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Prevalence and determinants of hypertension among Senegalese immigrants living in El Jadida, Morocco

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RESUMEN

La hipertensión es un importante problema multifactorial de salud pública, y cada vez más frecuente en todo el mundo. Objetivo: Evaluar la prevalencia e identificar los factores sociodemográficos, antropométricos y nutricionales que determinan la hipertensión entre los inmigrantes senegaleses que residen en Marruecos. Materiales y métodos: En 2020 se llevó a cabo un estudio transversal con 197 inmigrantes senegaleses que vivían en la ciudad de El Jadida, Marruecos. Las mediciones antropométricas incluyeron el peso, la estatura, el índice de masa corporal (IMC), las circunferencias de cintura y cadera, y la relación cintura-cadera. La presión arterial se midió de acuerdo con las directrices internacionales, y la hipertensión se definió como una presión arterial sistólica ≥140 mmHg y/o una presión arterial diastólica ≥90 mmHg. La calidad general de la dieta se evaluó utilizando el índice de adecuación media (MAR), basado en las recomendaciones de la OMS y la FAO (2002). Resultados: La población presentaba una distribución equilibrada por sexos, con un predominio de personas solteras. En general, el 48.2 % tenía un peso normal, mientras que el 28.4 % presentaba sobrepeso y el 20.3 % era obeso. La prevalencia de la hipertensión fue del 20.8%. El MAR medio fue relativamente alto (0.82 ± 0.06), lo que sugiere una adecuación nutricional moderada. El análisis bivariado reveló que la hipertensión se asociaba significativamente con el IMC (p=0.023), así como con unos ingresos mensuales bajos (p=0.017), lo que pone de relieve el papel del sobrepeso y la vulnerabilidad socioeconómica. Conclusión: La hipertensión es muy frecuente entre los inmigrantes senegaleses de El Jadida y está estrechamente relacionada con factores antropométricos y socioeconómicos. Sin embargo, a pesar de que la calidad general de la dieta parece adecuada, pueden persistir posibles desequilibrios nutricionales. Estos hallazgos respaldan la necesidad de estrategias de prevención integradas centradas en el control del peso, la mejora de la situación socioeconómica e intervenciones dietéticas adaptadas a la cultura.

Palabras clave:

Hipertensión
IMC
MAR
Inmigrantes senegaleses
Marruecos

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ABSTRACT

Hypertension is a major multifactorial and growing public health concern worldwide. Objective: To assess the prevalence and identify the sociodemographic, anthropometric, and nutritional determinants of hypertension among Senegalese immigrants residing in Morocco. Materials and Methods: A cross-sectional study was conducted in 2020 on 197 Senegalese immigrants living in El Jadida city, Morocco. Anthropometric measurements included weight, height, body mass index (BMI), waist and hip circumferences, and waist-to-hip ratio. Blood pressure was measured according to international guidelines, and hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg. Overall diet quality was evaluated using the Mean Adequacy Ratio (MAR) based on WHO/FAO (2002) recommendations. Results: The population was evenly distributed by sex, with a predominance of single individuals. Overall, 48.2% had normal weight, while 28.4% were overweight and 20.3% obese. The prevalence of hypertension was 20.8%. The mean MAR was relatively high (0.82 ± 0.06), suggesting moderate nutritional adequacy. Bivariate analysis revealed that hypertension was significantly associated with BMI (p=0.023) as well as low monthly income (p=0.017), highlighting the role of excess weight and socioeconomic vulnerability. Conclusion: Hypertension is highly prevalent among Senegalese immigrants in El Jadida and is strongly associated with anthropometric and socioeconomic factors. However, despite an apparently adequate overall diet quality, potential nutritional imbalances may persist. These findings support the need for integrated prevention strategies targeting weight control, socioeconomic improvement, and culturally adapted dietary interventions.

Keywords:

Hypertension
BMI
MAR
Senegalese immigrants
Morocco

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Introduction

Hypertension, a major non-communicable disease, remains a leading determinant of cardiovascular morbidity and mortality worldwide, affecting both developed and developing countries. According to the World Health Organization (WHO), approximately 1.4 billion people aged 30 to 79 years were living with hypertension globally in 2024, with nearly two-thirds residing in low- and middle-income countries where health systems are often inadequately equipped for effective screening and management (Mills, Stefanescu and He, 2020; Zhou et al., 2021; WHO, 2023a, 2023b, 2025). Furthermore, hypertension is frequently asymptomatic, and it is estimated that about 44% of affected individuals remain unaware of their condition, highlighting the magnitude of undiagnosed cases worldwide (WHO, 2025).

In Africa, the burden of hypertension is particularly concerning. In North Africa, data show that hypertension is steadily increasing in Tunisia and is associated with aging and non-diabetic diseases such as obesity and diabetes, with more than a third of the population affected (WHO, 2021, 2025; Hamoudi et al., 2022). Similarly, in Morocco, the WHO reported that 6.1 million Moroccan adults are affected by HTA, of whom only 43% have received a diagnosis, distributed as 34% among men and 52% among women. The same data indicate insufficient screening for this disease (El Hendaoui, Mziwira and Belahsen, 2023). Sub-Saharan Africa has also become a region characterized by a rapid increase in the prevalence of hypertension and a low proportion of diagnosed individuals, in addition to often inadequate blood pressure control (The Lancet, 2017; Geldsetzer et al., 2019 ; Ataklte et al., 2015).

Furthermore, sub-Saharan migrant populations also constitute a particularly vulnerable group. Migration trajectories are frequently accompanied by socio-economic and environmental changes that can influence population behaviors, including health behaviors, particularly those related to diet, physical activity, and exposure to psychosocial stress (IOM, 2019). Several recent studies have shown a high prevalence of hypertension among sub-Saharan immigrants, linked to economic insecurity, excess weight, and difficulties accessing healthcare, regardless of the host country (van der Linden et al., 2022; Meeks and Agyemang, 2025).

