutrition*, *57*(7), 2639–2647. https://doi.org/10.1007/s00394-018-1687-0 [Crossref] [PubMed] [Google Scholar] [Publisher]

Lloyd-Sherlock, P., Ebrahim, S., & Grosskurth, H. (2014). Is hypertension the new HIV epidemic?. *International Journal of Epidemiology*, *43*(1), 8–10. https://doi.org/10.1093/ije/dyu019 [Crossref] [PubMed] [Google Scholar] [Publisher]

Matar, D., Frangieh, A. H., Abouassi, S., Bteich, F., Saleh, A., Salame, E., Kassab, R., & Azar, R. R. (2015). Prevalence, awareness, treatment, and control of hypertension in Lebanon. *Journal of Clinical Hypertension (Greenwich, Conn.)*, *17*(5), 381–388. https://doi.org/10.1111/jch.12485 [Crossref] [PubMed] [Google Scholar] [Publisher]

Mharchi, S., & Maamri, A. (2024). Physical Activity, and Their Impact on Chronic Diseases (Hypertension and T2DM) among North-Eastern Morocco's Population. *Medicina Moderna*, *31*. https://doi.org/10.31689/rmm.2024.31.1.37 [Crossref] [Google Scholar] [Publisher]

Mills, K. T., Bundy, J. D., Kelly, T. N., Reed, J. E., Kearney, P. M., Reynolds, K., Chen, J., & He, J. (2016). Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-Based Studies From 90 Countries. *Circulation*, *134*(6), 441–450. https://doi.org/10.1161/CIRCULATIONAHA.115.018912 [Crossref] [PubMed] [Google Scholar] [Publisher]

Mills, K. T., Stefanescu, A., & He, J. (2020). The global epidemiology of hypertension. *Nature Reviews. Nephrology*, *16*(4), 223–237. https://doi.org/10.1038/s41581-019-0244-2 [Crossref] [PubMed] [Google Scholar] [Publisher]

Ministère de la Santé. Enquête Nationale sur les Facteurs de Risque communs des Maladies Non Transmissibles, STEPS, 2017-2018: Rapport. 2019. Retrieved from https://www.sante.gov.ma/Documents/2019/05/Rapport%20de%20l%20enquête%20Stepwise.pdf

Mouzouni, F.-Z., Mehdad, S., Mounach, S., Iraqi, H., Benkirane, H., Benaich, S., EL Youbi, M., & Aguenaou, H. (2022). Diabetes prevalence is associated with obesity, hypertension, dyslipidemia, and sociodemographic factors in adults living in Casablanca-Settat and Rabat-Sale-Kenitra regions, Morocco. *International Journal of Diabetes in Developing Countries*, *42*(3), 565–572. https://doi.org/10.1007/s13410-021-01006-7 [Crossref] [Google Scholar] [Publisher]

Ortega, L. M., Sedki, E., & Nayer, A. (2015). Hypertension in the African American population: A succinct look at its epidemiology, pathogenesis, and therapy. *Nefrologia: Publicacion Oficial de la Sociedad Espanola Nefrologia*, *35*(2), 139–145. https://doi.org/10.1016/j.nefro.2015.05.014 [Crossref] [PubMed] [Google Scholar] [Publisher]

Otsuka, T., Takada, H., Nishiyama, Y., Kodani, E., Saiki, Y., Kato, K., & Kawada, T. (2016). Dyslipidemia and the risk of developing hypertension in a working-age male population. Journal of the American Heart Association, 5(3). https://doi.org/10.1161/jaha.115.003053 [Crossref] [PubMed] [Google Scholar] [Publisher]

Quinlan, C., Rattray, B., Pryor, D., Northey, J. M., Anstey, K. J., Butterworth, P., & Cherbuin, N. (2021). The accuracy of self-reported physical activity questionnaires varies with sex and body mass index. *PloS One*, *16*(8), e0256008. https://doi.org/10.1371/journal.pone.0256008 [Crossref] [PubMed] [Google Scholar] [Publisher]

