






# BMJ Open Prevalence and risk factors associated with chronic kidney disease in Nepal: evidence from a nationally representative population-based cross-sectional study

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## ABSTRACT

**Objective** This study aimed to determine population-based prevalence of chronic kidney disease (CKD) and its associated factors in Nepal.

**Study design** The study was a nationwide population-based cross-sectional study.

**Setting and participants** Cross-sectional survey conducted in a nationally representative sample of 12 109 Nepalese adult from 2016 to 2018 on selected chronic non-communicable diseases was examined. Multistage cluster sampling with a mix of probability proportionate to size and systematic random sampling was used for the selection of individuals aged 20 years and above.

**Primary and secondary outcome measures** Primary outcome in this study was population-based prevalence of CKD in Nepal. A participant was considered to have CKD if the urine albumin-to-creatinine ratio was greater than or equal to 30 mg/g and/or estimated glomerular filtration rate is less than 60 mL/min/1.73 m<sup>2</sup> at baseline and in follow-up using modification of diet in renal disease study equations. The secondary outcome measure was factors associated with CKD in Nepal. The covariate adjusted association of risk factors and CKD was calculated using multivariable binary logistic regression.

**Results** The overall prevalence of CKD in Nepal was 6.0% (95% CI 5.5 to 6.6). Factors independently associated with CKD included older age (adjusted OR (AOR) 2.6, 95% CI 1.9 to 3.6), Dalit caste (AOR 1.6, 95% CI 1.1 to 2.3), hypertension (AOR 2.4, 95% CI 2.0 to 3.0), diabetes mellitus (AOR 3.2, 95% CI 2.5 to 4.1), raised total cholesterol (AOR 1.3, 95% CI 1.0 to 1.6) and increased waist-to-hip ratio (AOR 1.6, 95% CI 1.2 to 2.3).

**Conclusion** This nationally representative study shows that the prevalence of CKD in the adult population of Nepal is substantial, and it is independently associated with several cardiometabolic traits. These findings warrant longitudinal studies to identify the causes of CKD in Nepal and effective strategies to prevent it.

## Strengths and limitations of this study

- This is the first large scale nationwide population-based prevalence of chronic kidney disease (CKD) in Nepal.
- Strict training processes and vigorous quality assurance programmes were used to ensure the quality of data collection
- The use of standardised definitions of CKD facilitates international comparisons of CKD prevalence and risk factors.
- High overall response rate of 91.7. % in first visit and 86.9% in follow-up visit.
- Causal inference is unknown.

## BACKGROUND

Chronic kidney disease (CKD) is one of the most rapidly growing non-communicable diseases (NCDs) worldwide.<sup>1</sup> According to the Global Burden of Disease (GBD) study, CKD was the 11th leading cause of death in 2019, up from 19th in 1990 accounting for 2.53% of total deaths.<sup>2</sup> CKD is also associated with substantial morbidity, mortality and health-care costs. Although it is largely preventable, over 9% of the population worldwide is estimated to be affected by the condition, particularly developing countries,<sup>3 4</sup> and it is associated with diabetes type II, hypertension and obesity, which are also growing at an alarming rate. The rapid increase of CKD is likely to impose a great socioeconomic and public health burden in resource-poor setting.<sup>5</sup>

The evidence on the prevalence of CKD in South East Asia is relatively limited, but it consistently shows a high prevalence of

CKD<sup>6-8</sup>; however, data remain poorly characterised due to inconsistent assessment of kidney function and non-standard approaches which might distort the true estimates of CKD prevalence. There are few studies in Nepal already warned the higher prevalence of CKD<sup>9-11</sup> and reported data largely depends on the population studied (rural/urban/or general/at high-risk group) methods and the lack of representativeness from the general population. Nepal has overcome many of the critical health challenges to survive the first 5 years of life, and that NCDs and burden of potential underlying risk factors such as obesity, hypertension and diabetes and unhealthy lifestyle habits including poor diets are highly prevalent.<sup>12</sup>

Understanding the burden and risk factors associated with CKD is important for making healthcare planning, designing screening strategies and prevention of these diseases in this resource constrains setting, where access to renal replacement therapy is costly. Therefore, this study aimed to determine the population-based prevalence of CKD and its associated factors in Nepal.