In Morocco, a country of transit and increasing settlement for sub-Saharan immigrants, few published epidemiological studies have specifically assessed the prevalence and determinants of hypertension in immigrant populations (Essayagh et al., 2023). The limited available research suggests a coexistence of cardiometabolic risk factors related to nutritional transition, urbanization, and unfavorable living conditions, which could contribute to elevated blood pressure among immigrants (WHO, 2023a, 2023b; Meeks and Agyemang, 2025). In this still poorly documented North African migratory context, this study is part of a major public health challenge, aiming to better understand the interaction between social determinants, nutritional status and cardiovascular risk with hypertension among Senegalese immigrants residing in El Jadida.

Materials and Methods

Study design

This descriptive cross-sectional study was conducted between May 2018 and January 2020 in El Jadida province, located on the Atlantic coast of Morocco. The study population consisted of Senegalese immigrants residing in El Jadida city for at least one year.

Population and sampling

Participants were recruited using a non-probability sampling method based on accessibility and voluntary participation. This approach was adopted due to the difficulty of reaching Senegalese immigrants residing in El Jadida because of the lack of a comprehensive sampling frame for this population. The sample is therefore considered a convenience sample rather than a probability sample representative of all Senegalese immigrants living in Morocco.

The study included a sample of 197 Senegalese immigrants of both sexes, aged 18 to 55 years, residing in El Jadida. As it is stated that blood pressure tends to increase with age (WHO, 2025); in this study, participants were divided into age groups to examine differences in the prevalence of hypertension

according to age. To participate in the study, the inclusion criteria were Senegalese nationality, residence in Morocco at the time of the study, for at least one year, ability to complete the questionnaire and informed consent of participants. Excluded from the study were pregnant women, individuals suffering from an acute illness at the time of the survey, and those whose data were incomplete for key variables (blood pressure, anthropometric measurements, sociodemographic characteristics, or dietary data).

Data were collected using a structured questionnaire administered through face-to-face interviews by trained interviewers. The sociodemographic and socioeconomic information collected included sex, age, marital status, education level, occupation, and monthly income. Age was analyzed as a continuous variable and then categorized into age groups of 18–25 years, 26–35 years, and ≥ 36 years. Monthly income was classified as < $300, $300–500, and ≥ $500, and educational attainment, assessed by the number of years of schooling, was grouped into two categories: less than seven years and seven or more years of schooling. Anthropometric measurements were taken according to WHO recommendations (WHO, 2000). Body weight was measured using a calibrated electronic scale, with an accuracy of 0.1 kg, in lightly clothed and barefoot participants, and height was measured in a standing position using a vertical measuring rod, with an accuracy of 0.1 cm. Body mass index (BMI) was calculated as the ratio of weight (kg) to height in meters squared (m^2). Overweight and obesity were defined according to the WHO criteria, with a BMI ≥ 25 kg/m^2 for overweight and ≥ 30 kg/m^2 for obesity (WHO, 2000). Waist and hip circumferences were measured using a non-stretch measuring tape, at the midpoint between the last rib and the iliac crest for waist circumference, and at the widest point of the hip circumference for hip circumference. The waist-to-hip ratio (WHR) was calculated as the ratio of waist circumference to hip circumference. Abdominal obesity was defined, according to WHO recommendations, as an WHR > 0.90 in men and > 0.85 in women (Nishida, Ko and Kumanyika, 2010).

Using a validated blood pressure monitor, systolic and diastolic blood pressures were measured on the morning of the survey, two hours after breakfast and after at least 10 minutes of rest in a seated position. Two successive measurements were taken, and the average of the two values was used for analysis. As recommended by the WHO and the European Society of Cardiology, hypertension was defined as a systolic blood pressure ≥ 140 mmHg and/or a diastolic blood pressure ≥ 90 mmHg (WHO, 2021). Participants were divided into two groups: a hypertensive group and a non-hypertensive group. Heart rate was also recorded. However, recent coffee or tobacco consumption and stress levels at the time of measurement were not systematically documented.

Dietary intake was assessed using two 24-hour dietary recalls, conducted on different days. Each participant was asked to provide a detailed list of foods consumed during the 24 hours preceding the survey, including main meals, snacks, and light meals, as well as the quantities of both food and beverages consumed. The dietary recalls were conducted on days other than Fridays, given the frequent consumption of couscous, a traditional Moroccan dish, on that day, which could potentially influence usual dietary intake. Public holidays were also avoided to minimize the influence of festive meals (which are generally large) on dietary intake estimates. This procedure aimed to better reflect the participants' usual eating habits. The quantities consumed were estimated using standardized household measurements and, where necessary, visual aids to improve the accuracy of the reports. The conversion of food consumed into energy and nutritional intake (energy, macronutrients, and micronutrients) was performed using the SCDA NUTRISOFT-BILNUT software, version 2.01 (France). This software calculates daily intakes based on integrated databases. For traditional Senegalese foods or ingredients not listed in the software's database, additional information was entered. Furthermore, the traditional dishes mentioned by participants were broken down into their main ingredients to better estimate their energy and nutritional value.

Average nutritional intakes were then calculated for all participants and compared to international nutritional recommendations to assess the adequacy of their intake and identify any potential nutritional deficiencies or excesses. The Mean Adequacy Ratio (MAR) was calculated as the average of the Nutrient Adequacy Ratios (NARs) of fifteen

nutrients, as previously assessed (Elfane, Sahel and Belahsen, 2024) with each NAR value truncated to 1 to avoid overestimating overall nutritional adequacy. A MAR below 0.75 was considered an indicator of inadequate diet quality, in accordance with methodological recommendations in the literature (Hatløy, Torheim and Oshaug, 1998; Gibson, 2005).

