ASSOCIATION BETWEEN DIABETES AND CHRONIC KIDNEY DISEASE IN MOROCCAN ADULT POPULATION

DOI: https://doi.org/10.26758/16.1.19

Rachida MOUSTAKIM (1), Hajar EL HENDAOUI (1), Habiba LIBA (1,3), Imane BARAKAT (1,3), Firdaous FRIKI (1), Mohamed MZIWIRA (2), Rekia BELAHSEN (1)

(1) Faculty of Sciences, Chouaib Doukkali University, Training and Research Unit on Nutrition & Food Sciences, LABS, El Jadida 24000, Morocco.
email: rachi-84@hotmail.fr, https://orcid.org/0000-0001-6980-3360
email: hajar.elhendaoui1995@gmail.com, https://orcid.org/0009-0003-3439-9320
email : frikifirdaous@gmail.com, https://orcid.org/0000-0003-0535-2841
email : rekiabelahsen@gmail.com, https://orcid.org/0000-0002-5641-5809

(2) Laboratory of Bio-Geosciences and Materials Engineering, Higher Normal School of Hassan II University, Casablanca, Morocco, email: m.mziwira@enscasa.ma, https://orcid.org/0000-0002-9814-4867

(3) Higher Institute of Professions Nurses and Health Techniques of Marrakesh, Morocco, email: imanebarakat@hotmail.com, https://orcid.org/0000-0002-3070-3642
email: libatonhabiba@gmail.com, https://orcid.org/0000-0002-2258-1315

Address correspondence to: Rekia BELAHSEN, Faculty of Sciences, Chouaib Doukkali University, Training and Research Unit on Nutrition & Food Sciences, LABS, El Jadida 24000, Morocco. Phone: 212 523 34 2325/212 664 97 16 16 Fax: 212 523 34 21 87/449 Email: rekiabelahsen@gmail.com/ rbelahsen@yahoo.com,

Abstract

Objectives: Chronic kidney disease (CKD) is a public health problem and a factor of high cardiovascular morbidity, mortality, and low quality of life, with a known link to diabetes. The aim of this study was to estimate the prevalence of CKD and its association with diabetes in a sample of Moroccan adults from the Casablanca-Settat region.
Material and methods: A prospective cohort study was carried out involving 210 subjects aged 18 or older, randomly selected from provincial health care centers. Sociodemographic and clinical data, as well as information on the participants' lifestyle, were collected using a structured questionnaire. Blood samples were collected in a subgroup of 205 subjects in order to analyse glycemia–and lipid profile, and to determine serum creatinine. Subsequently, the glomerular filtration rate (GFR) was estimated by the Modification of Diet in Renal Disease formula, and the CKD was defined by an estimated GFR (eGFR) < $60mL/min/1.73m^2$.
Results: The mean age of participants was 54.18 ± 13.45 years, and the prevalence of CKD was 4.4%. The results show a slight negative correlation between chronic kidney disease and type 2 diabetes ($r = -0.131$; $p = 0.06$). However, no statistically significant association was found between diabetes and kidney damage. On the other hand, type 1 diabetes was more prevalent in individuals with CKD (25%) than those without CKD (13.2%), but the difference was not statistically significant.
Conclusion: Data have shown no significant relationship between CKD and diabetes. Indeed, the study findings recommend monitoring of diabetes, which is considered as the main risk factor for

this chronic disease. The present study findings emphasize that CKD should be an important consideration in any strategy to address non-communicable diseases (NCDs).

Keywords: Chronic kidney disease, diabetes, eGFR, non-communicable diseases

Suggested citation (APA):

Moustakim, R., El Hendaoui, H., Liba, H., Barakat, I., Friki, F., Mziwira, M., & Belahsen, R. (2026). Association between diabetes and chronic kidney disease in Moroccan adult population. *Anthropological Researches and Studies, 16*, 269-279. https://doi.org/10.26758/16.1.19

Introduction

Chronic kidney disease (CKD) is recognized as a serious public health problem, associated with high cardiovascular morbidity, mortality, and low quality of life (Moustakim et al., 2020). Available data indicate a high prevalence of CKD from 10% to 16% of the general population worldwide (Mahmoodnia & Tamadon, 2017). The main determinants of CKD include diabetes, hypertension, chronic glomerulonephritis, chronic pyelonephritis, polycystic kidney disease, and chronic use of anti-inflammatory or nephrotoxic medication, as well as other factors such as age, gender, race, smoking, and genetic predisposition (Jha et al., 2013).

