

## Prevalence and determinants of chronic kidney disease in the Swiss population

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### Summary

**QUESTIONS UNDER STUDY:** The prevalence of chronic kidney disease (CKD) is increasing worldwide, corresponding to an increased risk of cardiovascular disease. The latest study on prevalence of CKD involving the three linguistic regions of Switzerland dates back to 2002–2003 and definitions have changed since then. We aimed to assess the current prevalence and determinants of CKD in the Swiss general population.

**METHODS:** We analysed the data of 1353 participants from a cross-sectional population-based survey performed in 2010–2012 in the three linguistic regions of Switzerland. The prevalence of CKD and the derived cardiovascular risk categories were assessed according to the Kidney Disease – Improving Global Outcomes (KDIGO) 2012 classification, using estimated glomerular filtration rate (GFR; CKD-Epidemiological Collaboration equation) and albuminuria level. Multivariate logistic regression was used to analyse factors associated with CKD.

**RESULTS:** We included 660 men and 693 women, equally distributed in four age categories (15–29, 30–44, 45–59 and over 60 years). The overall prevalence of CKD was 10.4%. The prevalence in the low, moderate, high and very high risk KDIGO categories were 89.6%, 8.4%, 1.6% and 0.5%, respectively. The prevalence of CKD was similar in all linguistic regions. In multivariate analysis, female gender, older age, diabetes and uric acid were independently associated with CKD in persons  $\geq 45$  y. In younger

participants, diabetes and lower educational level were associated with CKD.

**CONCLUSIONS:** In the general Swiss population, CKD affects one in ten adults. Subjects older than 60 years, as well as patients with diabetes and hypertension, show a high prevalence of CKD. Systematic screening may be recommended in this population.

**Key words:** chronic kidney disease; KDIGO 2012 classification; CKD-EPI equation; albuminuria; Switzerland

### Introduction

The prevalence of chronic kidney disease (CKD) is increasing worldwide, amounting to an epidemic outbreak, which parallels the population aging and the increasing prevalence of hypertension, diabetes and obesity [1]. CKD is clearly associated with an increased risk of cardiovascular morbidity and mortality. Indeed, CKD patients are more likely to die from a cardiovascular event than to have deteriorating kidney function and start dialysis [2].

To better account for the prognostic impact of CKD stages in term of cardiovascular and renal prognosis, a revised CKD staging system was proposed by the Kidney Disease – Improving Global Outcomes (KDIGO) group [3]. In fact, the previous Kidney Disease Outcomes Quality Initiative (KDOQI) CKD classification guidelines (2002) [4] have been questioned, in particular with regard to their tendency

to overestimate CKD prevalence and fail to predict accurately prognosis and risk [5–7]. According to KDOQI (2002), CKD is defined, from a two-dimensional algorithm, as either kidney damage (identified by albuminuria in the presence of an albumin-to-creatinine ratio [ACR] >30 mg/g) with or without impaired estimated glomerular filtration rate (eGFR), or impaired eGFR <60 ml/min/1.73 m<sup>2</sup>. Based on a collaborative meta-analysis confirming the independent and combined associations of eGFR and albuminuria as predictors for all-cause mortality, cardiovascular mortality, acute kidney injury, progressive CKD and end-stage renal disease (ESRD) [8], the CKD staging system was revised, incorporating the severity of albuminuria at all stages of CKD in a risk prediction instrument, as reported by the KDIGO (2012) CKD guidelines [3].

The new KDIGO (2012) classification was recently used to explore the prevalence of CKD in the CoLaus cohort, a Swiss population-based study performed in a single city, Lausanne [9]. However, the latest study focusing on CKD prevalence and its determinants in the three Swiss linguistic regions dates back to 2003 [10], relied on the KDOQI (2002) classification and used the Modification of Diet in Renal Disease (MDRD) instead of the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation. The aims of this study were (i) to estimate the prevalence of CKD in the Swiss adult population according to KDIGO (2012) classification, exploring the presence of regional differences, (ii) to analyse the CKD-associated cardiovascular risk, and (iii) to identify factors associated with CKD in the Swiss adult population that could guide targeted screening for CKD.

## Methods

### Sampling strategy

This analysis was based on the data of the cross-sectional, population-based Swiss Survey on Salt (SSS) [11], promoted by the Swiss Federal Office of Public Health (Bundesamt für Gesundheit; BAG) with the primary aim to estimate dietary salt intake and hypertension prevalence. The final study population included a population-based sample covering nine cantons: Basel, Fribourg, Geneva, Luzern, St-Gallen, Ticino, Vaud, Valais and Zürich, reflecting the geographical and cultural diversity of permanent residents in Switzerland aged ≥15 years.

Recruitment took place from January 2010 to March 2012 and was based on a two-level sampling strategy. Households were randomly selected by the Swiss Federal Statistical Office, based on the Swiss fixed-line phone directory, which includes all landline phone connections in Switzerland and is regularly updated by the major Swiss phone provider. In a first step, we contacted these households by sending an information letter, followed by phone calls with a maximum of three attempts on different days. In a second step, we randomly selected, during the phone call, one person from the household to take part in the study, using a computer-generated random number. The sample population was selected to represent the three linguistic regions of Switzerland (French, German and Italian) and to

be equally distributed in four age categories (15–30, 30–45, 45–60 and over 60 years) for each gender. The study included 1515 participants in total. The overall participation rate of SSS was 10%, without differences between linguistic regions. Limited convenience sampling was necessary to overcome recruitment difficulties in young and middle-aged people. Details of the SSS study design have been published previously [12].

Only subjects with complete data allowing kidney function assessment were considered for the present analysis. Participants with an incomplete urine collection (defined as reported incomplete collection, urinary volume <300 ml and/or collection time <20 h) or suspected urine overcollection (identified as 24-hour urinary creatinine >43 mg/mmol/kg, corresponding to the extreme outliers), were excluded from the analysis.