Given the central role of sodium in regulating blood pressure, a sodium intake above 2000 mg per day was considered high, in accordance with World Health Organization recommendations (WHO, 2012, 2023a, 2023b). However, since the effect of sodium on blood pressure is modulated by potassium intake, the sodium/potassium (Na/K) ratio was calculated as an indicator of overall nutritional balance, incorporating both excess sodium and potassium deficiency. A ratio greater than 1 was considered unfavorable. According to WHO recommendations and data from large international epidemiological studies, this threshold is recognized as more predictive of elevated blood pressure and cardiovascular risk than sodium intake alone (WHO, 2012; Groenland et al., 2023).

Statistical analyses were performed using IBM SPSS Statistics for Windows (version 25). The threshold for statistical significance was set at $p < 0.05$ for all tests. Qualitative variables were described as counts (n) and percentages (%), while quantitative variables were expressed as means ± standard deviations (SD). The normality of quantitative variables was assessed using the Shapiro–Wilk test, When the assumption of normality was not met, non-parametric tests were used.

Comparisons of anthropometric, cardiovascular, and nutritional parameters by sex were performed using Student's t-test for independent samples for normally distributed variables, and comparisons of qualitative variables were performed using Pearson's chi-squared test when the conditions for application were met (counts ≥ 5). For variables with small count categories (e.g., certain BMI and income categories), Fisher's exact test was used.

Initially, bivariate analyses were performed to explore the association between hypertension and the variables studied. Qualitative variables were compared between the groups with and without hypertension using crosstabs in SPSS software, employing Pearson's chi-squared test when the application conditions were met, and Fisher's exact test when the expected sample sizes were insufficient. Quantitative variables were compared between the two groups using the independent-samples t-test.

Variables associated with hypertension at a p-value < 0.20 in bivariate analysis were considered candidate variables for multivariate logistic regression. This intentionally broad threshold was used to avoid the premature exclusion of potentially confounding factors and in accordance with methodological recommendations in epidemiology; the statistical significance threshold for the final model was set at $p < 0.05$. A binary logistic regression was then performed using the Binary Logistic Regression procedure to identify factors independently associated with hypertension. The dependent variable was blood pressure status (hypertension: yes/no). The explanatory variables (age, sex, monthly income, overweight/obesity, Mean Adequacy Ratio, high sodium intake, and sodium/potassium ratio) were simultaneously included in the model. The results are presented as adjusted odds ratios, along with their 95% confidence intervals and corresponding p-values. The overall goodness of fit of the model and the absence of collinearity among the explanatory variables were verified before final interpretation.

The absence of collinearity among the explanatory variables included in the logistic regression model was verified, with no factor exhibiting a variance inflation factor (VIF) greater than 2.

Nutritional indicators

The nutritional quality of the diet was also assessed using the nutritional indicators Nutrient Adequacy Ratios (NARs) and Mean Adequacy Ratio (MAR).

The NAR, corresponding to the adequacy ratio of each nutrient, was calculated for each individual based on their dietary intake of nutrients relative to the Reference Intakes (RIs) (Waijers, Feskens and Ocké, 2007) using the following formula: NAR = Intake of nutrient x / Recommended intake for the same nutrient x. When the dietary intake of a given nutrient exceeds the RIs, the resulting NAR is greater than one. To avoid overestimating overall nutritional adequacy, each NAR value was truncated to 1, as described by the methodology of (Hatløy, Torheim and Oshaug, 1998).

The MAR is an overall score that allows for the assessment of the adequacy of a diet in relation to nutritional recommendations. It is calculated using the following formula: MAR = ∑NARs/Number of nutrients (∑x). It corresponds to the average of the Nutrient Adequacy Ratios (NARs) for the selected nutrients (Elfane, Sahel and Belahsen, 2024). It allows for consideration of the adequacy of consumption relative to the recommended nutrient intakes (RNIs) for several nutrients simultaneously. The reference value of the MAR, corresponding to 100% of the RNIs, is set at "1" (ideal adequacy to recommendations).

The MAR, used as a composite indicator of overall diet quality, is analyzed both as a continuous variable and as a categorical variable (< 0.75 vs. ≥ 0.75), in accordance with methodological recommendations in the literature (Hatløy, Torheim and Oshaug, 1998; Gibson, 2005). As an example, in this study, sodium intake > 2000 mg/day was considered high, and a sodium/potassium ratio > 1 was considered unfavorable to cardiovascular health.

Ethical considerations

The study was conducted in accordance with ethical principles. Participation was voluntary, and written informed consent was obtained from all participants before their inclusion. Data were collected and analyzed anonymously and confidentially.

Results

1. Sociodemographic and socioeconomic characteristics

Table 1 shows that among the study's sample of 197 Senegalese immigrants, 96 were men and 101 were women. There was no significant difference between the sexes in terms of age, marital status, or education level. However, a significant difference in monthly income was observed between the sexes (p = 0.018): the number of women in the lowest income category was slightly higher (<$300), while men were more represented in the middle income category ($300–$500). A significant difference was also found for occupation (p = 0.036), with students being proportionally more numerous among men than among women.

2. Comparison of Anthropometric Parameters of the Study Sample by Sex

Data concerning anthropometric parameters compared by sex in the surveyed sample of Senegalese immigrants residing in El Jadida are presented in Table 2. While overall weight status appeared comparable between men and women, the data revealed significant differences in body morphology and adiposity distribution (Table 2). According to the anthropometric parameters presented in Table 2, the mean BMI did not differ significantly between men and women. However, significant differences were observed for some indicators of fat mass distribution, notably waist circumference and the waist-to-hip ratio (WHR). Indeed, men had a higher WHR than women, reflecting a more android fat distribution. However, using the WHO WHR classification, no statistically significant difference was observed between the sexes. Overall, these results suggest that, despite a comparable BMI between men and women, body fat distribution differed by sex, with a tendency toward more pronounced abdominal adiposity in men.