## METHODS

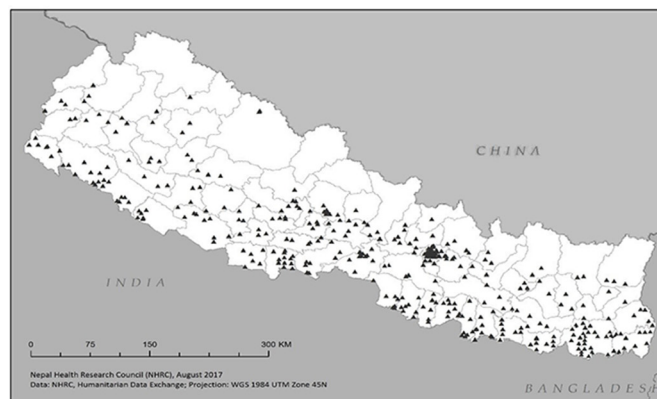
### Study design and subjects

The Nepal Health Research Council designed and implemented the ‘National Population based Prevalence Survey of Selected NCDs in Nepal’. This was a population-based survey to investigate the prevalence of NCDs including CKD, chronic obstructive pulmonary disease carried out between 2016 and 2018 in adult’s  $\geq 20$  years old from seven provinces of the country. Full details of the design and protocols of the survey are available elsewhere.<sup>13</sup>

### Participants, sample size and study setting

The sample size for the survey was calculated taking as reference the prevalence of raised blood glucose ( $p=4\%$ ) from NCD risk factors: STEPwise approach to Surveillance (STEPS) survey 2013,<sup>14</sup> Z value of 1.96 at 95% CI and margin of error (d) of 20%, design effect of 2, adjusting the sample across three domains of the Terai, hills and mountains and adding a non-response rate of 20% yielded a sample size of 12965. With a plan to enrol 33 participants in each cluster (400), the final sample size was 13200. A ward (lowest administrative unit of the then Village Development Committees and Municipalities) was considered as a cluster-primary sampling unit (PSU) of the study design. With the support from Central Bureau of Statistics, a total of 400 clusters were sampled. To select a representative sample of cluster, the rural and urban areas within each region were identified as the main sampling strata and the sample was selected in two stages in which ecological belts (Terai, Hill and Mountains) and five development regions (Central, Eastern, Mid-Western, Western and Far western), was taken into account.

The survey team members in the field used official or socially mapped household list to select 33 households (secondary sampling units) from each cluster using systematic random sampling. One participant out of



**Figure 1** Map of Nepal showing the study clusters (400 clusters)

the eligible candidates ( $\geq 20$  years and above, resident in the study area at least 6 months and able to provide informed consent) was selected to take part in the survey using the ‘Kish method’. Of 13200 participants who were approached for interview, 12557 responded to the invitation in day 1. Among 12557 who accepted the invitation, only 12148 participants responded in day 2 of clinical setting. For the present study, data from 12109 subjects were available for analyses with a response rate of 91.7%, 39 (0.32%) were excluded, because they refused providing blood and urine samples to evaluate renal function in day 2.

Data weighting was carried out to make the sampled population comparable to the national population. Data weighting was done using sampling weight. Sample weighting was carried out for probabilities of selection of PSU (ward/cluster), selection of households and selection of an individual in a household using 2011 population for Nepal with the support from Central Bureau of Statistics.

### Data collection and measurements

Data collection was performed in 400 clusters (figure 1) within 72 districts of Nepal. Data collection teams at each site consisted of five member having academic background of nursing, general medicine, bachelor in medical laboratory technology or public health.