### Ethics

The SSS complied with the Declaration of Helsinki and was approved by the local Institutional Ethics Committees of each participating centre. All participants gave written informed consent. For participants below age 18 years, written consent from one parent or a legal representative was obtained.

### Clinical data

The study participants attended the study centre on two occasions: one baseline visit and one follow-up visit the following day, after completion of the 24-hour urine collection. Body mass index (BMI) was calculated as weight divided by height in meter squared and categorised in three groups according to World Health Organization recommendations: lean (<25 kg/m<sup>2</sup>), overweight (≥25 to <30 kg/m<sup>2</sup>) and obese (≥30 kg/m<sup>2</sup>). Blood pressure was measured five times at each visit on the left arm after at least 5 minutes rest in the seated position using a clinically validated automated oscillometric device (Omron® HEM-907, Matsusaka, Japan). The mean of the ten blood pressure readings was used for analyses. Hypertension was defined as mean systolic blood pressure ≥140 mm Hg or mean diastolic blood pressure ≥90 mm Hg or antihypertensive medication. Diabetes mellitus was considered as present in participants taking antidiabetic drug treatment.

Data on medication, smoking status, education level, physical activity and dietary habits were collected in a questionnaire. The term ‘smokers’ was used for current smokers. Alcohol consumption was split into three categories (<1 unit in the last week, >1 unit/week but <1 unit/day, ≥1 unit/day). Education was split into three levels (primary, secondary, tertiary). Physical activity was considered as present if participants reported practising sport more than once a week. Linguistic regions were classified into three categories: French, German and Italian.

Participants were given two 3-litre plastic bottles and received standardised instructions on how to make a 24-hour urine collection. An optional nonfasting blood sample was collected.

### Laboratory analysis

Urine and blood samples were sent to the Central Chemical Laboratory of Lausanne University Hospital (CHUV,

Lausanne, Switzerland) for centralised analyses with standard methods. Serum and urine creatinine were measured using the Jaffé kinetic compensated method (Roche Diagnostics, Switzerland). Plasma uric acid was measured by means of enzymatic colorimetry (Uricase-PAP, Roche Diagnostics, Switzerland). Urine albumin was assessed with immunonephelometry.

### Chronic kidney disease definition

Kidney function was calculated with the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [13]. The CKD stages were defined according to the revised KDIGO (2012) classification, which includes five stages of eGFR (G1 to G5) and three levels of albuminuria based on the albumin-to-creatinine ratio, ACR (A1 <30 mg/g; A2 30–300 mg/g; A3 >300 mg/g) [3]. According to the guidelines, either ACR or the absolute value of 24-hour urinary albumin excretion can be used for CKD classification. The two measurements were strongly correlated in our population ( $r = 0.968$ ,  $p < 0.001$ ). The KDIGO (2012) classification allows further stratification into four categories with similar relative risk for renal and cardiovascular outcomes: low, medium, high and very high risk. For example, the cardiovascular mortality risk increases 1.5–2.2 fold in the medium-risk category, 2.2–3.7 fold in the high-risk and 4.1–14.0 fold in the very high-risk category, when compared with the low-risk population [3]. The term CKD was used to define the medium- to very high-risk KDIGO (2012) categories.

### Statistical analyses

Statistical analyses were performed using Stata 11.0 (Stata Corp, College Station, USA). Mean and standard deviation were used to describe normally distributed continuous variables, and percentages to describe dichotomous or categorical variables. Student *t*-test, analysis of variance and chi-squared test were performed to compare the characteristics of groups where appropriate. The four predefined age categories of the original study were maintained and a nonparametric test was used to assess trend across ordered age categories. Subsequently, the older age group was split into two groups, 60–69 years and  $\geq 70$  years, to give more detailed information about the incidence of CKD in these two age groups. Linear regression analysis was used to study the association between eGFR and age as continuous variables. Linearity of the correlation was confirmed visually by computing a locally weighted least-squares regression and a residual plot. Logistic regressions were used to explore the factors associated with CKD, defined as medium- to very high-risk KDIGO (2012) categories. Tested independent variables were: linguistic region, age, gender, BMI category, hypertension, diabetes, smoking status, educational status, physical activity and serum uric acid. The factors having significances of *p*-values  $< 0.10$  were inserted in a multivariate model using a forward-stepwise procedure and adding interactions term between the covariates. Since most of the covariates showed significant interaction with age ( $p < 0.05$ ), the multivariate analysis was stratified by age into two strata (15–44 years and 45 years and older

and the same procedure repeated for each stratum, finding no significant interaction between covariates.

## Results

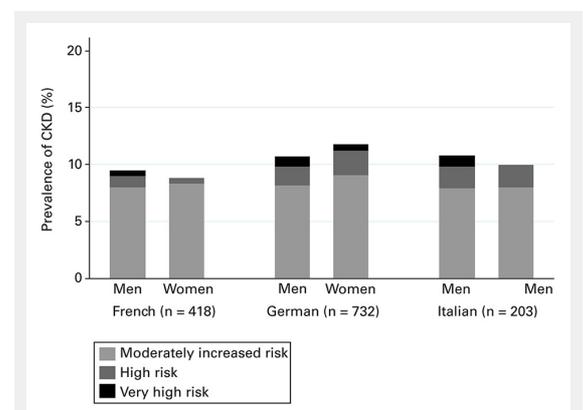
Of the 1515 participants who completed the SSS survey, 162 (10.7%) were excluded from this analysis as it was impossible to assess their renal function because of either blood sampling refusal ( $n = 132$ ), incomplete urine collection ( $n = 28$ ) or missing ACR results ( $n = 2$ ). Excluded subjects were younger ( $39.5 \pm 18.5$  vs  $48.6 \pm 18.2$  y,  $p < 0.001$ ), had a lower BMI ( $24.3 \pm 4.8$  vs  $25.3 \pm 4.6$  kg/m<sup>2</sup>,  $p = 0.004$ ) and were more likely to be nonhypertensive (13.4 vs 5.8%,  $p < 0.001$ ) than the analysed population. There was no difference in gender prevalence. Finally, 1353 participants (660 men and 693 women) were included in the present analysis; their characteristics by gender and age strata are presented in table 1.