3. Cardiovascular parameters and blood pressure by sex

The comparison of cardiovascular parameters by sex (Table 3) did not reveal any statistically significant difference between men and women in this immigrant community. The mean heart rate was slightly higher in men (84.88 ± 1.81 beats/min) than in women (81.61 ± 1.41 beats/min), but the difference was not significant (p=0.15). Regarding systolic blood pressure (SBP), the proportions of participants with elevated SBP (≥ 140 mmHg) were comparable in both sexes (20.8% in both groups), with no significant difference (p=0.99). No significant difference was also observed for diastolic blood pressure (DBP) either (DBP ≥ 90 mmHg in men (12.5%) and women (11.9%) (p=0.89)). These results indicate that, in this population of Senegalese immigrants, sex is not significantly associated with cardiovascular parameters or blood pressure status, suggesting that other factors, particularly anthropometric, nutritional, and socioeconomic factors, may play a more decisive role in blood pressure variation.

Table 1. Sociodemographic and socioeconomic characteristics of Senegalese immigrants by sex.

Variables	Modalities	Total n (%)	Males n (%)	Females n (%)	p-value
Age (years)	18–25	30 (15.2)	16 (16.7)	14 (13.9)	0.766
	26–35	74 (37.6)	37 (38.5)	37 (36.6)	
	≥36	93 (47.2)	43 (44.8)	50 (49.5)	
Marital status	Single	101 (51.3)	52 (54.2)	49 (48.5)	0.428
	Married/in couple	96 (48.7)	44 (45.8)	52 (51.5)	
Monthly income ($)	<300	156 (79.2)	74 (77.1)	82 (81.2)	**0.018**
	300–500	30 (15.2)	20 (20.8)	10 (9.9)	
	>500	11 (5.6)	2 (2.1)	9 (8.9)	
Profession	Traders/other professions	179 (90.9)	83 (86.5)	96 (95.0)	**0.036**
	Students	18 (9.1)	13 (13.5)	5 (5.0)	
Education level (years)	<7	124 (62.9)	59 (61.5)	65 (64.4)	0.647
	≥7	73 (37.1)	37 (38.5)	36 (35.6)	

Note: Data are expressed as counts (N) and percentages (%). Percentages were calculated based on the total sample size (N = 197). Income amounts are expressed in US dollars ($). p-values were obtained using the chi-square test.

Table 2. Comparison of anthropometric parameters by sex among Senegalese immigrants.

Variables	Males (n= 96)	Females (n = 101)	Test (p-value)
Weight (kg) (mean ± SD)	79.05 ± 1.59	81.57 ± 1.61	Student t = 1.23; (p = 0.27)
Height (m) (mean ± SD)	1.77 ± 0.01	1.76 ± 0.01	Student t = 0.01; (p = 0.92)
BMI (kg/m²) (mean ± SD)	25.41 ± 0.53	26.24 ± 0.53	Student t = 1.23; (p = 0.26)
BMI (categories) n (%)			
-Underweight	3 (3.1)	3 (3.0)	χ^2 = 2.77 (p = 0.42)
-Normal weight	52 (54.2)	43 (42.6)	
-Overweight	24 (25.0)	32 (31.7)	
-Obesity	17 (17.7)	23 (22.8)	
WC (cm) (mean ± SD)	94.5 ± 9.2	88.0 ± 10.1	t = 4.74 (**p < 0.001**)
Hip Circumference (cm) (mean ±SD)	101.0 ± 8.5	104.5 ± 9.0	t = 2.76 (**p = 0.006**)
WTH (mean ± SD)	0.94 ± 0.05	0.84 ± 0.06	t = 12.0 (**p < 0.001**)
WTH (catégories) n (%)			
-Normal	55 (57.3)	62 (61.4)	χ^2 = 2.70 (p = 0.10)
-High	41 (42.7)	39 (38.6)	

Note: Data are expressed as mean ± standard deviation (SD) or as counts (N) and percentages (%). Comparisons between sexes were performed using Student's t-test for quantitative variables and the chi-square test for qualitative variables. The threshold for statistical significance was set at $p < 0.05$. Abbreviations: BMI = body mass index; WHR = waist-to-hip ratio; SBP = systolic blood pressure; DBP = diastolic blood pressure; SD = standard deviation.

Table 3. Comparison of cardiovascular and blood pressure parameters according to sex in the studied sample.

Variables	Modalities	Male n (%) or Mean ± SD	Female n (%) or Mean ± SD	p-value
Heart rate (bpm)	—	84.88 ± 1.81	81.61 ± 1.41	p = 0.15
SBP	< 140 mmHg	76 (79.2)	80 (79.2)	p = 0.99
	≥ 140 mmHg	20 (20.8)	21 (20.8)	
DBP	< 90 mmHg	84 (87.5)	89 (88.1)	p = 0.89
	≥ 90 mmHg	12 (12.5)	12 (11.9)	

Note: Data are expressed as mean ± standard deviation (SD) or as counts (n) and percentages (%). Comparisons between sexes were performed using Student's t-test for quantitative variables and the chi-square test for qualitative variables. The threshold for statistical significance was set at $p < 0.05$. SBP: systolic blood pressure; DBP: diastolic blood pressure; bpm: beats per minute. Hypertension was defined as an SBP ≥ 140 mmHg and/or a DBP ≥ 90 mmHg (WHO/ESC).

4. Average daily nutritional intake and food quality among Senegalese immigrants residing in El Jadida, according to WHO recommendations.