Participants’ appointment for face-to-face personal interview at convenient and accessible site or at home on two occasions (day 1 and day 2): following written informed consent, from the participants in day 1, a structured questionnaire was administered to collect information about participants’ general health and socio-demographic characteristics. Participants self-reported their health and sociodemographic status, personal and family medical histories and history of medicine used. Information concerning their lifestyle factors (cigarette smoking, alcohol intake) was collected, and then physical and clinical measurements were performed. The clinical examination included measurements of height, weight, waist hip ratio and blood pressure (BP) following standard protocols. Height was measured in centimetres

with a portable Bioplus stature metre and weight with a portable digital seca 874 weighing scale (Seca, Germany) and recorded in kilograms ensuring that the participant was wearing light clothes and was without footwear. Waist circumference was measured using Seca tape in cm at the level midway between the twelfth rib and the uppermost lateral border of the iliac crest during normal expiration. BP was measured at least three times with a minimum 3 min, and then averaged to be recorded by using an Omron digital automatic BP monitor model HEM-8712 (Omron Health Care Co., Japan) with appropriate sized cuffs.<sup>15</sup> Participants were classified as hypertensive when the raised BP is defined as having systolic BP  $\geq 140$  mm Hg and/or diastolic BP  $\geq 90$  mm Hg during the study, or being previously diagnosed as having hypertension.

We used fasting, at least an 8-hour fast, and 2-hour post prandial (PP) blood sample to test various biochemical parameters. Following aseptic technique, blood samples were drawn by a trained enumerators using vacutainers to test laboratory parameters such as fasting blood glucose level, PP blood glucose level, serum creatinine, total cholesterol (TC), triglyceride (TG), high density lipoprotein (HDL) cholesterol and serum creatinine. The well-trained enumerators collected around 10 mL of blood sample at the fasting state and provided 82 g of glucose monohydrate (equivalent to 75 g of anhydrous glucose) in 250 mL water to drink. Second blood sample was collected at 2 hours of glucose intake. Fasting blood glucose, TC, TG, HDL cholesterol and serum creatinine were measured with the fasting sample and 2-hour PP sample was used for measuring PP blood glucose only. We carried out biochemical analysis with Biolyzer 100 Clinical Chemistry Analyzer (semiautomatic biochemistry analyzer, Analyticon, Germany) and used glucose oxidase-peroxidase method for blood glucose, cholesterol oxidase/phenol aminophenazone (CHOD-PAP) for TC, glycerol-3-phosphate oxidase/phenol aminophenazone for TG, HDL cholesterol by polyethylene glycol/cholesterol oxidase/phenol aminophenazone and serum creatinine measured by the Jaffe Reaction method. The laboratory supervisors calculated the low-density lipoprotein cholesterol by Freidewald's Formula using TC, TG and HDL cholesterol.

### Outcome measurements

A spot urine sample was collected from single-voided specimen to measure urine albumin and creatinine using the same semiautomatic biochemistry analyser (Analyticon Biolyzer 100 Clinical Chemistry Analyzer, Germany). Laboratory supervisors measured urine albumin concentration by Turbidimetric tests and urine creatinine concentration by the Jaffe Reaction method and finally albumin-creatinine ration (ACR) was calculated and expressed in mg/g. Renal function was evaluated by using estimated GFR (eGFR), based on the widely used 4-variable Modification of Diet in Renal Disease Study (MDRD) equation. A participant was considered to have CKD if the urine albumin-to-creatinine ratio (uACR) was

greater than or equal to 30 mg/g and/or e-GFR was less than 60 mL/min/1.73 m<sup>2</sup> at baseline and in follow up.<sup>16</sup> The secondary outcome measure was factors associated with CKD in Nepal

### Follow-up of study participants to determine CKD

Participants having either ACR greater than or equal to 30 mg/g in the baseline and/or decreased eGFR ( $< 60$  mL/min/1.73 m<sup>2</sup>) were revisited again after 3 months in their place of residence to ensure the chronicity of the renal disease. Written consent was taken prior to blood and urine sample collection using similar procedures as mentioned above. Out of 1382 participants having a high ACR ratio and/or decreased eGFR, 1202 gave consent. However, data of ACR was missing for 8 participants making the availability of complete data for 1194 participants for analysis, with a response rate of 86.9%.

