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Preventing renal and cardiovascular risk by renal function assessment: insights from a cross-sectional study in low-income countries and the USA

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ABSTRACT

Objective: To assess the prevalence of microalbuminuria and kidney dysfunction in low-income countries and in the USA.

Design: Cross-sectional study of screening programmes in five countries.

Setting: Screening programmes in Nepal, Bolivia, the USA (National Health and Nutrition Examination Survey (NHANES) 2005–2008) Bangladesh and Georgia.

Participants: General population in Nepal (n=20 811), Bolivia (n=3436) and in the USA (n=4299) and high-risk subjects in Bangladesh (n=1518) and Georgia (n=1549).

Primary and secondary outcome measures: Estimated glomerular filtration rate (eGFR)<60ml/min/1.73 m^2 and microalbuminuria (defined as urinary albumin creatinine ratio values of 30–300 mg/g) were the main outcome measures. The cardiovascular (CV) risk was also evaluated on the basis of demographic, clinical and blood data.

Results: The prevalence of eGFR<60ml/min/1.73 m^2 was 19%, 3.2% and 7% in Nepal, Bolivia and the USA, respectively. In Nepal, 7% of subjects were microalbuminuric compared to 8.6% in the USA. The prevalence of participants with predicted 10-year CV disease (CVD) risk ≥10% was 16.9%, 9.4% and 17% in Nepal, Bolivia and in the USA, respectively. In Bangladesh and Georgia, subjects with eGFR<60 ml/min/1.73 m^2 were 8.6% and 4.9%, whereas those with microalbuminuria were 45.4% and 56.5%, respectively. Predicted 10-year CVD risk ≥10% was 25.4% and 25% in Bangladesh and Georgia, respectively.

Conclusions: Renal abnormalities are common among low-income countries and in the USA. Prevention programmes, particularly focused on those with renal abnormalities, should be established worldwide to prevent CVD and progression to end-stage renal disease.

ARTICLE SUMMARY

Article focus

- Chronic kidney disease, a major risk factor for cardiovascular morbidity and mortality, is emerging as a worldwide healthcare burden, but data on its prevalence are very limited, especially in low-income countries.
- The present large, cross-sectional study aimed to assess prevalence of microalbuminuria in general population in Nepal, Bolivia and in the USA, and in high-risk subjects in Bangladesh and Georgia.

Key messages

- We found that about a half of high-risk patients has some degree of renal impairment, but reduced kidney function and microalbuminuria/proteinuria are common also within the general population, both in low-income countries and in the USA.
- This information will be crucial for implementation of future screening and intervention programmes of non-communicable diseases, especially in the developing countries.

Strengths and limitations of this study

- The major strength of the present study is the large number of subjects included in the screening programmes that provide crucial information on the prevalence of kidney disease and cardiovascular risk in low-income countries and in the USA.
- Results from low-income countries cannot be formally taken to infer the absolute or relative prevalence of renal abnormalities in these countries, since subjects were referred to a limited number of centres. Conversely, data from the National Health and Nutrition Examination Survey programme show characteristics of a cohort representative of US population.

INTRODUCTION

Chronic kidney disease (CKD) has emerged as one of the strongest cardiovascular (CV) risk factors. In the general population, glomerular filtration rate (GFR) lower than 60 ml/min/1.73 m^2 and albuminuria—one of the earliest manifestations of CKD—are associated with an independent risk of CV morbidity and mortality.[1–3] Importantly, albuminuria reduction through ACE inhibitor or angiotensin receptor blocker therapy is associated with a slower renal disease progression and decreased CV mortality and morbidity.[4 5] Thus, since measurement of renal function and albuminuria is easy and relatively inexpensive, kidney-targeted detection and prevention programmes seem to offer a valuable opportunity to establish early prevention strategies that go beyond traditional cardioprotective approaches.

Nonetheless, data on the prevalence of renal dysfunction and microalbuminuria from population screening programmes in developed countries are scarce. Even fewer information is available from low-income countries, where incidence of renal and CV risk factors such as obesity and diabetes are increasing at an even higher rate than in developed nations.[6]

In 2005, the International Society of Nephrology (ISN) established a Global Outreach Program (formerly called the Commission on Global Advancement of Nephrology (COMGAN)) aimed at building global capacity for preventing CKD in developing nations. In 2007, the ISN funded the establishment of an electronic database (Kidney Disease Data Center (KDDC)) to support the collection and analysis of data obtained through ISN-sponsored prevention programmes. In the two coordinating centres in Nepal and Bolivia, these programmes have been developed as general population screenings, providing the unique opportunity to assess prevalence of renal dysfunction and microalbuminuria/proteinuria in these areas. In the present study, we analysed general-population data from these two low-income country centres and from the National Health and Nutrition Examination Survey (NHANES), which provides data from a representative sample of the US civilian non-institutionalised population. Moreover, we reported data from screening programmes established in two other centres in Bangladesh and Georgia that focused on high-risk populations, such as subjects with hypertension, diabetes mellitus (DM), prior kidney disease or CV (heart/stroke) disease.

METHODS

Details of screening programs

Given variability in local resources, the programmes were implemented differently in each location. Details of the single screening programmes, including numbers of screening centres within each country are listed in table 1. Programmes established in Nepal and Bolivia included general populations. The programme established in Nepal included subjects ≥18 years old and was conducted in the community in Dharan, a city in eastern Nepal as follows. Dharan has 19 wards and the screening started from ward 1 and progressed sequentially to ward 2, ward 3 and so on.

All subjects older than 18 years were considered eligible for the evaluation in Bolivia. The screening programme was conducted in the community in the city of La Paz and El Alto located in Murillo province of the same department. The screening camp was organised in the Unit Nephrology Service at Hospital Juan XXIII. On the day of screening people were asked to come to the centre.

On the day of the screening, the subjects were enrolled after being informed on the objective of the survey, the procedures, the information that could be drawn for the survey and the potential benefits of such screening.

Entry criteria for Bangladesh and Georgia included known hypertension, DM, prior kidney or CV (heart/stroke) disease. Information from the NHANES screening programme of the US population is reported in table 1. Further details are available at http://www.cdc.gov/nchs/nhanes.htm.

Data from low-income countries were collected prospectively by the staff of the screening programmes, using the same cut-off points for clinical and laboratory parameters and the same web-based database and the same cut-off criteria at all participating sites. Data quality was monitored by the bioengineer team of the Clinical Research Center for Rare Diseases, 'Aldo e Cele Dacco", Bergamo, Italy.

Baseline data obtained from each participant included age, gender, marital and employment status, education level, smoking status, alcohol use, DM status and personal history of hypertension and kidney disease. Height and weight were measured and used to calculate body mass index (BMI). Systolic (SBP) and diastolic blood pressures (DBP) were measured by trained personnel using manual sphygmomanometers after participants rested quietly for at least 5 min.

Blood and urine specimens were provided by participants according to local protocols determined by the availability of resources (table 1). Urinary protein/albumin excretion was assessed, respectively, by dipstick and urinary albumin creatinine ratio (ACR) in Nepal and Georgia, by dipstick alone in Bolivia and by ACR alone in the USA. The screening programme in Bangladesh evaluated albumin excretion by Albustick. Results of urinalysis were interpreted by trained and experienced personnel working in appropriate conditions. Follow-up of abnormalities identified during screening varied, depending on local resources (table 1). Screening was carried out under research protocols approved in advance by the relevant institutional review boards.