Chronic kidney disease is defined by reduced estimated glomerular filtration rate, increased proteinuria, or both (Winocour, 2018). Hence, CKD is categorized into 5 stages of increasing severity, with a decrease in glomerular filtration rate (GFR) lower than 60 ml/min/1.73m² leading to end stage kidney disease (ESKD) requiring renal replacement therapy, such as dialysis or transplantation, and contributing to poor clinical outcomes (Winocour, 2018). Unfortunately, this chronic disease remains asymptomatic, without obvious clinical symptoms in the early stage of the disease, until the appearance of damage, occurring only in more advanced stages in patients with this disease (Kiefer & Ryan, 2015).

Currently, diabetes is constantly increasing, affecting a number of patients in many countries including Morocco (Tazi et al., 2003; Kowalski et al., 2015). Indeed, the prevalence of diabetes in Morocco has risen from 6.6% in 2000 (national survey on cardiovascular risk factors) to 10.6% in 2018 (STEPS survey), with a continuing upward trend (Tazi et al., 2003; Moustakim et al., 2020). This progression has been associated with numerous risk factors, including poor glycemic control, uncontrolled hypertension, smoking, age of onset, obesity, family history of diabetes, and genetic predisposition (Stevens et al., 2024).

This disease is considered the most common etiology of chronic kidney disease (Winocour, 2018). CKD can be directly attributed to type 1 and type 2 diabetes mellitus and is thus called diabetic nephropathy (DN) (Kowalski et al., 2015; Winocour, 2018). However, even though end-stage renal disease (ESRD) is a feared complication of CKD, patients with this disease have a much higher risk of dying from cardiovascular disease than progressing to renal failure (Ammirati, 2020; Moustakim et al., 2021). Also, the role of glycemic control in delaying the progression of CKD to advanced stages and preventing cardiovascular complications has already been highlighted by numerous studies, and several epidemiological studies have revealed an association between diabetes and chronic kidney disease (Chen et al., 2019; Hauwanga et al., 2024).

The aim of this study was to estimate the prevalence and the association of CKD with diabetes among a group of Moroccan adults from the Casablanca-Settat region.

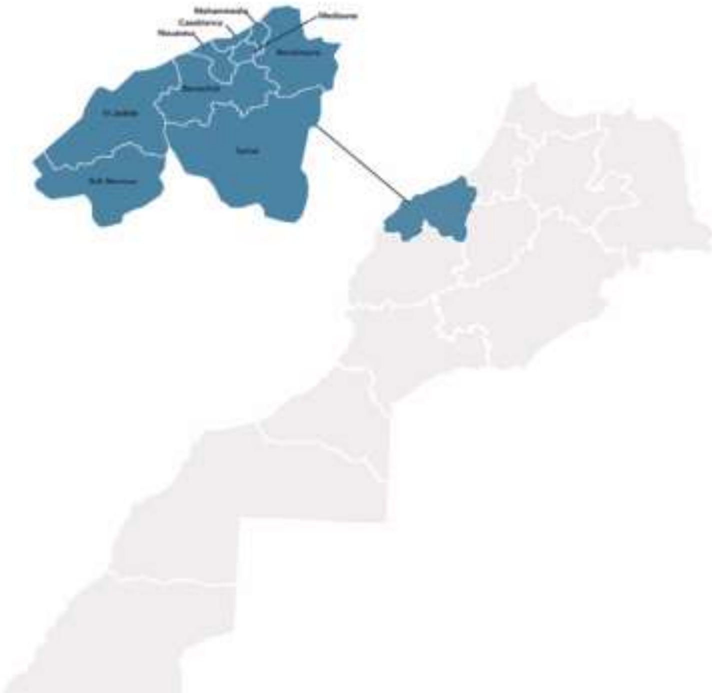
Material and methods

Study population

This is an observational, descriptive, and analytical epidemiological study. The survey was conducted in 2017, between January and December, with a sample of 210 participants aged 18 and over, randomly selected from primary health centers of the province of an agricultural commune, Sidi Bennour. This province belongs to the greater Casablanca-Settat region and is located along the western Atlantic coast of Morocco, bordered by El Jadida to the north and the province of Settat to the northeast (Figure 1).