### Data management and analysis

We used android mobile phones inbuilt with data collection software (REMO) to collect data digitally. Data cleaning including correction of inconsistencies was performed in SPSS V.20.0. We then exported the dataset to STATA V.13 for analysis. To adjust for unequal probability of selection, appropriate sampling weights with complex sampling analysis were used to provide valid estimates for the relevant Nepalese population which is based on 2011 national population and housing census data. Results are expressed as a percentage and OR with 95% CI. Bivariate analysis was conducted to analyse the unconditional association between each explanatory variable and CKD status. To be included in multivariable modelling, the level of significance  $\alpha=0.25$  was used during bivariate analysis (ie, p value 0.25 was not statistically significant). Independent variables included demographics (age, gender, ethnicity, education, province and place of residence), existing comorbidities (hypertension, diabetes, raised TC, increased waist hip ratio), any hypertension, any diabetes (self-reported or physician diagnosed (fasting blood glucose  $\geq 126$  mg/dL)), lifestyles (smoking and alcohol consumption), overweight or obesity (body mass index (BMI)  $\geq 25$  kg/m<sup>2</sup>).

Ethnicity/caste data were self-reported and categorised into six major groups based on the caste coding by government of Nepal and STEPS survey Nepal, 2013 categorisation.<sup>17</sup> (1) Upper caste groups (population with relatively higher socioeconomic and education status, mostly Brahmins, Chhetris, Thakuri and Sanyasi); (2) disadvantaged Janajatis (disadvantaged group of people and also indigenous, with relatively lower socioeconomic and education status); (3) Dalit (untouchables, most disadvantaged marginalised group of people, with relatively lower socioeconomic and education status); (4) disadvantaged non-Dalit Terai Caste Groups (disadvantaged group of people from the Terai, the lowlands, with relatively lower socioeconomic and education status but not the dalit groups); (5) religious minorities (Muslim, Christian, etc); (6) relatively advantaged Janajatis (indigenous group of people



**Table 1** Sociodemographic characteristics of the study participants (N=12 109)

Characteristics	n	%
<b>Age</b>		
20–39 years	4336	35.8
40–59 years	5034	41.6
60 years and above	2739	22.6
<b>Sex</b>		
Male	4708	38.9
Female	7401	61.1
<b>Ethnicity</b>		
Upper caste group	4144	34.2
Disadvantaged janajati	2546	21.0
Relatively advantaged janajati	2018	16.7
Disadvantaged non-dalit terai caste	1836	15.2
Dalit	1225	10.1
Religious minorities	340	2.8
<b>Education</b>		
Illiterate/No formal schooling	6607	54.6
Below secondary (<10 years)	2742	22.6
Secondary and above (≥10 years)	2760	22.8
<b>Province</b>		
Province 1	2049	16.9
Madhesh Province	2003	16.5
Bagmati Province	3096	25.6
Gandaki Province	1315	10.9
Lumbini Province	2030	16.8
Karnali Province	588	4.9
Sudurpaschim Province	1028	8.5
<b>Place of residence</b>		
Rural	6107	50.4
Urban	6002	49.6

with relatively higher socioeconomic status, such as Gurung, Newar and Thakali).

Multicollinearity, the variance inflation factor was assessed for all the independent variables found to be statistically significant from the bivariate analysis. Multivariable logistic regression modelling was conducted with CKD as a dependent variable using the independent variables identified as being statistically significant from the bivariate analysis.

## RESULTS

A total of 12 109 subjects aged 20 years and above were included in the analyses. Among them 61.1% were female, two-fifth were adults in the age group 20–59 years (41.6%), one-third was from upper caste ethnic group (34.2%), and just above half of them were either illiterate

or had no formal schooling (54.6%). Table 1 presents the unweighted numbers and proportions of different demographic characteristics of the study population as measured in the study.