Definitions of microalbuminuria, hypertension, diabetes, obesity and decreased estimated GFR

Microalbuminuria was defined as urinary ACR values of 30–300 mg/g. Subjects with ACR lower than 30 mg/g

Table 1 Details of participating screening programmes by country

	Nepal	Bolivia	USA-NHANES
Setting	Community-based, using a combination of permanent centres (health clinics, community centres, etc) and temporary screening centres (schools, clubs, houses of worship and private homes)	General population of the city of La Paz and El Alto attending to the screening centre at the Hospital Juan XXIII	The survey examines a nationally representative sample of about 5000 persons (aged 1 year and older) each year. Health interviews are conducted in respondents' homes. Health measurements are performed in specially designed and equipped mobile centres, which travel to locations throughout the country
Number of centres	Eight permanent centres with variable numbers of temporary centres	One permanent centre	A nation-wide screening programme, designed to obtain a statistically representative sample of the US population and many relevant demographic subgroups
Timing	Year-round	Year-round	Year-round
Inclusion criteria	Age ≥18 years	Age >18 years	Age >18 years
Exclusion criteria	Pregnancy and any acute illness	Pregnancy and any acute illness	Pregnancy and any acute illness
Measurements	Interview including demographic, socioeconomic, dietary and health-related questions. Fasting serum creatinine, glucose, total cholesterol and triglycerides, dipstick urinalysis with proteinuria confirmed by ACR	Interview including demographic, socioeconomic, dietary and health-related questions. Fasting serum creatinine, glucose, dipstick urinalysis with proteinuria	The NHANES interview includes demographic, socioeconomic, dietary and health-related questions. The examination component consists of medical, dental and physiological measurements, as well as laboratory tests administered by highly trained medical personnel. Specific in kidney-related laboratory measurements included fasting serum creatinine, glucose, total cholesterol and triglycerides and urinary ACR
Clinic staff	Trained community volunteers, medical students, nurses, physicians, laboratory technicians	Physicians, nurses, laboratory technicians, medical students	Physician, medical and health technicians, as well as dietary and health interviewers
Advertising/ promotion	Community health education: publicity (videos, leaflets, pamphlets, banners, radio/ television programmes news paper articles) targeted education/distribution of written materials to people at risk, students and physicians	Community health education: through leaflets, videos, television, news paper articles, organisation of World Kidney Day	In each location, local health and government officials are notified of the upcoming survey. Households in the study area receive a letter from the NCHS Director to introduce the survey. Local media may feature stories about the survey
Follow-up visits	People found to have CKD, diabetes or hypertensions were seen monthly for 1–3 month then every 3–6 month	People found to have hypertension, diabetes, CKD were advised for treatment and life style modification and asked to come back at 3–6 month intervals	No follow-up arranged. However, participants will receive Report of Findings in the mail 12-16 weeks after the exam

Table 1 Continued

	Bangladesh	Georgia
Setting	A multistaged prospective study done in all eligible subjects of the village Mollargaon in Sylhet	The Project emphasises two phases. The phase I comprises of screening of target population to determine patients with chronic renal injury, diabetes, hypertension, cardiovascular disease. Phase II: People eligible for the comprehensive management programme were screened. All patients have been admitted to the leading hospitals of main cities of all regions of Georgia
Number of centres	One temporary centre	Seven permanent centres
Timing	8 months	
Inclusion criteria	Age >18 years. High-risk subjects identified among those with hypertension, diabetes, prior CKD or prior heart attack or stroke at first stage screening/ interview	All patients who have been admitted to the leading hospitals of main cities of all regions of Georgia during last 10 years with the following reasons: ▶ Chronic pyelonephritis ▶ Chronic glomerulonephritis ▶ Nephrolithiasis/urolithiasis ▶ Kidney cystic disease ▶ Multicystic dysplastic kidney ▶ Congenital malformations with renal function impairment ▶ Hypertension ▶ Heart attack/stroke ▶ Chronic renal failure ▶ Diabetes mellitus ▶ Tubulo-interstitial nephritis
Exclusion criteria	Pregnancy and any acute illness	Patients without confirmed medical diagnoses (based on medical documentation) excluded
Measurements	Interview including demographic, socioeconomic, dietary and health-related questions; serum creatinine, fasting glucose, dipstick albuminuria	Patient interview includes demographic, socioeconomic, dietary and health-related questions; physical examination and fasting serum creatinine, fasting glucose, total cholesterol, dipstick urinalysis for proteinuria and urinary ACR (repeated if positive)
Clinic staff	Doctors, nurses, health workers, medical students, laboratory technicians	Physicians, nurses and students trained to take part in data collection of the project
Advertising/ promotion	Local community leaders and health workers were first contacted, the study was explained and showed them the medical information pamphlet	The appropriate education material for patients as well as for medical staff elaborated for further spread and acknowledgement
Follow-up visits	No follow-up arranged	Patients are followed up twice in the first month of the treatment period, particularly to monitor potential ACE inhibitor complications. Follow-up assessment made every 6 months

ACR, albumin creatinine ratio; CKD, chronic kidney disease NHANES, National Health and Nutrition Examination Survey.

were defined as normoalbuminuric, those with more than 300 mg/g as macroalbuminuric. Positive Albustick identified patients with microalbuminuria. Results of dipstick urinalysis were considered to indicate macroalbuminuria if they showed protein of 1+ or more. Hypertension was classified according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure scheme.[7] Participants were classified as having DM if they reported a history of or were currently treated for DM. Serum creatinine was used to estimate GFR using the Modification of Diet in Renal Disease (MDRD) Study equation in all participants.[8] Because the MDRD Study equation is less accurate at higher levels of true GFR, participants were classified regarding the presence or absence of estimated GFR (eGFR)<60 ml/min/1.73 m^2 (termed 'decreased eGFR'). Participants' BMI was classified according to the current WHO[9] scheme as follows: <18.49 (underweight), 18.5–24.9 (reference range), 25–29.9 (preobese) and ≥30 kg/m^2 (obese).

The likelihood of a serious CV outcome (death, myocardial infarction, stroke, heart failure or coronary revascularisation) during the next 10 years was estimated by using WHO charts for each studied country (available at http://www.ish-world.com/Documents/colour_charts_24_Aug_07.pdf).

Statistical analyses

Descriptive statistics were tabulated by country using count and percentage with CI or median and IQR, as appropriate. Missing values were not analysed and case-wise deletion did not occur; therefore, the total number of participants varied by variable. Outcomes of interest included hypertension, proteinuria, eGFR<60 ml/min/1.73 m^2, DM, BMI and CV risk. According to the WHO charts, the 10-year risk of a fatal or non-fatal CV event considered the following parameters: age (years), gender, smoking habit, SBP (mm Hg) and presence/absence of DM. A SAS V.9.1 code was constructed to generate the 10-year CV risk class for each participant. Results were stratified by gender, age, prior DM status and prior CV disease (CVD) status. Differences in listed variables between genders were analysed using Cochran-Mantel-Haenszel test—analysis of variance type or χ^2 test, as appropriate.

Age-adjusted eGFR<60ml/min/1.73 m^2 and ACR>30 prevalence estimates were adjusted by the direct method to the year 2000 US Census population using the age groups 18–24, 25–34, 35–44, 45–54 and 55 years and older. The 95% CIs were calculated using Taylor series linearisation.

Statistical analyses were performed using Stata software, V.12.0 (StataCorp, www.stata.com) for low-income countries and SAS-callable SUDAAN statistical software V.10.0 (Research Triangle Institute, Research Triangle Park, North Carolina, USA) to account for the complex survey sample design for the USA.

RESULTS

Participant characteristics

Table 2 shows demographic and clinical characteristics of the 31 613 participants.

General populations

Median age of participants and gender distribution were similar between the two general population screening cohorts in Nepal and Bolivia and in the USA. Levels of education were variable across nations, with people from Bolivia and the USA showing the highest fraction of subjects with more than 10 years of education. Prevalence of smoking habit was lower than 15% in both low-income countries, whereas it approximated 25% in US subjects. Levels of activity, vegetable intake and alcohol consumption were variable. Bolivian subjects had the highest prevalence of positive familiar history for CKD, hypertension, CVD and diabetes. At physical examination, US participants showed highest levels of BMI, whereas median blood pressure levels were within the normal range for all countries.

High-risk populations

High-risk subjects included in Bangladesh and Georgia programmes were older than in general population screenings and more frequently female. Level of education was relatively low in both countries, with people from Bangladesh showing the lower fraction of subjects with more than 10 years of education. Prevalence of smoking habit was almost 30% in Bangladesh and 10% in Georgia. Level of activity was high, with more than 70% of subjects in Bangladesh and 50% in Georgia doing more than 1 h/day of physical activity. Vegetable intake and alcohol consumption were variable. Georgian subjects had the highest prevalence of family history of CKD, hypertension, CVD and diabetes. By physical examination, they also showed the highest levels of BMI, whereas those from Bangladesh had the highest levels of blood pressure.

Prevalence of hypertension, eGFR<60 ml/min/1.73 m^2 and albuminuria

General populations

Within general population screening programmes, Nepalese participants had the highest prevalence of hypertension (assessed at the clinical visit). In each general population programme, the prevalence of hypertension was higher in participants who were male, older than 60 years, or had a history of DM or CVD (table 3).