### Chronic kidney disease prevalence and risk categories

Table 2 shows the percentages of participants in each category of the revised KDIGO (2012) classification for CKD. The overall prevalence of CKD in the population was 10.4%. The prevalence in the low-, moderate-, high- and very high-risk categories was 89.6%, 8.4%, 1.6% and 0.5%, respectively. The prevalence of CKD was similar across linguistic regions (fig. 1), being 9.1% in French-, 10.3% in Italian- and 11.2% in German-speaking Switzerland ( $p = 0.53$ ), with similar distributions across CKD risk categories ( $p = 0.43$ ).

### Factors associated with chronic kidney disease

Figure 2 represents the prevalence of CKD by gender and age group. CKD prevalence increased among age categories, with a steep increase after 60 years. For both genders combined, the prevalence was 3.1% in participants aged 15–29, 3.7% at 30–44 years, 4.3% at 45–59 years and 25.4% over 60 years ( $p < 0.0001$  for trend). Further splitting the older age category into two groups (60–69 years old,  $n = 244$  and  $\geq 70$  years,  $n = 174$ ) confirmed the significantly

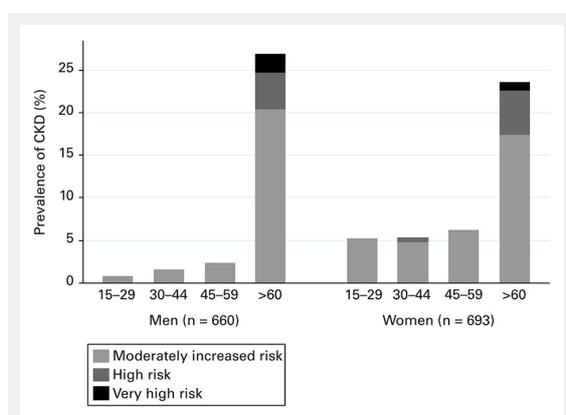


**Figure 1**

Prevalence of chronic kidney disease (KDIGO 2012), by gender and linguistic region. *p*-value not significant for difference between genders for each linguistic region (chi squared test); *p*-value not significant for difference between linguistic regions (chi squared test).

KDIGO = Kidney Disease – Improving Global Outcomes

higher prevalence of CKD in the oldest age group (41.4%) when compared with the 60–69 year group (13.9%,  $p < 0.001$ ). When considering the overall prevalence, there were no significant gender differences, with a prevalence of 10.3% in men and 10.5% in women ( $p = 0.89$ ). Prevalence between genders was similar in people aged  $\geq 60$  years: 26.9% and 23.6% in men and women, respectively, ( $p = 0.48$ ). However, CKD was significantly more prevalent in younger women than men (aged 15–59 years): 1.6% vs 5.6% ( $p = 0.001$ ). The unadjusted eGFR evolution with age was characterised by a linear decline, with a similar slope in both genders:  $-0.79$  (0.03) ml/min/1.73 m<sup>2</sup>/y for men and  $-0.80$  (0.03) ml/min/1.73 m<sup>2</sup>/y for women (fig. 3). The unadjusted prevalence of CKD was significantly higher in hypertensive patients (5.7% vs 22.7%,  $p < 0.0001$ ) and diabetic subjects (9.5% vs 37.8%,  $p < 0.0001$ ) compared to participants without these conditions (fig. 4). We observed no significant trend in the prevalence of CKD across BMI



**Figure 2**

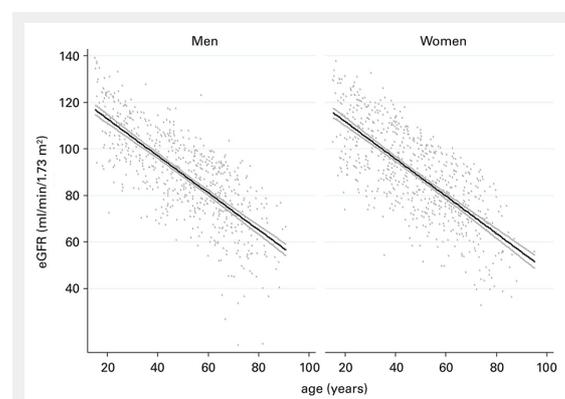
Prevalence of chronic kidney disease (KDIGO 2012), by gender and age category.  $p$ -values are from a nonparametric test for trend, comparing the trend in combined medium- to very high-risk categories vs low-risk category across age groups  
KDIGO = Kidney Disease – Improving Global Outcomes

categories: 9.2% in normal weight people, 12.1% in overweight people and 11.1% in obese people ( $p$  for trend = 0.181) (fig. 4). Results were similar in both genders.

In the multivariate analysis (table 3), female gender, older age, diabetes and uric acid were independently associated with a higher prevalence of CKD in subjects aged 45 years and older. In younger participants, only diabetes and a lower educational level were independent determinants of CKD.

## Discussion

We report the first data about the prevalence of CKD in the three linguistic regions of Switzerland, defined on the basis of both eGFR, calculated with the CKD-EPI formula, and albuminuria, according to the new KDIGO (2012) classification, in a population-based sample. We found CKD to



**Figure 3**

Relationship between renal function (eGFR by CKD-EPI equation) and age in the Swiss population.