## Prevalence of CKD

The overall prevalence of CKD based on the eGFR MDRD equation (uACR of ≥30 mg/g and/or glomerular filtration rate <60 both at baseline and follow-up) was 6.0% (95% CI 5.5 to 6.6). The prevalence was higher in males compared with female (6.5 vs 5.7) though not statistically significant. Prevalence increased with increasing age (11.5% among 60 years and above and 2.6% among 20–39 years age group) (table 2). The mean (±SD) eGFR in baseline was 92.6 (±22.1) mL/min/1.73 m<sup>2</sup> for male and 88.2 (±20.5) mL/min/1.73 m<sup>2</sup> for female (figure 2). The mean (±SD) eGFR was 88.0 (±25.7) mL/min/1.73 m<sup>2</sup> for male and 81.1 (±23.4) mL/min/1.73 m<sup>2</sup> for female in follow-up (figure 3).

## Factors associated with CKD

The multivariable analyses to investigate the association of independent factors and CKD are shown in table 2. In the bivariate analysis, age, smoking, BMI, ethnicity, education, having diabetes mellitus (DM), being hypertensive, increased waist hip ratio and having raised TC were found to be statistically significantly associated with CKD. Therefore, those nine factors including place of residence, province and sex of participants (p value≤0.25) were considered in the multiple logistic models. After adjustment, only six variables: age, ethnicity, diabetes, hypertension, raised TC and increased waist hip ratio, were found to be significant predictors of CKD. There was a strong positive association between age and CKD, that is, the odds of having CKD were about 1.4 (95% CI 1.0 to 1.8) and 2.6 (95% CI 1.9 to 3.6) times higher for people aged 40–59 years and ≥60 years respectively, compared with people aged 20–39 years. Participants with DM had about 3.2 (95% CI 2.5 to 4.1) times higher odds of occurrence of CKD than non-diabetic participants. Similarly, participants with raised BP had 2.4 (95% CI 2.0 to 3.0) higher odds of having CKD than non-hypertensive/normal participants.

Participants with raised TC had 1.3 (95% CI 1.0 to 1.6) times higher odds of having CKD relative to participants who had normal cholesterol level, whereas those with raised waist hip ratio had 1.6 (95% CI 1.2 to 2.3) times higher odds than normal participants to have CKD. Individuals who were classified as Dalit by ethnicity were 1.6 (95% CI 1.1 to 2.3) times or relatively advantaged janajati had 1.4 (95% CI 1.0 to 1.9) times higher odds of having CKD when compared with individuals with an upper caste.

## DISCUSSION

This is the first large-scale nationwide population-based representative study to report prevalence of and factors