Table 4 presents the analysis of dietary intake, providing information on food quality according to WHO reference intake levels. These results highlight a dietary profile characteristic of a nutritional transition, marked by several quantitative and qualitative imbalances influencing cardiometabolic risk. Table 4 shows that the average energy intake observed is high compared to the individual needs recommended by the FAO/WHO (2010) (see also FAO/WHO/UNU, 2001, 2007). This result is consistent with the significant prevalence of overweight and obesity observed in the studied population. The indirect contribution of this energy overload is the elevation of blood pressure, notably through increased body mass and adiposity (El Hendaoui, Mziwira and Belahsen, 2023).

Regarding macronutrients, protein intake is generally in line with international recommendations, suggesting adequate coverage of needs. However, total fat intake exceeds WHO recommended levels, with an excessive contribution of saturated fatty acids, exceeding 10% of total energy intake. This lipid profile, linked to an unbalanced diet, suggests exposition of the study immigrant community to a detrimental effects on cardiovascular health. Excess fat, particularly saturated fat, is known to have potential effects on arterial stiffness and endothelial function, with consequences for blood pressure regulation. Carbohydrate intake appears to be quantitatively high; however, the lack of information on the quality of the carbohydrates consumed prevents a precise assessment of their metabolic impact. Nevertheless, the combination of high energy intake and low dietary fiber intake suggests insufficient consumption of minimally processed plant foods (fruits, vegetables, whole grains), in favor of more refined foods. Dietary fiber is among the most deficient nutrients in this population, with intakes significantly below the WHO recommended threshold of 25 g/day. This fiber deficiency is particularly concerning in the context of hypertension. Indeed, fiber is known for its protective role in regulating blood pressure, notably through improved insulin sensitivity, modulation of the gut microbiota, and reduction of low-grade inflammation.

Regarding micronutrients, sodium is known to play a role in regulating blood pressure. In the immigrant community studied, sodium intake far exceeded the maximum recommended threshold of 2,000 mg/day in a significant proportion of participants, thus constituting one of the most marked nutritional imbalances observed. At the same time, potassium intake was frequently insufficient and below international recommendations (≥ 3,510 mg/day), resulting in an unfavorable sodium/potassium ratio, recognized as a major determinant of cardiovascular risk and hypertension, independent of total energy intake.

Table 4. Average daily nutritional intake of the studied Senegalese immigrant community compared with WHO recommendations.

Nutrient	Mean Intake ± SD	WHO Reference	Interpretation
Energy (kcal/d)	2780 ± 520	Individual needs according to age, sex and physical activity [20]	High intake
Proteins (g/d)	88 ± 22	**0.83 g/d** in adults [21]	Globally sufficient
Carbohydrates (g/d)	330 ± 75	**55–75 %** of TEI [22]	High intake
Total Lipids (g/d)	95 ± 28	**15–30 %** of TEI [22]	High intake
SFA (%TEI)	13.5 ± 4.0	**< 10 %** of TEI [23]	Frequent excess
MUFA (% AET)	12.0 ± 3.5	No specific WHO threshold; recommended as a substitute for SFA [23]	Intermediate intake
UFA (% AET)	6.5 ± 2.2	**6–11 %** of TEI [23]	Consistent
Dietary Fibres (g/d)	14.0 ± 6.0	**≥ 25 g/d** in adults [22]	Insufficient
Na (mg/d)	3240 ± 1 050	**< 2000 mg/d** [1]	Marked excess
K (mg/d)	2650 ± 850	**≥ 3510 mg/d** in adults [18]	Often insufficient
Na/K	1.35 ± 0.55	**Ratio < 1** desirable for cardiovascular prevention [18]	Unfavorable
Total water (mL/d)	1850 ± 650	No strict WHO value; needs depend on climate and activity [20]	Intake possibly low
MAR (0–1)	0.82 ± 0.06	**< 0.75 :** overall nutritional inadequacy [16]	Moderately adequate

Note: Reference Intakes (RI); Total Energy Intake (TEI); WHO = World Health Organization; MAR = Mean Adequacy Ratio; Na/K = Sodium/Potassium Ratio; SFA: Saturated Fatty Acids; UFA: Unsaturated Fatty Acids; MUFA: Monounsaturated Fatty Acids. Reference intakes are derived from WHO reports and joint WHO/FAO reports. The Mean Adequacy Ratio (MAR) is a methodological indicator of overall nutritional adequacy (and not a WHO recommendation).

5. Factors Associated with Hypertension

As shown in Table 5, the comparison between the hypertensive and non-hypertensive participants groups reveals differences in sociodemographic, anthropometric, and nutritional variables. Among the sociodemographic factors, sex was not significantly associated with hypertension, with the proportion of men being almost identical in both groups (48.8% in the hypertensive group versus 48.7% in the non-hypertensive group; ($p = 0.99$)). The same was true for marital status, which did not differ significantly between the two groups, with a proportion of single individuals of 46.3% in the hypertensive group versus 52.6% in the non-hypertensive group ($p = 0.48$). Regarding age, participants aged 36 and over were proportionally more numerous in the hypertensive group than in the non-hypertensive group, at 43.9% versus 31.4%. However, this difference was not statistically significant ($p = 0.12$), suggesting a possible trend that should be interpreted with caution. A monthly income below USD 300 was significantly associated with hypertension. Indeed, 97.6% of hypertensive participants belonged to this income bracket, compared to 74.4% of non-hypertensive participants ($p = 0.017$), suggesting a potential link between socioeconomic vulnerability and hypertension in this immigrant population. Regarding the anthropometric variable, a significantly higher mean BMI was found in hypertensive participants (27.6 ± 4.2 kg/m²) compared to non-hypertensive participants (24.8 ± 3.9 kg/m²) ($p = 0.023$). Furthermore, the prevalence of overweight and obesity was significantly higher among hypertensive participants (87.8%) than among non-hypertensive participants (38.5%) ($p < 0.001$). These results highlight that excess weight is among the important factors associated with hypertension in this population. From a nutritional standpoint, the overall quality of the diet, assessed by

the Mean Adequacy Ratio (MAR), did not differ significantly between the two groups. The mean MAR was 0.81 ± 0.06 in hypertensive participants versus 0.83 ± 0.05 in non-hypertensive participants (p = 0.19). In contrast, a sodium intake exceeding 2000 mg/day was more frequent among hypertensive participants than among non-hypertensive participants (87.8% versus 71.8%). However, this association was close to the threshold of statistical significance (p = 0.06). This result should therefore not be presented as a statistically significant association, but rather as a possible trend suggesting a potential role of high sodium intake in hypertension.