The prevalence of eGFR<60 ml/min/1.73 m^2 was highly variable, ranging from 3.2% in Bolivia to 19% in Nepal. The fraction of US participants with eGFR<60 ml/min/1.73 m^2 was 7%. In these nations, the prevalence of eGFR<60 ml/min/1.73 m^2 was higher in male subjects and in participants older than 60 years and in those with prior DM or CVD.

The prevalence of microalbuminuria was similar between Nepal and the USA. Only a minority of patients (13.3%) with microalbuminuria in Nepal was positive for proteinuria (≥1+) at urinary dipstick. To take into account for the difference in the age distributions of the programmes examined, we performed age-adjusted prevalence estimates of eGFR<60 ml/min/1.83 m^2 and ACR>30. As shown in table 4, age-adjusted analyses confirmed crude data of the prevalence of renal dysfunction in these countries.

Roughly the same prevalence of proteinuria (≥1+) was found in Nepal and Bolivia. In analogy with hypertension, the higher prevalence of microalbuminuria and proteinuria was found within subjects who were male, older than 60 years, or who had a history of DM or CVD.

The proportion of participants who had both eGFR<60 ml/min/1.73 m^2 and microalbuminuria or macroalbuminuria was 2.1% and 1.4% in Nepal and Bolivia, respectively. The proportion of participants with both heavy proteinuria (≥3+) and eGFR<60 ml/min/1.73 m^2 was markedly lower (Nepal 0.1%, Bolivia 0.5%).

High-risk populations

Subjects included in the high-risk population screenings had a high prevalence of hypertension, with almost one-fourth of those in Georgia with stage 2 hypertension.

Table 2 Demographics and clinical characteristics of participants in screening programmes

	Community screenings			High-risk population screenings	
	Nepal	Bolivia	USA	Bangladesh	Georgia
Participants (n)	20811	3436	4299	1518	1549
Age (year)	39 (27 to 51)	40 (31 to 51)	45 (32 to 58)	48 (38 to 60)	52 (18 to 85)
Women	61.4 (60.8 to 62.1)	63.8 (62.2 to65.4)	50.6 (49.0 to 52.1)	56.6 (54.1 to 59.1)	74.6 (72.4 to 76.8)
Married	82.7 (82.2 to 83.2)	68.4 (66.8 to 69.9)	56.6 (54.0 to 59.2)	91.0 (89.4 to 92.4)	89.7 (88.0 to 91.2)
Education (years)					
>10	35.5 (34.8 to 36.3)	56.1 (54.4 to 57.8)	55.6* (51.8 to 59.3)	4.2 (3.3 to 5.4)	38.1 (35.6 to 40.7)
6–10	21.9 (21.3 to 22.5)	19.6 (18.3 to 21.0)	38.1† (34.8 to 41.4)	13.7 (12.0 to 15.5)	57.0 (54.4 to 59.5)
1–5	14.3 (13.8 to 14.9)	21.0 (19.6 to 22.4)	6.3‡ (5.4 to 7.4)	32.3 (29.9 to 34.7)	3.3 (2.4 to 4.4)
None	28.2 (27.5 to 28.9)	3.4 (2.8 to 4.0)		49.8 (47.2 to 52.4)	1.6 (1.0 to 2.4)
Work					
Physical labour	10.4 (10.0 to 10.8)	5.1 (4.4 to 5.9)		29.0 (26.7 to 31.4)	9.7 (8.2 to 11.3)
Office work	17.4 (16.9 to 17.9)	21.7 (20.3 to 23.1)		3.1 (2.3 to 4.1)	22.0 (19.9 to 24.3)
House work	52.9 (52.2 to 53.6)	28.2 (26.7 to 29.7)		48.9 (46.3 to 51.4)	31.2 (28.8 to 33.7)
Unemployed	14.2 (13.8 to 14.7)	45.1 (43.4 to 46.7)		19.0 (17.1 to 21.1)	37.1 (34.6 to 39.7)
Fruit/vegetable intake					
1×/day	30.9 (30.3 to 31.5)	8.5 (7.6 to 9.5)		5.6 (4.5 to 6.8)	45.9 (43.3 to 48.5)
3–5×/day	58.0 (57.4 to 58.7)	61.7 (60.1 to 63.4)		60.8 (58.3 to 63.3)	41.8 (39.3 to 44.4)
1×/week	10.2 (9.8 to 10.7)	28.9 (27.3 to 30.4)		32.3 (29.9 to 34.7)	7.6 (6.3 to 9.1)
None	0.8 (0.7 to 9.5)	0.9 (0.6 to 1.2)		1.3 (0.8 to 2.1)	4.7 (3.7 to 5.9)
Smoking					
Current	13.2 (12.8 to 13.7)	11.7 (10.7 to 12.9)	23.6 (21.1 to 26.2)	29.2 (26.9 to 31.6)	10.3 (8.8 to 12.0)
Former	9.4 (9.0 to 9.8)	7.4 (6.5 to 8.3)	24.9 (23.0 to 27.0)	2.9 (2.1 to 3.9)	4.4 (3.4 to 5.6)
No	77.3 (76.8 to 77.9)	80.9 (79.5 to 82.2)	51.5 (48.6 to 54.3)	67.9 (65.5 to 70.2)	85.3 (83.4 to 87.1)
Alcohol					
1×/day	7.4 (7.1 to 7.8)	0.4 (0.2 to 0.6)	5.7 (4.6 to 7.1)		1.6 (1.0 to 2.4)
1×/week	6.5 (6.2 to 6.9)	5.0 (4.3 to 5.8)	31.6 (29.2 to 34.1)		10.6 (9.0 to 12.2)
1×/month	11.8 (11.3 to 12.2)	36.4 (34.8 to 38.0)	43.3 (41.0 to 45.7)	0.3 –	19.1 (17.1 to 21.2)
None	74.3 (73.7 to 74.9)	58.2 (56.5 to 59.8)	19.4 (17.3 to 21.6)	99.7 (99.2 to 99.9)	68.7 (66.2 to 71.1)
Physical activity (min/day)					
>60	33.3 (32.7 to 34.0)	23.0 (21.6 to 24.5)		73.6 (71.3 to 75.8)	55.3 (52.7 to 58.0)
30–60	23.2 (22.6 to 23.8)	43.7 (42.0 to 45.4)		5.7 (4.6 to 7.0)	19.1 (17.01 to 21.2)
<30	21.0 (20.5 to 21.6)	27.0 (25.5 to 28.5)		2.5 (1.8 to 3.4)	14.2 (12.4 to 16.2)
None	22.4 (21.9 to 23.0)	6.3 (5.5 to 7.1)		18.2 (16.3 to 20.3)	11.4 (9.7 to 13.1)
Family history					
CKD	2.3 (2.1 to 2.6)	12.3 (11.2 to 13.4)		0.8 (0.4 to 1.4)	26.4 (24.1 to 28.7)
HTN	22.0 (21.4 to 22.6)	29.1 (27.6 to 30.6)		18.5 (16.6 to 20.5)	61.5 (58.9 to 64.0)
DM	11.9 (11.4 to 12.3)	17.6 (16.3 to 18.9)		6.3 (5.1 to 7.6)	29.8 (27.4 to 32.2)
MI/CVD	3.4 (3.2 to 3.6)	12.3 (11.2 to 13.4)		0.7 –	25.2 (23.0 to 27.6)

Continued

Table 2 Continued

	Community screenings			High-risk population screenings	
	Nepal	Bolivia	USA	Bangladesh	Georgia
Physical examination					
Weight (kg)	56 (49 to 65)	64 (56 to 73)	79.1 (66.4 to 93.0)	52 (45 to 58)	76 (23 to 151)
Height (cm)	155 (90 to 198)	156 (150 to 163)	169.0 (161.9 to 177)	155 (150 to 162)	165 (69 to 202)
BMI (kg/m^2)	23.1 (20.5 to 26.0)	25.9 (23 to 29)	27.3 (23.9 to 31.7)	21.4 (19.1 to 23.8)	28 (15 to 65)
Waist circumference (cm)	79 (70 to 87)	87 (78 to 95)	96.0 (85.6 to 107.1)	78 (71 to 85)	90 (48 to 190)
Hip circumference (cm)	89 (83 to 95)	99 (93 to 106)		88 (83 to 93)	104 (40 to 196)
Waist to hip ratio	0.9 (0.8 to 0.9)	0.9 (0.8 to 0.9)		0.9 (0.9 to 1)	0.8 (0.2 to 4.2)
Blood pressure (mm Hg)					
SBP	120 (110 to 130)	106 (97 to 117)	118 (109 to 129)	140 (110 to 150)	136 (63 to 237)
DBP	80 (70 to 90)	73 (67 to 80)	70 (62 to 76)	90 (80 to 90)	80 (46 to 143)
MAP			85 (79 to 93)		

Data are expressed as percentage (CI) or median (IQR) if not otherwise specified.
CIs are not presented when relative SE>30%, because of unreliable estimates.
*Higher than high school.
†9th–12th grade.
‡<9th grade.
BMI, body mass index; CKD, chronic kidney disease; DM, diabetes mellitus; DBP, diastolic blood pressure; HTN, hypertension; MI/CVD, myocardial infarction/cardiovascular disease; MAP, mean arterial pressure; SBP, systolic blood pressure.