Bold lines represent the unadjusted linear regression estimation, gray lines 95% confidence interval. Decline slope (SE):  $-0.79$  (0.03) ml/min/1.73 m<sup>2</sup>/year for men,  $-0.80$  (0.03) ml/min/1.73 m<sup>2</sup>/year for women

CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration

**Table 1:** Participants' characteristics, by gender and age strata.

	Men				Women			
	15–29	30–44	45–59	≥60	15–29	30–44	45–59	≥60
Age group (y)	15–29	30–44	45–59	≥60	15–29	30–44	45–59	≥60
No.	135	127	171	227	155	169	178	191
Age (years)	23.4 (4.1)	38.6 (4.5)	52.5 (4.3)	69.8 (7.1) <sup>a</sup>	23.5 (4.1)	38.1 (4.1)	52.7 (4.2)	70.1 (7.0) <sup>a</sup>
Nationality (% Swiss)	80	71.6	77.2	81.1	85.2	75.1	75.3	83.2
Education (%)								
Primary	28.9	6.30	10.0	14.2 <sup>a</sup>	13.5	8.3	17.5	28.0 <sup>a</sup>
Secondary	40.0	22.8	37.6	48.7 <sup>a</sup>	52.3	41.7	50.9	48.2 <sup>a</sup>
Tertiary	31.1	70.9	52.4	37.2 <sup>a</sup>	34.2	50.0	31.6	23.8 <sup>a</sup>
Current smoking (%)	11.3	24.4	41.0	46.7 <sup>a</sup>	14.8	24.3	32.6	24.6 <sup>b</sup>
BMI (kg/m <sup>2</sup> )	23.1 (3.4)	25.8 (3.7)	27.3 (4.1)	27.2 (4.0) <sup>c</sup>	22.6 (4.3)	23.9 (4.3)	25.3 (5.1)	26.0 (5.1) <sup>c</sup>
Hypertension (%)	3.7	13.4	39.2	66.1 <sup>a</sup>	1.9	3.0	15.7	51.8 <sup>a</sup>
Diabetes (%)	0	1.6	2.3	11.0	0	0.6	2.2	4.7
Plasma creatinine (μmol/l)	85.1 (9.8)	88.2 (12.4)	86.7 (11.8)	95.3 (29.0) <sup>c</sup>	68.9 (8.7)	68.0 (10.4)	71.5 (11.1)	75.4 (14.6) <sup>c</sup>
eGFR CKD-EPI (ml/min/1.73 m <sup>2</sup> )	110.7 (12.9)	95.8 (13.3)	88.4 (11.7)	73.4 (16.2) <sup>c</sup>	108.0 (14.3)	98.4 (13.9)	84.9 (13.6)	71.9 (14.7) <sup>c</sup>
Albuminuria (mg/24 h)	6.9 (8.1)	7.1 (22.5)	7.1 (9.9)	25.4 (127.1) <sup>d</sup>	9.1 (17.7)	14.2 (55.3)	6.9 (10.0)	8.6 (13.3)

BMI = body mass index; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; eGFR = estimated glomerular filtration rate

Data are mean (standard deviation) unless otherwise specified.

<sup>a</sup>  $p < 0.001$  between age groups, by gender (chi-squared test)

<sup>b</sup>  $p < 0.05$  between age groups, by gender (chi-squared test)

<sup>c</sup>  $p < 0.001$  between age groups, by gender (ANOVA)

<sup>d</sup>  $p < 0.05$  between age groups, by gender (ANOVA)

be present in one in ten Swiss adults and one in four participants over 60 years of age. These data match with similar population-based studies from other countries, combining eGFR and albuminuria to define CKD, which reported a CKD prevalence of between 8% and 13.2% [6, 14–19]. The three linguistic/geographic regions of Switzerland presented similar results. The global prevalence of CKD was similarly distributed across the genders in older people, but among those younger than 60 years CKD was more frequent in women than men. However, in an age-stratified, adjusted analysis, we found several differences in the determinants of CKD between younger and older participants. Diabetes was the only factor associated with a higher prevalence of CKD in both age strata, despite a greater risk increase in younger than in older subjects. In several previous cross-sectional and longitudinal analyses, older age, female gender and higher serum uric acid were

independently associated with CKD prevalence [9, 20–25]. In our population, these factors were also independently associated with CKD in participants aged over 45 years, but not in younger ones. Interestingly, a lower educational level was associated with a higher prevalence of CKD in younger participants. This factor has also been associated with kidney outcomes in the CoLaus population [26]. In contrast to some previous reports, we found neither a difference in CKD prevalence between lean, overweight and obese participants, nor an association between hypertension and CKD prevalence [9, 27, 28].

In Europe there appears to be a south-north gradient in CKD prevalence: the prevalence of CKD is higher in Southern countries (12.7–13.2%) [29, 30] than in the Northern countries (8–10.2%) [31, 32]. In contrast with these observations, we found no differences between linguistic regions in our analysis.

**Table 2:** Distribution of the chronic kidney disease risk categories according to KDIGO (2012).

				Albuminuria stages			Total
				A1	A2	A3	
				Normal to mildly increased	Moderately increased	Severely increased	
				<30 mg/g <3 mg/mmol	30–300 3–30 mg/mmol	>300 mg/g >30 mg/mmol	
<b>GFR</b> (ml/min/1.73 m <sup>2</sup> ) <b>CKD-EPI equation</b>	G1	Normal or high	≥90	48.04	1.85	0.07	<b>49.96</b>
	G2	Mildly decreased	60–89	41.54	1.26	0	<b>42.79</b>
	G3a	Mild-moderate	45–59	5.25	0.30	0.07	<b>5.62</b>
	G3b	Moderate-Severe	30–44	1.18	0.22	0	<b>1.40</b>
	G4	Severe	15–29	0.07	0.07	0.07	<b>0.22</b>
	G5	Kidney failure	<15	0	0	0	<b>0</b>
<b>Total</b>				<b>96.08</b>	<b>3.70</b>	<b>0.22</b>	<b>100</b>