**Table 2** Factors associated with chronic kidney disease (CKD) by univariate and multivariate analysis (N= 12 109)

Characteristics	Count	CKD		
	N	CKD prevalence (n %)	COR (95% CI)	AOR (95% CI)
<b>Age</b>				
20–39 years	4336	118 (2.6)	1	1
40–59 years	5034	294 (5.8)	2.3 (1.8 to 3.0)‡	1.4 (1.0 to 1.8)*
60 years and above	2739	316 (11.5)	4.9 (3.8 to 6.3)‡	2.6 (1.9 to 3.6)‡
<b>Sex</b>				
Female	7401	415 (5.7)	1	1
Male	4708	313 (6.5)	1.2 (1.0 to 1.4)	1.2 (0.8 to 1.6)
<b>Ethnicity</b>				
Upper caste	4144	212 (5.1)	1	1
Disadvantaged Janajati	2546	138 (5.4)	1.1 (0.8 to 1.4)	1.1 (0.9 to 1.5)
Dalit	1225	84 (7.1)	1.4 (1.0 to 1.9)*	1.6 (1.1 to 2.3)†
Disadvantaged non-Dalit/terai caste	1836	116 (6.4)	1.3 (0.9 to 1.7)	1.4 (0.9 to 2.1)
Religious minorities	340	25 (8.0)	1.6 (1.0 to 2.7)	1.7 (1.0 to 2.9)
Relatively advantaged Janajati	2018	153 (7.4)	1.5 (1.1 to 2.0)*	1.4 (1.0 to 1.9)*
<b>Education</b>				
Illiterate/no formal schooling	6607	459 (7.0)	1	1
Below secondary (<10 years)	2742	146 (5.4)	0.8 (0.6 to 0.9)†	1.1 (0.9 to 1.5)
Secondary and above (≥10 years)	2760	123 (4.5)	0.6 (0.5 to 0.8)‡	1.1 (0.7 to 1.4)
<b>Province</b>				
Karnali Province	588	30 (4.7)	1	1
Province 1	2049	100 (5.2)	1.1 (0.7 to 1.8)	1.1 (0.6 to 2.0)
Madhesh Province	2003	133 (6.6)	1.4 (0.9 to 2.3)	1.2 (0.6 to 2.2)
Bagmati Province	3096	196 (6.5)	1.4 (0.9 to 2.2)	1.1 (0.6 to 1.9)
Gandaki Province	1315	93 (6.8)	1.5 (0.9 to 2.3)	1.2 (0.7 to 2.0)
Lumbini Province	2030	118 (5.7)	1.2 (0.7 to 2.2)	0.9 (0.5 to 1.6)
Sudurpashchim Province	1028	58 (5.9)	1.3 (0.7 to 2.2)	1.4 (0.7 to 2.6)
<b>Place of residence</b>				
Rural	6107	341 (5.8)	1	1
Urban	6002	387 (6.5)	1.2 (1.0 to 1.4)	1.0 (0.8 to 1.3)
<b>Smoking habit</b>				
Non smoker	8305	443 (5.3)	1	1
Smokers	3804	285 (7.6)	1.5 (1.2 to 1.7)‡	1.2 (1.0 to 1.5)
<b>Alcohol consumption</b>				
No	9131	537 (6.0)	1	1
Yes	2978	191 (6.2)	1.0 (0.9 to 1.2)	
<b>Blood pressure</b>				
Normal	7754	256 (3.3)	1	1
Raised	4355	472 (10.8)	3.6 (3.0 to 4.3)‡	2.4 (2.0 to 3.0)‡
<b>Body mass index (N=12108)§</b>				
Normal	6896	377 (5.5)	1	1
Underweight	1494	88 (6.2)	1.1 (0.9 to 1.5)	1.1 (0.8 to 1.6)
Overweight and obese	3718	263 (6.9)	1.3 (1.1 to 1.5)†	0.9 (0.7 to 1.1)
<b>Total cholesterol (N=10861)§</b>				
Normal	7741	398 (5.2)	1	1
Raised	3120	254 (8.2)	1.6 (1.3 to 2.0)‡	1.3 (1.0 to 1.6)*
<b>Waist hip ratio (N=11979)§</b>				

Continued

Table 2 Continued

Characteristics	Count	CKD		
	N	CKD prevalence (n %)	COR (95% CI)	AOR (95% CI)
Normal	5095	282 (5.4)	1	1
Increased	6884	440 (6.6)	1.2 (1.0 to 1.5)*	1.6 (1.2 to 2.3)*
Diabetes mellitus (N=11 271)§				
No	10 393	506 (4.8)	1	1
Yes	878	172 (19.8)	4.9 (3.8 to 6.2)‡	3.2 (2.5 to 4.1)‡
Total	12 109	6.0 (95% CI 5.5 to 6.6)		

Definition of CKD status: urinary albumin-to-creatinine ratio of  $\geq 30$  mg/g and/or glomerular filtration rate  $< 60$  ml/min/1.73 m<sup>2</sup> both at baseline and follow-up).

AOR estimated from the stepwise multivariate logistic regression model with all the above variables added except alcohol consumption

\*P value  $\leq 0.05$ .