Figure 1

Mapping of Sidi Bennour, part of the Casablanca-Settat region



Data collection

The data were collected through a questionnaire including information on sociodemographic status (age, sex, income, and education), personal and family health history (hypertension, diabetes, and kidney disease) and lifestyle (smoking, alcohol consumption, and physical activity), and use of nephrotoxic medication (non-steroidal anti-inflammatory drugs and natural remedies). Blood pressure and anthropometric parameters were measured (height, weight, waist and hip circumferences). Body mass index (BMI) was calculated as body weight (in kg) divided by the square of height (in m).

Laboratory measurements

Blood samples were collected by venipuncture after an overnight fast of at least 12 hours, and the analyses were done on the same day. The analysis of blood samples was performed using a semi-automatic spectrophotometer, type BTS 350. Fasting plasma glucose (FPG) was measured using an enzymatic colorimetric method with glucose oxidase. The triglycerides (TGs) and total cholesterol (TC) measurements were performed using an enzymatic colorimetric method with glycerol phosphate oxidase and cholesterol esterase and cholesterol oxidase, respectively.

Chronic kidney disease

Serum creatinine was measured according to the standard colorimetric Jaffe kinetic reaction method. Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) formula as follows (Farhadnejad et al., 2016; Levey & Coresh, 2012; Nelson & Tuttle, 2007):

$eGFR = 186 \times (\text{serum creatinine})^{-1.154} \times (\text{age})^{-0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})$

Subjects were classified as having CKD if eGFR < 60 mL/min/1.73 m^2, according to the National Kidney Foundation guidelines.

Hypertension is defined as a systolic blood pressure (SBP) ≥ 140 mmHg, diastolic blood pressure (DBP) ≥ 90 mmHg, or current use of antihypertensive drugs.

Diabetes mellitus was defined, according to the criteria of the American Diabetes Association, as fasting plasma glucose level of ≥ 126 mg/dL, or current use of hypoglycaemic agents.

Dyslipidemia was defined by serum concentrations of total cholesterol ≥ 200 mg/dL and/or triglycerides ≥ 150 mg/dL or patients already being treated with lipid-lowering medication (Rguibi & Belahsen, 2004).

According to the World Health Organization (WHO) criteria, normal weight was defined as 18 ≤ BMI ≤ 24.9 kg/m2, overweight as 25 ≤ BMI ≤ 29.9 kg/m2 and overall obesity was defined as BMI ≥ 30 kg/m2.

Abdominal obesity was defined, according to the definition of the National Cholesterol Education Program (NCEP), by WC ≥ 88 cm in women and WC ≥102 cm in men.

Subjects engaging in less than 150 minutes of physical activity per week were considered to have low physical activity (Faye et al., 2017; Moustakim et al., 2020).

Statistical analyses

All calculations were performed using the SPSS statistics program, version 24.0. Continuous variables were expressed by mean ± standard deviation and categorical variables were reported as frequencies and proportions. Differences in means were compared using Student's t-test, and differences in proportions were assessed using the Chi-square test. In all statistical tests, a p-value < 0.05 was considered statistically significant.

Results

Baseline characteristics of the population

Table 1 presents the different sociodemographic characteristics of the study sample population. The current study included 210 individuals with a predominance of women (n = 152, 72.4%) compared to men (n = 58, 27.6%), with a mean age of 54.18 ± 13.45 years. Thirty-one percent of the participants resided in urban area, while 69% resided in rural area. The total illiteracy rate of the sample was 74.8% and about 58% of the participants had a low socioeconomic status.