The prevalence of hypertension was higher in male participants and in those older than 60 years, or with a history of DM or CVD (table 3).

In Bangladesh, 45.4% of screened subjects had positive albumin dipstick. More than 50% of screened subjects in Georgia had microalbuminuria and 14% had proteinuria (≥1+). Male gender, older age and a history of DM or CVD were associated with higher levels of proteinuria in both nations. The proportion of participants who had both eGFR<60 ml/min/1.73 m^2 and microalbuminuria or macroalbuminuria was 4.8% in Bangladesh and 2.9% in Georgia. The proportion of participants with both heavy proteinuria (≥3+) and eGFR<60 ml/min/1.73 m^2 was markedly lower in Georgia (0.5%) where both these measurements were performed.

Prevalence of DM, obesity/underweight and distribution of CV risk

General populations

Subjects with DM (assessed at the clinical visit) were 5.9% in Nepal, 2.6% in Bolivia and 7.9% in the USA. In all the countries, prevalence of DM progressively increased with BMI. No significant difference was found in the prevalence of DM between female and male subjects in Bolivia and in the USA. Conversely, DM was significantly more frequent among males in Nepal programme. Except for Bolivia, where all people with hyperglycaemia had a previous diagnosis of DM, 3.5% and 2.9% of subjects found hyperglycaemic during Nepal and US screening programmes did not have a previous diagnosis of DM. The prevalence of underweight was highest among Nepalese subjects, whereas that of obese subjects was highest in Bolivia (table 5). The prevalence of participants with predicted 10-year CV risk ≥10% was 16.9%, 9.4% and 17.0% in Nepal, Bolivia, and the USA, respectively (table 6).

High-risk populations

Subjects with DM were frequent both in Bangladesh (9.6%) and in Georgia (15.2%), with 8.5% and 4.4% of subjects with fasting hyperglycaemia having no previous diagnosis of DM, respectively. Prevalence of DM was similar between female and male subjects in both Bangladesh and Georgia. A complementary pattern of nutritional status was found in the two nations. Almost one-fifth of subjects in Bangladesh were undernourished, with only 1.4% of obese people in the nation. Conversely, undernourishment was seen in only 2.6% of Georgian people and 37.4% of cases were obese (table 5). The prevalence of participants with predicted 10-year CV risk ≥10% was 25.4% in Bangladesh and 25.0% in Georgia (table 6).

DISCUSSION

The present large screening programmes of general populations showed a high prevalence of eGFR<60 ml/min/1.73 m^2 and microalbuminuria in Nepal and

Table 3 Prevalence of hypertension, urinary abnormalities and kidney dysfunction in participants by country

	Number of participants	HTN			Proteinuria			ACR		eGFR (ml/min/1.73 m^2)		
		Pre-HTN	Stage 1	Stage 2	1+	2+	3+	30–300	>300	30–59.9	15–29.9	<15
Nepal												
All	20811	8121 (39.0) (38.4 to 39.7)	4665 (22.4) (21.9 to 23.0)	2229 (10.7) (10.3 to 11.1)	503 (2.4) (2.2 to 2.6)	162 (0.8) (0.7 to 0.9)	58 (0.3) (0.2 to 0.4)	604 (7.0) (6.4 to 7.5)	6 (0.1) –	3859 (18.6) (18.1 to 19.2)	56 (0.3) (0.2 to 0.4)	16 (0.1) (0.0 to 0.1)
Gender												
Women	12792	4895 (38.3) (37.4 to 39.1)	2529 (19.8) (19.1 to 20.5)	1171 (9.2) (8.7 to 9.7)	297 (2.3) (2.1 to 2.6)	87 (0.7) (0.5 to 0.8)	36 (0.3) (0.2 to 0.4)	340 (6.3) (5.7 to 7.0)	3 (0.1) –	2677 (21) (20.3 to 21.7)	28 (0.2) (0.1 to 0.3)	9 (0.1) –
Men	8019	3226 (40.2) (39.2 to 41.3)	2136 (26.6) (25.7 to 27.6)	1058 (13.2) (12.5 to 14.0)	206 (2.6) (2.2 to 3.0)	75 (0.9) (0.7 to 1.2)	22 (0.3) (0.2 to 0.4)	264 (8) (7.1 to 8.9)	3 (0.1) –	1182 (14.8) (14.0 to 15.6)	28 (0.4) (0.2 to 0.5)	7 (0.1) –
Age (years)												
18–40	11283	4922 (43.6) (42.7 to 44.6)	1617 (14.3) (13.7 to 15.0)	473 (4.2) (38.3 to 45.8)	199 (1.8) (1.5 to 2.0)	47 (0.4) (0.3 to 0.6)	21 (0.2) (0.1 to 0.3)	207 (4.4) (3.8 to 5.0)	2 (0.0) –	997 (8.9) (8.4 to 9.4)	12 (0.1) (0.0 to 0.2)	4 (0.0) –
41–60	6973	2500 (35.9) (34.7 to 37.0)	2137 (30.6) (29.6 to 31.7)	1089 (15.6) (14.8 to 16.5)	180 (2.6) (2.2 to 3.0)	65 (0.9) (0.7 to 1.2)	16 (0.2) (0.1 to 0.4)	267 (9.3) (8.2 to 10.4)	2 (0.1) –	1681 (24.2) (23.2 to 25.2)	24 (0.3) (0.2 to 0.5)	7 (0.1) –
>60	2555	699 (27.4) (25.6 to 29.1)	911 (35.7) (33.8 to 37.5)	667 (26.1) (24.4 to 27.9)	124 (4.9) (4.1 to 5.8)	50 (2.0) (1.5 to 2.6)	21 (0.8) (0.5 to 1.3)	130 (12.3) (10.4 to 14.5)	2 (0.2) –	1181 (46.3) (44.4 to 48.3)	20 (0.8) (0.5 to 1.2)	5 (0.2) –
Prior DM	1330 (30.6 to 35.8)	441 (33.2) (31.7 to 36.8)	455 (34.2) (18.0 to 22.4)	268 (20.2) (3.9 to 6.3)	66 (5.0) (2.2 to 4.2)	41 (3.1) (0.7 to 2.0)	17 (1.3) (22.3 to 29.5)	154 (25.8) –	3 (0.5) (27.2 to 32.2)	393 (29.7) (0.7 to 2.0)	17 (1.3) –	3 (0.2)
No prior DM	16623	6531 (39.3) (38.6 to 40.0)	3644 (21.9) (21.3 to 22.6)	1647 (9.9) (9.5 to 10.4)	385 (2.3) (2.1 to 2.6)	110 (0.7) (0.5 to 0.8)	39 (0.2) (0.2 to 0.3)	424 (5.3) (4.8 to 5.8)	3 (0.04) –	2868 (17.3) (16.8 to 18.0)	34 (0.2) (0.1 to 0.3)	12 (0.1) (0.0 to 0.1)
Prior CVD	304	105 (34.5) (29.2 to 40.2)	78 (25.7) (20.8 to 31.0)	64 (21.1) (16.6 to 26.1)	20 (6.6) (4.1 to 10.0)	4 (1.3) –	4 (1.3) –	20 (14.9) (9.4 to 22.1)	1 (0.7) –	99 (32.7) (27.4 to 38.3)	3 (1.0) –	0 (0.0) –
No prior CVD	17737	6920 (39.0) (38.3 to 39.7)	4020 (22.7) (22.1 to 23.3)	1856 (10.5) (10.0 to 10.9)	421 (2.4) (2.2 to 2.6)	141 (0.8) (0.7 to 0.9)	52 (0.3) (0.2 to 0.4)	561 (6.6) (6.1 to 7.1)	5 (0.1) –	3159 (17.9) (17.3 to 18.5)	46 (0.3) (0.2 to 0.3)	15 (0.1) (0.0 to 0.1)
Bolivia												
All	3436	896 (26.1) (24.6 to 27.6)	312 (9.1) (8.1 to 10.1)	104 (3.0) (2.5 to 3.7)	60 (1.8) (1.4 to 2.3)	65 (1.9) (1.5 to 2.4)	27 (0.8) (0.5 to 1.2)			45 (2.4) (1.8 to 3.2)	7 (0.4) –	8 (0.4) –
Gender												
Women	2192	485 (22.1) (20.4 to 23.9)	155 (7.1) (6 to 8.2)	67 (3.1) (2.4 to 3.9)	34 (1.6) (1.1 to 2.2)	37 (1.7) (1.2 to 2.3)	14 (0.7) (0.4 to 1.1)			23 (1.9) (1.2 to 2.8)	4 (0.3) –	5 (0.4) –
Men	1244	411 (33.1) (30.5 to 35.8)	157 (12.6) (10.8 to 14.6)	37 (3) (2.1 to 4.1)	26 (2.1) (1.4 to 3.1)	28 (2.3) (1.5 to 3.3)	13 (1.1) (0.6 to 1.8)			22 (3.5) (2.2 to 5.2)	3 (0.5) –	3 (0.5) –
Age (years)												
18–40	1732	333 (19.2) (17.4 to 21.2)	62 (3.6) (2.8 to 4.6)	10 (0.6) –	29 (1.7) (1.1 to 2.4)	16 (0.9) (0.5 to 1.5)	8 (0.5) –			6 (0.7) –	1 (0.1) –	0
41–60	1386	436 (31.5) (29.0 to 34)	173 (12.5) (10.8 to 14.3)	64 (4.6) (3.6 to 5.9)	20 (1.5) (0.9 to 2.2)	32 (2.3) (1.6 to 3.3)	17 (1.2) (0.7 to 2.0)			14 (1.9) (1.0 to 3.1)	4 (0.5) –	5 (0.7) –
>60	318	127 (39.9) (34.5 to 45.6)	77 (24.2) (19.6 to 29.3)	30 (9.4) (6.5 to 13.2)	11 (3.5) (1.8 to 6.2)	17 (5.4) (3.2 to 8.6)	2 (0.6) –			25 (12.5) (8.3 to 17.9)	2 (1.0) –	3 (1.5) –
Prior DM	87	20 (23.0) (14.6 to 33.2)	27 (31.0) (21.5 to 41.9)	8 (9.2) –	3 (3.5) –	11 (12.9) (6.6 to 22.0)	8 (9.4) –			4 (8.0) –	3 (6.0) –	1 (2.0) –
No prior DM	2393	619 (25.9) (24.1 to 27.7)	198 (8.3) (7.2 to 9.5)	68 (2.8) (2.2 to 3.6)	49 (2.1) (1.5 to 2.7)	38 (1.6) (1.1 to 2.2)	16 (0.7) (0.4 to 1.1)			30 (2.6) (1.7 to 3.6)	1 (0.1) –	5 (0.4) –
Prior CVD	71	21 (30.0) (19.6 to 42.1)	15 (21.4) (12.5 to 32.9)	5 (7.1) –	5 (7.4) –	5 (7.4) –	2 (2.9) –			1 (2.4) –	0	0