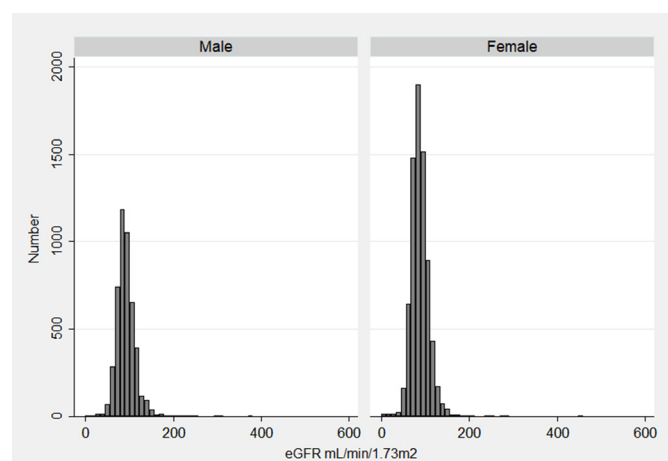
‡P value  $\leq 0.01$ .

‡P value  $\leq 0.0001$ .

§Missing value; refusal for blood sample collection led to variation in the sample size.

AOR, adjusted OR; COR, crude OR.

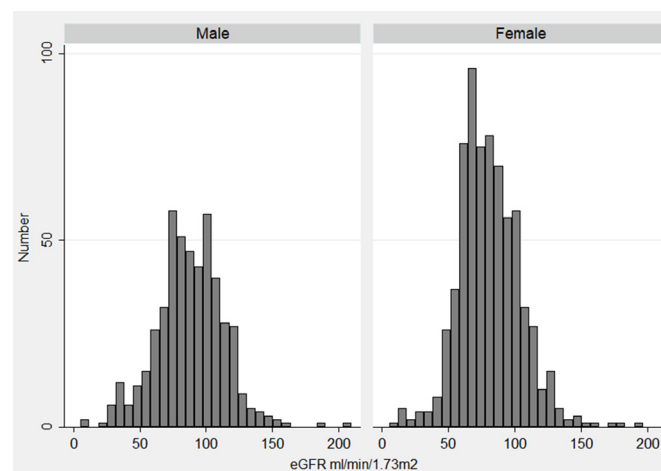
associated with CKD in Nepal among population aged 20 years and above. In the absence of population validated e-GFR equation for our population, MDRD equation as done in previous studies was chosen over the CKD-EPI equation to facilitate comparison of results. The findings show that approximately 1 in every 16 adults (6%) is affected by CKD in Nepal. This value is higher than the population-based study conducted in Morocco 5.1%<sup>18</sup> and Vietnam 3.1%,<sup>19</sup> almost similar to 6.8% in South Korea,<sup>20</sup> east African countries including Uganda and Kenya<sup>21</sup> but much lower than the prevalence of many Asian countries with 10.2% in China,<sup>22</sup> 17.5% in Thailand,<sup>23</sup> 18.9% in Iran<sup>24</sup> and 17.2% in India.<sup>25</sup> Prevalence of CKD in Nepal is lower than the GBD study estimated prevalence of 8%–10%<sup>3</sup> globally. However, these differences in the prevalence of CKD may be in part due to the differences in CKD diagnostic criteria, study design, laboratory methods and lack of validated measures for eGFR for Nepalese population.



**Figure 2** Histogram of estimated glomerular filtration rate (eGFR) distribution among 12 097 participants in baseline by sex

Our multivariable analysis found that CKD was independently associated with older age, hypertension, diabetes, raised TC, dalit and relatively advantaged jana-jati ethnicity and increased waist hip ratio ( $p < 0.05$  for each) which are all major NCDs risk factors and consistent with previous findings.<sup>26–30</sup> Age is a well-established risk factor for development of CKD.<sup>31</sup> As expected, age was found to be the most strongly associated risk factor in our study, we observed nearly three times higher odds of occurrence of CKD among people aged 60 years or older compared with people aged 20–39 years.