Table 2 shows the clinical and anthropometric characteristics in both sexes of the participants. Thus, there was a significant difference between men and women regarding anthropometric characteristics, type 2 diabetes, family history of hypertension, creatinine, urea, and total cholesterol parameters. The serum concentrations of creatinine and urea were significantly higher in men than women, while the total cholesterol level was higher in women compared to men.

Table 1

Baseline Characteristics of the Participants (n = 210)

Baseline characteristics	Values
Age, mean ± SD	54.18 ± 13.45
Gender, n (%)	
Female	152 (72.4)
Male	58 (27.6)
Age group, n (%)	
18–29	11 (5.2)
30–39	23 (11)
40–49	31 (14.8)
50–59	59 (28.0)
≥60	86 (41.0)
Marital status, n (%)	
Married	136 (64.8)
Single	15 (7.1)
Widower	53 (25.2)
Divorced	6 (2.9)
Residential environment, n (%)	
Urban	65 (31)
Rural	145 (69)
Professional activity, n (%)	
Yes	61 (29)
No	149 (71)
Socioeconomic status (SES), n (%)	
Low	122 (58.1)
Medium	64 (30.5)
High	24 (11.4)
Education attainment, n (%)	
Unable to read/write	157 (74.8)
Koranic	12 (5.7)
Primary school	21 (10.0)
Secondary school	13 (6.2)
University	7 (3.3)

Note: Data are presented as means ± SD, or as numbers and percentages [n (%)]. SD = standard deviation; SES = Socioeconomic status.

The comparison of characteristics between subjects with and without CKD is summarized in Table 3. Subjects with CKD were more likely to be older, hypertensive, have higher serum creatinine and urea levels, lower eGFR, engage in less physical activity, and use more nephrotoxic medications compared to those without CKD, with these differences reaching statistical significance.

However, no significant differences were found for others parameters, including gender, anthropometric characteristics, glycemia, and lipid profile ($p > 0.05$).

Table 2

Clinical, Anthropometric, and Biochemical Characteristics of the Study Population

Characteristics	Total (n=210)	Men (n=58)	Women (n=152)	P-value
T2DM	56 (26.7)	8 (13.8)	48 (31.6)	0.009
T1DM	28 (13.3)	10 (17.2)	18 (11.8)	0. 303
HTN	74 (35.2)	18 (31.0)	56 (36.8)	0.431
Family History of DM	125 (59.5)	30 (51.7)	95 (62.5)	0.155
Family History of HTN	85 (40.5)	15 (25.9)	70 (46.1)	0.008
Family History of CKD	20 (9.5)	2 (3.4)	18 (11.8)	0.064
BMI (kg/m²)	28.69 ± 5.67	25.77 ± 4.63	29.80 ± 5.65	0.000
Obesity	78 (37.1)	12(20.7)	66 (43.4)	0.001
SBP (mmHg)	132.40 ± 19.29	132.71 ± 17.64	132.29 ± 19.94	0.889
DBP (mmHg)	76.44 ± 10.66	76.10 ± 10.21	76.57 ± 10.85	0.776
	Total (n=205)	**Men (n=54)**	**Women (n=151)**	**P-value**
CKD	9(4.4)	3 (5.6)	6 (4.0)	0,626
eGFR (mL/min/1.73m²)	92.41 ± 21.42	96.94 ± 25.65	90.79 ± 19.54	0.070
FPG(mg/dL)	125.83 ± 61.15	123,93 ± 63.06	126.52 ± 60.65	0.790
Creatinine (mg/dL)	0.93 ±0.21	1.08 ±0.26	0.87 ± 0.15	0.000
Urea (mg/dL)	30.86 ± 9.49	35.31 ± 8.98	29.26 ±9.18	0.000
Total cholesterol (mg/dL)	185.03±38.36	170.35 ± 37.86	190.28 ± 37.28	0.001
Triglycerides (mg/dL)	125.51±63.76	126.39 ± 78.35	125.19 ± 57.96	0.906

Note: Data are presented as means ± SD, or as numbers and percentages [n (%)]. Categorical variables were compared using the chi-square test, and continuous variables using Student's t-test. BMI = body mass index; CKD = chronic kidney disease; DBP = diastolic blood pressure; DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; FPG = fasting plasma glucose; HTN = hypertension; SBP = systolic blood pressure; T1DM = type 1 diabetes mellitus; T2DM = type 2 diabetes mellitus.