Although the sodium/potassium ratio allows for a joint assessment of the balance between sodium and potassium intake, the interpretation in Table 5 focused on sodium intake above 2000 mg/day, which corresponds to a clearly defined nutritional threshold. The Na/K ratio was not included in Table 5 and will be considered in the supplementary nutritional analysis to avoid redundancy with the detailed nutritional indicators presented in Table 6.

Table 5. Factors associated with hypertension in Senegalese immigrants.

Variables	Total n (%) or Mean ± SD	Non-HTA (n = 156)	HTA (n = 41)	p-value
Sociodemographic				
Sex (Male)	96 (48.7)	76 (48.7)	20 (48.8)	0.99
Age ≥ 36 yrs	67 (34.0)	49 (31.4)	18 (43.9)	0.12
Single	101 (51.3)	82 (52.6)	19 (46.3)	0.48
Income < 300 $	156 (79.2)	116 (74.4)	40 (97.6)	**0.017**
Anthropometrics				
BMI (kg/m²)	25.3 ± 4.1	24.8 ± 3.9	27.6 ± 4.2	**0.023**
Overweight/obesity	96 (48.7)	60 (38.5)	36 (87.8)	**<0.001**
Nutrition				
MAR	0.82 ± 0.06	0.83 ± 0.05	0.81 ± 0.06	0.19
Sodium > 2000 mg/d	148 (75.1)	112 (71.8)	36 (87.8)	0.06

Note: Data are expressed as counts (n) and percentages (%) or as mean ± standard deviation (SD). Comparisons between the groups with or without hypertension were performed using the chi-square test for categorical variables and the Student's t-test for continuous variables. The threshold for statistical significance was set at $p < 0.05$. Hypertension is defined as a systolic blood pressure (SBP) ≥ 140 mmHg and/or a diastolic blood pressure (DBP) ≥ 90 mmHg; BMI = body mass index (kg/m²); MAR = mean adequacy ratio.

Table 6. Factors independently associated with hypertension in Senegalese immigrants.

Variables	Adjusted OR	IC 95 %	p-value
Age ≥ 36 yrs	1.68	[0.82 – 3.44]	0.15
Sex (Male)	1.01	[0.49 – 2.08]	0.98
Low income < 300 $	**4.72**	**[1.08 – 20.65]**	**0.039**
Overweight/obesity (BMI ≥ 25kg/m²)	**6.31**	**[2.58 – 15.43]**	**< 0.001**
Low MAR (< 0.75)	1.29	[0.54 – 3.09]	0.56
High Sodium (> 2000 mg/j)	2.11	[0.88 – 5.03]	0.09
Unfavorable Na/K Ratio (> 1)	1.47	[0.65 – 3.32]	0.35

Note: SBP: Systolic blood pressure, DBP: Diastolic blood pressure; The dependent variable was hypertension, defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg; Odds ratios (ORs) were adjusted for all variables included in the model; The threshold for statistical significance was set at $p < 0.05$.

6. Factors Independently Associated with Hypertension

Multivariate analysis using logistic regression in Table 6 identified factors independently associated with hypertension among Senegalese immigrants residing in El Jadida, after adjusting for sociodemographic, anthropometric, and nutritional variables included in the model. Among the variables studied, low monthly income (< $300) emerged as a factor significantly associated with hypertension. Subjects in this category had a nearly five times greater risk of hypertension compared to those with higher incomes (adjusted OR = 4.72; 95% CI: [1.08–20.65]; p=0.039). This result highlights the major impact of socioeconomic determinants on cardiovascular health in this migrant population. Overweight/obesity (BMI ≥ 25 kg/m²) appeared to be the strongest association observed with hypertension. Overweight or obese individuals had a more than sixfold increased risk of hypertension compared to individuals of normal weight (adjusted OR = 6.31; 95% CI: [2.58–15.43]; p<0.001). This robust association confirms the central role of excess weight in the pathophysiology of hypertension.

Discussion

This study highlighted the importance of certain factors related to socioeconomic vulnerability and health status, specifically hypertension, in an immigrant population. As the IOM report emphasizes, these factors can be associated with health status through several social, economic, and health-related mechanisms, including living conditions, access to healthcare, and integration into the host country (IOM, 2019). The data presented here reveal that monthly income and professional status differ by gender, suggesting that vulnerability is heterogeneous within this studied immigrant population. Results obtained by Essayagh et al. (2023) in the Moroccan context also showed that migrants have a significant burden of chronic diseases, including hypertension, which underscores the importance of studying these determinants in immigrant populations living in Morocco. Furthermore, the importance of the role played by the social and migratory context was also suggested by the findings of van der Linden et al. (2022), who showed that the determinants of hypertension can vary according to place of residence in African populations (van der Linden et al., 2022). Finally, the review by Meeks and Agyemang highlights that cardiovascular risk in African migrants is multifactorial and can be influenced by socioeconomic conditions and the post-migration environment (Meeks and Agyemang, 2025). Thus, the higher representation of women in the lowest income category observed in this study could reflect economic vulnerability possibly associated with a less favorable cardiovascular risk profile, particularly through more limited access to quality food, healthcare, and adequate living conditions.