Continued

Table 3 Continued

	Number of participants	HTN			Proteinuria			ACR		eGFR (ml/min/1.73 m^2)		
		Pre-HTN	Stage 1	Stage 2	1+	2+	3+	30–300	>300	30–59.9	15–29.9	<15
No prior CVD	2718 (24 to 27.3)	696 (25.6) (7.7 to 9.8)	236 (8.7) (2.1 to 3.4)	74 (2.7) (1.3 to 2.4)	48 (1.8) (1.3 to 2.3)	46 (1.7) (0.5 to 1.1)	20 (0.7)		(1.8 to 3.5)	36 (2.5) –	3 (0.2) –	6 (0.4)
US												
All	4299	1508 (25.5) (23.4 to 27.6)	280 (5.8) (5.0 to 6.7)	74 (1.3) (1.0 to 1.6)				499 (8.6) (7.5 to 9.8)	109 (1.8) (1.5 to 2.3)	337 (6.4) (5.3 to 7.8)	30 (0.5) (0.4 to 0.6)	–
Gender												
Women	2091	396 (19.5) (17.2 to 22.1)	112 (4.8) (3.9 to 5.9)	28 (0.9) (0.6 to 1.3)				256 (9.7) (8.1 to 11.5)	58 (2.0) (1.4 to 2.8)	184 (7.9) (6.3 to 9.8)	17 (0.6) (0.4 to 0.9)	–
Men	2208	662 (31.5) (28.9 to 34.3)	168 (6.8) (5.6 to 8.3)	46 (1.7) (1.2 to 2.3)				243 (7.5) (6.5 to 8.8)	51 (1.7) (1.2 to 2.5)	153 (4.9) (3.8 to 6.4)	13 (0.3) (0.2 to 0.6)	–
Age (year)												
18–40	1652	440 (25.1) (22.3 to 28.1)	56 (3.3) (2.3 to 4.5)	–				103 (6.3) (5.0 to 8.0)	–	–	0	0
41–60	1337	377 (30.1) (26.3 to 34.2)	107 (7.2) (5.8 to 8.9)	–				126 (6.4) (4.9 to 8.3)	33 (2.0) (1.3 to 3.0)	44 (4.0) (2.7 to 6.0)	–	–
>60	1310	241 (17.6) (15.7 to 19.8)	117 (8.2) (6.6 to 10.3)	47 (3.1) (2.3 to 4.2)				270 (17.1) (14.6 to 19.8)	63 (4.1) (2.8 to 5.7)	291 (23.0) (20.3 to 25.9)	24 (1.8) (1.3 to 2.5)	–
Prior DM	516	62 (12.9) (10.3 to 16.2)	38 (6.4) (4.5 to 9.0)	–				148 (25.5) (19.9 to 32.1)	56 (9.6) (6.7 to 13.6)	84 (14.1) (10.6 to 18.6)	17 (2.9) (2.0 to 4.2)	–
No prior DM	3779	995 (26.6) (24.5 to 28.9)	242 (5.7) (4.9 to 6.7)	66 (1.3) (1.0 to 1.7)				350 (7.1) (6.1 to 8.2)	53 (1.1) (0.9 to 1.5)	253 (5.7) (4.7 to 7.0)	13 (0.3) (0.2 to 0.4)	–
Prior CVD*	467	49 (11.0) (7.3 to 16.1)	26 (4.9) (3.4 to 7.0)	–				120 (21.7) (16.9 to 27.4)	40 (8.2) (5.1 to 13.1)	116 (22.2) (17.7 to 27.5)	18 (3.4) (2.5 to 4.7)	–
No prior CVD*	3493	921 (27.0) (24.8 to 29.3)	248 (6.1) (5.2 to 7.0)	65 (1.3) (1.0 to 1.6)				344 (7.2) (6.3 to 8.4)	68 (1.3) (1.0 to 1.5)	217 (5.1) (4.1 to 6.4)	–	–
Bangladesh												
All	1518	533 (35.5) (33.1 to 38.0)	621 (41.4) (38.9 to 43.9)	210 (14) (12.3 to 15.8)				690 (45.4)† (42.9 to 48.0)		108 (7.1) (5.9 to 8.6)	21 (1.4) (0.9 to 2.1)	2 (0.1) –
Gender												
Women	859	289 (34.1) (30.9 to 37.4)	380 (44.8) (41.4 to 48.2)	112 (13.2) (11.0 to 15.7)				364 (42.4) (39.0 to 45.8)		63 (7.4) (5.7 to 9.3)	15 (1.7) (1.0 to 2.9)	1 (0.1) –
Men	659	244 (37.4) (33.6 to 41.2)	241 (36.9) (33.2 to 40.7)	98 (15) (12.4 to 18.0)				326 (49.5) 45.6 to 53.4)		45 (6.9) (5.0 to 9.1)	6 (0.9) –	1 (0.1) –
Age (years)												
18–40	575	244 (42.7) (38.6 to 46.8)	203 (35.5) (31.6 to 39.6)	64 (11.2) (8.7 to 14.1)				369 (64.2) (60.1 to 68.1)		40 (7) (5.0 to 9.4)	4 (0.7) –	2 (0.3) –
41–60	690	198 (29.1) (25.7 to 32.7)	327 (48.1) (44.3 to 51.9)	105 (15.4) (12.8 to 18.4)				202 (29.3) (25.9 to 32.8)		45 (6.5) (4.8 to 8.7)	10 (1.4) –	0
>60	253	91 (36.6) (30.6 to 42.9)	91 (36.6) (30.6 to 42.9)	41 (16.5) (12.1 to 21.7)				119 (47.0) (40.8 to 53.4)		23 (9.2) (5.9 to 13.4)	7 (2.8) –	0
Prior DM	111	53 (48.2)	36 (32.7) (38.6 to 57.9)	14 (12.7) (24.1 to 42.3)	(7.1 to 20.4)			32 (28.8)	(20.6 to 38.2)	11 (9.9)	8 (7.2) (5.1 to 17.0)	0 –
No prior DM	1404	478 (34.4) (31.9 to 37.0)	584 (42.1) (39.5 to 44.7)	196 (14.1) (12.3 to 16.1)				656 (46.7) (44.1 to 49.4)		97 (6.9) (5.7 to 8.4)	13 (0.9) (0.5 to 1.6)	2 (0.1) –