Table 3

Comparison of Characteristics Between Subjects With and Without CKD (n=205)

Characteristics	Without CKD (n=196)	With CKD (n=9)	p-value
Age (years)	54.33 ± 12.53	67.78 ± 10.32	0.002
Weight (Kg)	76.26 ± 14.72	78.22 ± 13.35	0.695
Height (cm)	162.93 ± 8.17	162.56 ± 6.61	0.892
WC (cm)	99.24 ± 12.30	99.78 ± 10.29	0.898
HC (cm)	105.10 ± 9.77	103.44 ± 9.09	0.620
WHR	0.94 ± 0.07	0.96 ± 0.07	0.376
BMI (kg/m²)	28.82 ± 5.65	29.67 ± 5.43	0.657
SBP (mmHg)	131.70 ± 18.99	151.44 ± 20.90	0.003
DBP (mmHg)	76.13 ± 10.58	82.67 ± 13.68	0.075
FPG (mg/dL)	126.21 ± 61.82	117.56 ± 46.08	0.679
Creatinine (mg/dL)	0.90 ± 0.16	1.51 ±0.33	0.000
Urea (mg/dL)	30.19 ± 8.81	45.44 ± 12.46	0.000
eGFR (mL/min/1.73m²)	94.34 ± 19.82	50.44 ± 7.60	0.000
TC (mg/dL)	184.69 ± 38.39	192.44 ± 39.17	0.554
TG (mg/dL)	124.57 ± 63.46	146.00 ± 70.91	0.325
Low PA	102 (52.0)	9 (100)	0.005
Sex			0.626
Men	51(26)	3 (33.3)	
Women	145 (74)	6 (66.7)	
T2DM	56 (28.6)	0 (0.0)	0.060
T1DM	26 (13.3)	2 (22.2)	0.444
HTN	67 (34.2)	7 (77.8)	0.008
Nephrotoxic medication	50 (25.5)	6 (66.7)	0.007

Note: Data are presented as means ± SD, or as numbers and percentages [n (%)]. Categorical variables were compared using the chi-square test, and continuous variables using Student's t-test. BMI = body mass index; CKD = chronic kidney disease; DBP = diastolic blood pressure; eGFR = estimated glomerular filtration rate; FPG = fasting plasma glucose; HC = hip circumference; HTN = hypertension; PA = physical activity; SBP = systolic blood pressure; TC = total cholesterol; TG = triglycerides; T1DM = type 1 diabetes mellitus; T2DM = type 2 diabetes mellitus; WC = waist circumference; WHR = waist-to-hip ratio.

Discussion

Chronic kidney disease (CKD) is a growing public health problem that represents a significant economic and social burden. Therefore, prevention and early detection are key strategies to reduce it (Vupputuri et al., 2014). This study estimated the prevalence of CKD and examined its association with diabetes in a group of Moroccan adults from the Casablanca-Settat region. The rationale for this research is based on numerous epidemiological studies that have revealed the close association between CKD and certain metabolic disorders, including diabetes, hypertension, and obesity (Kiefer & Ryan, 2015; Zhang et al., 2012). Indeed, hypertension has been reported to be the main risk factor responsible for kidney function decline and represents the most common complication of CKD (Wang et al., 2019). In the current study, the results clearly illustrated a significant association of CKD with hypertension, which is consistent with the results found by other studies (Ong-ajyooth et al., 2009; Atkins, 2005; Zhang et al., 2012; Faye et al., 2017).

The present data show that ageing was also a risk factor for CKD in this population. Indeed, similarly to other studies (Winocour, 2018), subjects with CKD were older than those without CKD, with a significant association between both variables. This result highlights that age is related to physiological decline in kidney function and notably to the presence of cardiovascular risk factors, including hypertension, diabetes, and obesity (Kiefer & Ryan, 2015).