CKD = chronic kidney disease; CKD-EPI = Chronic Kidney Disease Epidemiology Collaboration; GFR = glomerular filtration rate; KDIGO = Kidney Disease – Improving Global Outcomes

Colours correspond to categories with similar relative risk for renal and cardiovascular outcomes [3]: low risk (light grey, 89.6%): reference category (relative risk, RR = 1); moderately increased risk (medium grey, 8.4%): RR for cardiovascular mortality 1.5–2.2; RR for progressive CKD 1.9–3.3; high risk (dark grey, 1.6%): RR for cardiovascular mortality 2.2–3.7; RR for progressive CKD 4.0–8.1; very high risk (black, 0.5%): RR for cardiovascular mortality 4.1–14.0; RR for progressive CKD 9.4–57.0

**Table 3:** Factors associated with chronic kidney disease in univariate and multivariate logistic regression stratified by age.

Covariable	Univariate		Multivariate age 15–44 (n = 586)		Multivariate age ≥45 (n = 767)	
	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Gender (women vs men)	1.03 (0.72–1.45)	0.890	3.44 (0.76–15.67)	0.110	1.88 (1.13–3.14)	0.016
Age (per 1 year increase)	1.07 (1.06–1.09)	<0.001	1.00 (0.94–1.06)	0.928	1.11 (1.08–1.14)	<0.001
Diabetes (absent = Ref.)	5.80 (3.09–10.89)	<0.001	44.23 (1.76–1115)	0.021	2.75 (1.30–5.81)	0.008
Hypertension (absent = Ref.)	4.85 (3.37–6.96)	<0.001	1.90 (0.18–20.07)	0.593	1.18 (0.71–1.95)	0.520
Serum uric acid (mmol/l)	1.006 (1.00–1.01)	<0.001	0.992 (0.983–1.001)	0.094	1.008 (1.005–1.011)	<0.001
Education level						
Primary	1.0 (Ref.)		1.0 (Ref.)		1.0 (Ref.)	
Secondary	0.57 (0.36–0.90)	0.015	0.09 (0.02–0.39)	0.001	1.04 (0.58–1.88)	0.891
Tertiary	0.49 (0.30–0.78)	0.003	0.32 (0.11–1.00)	0.051	0.76 (0.40–1.44)	0.397
Body mass index						
<25 kg/m <sup>2</sup>	1.0 (Ref.)					
25–30 kg/m <sup>2</sup>	1.36 (0.93–2.00)	0.111	–		–	
>30 kg/m <sup>2</sup>	1.24 (0.74–2.07)	0.412				
Current smoking (absent = Ref.)	1.22 (0.84–1.78)	0.304	–		–	
Physical activity (absent = Ref.)	1.02 (0.72–1.46)	0.904	–		–	
Language region						
French	1.0 (Ref.)					
German	1.26 (0.84–1.89)	0.261	–		–	
Italian	1.15 (0.66–2.02)	0.617				

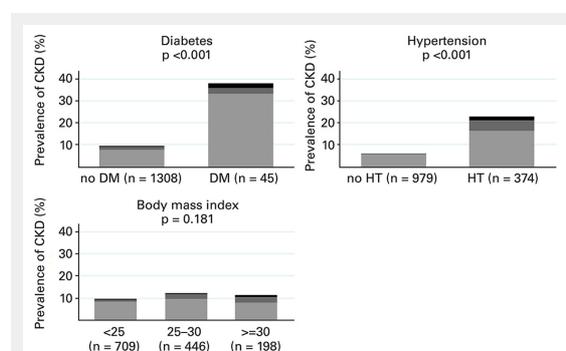
Direct comparisons between our results and previous population-based analyses performed in Switzerland are complicated by differences in population sampling, age restriction and definition of CKD. The prevalence of CKD we found is in line with the results of the CoLaus cohort [9], based on a single Swiss city, Lausanne, and using the same definitions. The Swiss SAPALDIA study [10] reported a CKD prevalence of 1.1% in men and 7.9% in women aged below 55 years, 7.1% in men and 23.5% in women between 55 and 65 years, 12.9% in men and 35.9% in women over 65 years. However, in this study CKD was defined using the MDRD formula, with an eGFR cut-off <60 ml/min/1.73 m<sup>2</sup>, and albuminuria was not measured. Growing evidence supports the use of eGFR and urinary spot albumin in the assessment of CKD prevalence in epidemiological and clinical works, both being strong independent risk factors for increased mortality, cardiovascular events, acute kidney injury [8, 33, 34], and venous thromboembolism [35]. Unfortunately, these tests have significant limitations. Urinary albumin-to-creatinine ratio correlates closely with 24-hour urinary albumin excretion, but mild albuminuria may be transiently present in the absence of kidney pathology, for example by fever or after exercise. Longitudinal studies have shown that albuminuria may regress in people with nondiabetic [36] and diabetic CKD [37]. The equation used to estimate GFR also plays an important role, especially in subjects with early CKD. Several Swiss laboratories automatically still report the MDRD [38] equation-based eGFR whenever a serum creatinine is requested. The MDRD equation was developed in people with CKD and has been shown to systematically underestimate GFR above the threshold of 60 ml/min/1.73 m<sup>2</sup> [39], leading to an overestimation of CKD prevalence in healthy subjects. The CKD-EPI equation [13] has proven to be more accurate than MDRD in patients with eGFR ≥60 mL/min/1.73 m<sup>2</sup> and [40] and to predict all cause and cardiovascular mortality, and progression toward end-stage renal disease [41].