Continued

Table 3 Continued

	Number of participants	HTN			Proteinuria			ACR		eGFR (ml/min/1.73 m^2)		
		Pre-HTN	Stage 1	Stage 2	1+	2+	3+	30–300	>300	30–59.9	15–29.9	<15
Prior CVD	20	7 (35) –	7 (35) –	 –	5 (25)			7 (35) –		4 (20) –	2 (10) –	0
No prior CVD	1494 (33.0 to 37.9)	523 (35.4) (39.0 to 44.1)	613 (41.5) (12.2 to 15.7)	205 (13.9)			 (43.0 to 48.1)	680 (45.5)	 (5.7 to 8.4)	104 (7) (0.8 to 2.0)	19 (1.3) –	2 (0.1)
Georgia												
All	1549	565 (36.5) (34.1 to 39.0)	369 (23.8) (21.7 to 26.0)	385 (24.9) (22.7 to 27.1)	121 (7.9) (6.6 to 9.3)	53 (3.4) (2.6 to 4.5)	42 (2.7) (2.0 to 3.7)	95 (56.5) (48.7 to 64.2)	28 (16.7) (11.4 to 23.2)	47 (3) (2.2 to 4.0)	22 (1.4) (0.9 to 2.1)	8 (0.5) –
Gender												
Women	1156	433 (37.5) (34.7 to 40.4)	267 (23.1) (20.7 to 25.7)	276 (23.9) (21.5 to 26.5)	82 (7.2) (5.7 to 8.8)	33 (2.9) (2.0 to 4.0)	17 (1.5) (0.9 to 2.4)	65 (56) (46.5 to 65.2)	21 (18.1) (11.6 to 26.3)	31 (2.7) (1.8 to 3.8)	15 (1.3) (0.7 to 2.1)	7 (0.6) –
Men	393	132 (33.6) (28.9 to 38.5)	102 (25.9) (21.7 to 30.6)	109 (27.7) (23.4 to 32.4)	39 (10) (7.2 to 13.4)	20 (5.1) (3.2 to 7.8)	25 (6.4) (4.2 to 9.3)	30 (57.7) (43.2 to 71.3)	7 (13.5) –	16 (4.1) (2.3 to 6.5)	7 (1.8) –	1 (0.2) –
Age (years)												
18–40	405	180 (44.4) (39.5 to 49.4)	62 (15.3) (11.9 to 19.2)	38 (9.4) (6.7 to 12.7)	20 (5) (3.1 to 7.6)	6 (1.5) –	7 (1.7) –	10 (50) (27.2 to 72.8)	1 (5) –	4 (1) –	2 (0.5) –	0 –
41–60	731	279 (38.2) (34.6 to 41.8)	192 (26.3) (23.1 to 29.6)	179 (24.5) (21.4 to 27.8)	54 (7.4) (5.6 to 9.6)	20 (2.8) (1.7 to 4.2)	22 (3) (1.9 to 4.6)	45 (58.4) (46.6 to 69.6)	13 (16.9) (9.3 to 27.1)	11 (1.5) (0.8 to 2.7)	10 (1.4) –	4 (0.5) –
>60	413	106 (25.7) (21.5 to 30.2)	115 (27.8) (23.6 to 32.4)	168 (40.7) (35.9 to 45.6)	47 (11.5) (8.5 to 15.0)	27 (6.6) (4.4 to 9.4)	13 (3.2) (1.7 to 5.4)	40 (56.3) (44.0 to 68.1)	14 (19.7) (11.2 to 30.9)	32 (7.7) (5.4 to 10.8)	10 (2.4) –	4 (1) –
Prior DM	322	99 (30.7) (25.7 to 36.1)	68 (21.1) (16.8 to 26.0)	103 (31.9) (26.9 to 37.4)	33 (10.4) (7.3 to 14.3)	17 (5.3) (3.1 to 8.4)	15 (4.7) (2.7 to 7.7)	37 (66.1) (52.2 to 78.2)	11 (19.6) (10.2 to 32.4)	14 (4.3) (2.4 to 7.2)	9 (2.8) –	3 (0.9) –
No prior DM	1095	407 (37.2) (34.3 to 40.1)	272 (24.8) (22.3 to 27.5)	247 (22.6) (20.1 to 25.2)	83 (7.6) (6.1 to 9.4)	30 (2.7) (1.9 to 3.9)	25 (2.3) (1.5 to 3.4)	53 (53.5) (43.2 to 63.6)	15 (15.1) (8.7 to 23.8)	27 (2.5) (1.6 to 3.6)	12 (1.1) (0.6 to 1.9)	5 (0.4)
Prior CVD	196	64 (32.6) (26.1 to 39.7)	41 (20.9) (15.4 to 27.3)	75 (38.3) (31.4 to 45.5)	23 (11.8) (7.6 to 17.2)	10 (5.1) –	11 (5.6) (2.8 to 9.9)	16 (55.2) (35.7 to 73.6)	7 (24.1) –	10 (5.1) –	6 (3.1) –	2 (1) –
No prior CVD	1170	417 (35.6) (32.9 to 38.5)	286 (24.4) (22.0 to 27.0)	272 (23.2) (20.9 to 25.8)	91 (7.8) (6.4 to 9.5)	35 (3) (2.1 to 4.2)	28 (2.4) (1.6 to 3.5)	70 (60.3) (50.8 to 69.3)	17 (14.7) (8.8 to 22.4)	30 (2.6) (1.7 to 3.6)	14 (1.2) (0.7 to 2.0)	6 (0.5) –

Data are expressed as number (percentage) (CI).
CIs are not presented when relative SE>30%, because of unreliable estimates.
*Results for aged 20+ adults only.
†Measured by Albustick.
ACR, albumin creatinine ratio; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension.

Table 4 Age-adjusted prevalence of eGFR<60 ml/min/1.73 m^2 and ACR>30

		eGFR<60 ml/min/1.73 m^2			ACR>30		
	n	Unadjusted %	%	95% CI	Unadjusted %	%	95% CI
Nepal							
All	20811	19	22.1	21.5 to 22.7	7	7.8	7.2 to 8.4
Gender							
Women	12792	21.3	26	25.2 to 26.8	6.4	7.1	6.3 to 7.9
Men	8019	15.3	16.8	16.0 to 17.6	8.1	8.8	7.8 to 9.8
Bolivia							
All	3436	3.2	4	3.0 to 5.0		–	
Gender							
Women	2192	2.6	3.4	2.2 to 4.7		–	
Men	1244	4.4	4.6	3.0 to 6.3		–	
USA							
All	4299	7.0	6.6	5.8 to 7.6	10.4	10.2	9.1 to 11.3
Gender							
Women	2091	8.6	8.1	6.8 to 9.6	11.5	11.3	9.7 to 13.2
Men	2208	5.3	5.1	4.2 to 6.1	9.2	9.0	8.0 to 10.2

GFR<60 ml/min/1.73 m^2 and A/C>30 estimates were age adjusted to the 2000 US standard population.
ACR, albumin creatinine ratio; eGFR, estimated glomerular filtration rate.