The results reported here highlight an overall dietary profile that is unfavorable to cardiovascular health, and may be related to the blood pressure profile observed in this migrant population, without allowing any causal inference due to the cross-sectional design of the study. Indeed, the nutritional profile of the studied population was characterized by high energy intake, excessive sodium consumption, and a lipid intake containing a significant proportion of saturated fatty acids, in addition to excess body weight. The observed association between excess weight and hypertension suggests that overweight and obesity may represent important factors associated with arterial hypertension in this population. The relationship between excessive adiposity and cardiovascular dysfunction has been widely described in the literature (Wu, Micha and Mozaffarian, 2019; Challa, Ameer and Uppaluri, 2023; Onwuzo et al., 2023). These factors collectively may be linked to blood pressure regulation through mechanisms described in the literature, but the present study does not allow causal conclusions to be drawn.

In addition to anthropometric and nutritional factors, a comparison between hypertensive and non-hypertensive participants showed that a monthly income below USD 300 was significantly more frequent among hypertensive subjects. This finding suggests that socioeconomic vulnerability may be associated with hypertension in this immigrant population. However, given the cross-sectional nature of the study, this association does not establish a causal relationship between low income and hypertension.

Rather, low income may be part of a broader context of social vulnerability, characterized by more limited access to healthy food, increased exposure to chronic stress, unfavorable living conditions, and more restricted access to healthcare (Batis et al., 2011; Osei-Kwasi et al., 2017; Wang et al., 2020; WHO, 2023a, 2023b). Since the majority of participants belonged to the low-income category, this association should be interpreted with caution. The comparison with participants having a higher income was therefore based on a small subgroup, which may have influenced the stability and accuracy of the estimate. This is generally the case for the associations observed in this study, which, due to the cross-sectional nature of the protocol, must also be interpreted with caution, since this type of study does not allow for establishing a causal relationship between the sociodemographic, anthropometric, or nutritional factors studied and hypertension. Thus, the observed dietary factors should be considered as descriptive elements of the population's nutritional profile or as factors possibly associated with hypertension, and not as direct causes of elevated blood pressure.

In the context of an ongoing nutritional transition in developing countries (Wang et al., 2020; WHO, 2023a, 2023b), these results are consistent with the literature reporting associations between diets high in sodium and saturated fats and an increased risk of hypertension and cardiovascular disease (Challa, Ameer and Uppaluri, 2023; Onwuzo et al., 2023).

In this study, although the association with salt intake was borderline statistically significant and did not reach the conventional threshold of 5% ($p = 0.06$), a sodium intake exceeding 2,000 mg/day was more frequent in hypertensive subjects than in non-hypertensive participants. This result should nevertheless be interpreted with caution and considered a possible trend rather than a statistically significant association. This observation remains biologically plausible, however, as reducing sodium intake is recognized by the WHO as one of the most effective and cost-efficient nutritional interventions for the prevention of hypertension (WHO, 2023a, 2023b).

These WHO recommendations set a global target of a 30% reduction in salt consumption by 2025 (WHO, 2023a, 2023b). Furthermore, recent analyses confirm that excess sodium exerts its deleterious effects independently of overall energy intake, through mechanisms including increased plasma volume and vascular dysfunction (Popkin, 2017; Wu, Micha and Mozaffarian, 2019; He et al., 2021).

The sodium/potassium ratio, although a relevant complementary indicator for interpreting the dietary profile and cardiovascular risk of this population, was not included in Table 5 to avoid redundancy with the detailed nutritional indicators presented in Table 6. It has been shown that the association between sodium and cardiovascular risk should be interpreted in conjunction with potassium intake (O'Donnell et al., 2019). Furthermore, profiles combining moderate sodium intake and higher potassium intake are associated with the lowest risk of cardiovascular events and mortality. Similarly, Gonçalves and Abreu (2020), in a systematic review, reported that higher potassium intake and a lower sodium/potassium ratio are associated with a lower cardiovascular risk. Thus, even though it is not shown in Table 5, the Na/K ratio provides important additional information, as it allows for a better assessment of the balance between excess sodium and insufficient potassium intake, two elements involved in the regulation of blood pressure (O'Donnell et al., 2019; Gonçalves and Abreu 2020).

Importantly, it is the unfavorable sodium/potassium ratio, and in particular insufficient potassium intake as observed in this study, that may reflect an unfavorable nutritional balance related to blood pressure regulation. The relevance of the sodium/potassium ratio as an indicator of cardiovascular risk, rather than each nutrient considered individually, has been demonstrated in large prospective studies and systematic reviews showing an association between a high ratio and increased blood pressure as well as cardiovascular events (O'Donnell et al., 2019 ; Gonçalves and Abreu, 2020).

In this context, current nutritional recommendations advocate increasing the consumption of foods naturally rich in potassium, such as fruits, vegetables, and legumes, in order to counteract the detrimental effects of excessive sodium intake on blood pressure regulation (WHO, 2023a, 2023b). These findings support the importance of comprehensive dietary approaches, focusing not only on salt reduction but also on improving overall dietary quality (Challa,

Ameer and Uppaluri, 2023; Onwuzo et al., 2023; WHO, 2023a, 2023b).

Another unfavorable factor is fiber intake, which is known to play a role in blood pressure regulation and cardiovascular prevention (Filippou et al., 2020; Tejani et al., 2023). The insufficient dietary fiber intake observed in this population may represent an additional unfavorable dietary characteristic. Recent reviews indicate that high fiber intake, integrated into comprehensive dietary patterns such as the DASH diet, is associated with significant reductions in blood pressure, independent of body weight (Filippou et al., 2020; Challa, Ameer and Uppaluri, 2023; Onwuzo et al., 2023; Tejani et al., 2023). The coexistence, in this study, of high energy intake and low fiber intake suggests a limited consumption of minimally processed plant-based foods, in favor of refined and energy-dense foods, a situation frequently described in migrant populations facing socioeconomic constraints (Batis et al., 2011; Osei-Kwasi et al., 2017).