In line with other surveys in South East Asia, our findings show that the odds of CKD occurrence was significantly and independently higher by around twofold with the presence of hypertension; this supports previous reports<sup>32–35</sup> indicating the importance of early detection and treatment of hypertension in Nepal. Similarly, people with DM had more than three times higher odds of occurrence of CKD. Studies around the world show diabetes



**Figure 3** Histogram of estimated glomerular filtration rate (eGFR) distribution among 1194 participants in follow-up by sex

to be independently associated with development of CKD.<sup>36 37</sup> A survey across 10 Asian countries showed that the most common cause of end-stage renal disease in 9 out of 10 countries was diabetic nephropathy.<sup>38</sup> In addition, elevated TC though marginal was associated with higher odds of CKD.

Nepal is an ethnically diverse country with more than 125 castes/ethnic groups. Interestingly ethnicity/caste was another factor associated with CKD in our study. Compared with upper caste participants, Dalit participants had a significantly higher prevalence of CKD. The mechanism underlying these differences might be multifactorial, including cultural differences such as smoking and drinking habit, lifestyle and genetic factors. By ethnicity, Dalit group of people are considered as one of the most marginalised in terms of socioeconomic, education, political and health indicators, resulting in decreased access to resources and higher vulnerability to poor health outcomes. This calls for future studies regarding CKD on ethnic differences.

Despite finding an association between CKD and several known established risk factors including waist hip ratio, no association was found between CKD and BMI. The correlation between CKD and waist hip ratio and not BMI is plausible since this ratio is a more sensitive marker for central obesity, metabolic syndrome and potentially less influenced by muscle mass than BMI, this is in agreement with earlier studies.<sup>28 39 40</sup> The association between smoking and CKD was reported in bivariate analysis only in our study.

In general, the prevalence of CKD was higher among women compared with men, and this difference has been demonstrated in the past by several population based cross sectional studies.<sup>41</sup> However, in the present study, though not statistically significant, we found slightly higher prevalence of CKD among male participants. These discrepancies in the prevalence may be due to the traditional risk factors such as hypertension and hyperglycaemia being prevalent among male participant in our study. We also could not find significant association between CKD and alcohol consumption, place of residence and provinces.

Traditional risk factors such as diabetes and hypertension are the major cause of CKD in most developed and developing countries,<sup>42 43</sup> and several other non-traditional and environmental risk factors such as infectious diseases, analgesic abuse, exposure to heavy metal (lead, arsenic, mercury and uranium), pesticides, herbal medications and environmental pollution, impose an additional threat worsening CKD especially in developing countries<sup>44</sup> including Nepal. However, we lack information about environmental and some of the non-traditional risk factor, which could be used to quantify the effects of these factors on CKD.

Our study poses several strengths. To the best of our knowledge, this is the first national survey with a large representative population-based sample of the adult population to report prevalence of CKD in Nepal as per Kidney Disease Outcomes Quality Initiative (KDOQI)

clinical practice guideline; using (eGFR <60 mL/min/1.73 m<sup>2</sup>, presence of albuminuria ≥30 mg/g and chronicity confirmed by repeated testing after 3 months) to confirm presence of CKD. The study has used a validated standardised eGFR by the MDRD equation and all necessary protocols, standard operating procedures and quality assurance mechanism were followed to ensure the quality of data collection. Additional strengths of the study include a high overall response rate and analyses based on survey weights which ensure geographical representativeness of the study making the study findings generalisable to the general population. At the same time, potential limitations include dependency on estimation of GFR, rather than direct measurement using injection of an exogenous marker factors as well as cross-sectional design of the study which does not permit inferences regarding causal relationships.

## CONCLUSIONS

This is the first population-based epidemiological survey of CKD using the protocols recommended by KDOQI in Nepal. The prevalence of CKD was found to be 6.0% with higher prevalence among male, participants with no formal education, urban residents, smokers and participants with overweight and obese. CKD was independently associated with older age, hypertension, DM, increased waist hip ratio, raised TC and individual belonging to the Dalit caste by ethnicity. Our findings highlight the need for early preventive measures to manage predisposing conditions such as diabetes and hypertension which could ultimately lead to CKD and to reduce the prevalence and mortality arising from the associated comorbidities in Nepal.

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