Bolivia, similar to that found in the US population by NHANES. Hypertension, DM and obesity were relatively common among these populations and clustered in subjects with renal dysfunction. As expected, prevention programmes in Bangladesh and Georgia focusing on subjects with already known CVD risk factors such as DM, hypertension or previous CV events found higher prevalence of microalbuminuria. In accordance with previously published studies, male gender was associated with an increased prevalence of hypertension, reduced renal function and proteinuria.[10–12]

The prevalence of renal dysfunction and microalbuminuria found in Nepal and Bolivia is in line with those reported by other ISN-sponsored screening programmes in indigent residents of Guadalajara, Mexico[13] or of Kinshasa, in the Democratic Republic of Congo,[14] highlighting the generalisability of this approach for case detection in diverse settings around the world. Notably, the availability of the NHANES dataset allowed us to infer that the burden of CKD is similar across different populations worldwide, including both high-income and low-income countries. Importantly, data on the prevalence of albuminuria retrieved from the NHANES cohort are similar to those reported by the Prevention of Renal and Vascular ENd-stage Disease study, a large European screening programme.[15] This is consistent with other evidence that chronic non-communicable diseases are now the major cause of morbidity and mortality in the entire world.[16–19] Intriguingly, prevalence of CKD and of subjects with high CV risk was consistent across different countries, independent of per capita incomes (available at http://www.heritage.org/index/default). Of note, prevalence of CKD in low-income countries and in the USA was confirmed when data were corrected for different age distributions across nations. In low-income countries, levels of physical activity were higher than in the US population, whereas smoking habit and alcohol consumption tended to be lower. However, in light of progressive spread of Western lifestyles,[20] incidence of DM and hypertension has been forecast to increase in these nations during the next few years, which is also expected to translate into increased CKD and CVD. This clearly highlights the importance of prevention programmes especially in low-income countries, where renal replacement therapies and coronary revascularisation procedures are available only for a minority of people.

About 15% of subjects had an estimated 10% or higher risk of developing a CV risk in the following 10 years. In consideration of the high prevalence of renal dysfunction and microalbuminuria, this risk was probably underestimated, although the net additional contribution of eGFR and albuminuria on CVD risk is still unclear. Long term outcome analysis of the present screened cohorts will allow assessing whether inclusion of albuminuria and/or reduced GFR among the variables considered in algorithms for prediction of individual CVD risk will improve the performance of current WHO prediction algorithms.

Evidence is emerging that CKD and CVD have a major impact on macroeconomic development due to diminished labour supply related to premature death and disability in people of working age. According to WHO, these conditions decrease the potential annual growth rate in gross domestic product by 1–5% in developing countries experiencing rapid economic growth.[21] Importantly, data from large trials have consistently shown that off-patent drugs such as ACE inhibitors can reduce albuminuria and prevent GFR decline and CV events.[5] Thus, prevention programmes should identify and treat renal abnormalities early, with the primary goal to reduce CV mortality and morbidity, which, on its turn, may translate into an economical benefit.

Table 5 Prevalence of obesity/underweight and DM in participants by country

	Participants (n)	BMI (kg/m^2)			FPG>126 mg/dl
		<18.5	25–29.9	≥30	
Nepal					
All	20811	2175 (10.5) (10.0 to 10.9)	5478 (26.3) (25.7 to 26.9)	1395 (6.7) (6.4 to 7.1)	1227 (5.9) (5.6 to 6.3)
Gender					
Women	12792	1291 (10.1) (9.6 to 10.6)	3464 (27.1) (26.3 to 27.9)	1073 (8.4) (7.9 to 8.9)	650 (5.1) (4.7 to 5.5)
Men	8019	884 (11) (10.4 to 11.7)	2014 (25.1) (24.2 to 26.1)	322 (4) (3.6 to 4.5)	577 (7.2)* (6.7 to 7.8)
Age (years)					
18–40	11283	1323 (11.7) (11.1 to 12.3)	2390 (21.2) (20.4 to 22.0)	494 (4.4) (4.0 to 4.8)	305 (2.7) (2.4 to 3.0)
41–60	6973	485 (7) (6.4 to 7.6)	2430 (34.9) (33.7 to 36.0)	718 (10.3) (9.6 to 11.0)	648 (9.3) (8.7 to 10.0)
>60	2555	367 (14.4) (13.0 to 15.8)	658 (25.8) (24.1 to 27.5)	183 (7.2) (6.2 to 8.2)	274 (10.7) (9.6 to 12.0)
Prior DM	1330	46 (3.5) (2.5 to 4.6)	508 (38.2) (35.6 to 40.9)	150 (11.3) (9.6 to 13.1)	606 (45.7) (43.0 to 48.4)
No Prior DM	16623	1887 (11.4) (10.9 to 11.8)	4160 (25) (24.4 to 25.7)	988 (5.9) (5.6 to 6.3)	573 (3.5) (3.2 to 3.8)
Prior CVD	304	20 (6.6) (4.1 to 10.0)	91 (29.9) (24.8 to 35.4)	32 (10.5) (7.3 to 14.5)	35 (11.5) (8.2 to 15.7)
No Prior CVD	17737	1923 (10.8) (10.4 to 11.3)	4602 (26) (25.3 to 26.6)	1093 (6.2) (5.8 to 6.5)	1070 (6.1) (5.7 to 6.4)
Bolivia					
All	3436	57 (1.7) (1.3 to 2.1)	1253 (36.5) (34.9 to 38.1)	721 (21) (19.6 to 22.4)	88 (2.6) (2.1 to 3.1)
Gender					
Women	2192	31 (1.4) (1.0 to 2.0)	767 (35) (33.0 to 37.0)	553 (25.2) (23.4 to 27.1)	52 (2.4) (1.8 to 3.1)
Men	1244	26 (2.1) (1.4 to 3.0)	486 (39.1) (36.3 to 41.8)	168 (13.5) (11.7 to 15.5)	36 (2.9) (2.0 to 4.0)
Age (years)					
18–40	1732	39 (2.2) (1.6 to 3.1)	541 (31.2) (29.1 to 33.5)	198 (11.4) (10.0 to 13.0)	5 (0.3) –
41–60	1386	11 (0.8) –	570 (41.1) (38.5 to 43.8)	439 (31.7) (29.2 to 34.2)	55 (4) (3.0 to 5.1)
>60	318	7 (2.2) –	142 (44.6) (39.1 to 50.3)	84 (26.4) (21.7 to 31.6)	28 (8.8) (5.9 to 12.5)
Prior DM	87	0	32 (36.8) (26.7 to 47.8)	34 (39.1) (28.8 to 50.1)	87 (100) –
No Prior DM	2392	38 (1.6) (1.1 to 2.2)	863 (36.1) (34.1 to 38.0)	506 (21.1) (19.5 to 22.8)	0
Prior CVD	71	0	30 (42.2) (30.6 to 54.6)	21 (29.6) (19.3 to 41.6)	6 (8.4) –
No Prior CVD	2718	44 (1.6) (1.2 to 2.2)	984 (36.2) (34.4 to 38.0)	571 (21) (19.5 to 22.6)	76 (2.8) (2.2 to 3.5)
US					
All	4299	77 (1.9) (1.3 to 2.6)	1426 (33.2) (31.4 to 35.0)	1489 (33.0) (30.9 to 35.3)	478 (7.9) (7.0 to 8.9)
Gender					
Women	2091	51 (2.5) (1.9 to 3.4)	582 (27.3) (24.9 to 29.8)	821 (35.4) (32.9 to 38.0)	226 (7.5) (6.2 to 9.1)
Men	2208	26 (–)	844 (39.2) (36.7 to 41.7)	668 (30.6) (27.7 to 33.7)	252 (8.3) (6.9 to 9.9)