In this research, the use of nephrotoxic medications, namely nonsteroidal anti-inflammatory and analgesic drugs, among participants was also linked to CKD. Consistent with the results of other similar studies, the use of these medications was significantly more common among subjects with CKD than among those without CKD (Zhang et al., 2012).

Several recent studies have also demonstrated the impact of physical activity on the prevention of numerous chronic diseases, including CKD (Martens et al., 2018). Similarly, the results of the current study also highlighted a significant association between physical activity and CKD. Thus, subjects with CKD were less active than their counterparts. The biological mechanisms of physical activity have been shown to provide multiple metabolic benefits, including improved vascular health, better regulation of blood pressure and blood glucose, and reduced inflammation (Martens et al., 2018).

A strong relationship was also reported by several recent studies, between the coexistence of diabetes and chronic kidney disease and an increased risk of both microvascular and macrovascular complications leading to the end stage renal disease and cardiovascular mortality in these patients (Aikaeli et al., 2022; Hauwanga et al., 2024; Winocour, 2018). Additionally, a combination of poor glycemic control and microvascular complications has also been found to lead to both cardiovascular disease and renal outcomes (Hauwanga et al., 2024; Kowalski et al., 2015; Winocour, 2018). These findings demonstrated the pivotal role and need for a multidisciplinary approach involving endocrinologists, nephrologists, cardiologists, and dietitians for the management of chronic kidney disease and diabetes, and in improving patient outcomes and quality of life (Hauwanga et al., 2024; Moustakim et al., 2020).

Although the data from this study did not reveal a significant association between diabetes and CKD in this population, the results obtained indicated that type 1 diabetes was more prevalent among subjects with CKD than those without CKD, with no statistically significant association. This is mainly due to the small sample size, low statistical power, and the cross-sectional design, which limits causal inference.

The results of this study support the need for earlier interventions, including CKD screening, promoting lifestyle change, optimizing blood pressure and glycemia control, and patient education on nephrotoxic drug use and increased physical activity, in order to reduce disease progression, manage risk factors, and delay the incidence of ESRD.

Limitations and future directions

The present study has several limitations. First, the cross-sectional design and small sample size with convenience sampling limit causal inference and statistical power. Second, no interventions were tested, and certain early markers of CKD, such as proteinuria, were not measured. Third, creatinine was obtained from a single measurement to estimate chronic reduction in GFR using the MDRD equation, which may be less accurate in certain populations. Nevertheless, the observed associations with hypertension, aging, physical inactivity, and nephrotoxic medication use highlight the relevance of evidence-based interventions suggested in the literature, including CKD screening, lifestyle modification, blood pressure and glycemia control, and patient education. Future studies should focus on larger cohorts, longitudinal designs, and interventional trials to evaluate the effectiveness of these strategies in preventing CKD progression.

Conclusion

In Morocco, few studies have assessed the prevalence of chronic kidney disease. The study results highlight that this disease must be considered in any strategy to combat non-communicable diseases. Although diabetes was not significantly associated with CKD in this sample, it remains a well-established risk factor according to extensive literature. Additionally, the findings in this study cannot be generalized to the whole population of Morocco as they are descriptive and correlational rather than causal. The small sample size further limits generalizability, and a larger study is suggested to validate these findings. Many determinants of CKD, including aging, hypertension, nephrotoxic medication use, and low physical activity, were notably observed in this sample. Thus, these findings support the need for appropriate screening, diagnosis, and management by primary care clinicians, who therefore play a crucial role in preventing adverse outcomes associated with CKD and its several risk factors.

Competing interests

The authors declare no competing interests.

Ethics Committee Approval

The study was supported by the Moroccan Ministry of Higher Education, Scientific Research and Innovation and the Ministry of Health and Social Protection of Morocco and approved by the respective Ethics Committees of the Provincial hospital, affiliated to Chouaib Doukkali University (Approval No 1475/14).

Consent to participate

Written informed consent was obtained from all participants prior to their inclusion in the survey.

Acknowledgments

We would like to thank the medical delegation of Sidi Bennour Province, Ministry of Health and Social Protection of Morocco and also the medical staff of all primary health care centers in the province of Sidi Bennour for their cooperation and allowing us to collect data.