The new KDIGO (2012) CKD classification integrates a cardiovascular risk prediction instrument, based on eGFR and albuminuria, which allowed us to assess the CKD-associated cardiovascular risk in the Swiss population: in our

study, 89.6% of the population ranked in the low-risk category, 8.4% in the moderate-risk, 1.6% in the high-risk, and only 0.5% in the very high-risk category. The risk-category distribution we found is in line with the results recently reported for the population of the CoLaus cohort [9]. In our population, a higher prevalence of CKD was found in three subgroups: participants older than 60 years (25%), diabetic (37%) and hypertensive (23%) subjects. This observation may warrant systematic screening of asymptomatic subjects presenting these risk factors for CKD, as suggested by several international medical societies [42–44], although the risk of progression towards end-stage renal disease is very low for the majority of elderly subjects with CKD stage 2 and 3. Contrariwise, routine screening for CKD in asymptomatic adults without risk factors for CKD is not supported by scientific evidence [43, 45].

Our analysis has some limitations. First, as in many other epidemiological studies in this area, our estimates have been based on single serum creatinine and urinary albumin analysis results. According to the guidelines, the definition of CKD requires the demonstration of reduced kidney function or kidney damage signs for >3 months and this time constraint is likely to reduce the CKD prevalence observed in single sample studies. The cross-sectional nature of the study furthermore limits causal inferences. Some of the factors (such as serum uric acid) that we observed to be associated with CKD could either precede or follow the appearance of CKD. Only a longitudinal trial would clarify the temporal sequence and whether baseline characteristics are associated with incident CKD or vice versa. For serum and urine creatinine analysis, a compensated isotope dilution mass spectrometry-traceable Jaffe method (not enzymatic) was used, similarly to most of the previous epidemiological studies about CKD prevalence. The small bias due to the method is minimised by the use of the appropriate calibrated CKD-EPI equation and centralised analyses. Because of the limited numbers of participants belonging to the medium-, high- and very high-risk categories of the KDIGO (2012) classification, we were obliged to pool the three categories in one group (the CKD group) to explore correlations. One main limitation of our study is the low overall participation rate of 10% from the original randomly selected sample, which could limit generalisability of the results and could be explained by the two-stage sampling strategy (the subject we contacted by phone was not automatically the one selected to enter the study) and the unattractiveness of 24-hour urine collection. Furthermore, the optional character of the blood sample may have biased the results of the present analysis in young and middle-aged population strata, where more women than men accepted the blood collection.

In conclusion, one in ten adults has CKD in the Swiss general population, without significant regional differences. Subjects older than 60 years, as well as diabetic and hypertensive patients show a higher prevalence of CKD and systematic screening including creatinine and albuminuria measurement may be warranted in these groups of subjects to prevent hospitalisations and to reduce cardiovascular complications by implementing adequate cardiovascular prevention [46].



**Figure 4**

Prevalence of moderate, high and very high risk categories using the CKD KDIGO(2012) classification, by diabetes (panel a), hypertension (panel b), and BMI categories (panel c). CKD = chronic kidney disease; DM = diabetes mellitus; KDIGO = Kidney Disease – Improving Global Outcomes; HT = arterial hypertension.

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All authors declare that they have no competing interests that may be relevant to the submitted work.