Using the Mean Adequacy Ratio (MAR) for the overall assessment of diet quality, the results indicate moderate nutritional adequacy, with no independent association with hypertension after adjustment. Although MAR reflects a moderately satisfactory overall nutritional adequacy, this composite indicator does not allow identification of specific nutritional imbalances potentially relevant to blood pressure regulation (Hatløy, Torheim and Oshaug, 1998; Gibson, 2005). This result suggests that overall indicators of nutritional adequacy can mask specific imbalances in nutrients with a well-established impact on blood pressure, such as excess sodium or poor lipid quality (Mozaffarian, 2016). In particular, beyond sodium intake alone, the balance between sodium and potassium intake plays a central role in blood pressure regulation (WHO, 2012; O'Donnell et al., 2019; Gonçalves and Abreu, 2020).

However, the absence of a significant association between the MAR and hypertension after adjustment does not necessarily mean the absence of relevant nutritional imbalances. Since the MAR is a global indicator, it can mask certain imbalances in specific nutrients, such as high sodium intake, an unfavorable Na/K ratio, low fiber consumption, or poor lipid quality. Furthermore, the observed trends for sodium and the Na/K ratio may be due to the likely influence of measurement errors in the dietary assessment, particularly those related to recall bias, social desirability, and intra-individual variability in intake. In addition, the limited statistical power, due in particular to the relatively small number of hypertensive subjects, may have reduced the study's ability to detect significant associations for certain nutritional variables.

In this context, the dietary imbalances observed in this study may help inform future nutritional interventions, including salt reduction, improvement of lipid quality, and increased consumption of foods rich in fiber and potassium. However, these dietary variables should be considered as descriptive elements of the nutritional profile rather than as independent determinants of hypertension in this study. Such interventions should be integrated into multidimensional prevention strategies, taking into account the socioeconomic and cultural constraints specific to the migration context, in order to improve their acceptability and effectiveness. These strategies should also be aligned with existing public health initiatives, such as universal salt iodization, since reducing iodized salt consumption may have unintended consequences, particularly with regard to iodine deficiency.

Study limitations

This study has certain methodological limitations that must be considered when interpreting the results. First, its cross-sectional nature does not allow for establishing a causal link between the sociodemographic, anthropometric, or nutritional factors studied and hypertension; therefore, these results should be interpreted as associations. Second, although the assessment of dietary intake is based on two 24-hour dietary recalls taken on different days, this method may not fully reflect participants' usual dietary intake or capture all intra-individual variability. Furthermore, like any self-reported method, it may be subject to recall bias and social desirability bias, which could lead to an underestimation or overestimation of certain intakes relevant to the research question, particularly energy, sodium, or lipid intake. Furthermore, because the recalls were taken on days other than Fridays and public holidays to avoid the influence of specific or exceptional meals, some

weekly or holiday-related dietary variations may not have been fully captured. Third, the use of non-probability sampling may also introduce selection bias and limit the representativeness of the sample studied. In addition, the socio-professional and economic homogeneity of the sample may have reduced the variability of some explanatory variables, particularly occupation and income. Consequently, although low income remains independently associated with hypertension in the multivariate model, this result should be interpreted with caution.

Moreover, the majority of participants belonged to the low-income category, meaning that the comparison was made with a relatively small subgroup of higher-income participants. This skewed distribution may have affected the stability and precision of the income-related estimates, as suggested by the width of the confidence interval. Nevertheless, this result remains relevant as it highlights the potential importance of socioeconomic factors on the cardiovascular health of this immigrant population. The results obtained cannot therefore be generalized to all Senegalese immigrants or to other sub-Saharan populations living in Morocco. Similarly, the sample size and the limited geographical context of the city of El Jadida may restrict the scope of the results and must also be taken into account. Furthermore, although blood pressure was measured in the morning according to a standardized protocol and conditions, certain factors contributing to its variability, such as recent coffee or tobacco consumption and stress levels at the time of the survey, were not systematically collected and must be considered when interpreting the results.

It should also be noted that it would have been useful for this study to include a comparison with a reference group of Senegalese residents in their country of origin, in order to facilitate and complement the comparative interpretation of the results. Such data would have allowed for a better distinction between factors related to the migratory context, local living conditions, and the specific characteristics of the studied population.

Despite these limitations, the strength of this study lies in providing useful data on the prevalence of hypertension and its associated factors within a still poorly documented immigrant population.

Conclusion

The data from this study revealed a significant prevalence of hypertension and highlighted the importance of associated socioeconomic and anthropometric factors among Senegalese immigrants residing in El Jadida. Analysis of these data also indicates that hypertension is primarily associated with socioeconomic vulnerability and excess weight in this immigrant population. The results show that, after multivariate analysis, low income remained independently associated with hypertension, suggesting the possible influence of living conditions, access to quality food, healthcare utilization, and prevention as social determinants of health. Overweight and obesity were also independently associated with hypertension, representing the strongest association observed in the final model, and underscore the importance of weight management and consideration of socioeconomic factors in hypertension prevention strategies for immigrant populations.

On the other hand, although several nutritional imbalances were observed, including high sodium intake and poor lipid quality, these parameters were not identified as independently associated factors for hypertension in the final model and should therefore be interpreted as descriptive elements of this population's dietary profile. They may also be useful for guiding future research or prevention efforts, but should not be presented as independent determinants of hypertension in this study. The reported results support the implementation of integrated and culturally appropriate interventions, combining systematic screening, improved access to healthcare, prevention of overweight and obesity, and general nutrition education tailored to the socioeconomic context of this population.

Finally, longitudinal studies and repeated dietary assessments are needed to better understand causal pathways and risk profiles, and to identify the most effective strategies for reducing the burden of hypertension among sub-Saharan migrants in Morocco and elsewhere.

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