References

1. Aikaeli, F., Njim, T., Gissing, S., Moyo, F., Alam, U., Mfinanga, S. G., Okebe, J., Ramaiya, K., Webb, E. L., Jaffar, S., & Garrib, A. (2022). Prevalence of microvascular and macrovascular complications of diabetes in newly diagnosed type 2 diabetes in low-and-middle-income countries : A systematic review and meta-analysis. *PLOS Global Public Health, 2*(6), e0000599. https://doi.org/10.1371/journal.pgph.0000599
2. Ammirati, A. L. (2020). Chronic Kidney Disease. *Revista Da Associação Médica Brasileira, 66*(suppl 1), s03-s09. https://doi.org/10.1590/1806-9282.66.s1.3
3. Atkins, R. C. (2005). The epidemiology of chronic kidney disease. *Kidney International, 67*, S14-S18. https://doi.org/10.1111/j.1523-1755.2005.09403.x
4. Chen, T. K., Knicely, D. H., & Grams, M. E. (2019). Chronic kidney disease diagnosis and management: A review.. *JAMA, 322*(13), 1294. https://doi.org/10.1001/jama.2019.14745
5. Farhadnejad, H., Asghari, G., Mirmiran, P., Yuzbashian, E., & Azizi, F. (2016). Micronutrient Intakes and Incidence of Chronic Kidney Disease in Adults: Tehran Lipid and Glucose Study. *Nutrients, 8*(4), 217. https://doi.org/10.3390/nu8040217
6. Faye, M., Lemrabott, A., Cissé, M., Fall, K., Keita, Y., Ngaide, A., Mbaye, A., Fary Ka, E. H., Niang, A., Kane, A., & Diouf, B. (2017). Prevalence and risk factors of chronic kidney disease in an african semi-urban area: Results from a cross-sectional survey in Gueoul, Senegal. *Saudi Journal of Kidney Diseases and Transplantation, 28*(6), 1389. https://doi.org/10.4103/1319-2442.220878
7. Hauwanga, W. N., Abdalhamed, T. Y., Ezike, L. A., Chukwulebe, I. S., Ko Oo, A., Wilfred, A., Khan, A. R. A. K. A., Chukwuwike, J., Florial, E., Lawan, H., Felix, A., & McBenedict, B. (2024). The Pathophysiology and Vascular Complications of Diabetes in Chronic Kidney Disease: A Comprehensive Review. *Cureus, 16*(12). https://doi.org/10.7759/cureus.76498
8. Jha, V., Garcia-Garcia, G., Iseki, K., Li, Z., Naicker, S., Plattner, B., Saran, R., Wang, A. Y.-M., & Yang, C.-W. (2013). Chronic kidney disease: Global dimension and perspectives. *The Lancet, 382*(9888), 260-272. https://doi.org/10.1016/s0140-6736(13)60687-x
9. Kiefer, M. M., & Ryan, M. J. (2015). Primary Care of the Patient with Chronic Kidney Disease. *Medical Clinics of North America, 99*(5), 935-952. https://doi.org/10.1016/j.mcna.2015.05.003
10. Kowalski, A., Krikorian, A., & Lerma, E. V. (2015). Diabetes and chronic kidney disease. *Disease-a-Month, 61*(9), 378-386. https://doi.org/10.1016/j.disamonth.2015.07.002
11. Levey, A. S., & Coresh, J. (2012). Chronic kidney disease. *The Lancet, 379*(9811), 165-180. https://doi.org/10.1016/s0140-6736(11)60178-5
12. Mahmoodnia, L., & Tamadon, M. R. (2017). On the occasion of world kidney day 2017; obesity and its relationship with chronic kidney disease. *Journal of Nephropathology, 6*(3), 105. https://doi.org/10.15171/jnp.2017.18
13. Martens, R. J. H., Van Der Berg, J. D., Stehouwer, C. D. A., Henry, R. M. A., Bosma, H., Dagnelie, P. C., Van Dongen, M. C. J. M., Eussen, S. J. P. M., Schram, M. T., Sep, S. J. S., Van Der Kallen, C. J. H., Schaper, N. C., Savelberg, H. H. C. M., Van Der Sande, F. M., Kroon, A. A., Kooman, J. P., & Koster, A. (2018). Amount and pattern of physical activity and sedentary behavior are associated with kidney function and kidney damage : The Maastricht Study. *PLOS ONE, 13*(4), e0195306. https://doi.org/10.1371/journal.pone.0195306
14. Moustakim, R., El Ayachi, M., Mziwira, M., & Belahsen, R. (2020). Undiagnosed chronic kidney disease and its associated risk factors in an agricultural Moroccan adult's population. *Néphrologie & Thérapeutique, 16*(3), 147-152. https://doi.org/10.1016/j.nephro.2019.12.003