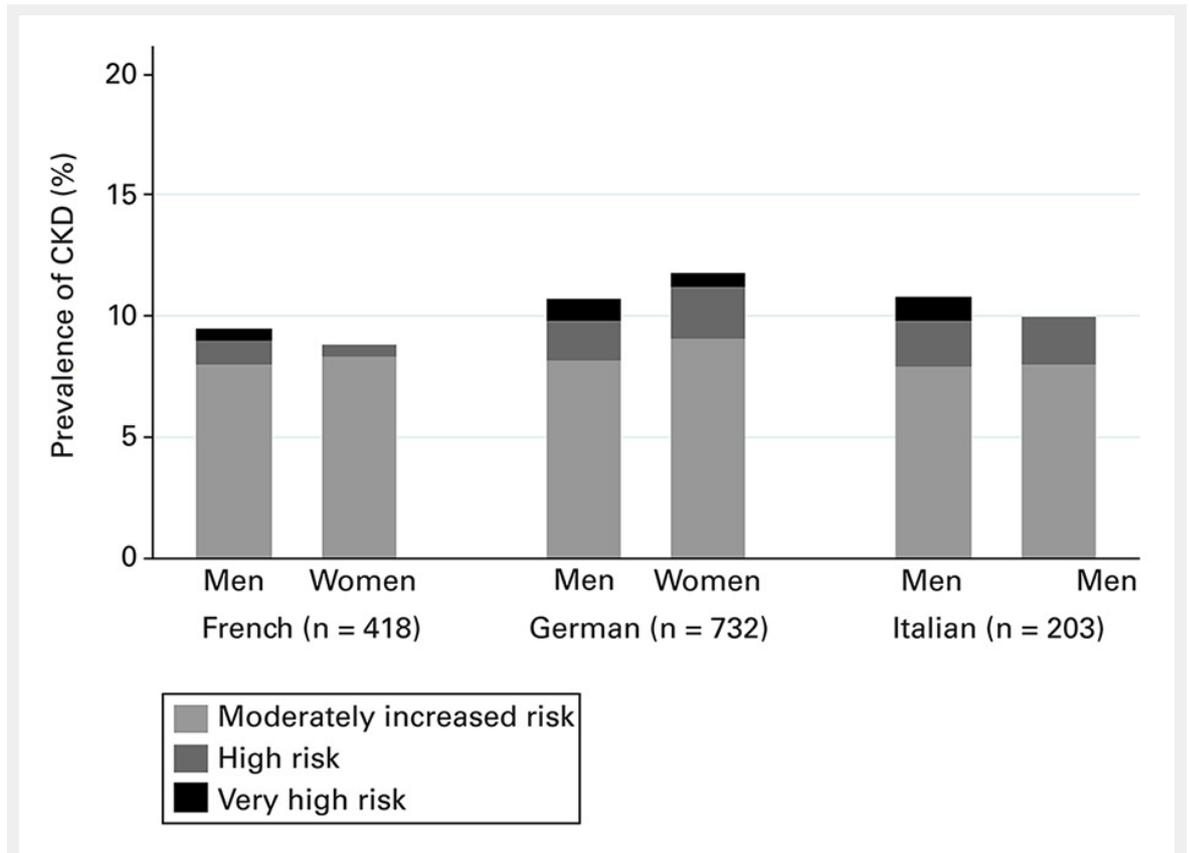
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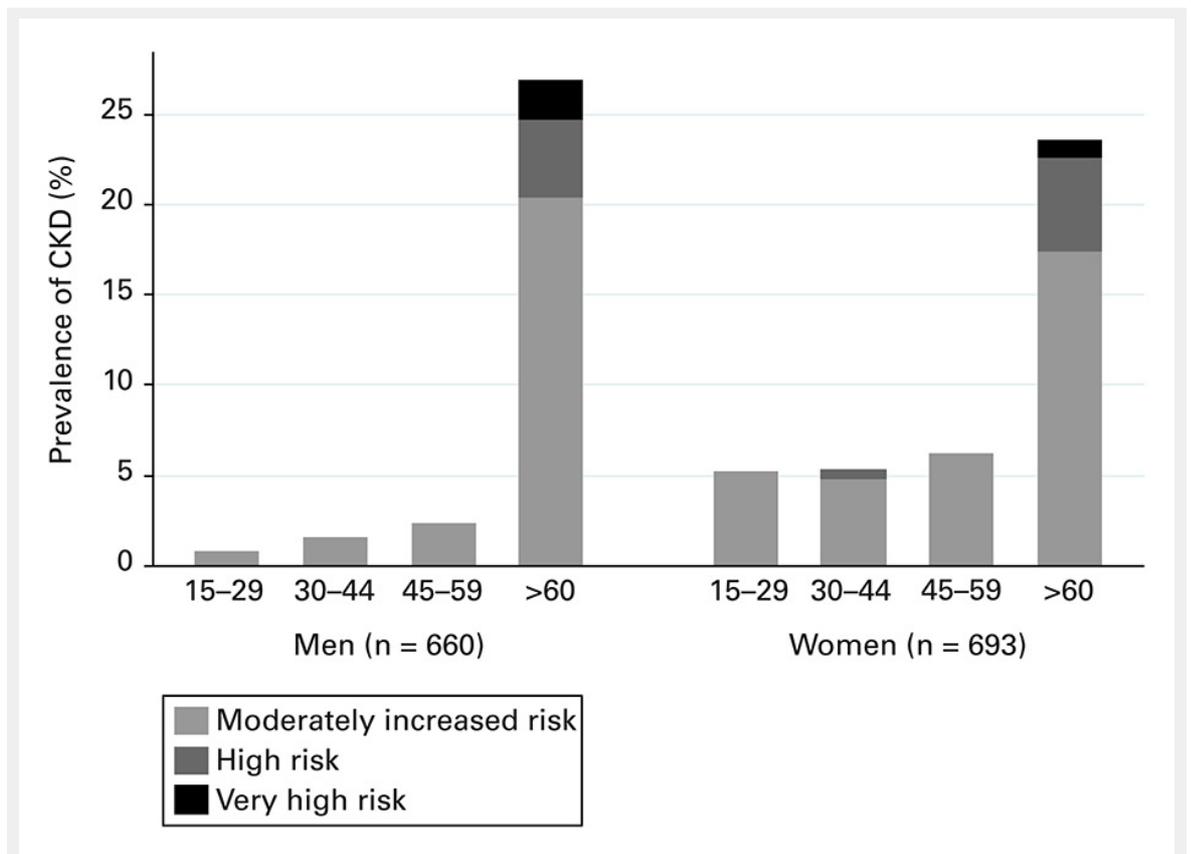
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Figures (large format)