Ramezankhani, A., Azizi, F., & Hadaegh, F. (2019). Associations of marital status with diabetes, hypertension, cardiovascular disease and all-cause mortality: A long term follow-up study. *PloS One*, *14*(4), e0215593. https://doi.org/10.1371/journal.pone.0215593 [Crossref] [PubMed] [Google Scholar] [Publisher]

Riley, L., Guthold, R., Cowan, M., Savin, S., Bhatti, L., Armstrong, T., & Bonita, R. (2016). The World Health Organization STEPwise Approach to Noncommunicable Disease Risk-Factor Surveillance: Methods, Challenges, and Opportunities. *American Journal of Public Health*, *106*(1), 74–78. https://doi.org/10.2105/AJPH.2015.302962 [Crossref] [PubMed] [Google Scholar] [Publisher]

Sandberg, K., & Ji, H. (2012). Sex differences in primary hypertension. *Biology of Sex Differences*, *3*(1), 7. https://doi.org/10.1186/2042-6410-3-7 [Crossref] [PubMed] [Google Scholar] [Publisher]

Singh, S., Shankar, R., & Singh, G. P. (2017). Prevalence and Associated Risk Factors of Hypertension: A Cross-Sectional Study in Urban Varanasi. *International Journal of Hypertension*, *2017*, 5491838. https://doi.org/10.1155/2017/5491838 [Crossref] [PubMed] [Google Scholar] [Publisher]

Sohn K. (2018). Relationship of Smoking to Hypertension in a Developing Country. *Global Heart*, *13*(4), 285–292. https://doi.org/10.1016/j.gheart.2018.01.004 [Crossref] [PubMed] [Google Scholar] [Publisher]

Tailakh, A., Evangelista, L. S., Mentes, J. C., Pike, N. A., Phillips, L. R., & Morisky, D. E. (2014). Hypertension prevalence, awareness, and control in Arab countries: a systematic review. *Nursing & Health Sciences*, *16*(1), 126–130. https://doi.org/10.1111/nhs.12060 [Crossref] [PubMed] [Google Scholar] [Publisher]

Tazi, M. A., Abir-Khalil, S., Chaouki, N., Cherqaoui, S., Lahmouz, F., Sraïri, J. E., & Mahjour, J. (2003). Prevalence of the main cardiovascular risk factors in Morocco: results of a National Survey, 2000. *Journal of Hypertension*, *21*(5), 897–903. https://doi.org/10.1097/00004872-200305000-00013 [Crossref] [PubMed] [Google Scholar] [Publisher]

Wehling, H., & Lusher, J. (2019). People with a body mass index ≥ 30 under-report their dietary intake: A systematic review. *Journal of health psychology*, *24*(14), 2042–2059. https://doi.org/10.1177/1359105317714318 [Crossref] [PubMed] [Google Scholar] [Publisher]

World Health Organization, & International Diabetes Federation. (2006). *Definition and diagnosis of Diabetes Mellitus and intermediate hyperglycaemia: Report of a WHO/IDF consultation*. World Health Organization.

World Health Organization. (2017). Cardiovascular diseases (cvds). *World Health Organization.* https://www.who.int/fr/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

World Health Organization. (2018). Obesity and overweight. *World Health Organization.*

https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

World Health Organization. (2019). Global physical activity questionnaire (GPAQ). *World Health Organization.* https://www.who.int/publications/m/item/global-physical-activity-questionnaire

World Health Organization. (2021). Hypertension artérielle. *World Health Organization.* https://www.who.int/fr/news-room/fact-sheets/detail/hypertension

World Health Organization. (2023, August). Increasing fruit and vegetable consumption to reduce the risk of Noncommunicable Diseases. *World Health Organization.* https://www.who.int/tools/elena/interventions/fruit-vegetables-ncds