15. Moustakim, R., Mziwira, M., El Ayachi, M., & Belahsen, R. (2021). Association of Metabolic Syndrome and Chronic Kidney Disease in Moroccan Adult Population. *Metabolic Syndrome and Related Disorders, 19*(8), 460-468. https://doi.org/10.1089/met.2020.0117
16. Nelson, R. G., & Tuttle, K. R. (2007). The New KDOQITM Clinical Practice Guidelines and Clinical Practice Recommendations for Diabetes and CKD. *Blood Purification, 25*(1), 112-114. https://doi.org/10.1159/000096407
17. Ong-ajyooth, L., Vareesangthip, K., Khonputsa, P., & Aekplakorn, W. (2009). Prevalence of chronic kidney disease in Thai adults : A national health survey. *BMC Nephrology, 10*(1). https://doi.org/10.1186/1471-2369-10-35
18. Rguibi, M., & Belahsen, R. (2004). Metabolic syndrome among Moroccan Sahraoui adult women. *American Journal of Human Biology: The Official Journal of the Human Biology Association, 16*(5), 598-601. https://doi.org/10.1002/ajhb.20065
19. Stevens, P. E., Ahmed, S. B., Carrero, J. J., Foster, B., Francis, A., Hall, R. K., Herrington, W. G., Hill, G., Inker, L. A., Kazancıoğlu, R., Lamb, E., Lin, P., Madero, M., McIntyre, N., Morrow, K., Roberts, G., Sabanayagam, D., Schaeffner, E., Shlipak, M., … Levin, A. (2024). KDIGO 2024 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. *Kidney International, 105*(4), S117-S314. https://doi.org/10.1016/j.kint.2023.10.018
20. Tazi, M. A., Cherqaoui, S., Lahmouz, F., Sraıri, 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
21. Vupputuri, S., Kimes, T. M., Calloway, M. O., Christian, J. B., Bruhn, D., Martin, A. A., & Nichols, G. A. (2014). The economic burden of progressive chronic kidney disease among patients with type 2 diabetes. *Journal of Diabetes and Its Complications, 28*(1), 10-16. https://doi.org/10.1016/j.jdiacomp.2013.09.014
22. Wang, Y.-N., Ma, S.-X., Chen, Y.-Y., Chen, L., Liu, B.-L., Liu, Q.-Q., & Zhao, Y.-Y. (2019). Chronic kidney disease: Biomarker diagnosis to therapeutic targets. *Clinica Chimica Acta, 499*, 54-63. https://doi.org/10.1016/j.cca.2019.08.030
23. Winocour, P. H. (2018). Diabetes and chronic kidney disease : An increasingly common multi-morbid disease in need of a paradigm shift in care. *Diabetic Medicine, 35*(3), 300-305. https://doi.org/10.1111/dme.13564
24. Zhang, L., Wang, F., Wang, L., Wang, W., Liu, B., Liu, J., Chen, M., He, Q., Liao, Y., Yu, X., Chen, N., Zhang, J., Hu, Z., Liu, F., Hong, D., Ma, L., Liu, H., Zhou, X., Chen, J., … Wang, H. (2012). Prevalence of chronic kidney disease in China: A cross-sectional survey. *The Lancet, 379*(9818), 815-822. https://doi.org/10.1016/s0140-6736(12)60033-6