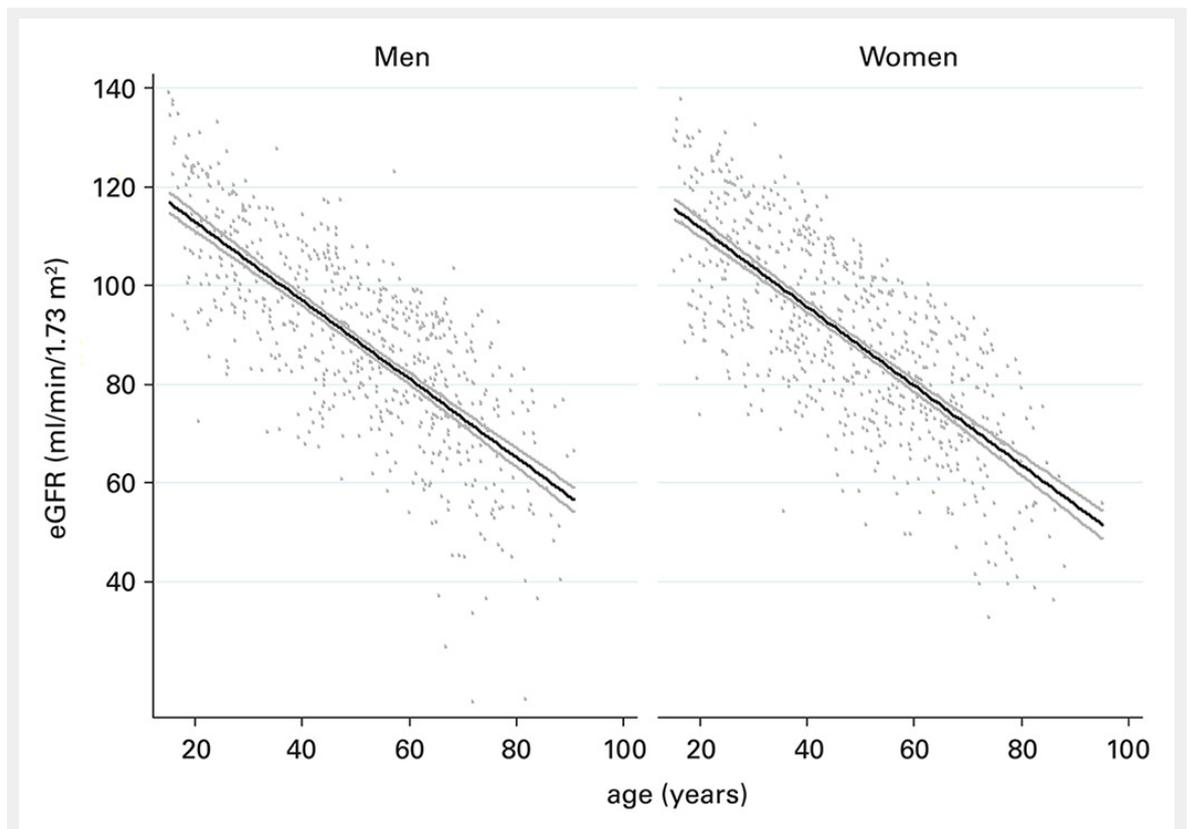
**Figure 1**

Prevalence of chronic kidney disease (KDIGO 2012), by gender and linguistic region. p-value not significant for difference between genders for each linguistic region (chi squared test); p-value not significant for difference between linguistic regions (chi squared test).  
 KDIGO = Kidney Disease – Improving Global Outcomes



**Figure 2**

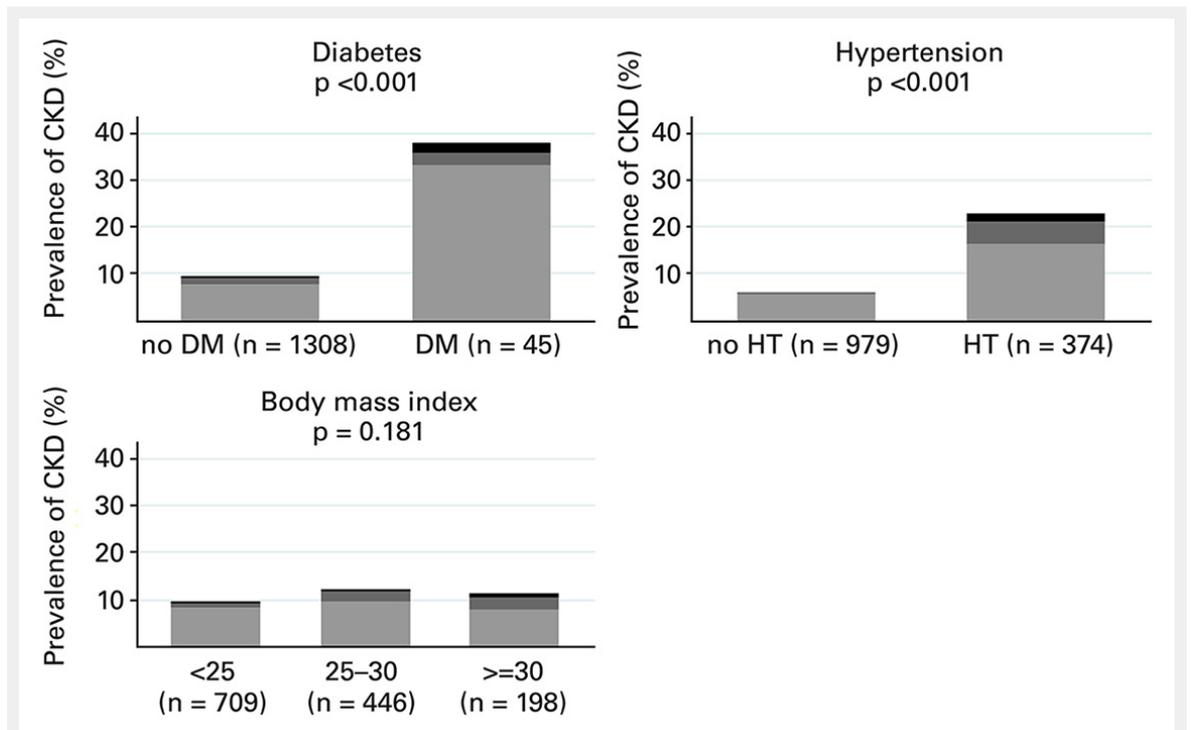
Prevalence of chronic kidney disease (KDIGO 2012), by gender and age category. p-values are from a nonparametric test for trend, comparing the trend in combined medium- to very high-risk categories vs low-risk category across age groups  
 KDIGO = Kidney Disease – Improving Global Outcomes



**Figure 3**

Relationship between renal function (eGFR by CKD-EPI equation) and age in the Swiss population.

Bold lines represent the unadjusted linear regression estimation, gray lines 95% confidence interval. Decline slope (SE):  $-0.79$  ( $0.03$ ) ml/min/ $1.73$  m<sup>2</sup>/year for men,  $-0.80$  ( $0.03$ ) ml/min/ $1.73$  m<sup>2</sup>/year for women  
CKD-EPI = Chronic Kidney Disease Epidemiological Collaboration



**Figure 4**

Prevalence of moderate, high and very high risk categories using the CKD KDIGO(2012) classification, by diabetes (panel a), hypertension (panel b), and BMI categories (panel c).

CKD = chronic kidney disease; DM = diabetes mellitus; KDIGO = Kidney Disease – Improving Global Outcomes; HT = arterial hypertension.