Continued

Table 5 Continued

	Participants (n)	BMI (kg/m^2) <18.5	25–29.9	≥30	FPG>126 mg/dl
Age (years)					
18–40	1652	40 (2.6) (1.8 to 3.9)	484 (29.4) (26.5 to 32.5)	497 (28.2) (24.8 to 31.9)	48 (2.7) (1.9 to 3.8)
41–60	1337	19 (–)	477 (35.4) (33.0 to 37.8)	522 (37.2) (34.0 to 40.5)	152 (7.6) (6.3 to 9.1)
>60	1310	18 (1.4) (0.9 to 2.1)	465 (36.5) (33.0 to 40.2)	470 (35.0) (32.3 to 37.7)	278 (18.6) (16.5 to 20.9)
Prior DM	516	2 (–)	140 (24.4) (19.7 to 29.9)	299 (61.3) (55.4 to 66.9)	329 (62.4) (57.2 to 67.3)
No prior DM	3779	75 (2.0) (1.4 to 2.8)	1284 (34.0) (31.9 to 36.1)	1189 (30.5) (28.4 to 32.7)	148 (2.9) (2.3 to 3.7)
Prior CVD	467	6 (–)	146 (31.6) (27.2 to 36.4)	212 (45.2) (38.8 to 51.8)	115 (21.2) (17.3 to 25.7)
No prior CVD	3493	56 (1.7) (1.2 to 2.5)	1199 (33.6) (31.8 to 35.6)	1207 (32.5) (30.3 to 34.7)	355 (6.8) (6.0 to 7.6)
Bangladesh					
All	1518	307 (20.2) (18.2 to 22.3)	215 (14.1) (12.4 to 16.0)	22 (1.4) (0.9 to 2.2)	132 (9.6) (8.1 to 11.2)
Gender					
Women	859	155 (18) (15.5 to 20.8)	128 (14.9) (12.6 to 17.5)	15 (1.7) (1.0 to 2.9)	78 (9.9) 7.9 to 12.2)
Men	659	152 (23.1) (19.9 to 26.5)	87 (13.2) (10.7 to 16.0)	7 (1.1) –	54 (9.1) (6.9 to 11.6)
Age (years)					
18–40	575	135 (23.5) (20.1 to 27.2)	103 (17.9) (14.9 to 21.3)	8 (1.4) –	46 (9.1) (6.7 to 11.9)
41–60	690	97 (14.1) (11.6 to 16.9)	86 (12.5) (10.1 to 15.2)	13 (1.9) (1.0 to 3.2)	65 (10) (7.8 to 12.6)
>60	253	75 (29.6) (24.1 to 35.7)	26 (10.3) (6.8 to 14.7)	1 (0.4) –	21 (9.3) (5.8 to 13.9)
Prior DM	111	8 (7.2) –	17 (15.3) (9.2 to 23.4)	10 (9.1) –	24 (23.5) (15.7 to 33.0)
No Prior DM	1404	297 (21.1) (19.0 to 23.4)	198 (14.1) (12.3 to 16.0)	12 (0.8) (0.4 to 1.5)	108 (8.5) (7.0 to 10.1)
Prior CVD	20	4 (20) –	4 (20) –	3 (15) –	3 (16.7) –
No Prior CVD	1494	301 (20.1) (18.1 to 22.3)	211 (14.1) (12.4 to 16.0)	19 (1.2) (0.8 to 2.0)	129 (9.5) (8.0 to 11.2)
Georgia					
All	1549	41 (2.6) (1.9 to 3.6)	498 (32.1) (29.8 to 34.5)	580 (37.4) (35.0 to 39.9)	232 (15.2) (13.4 to 17.1)
Gender					
Women	1156	33 (2.8) (2.0 to 4.0)	370 (32) (29.3 to 34.8)	450 (38.9) (36.1 to 41.8)	170 (14.9) (12.9 to 17.1)
Men	393	8 (2) –	128 (32.6) (28.0 to 37.4)	130 (33.1) (28.4 to 38.0)	62 (16.1) (12.5 to 20.1)
Age (years)					
18–40	405	28 (6.9) (4.6 to 9.8)	105 (25.9) (21.7 to 30.5)	74 (18.3) (14.6 to 22.4)	38 (9.5) (6.8 to 12.8)
41–60	731	8 (1.1) –	233 (31.9) (28.5 to 35.4)	349 (47.7) (44.1 to 51.4)	104 (14.4) (12.0 to 17.2)
>60	413	5 (1.2) –	160 (38.7) (34.0 to 43.6)	157 (38) (33.3 to 42.9)	90 (22.1) (18.1 to 26.4)
Prior DM	322	7 (2.2) –	95 (29.5) (24.6 to 34.8)	142 (44.1) (38.6 to 49.7)	166 (52.2) (46.6 to 57.8)

Continued

Table 5 Continued

	Participants (n)	BMI (kg/m^2) <18.5	25–29.9	≥30	FPG>126 mg/dl
No Prior DM	1095	31 (2.8) (1.9 to 4.0)	367 (33.5) (30.7 to 36.4)	382 (34.9) (32.1 to 37.8)	48 (4.4) (3.3 to 5.8)
Prior CVD	196	1 (0.5) –	60 (30.6) (24.2 to 37.6)	96 (49) (41.8 to 56.2)	36 (18.6) (13.4 to 24.9)
No Prior CVD	1170	35 (3) (2.1 to 4.1)	388 (33.2) (30.5 to 35.9)	402 (34.4) (31.6 to 37.2)	162 (14) (12.1 to 16.2)

Data are expressed as number (percentage) (CI). CIs are not presented when relative SE>30%, because of unreliable estimates.
*p<0.05 versus women.
BMI, body mass index; CVD, cardiovascular disease; DM, diabetes mellitus; FPG, fasting plasma glucose.

There is little debate that screening for albuminuria should be performed in patients with DM and/or hypertension, where early intervention can slow down deterioration of renal function. However, due to the difficulty of identifying subjects at risk in low-income countries, a prescreening phase including clinical history, BP and anthropometric values might be instrumental in identifying patients in whom screening with serum and urine testing could be most cost-effective. On the contrary, data from Nepal and Bolivia showed that more than 5% of people younger than 60 years without previous history of diabetes and hypertension had microalbuminuria/proteinuria. Consistently, screening also low-risk groups, or even the general population, has been advocated to identify and treat those at risk for progressive renal disease, arguing that most persons with albuminuria and/or reduced eGFR (<60 ml/min/1.73 m^2) are asymptomatic. However, concerns towards general population screenings regard not only the cost of screening itself, but, more importantly, the risk and the cost of treating false-positive subjects with no other modifiable risk factors. Thus, patients with a first positive test should be always asked to repeat the analyses and only those with confirmed positivity should be treated.[22] However, when debating how to address the issue of screening for non-communicable diseases and, more in general, of health in developing nations, we should look at the problem from the perspective of the low-income and middle-income countries, not from that of industrialised nations. Indeed, there is not a unique blueprint of screening strategy even among developing countries, so that the approaches should be adapted on single-nation conditions and socioeconomic status.[23]

Strengths and limitations of the study

Our study has several limitations. At variance with NHANES data, showing characteristics of a cohort representative of US population, results from Bolivia cannot be taken to infer the absolute or relative prevalence of renal abnormalities in this country, since all subjects were referred to a single centre. However, in consideration of the limited availability of local resources, current data seem reasonably reliable and representative of a large fraction of people, at least those living at the altitude regions of this country. Reliability of data is supported by the fact that, in line with available evidence, prevalence of microalbuminuria was higher in older subjects and in those with hypertension or diabetes. Also data from Nepal cannot be formally considered representative of the whole Nepalese population. However, the multiple sites used for the screening, along with the large sample size and consistency with data retrieved from a previous smaller cohort of Nepalese subjects[24] make the present dataset insightful of the prevalence of CKD and CVD in this nation. Importantly, data from Bolivia were similar to those found in Nepal and this

Table 6 Cardiovascular risk distribution in participants by country

Country	Participants	10-year cardiovascular risk <10	10.1–20	20.1–30	30.1–40	>40
Nepal	5187	4309 (83.1) (82.0 to 84.1)	829 (16.0) (15.0 to 17.0)	33 (0.6) (0.4 to 0.9)	9 (0.2) –	7 (0.1) –
Bolivia	601	545 (90.7) (88.1 to 92.9)	43 (7.2) (5.2 to 9.5)	9 (1.5) –	3 (0.5) –	1 (0.2) –
USA	1093	794 (81.8) (79.3 to 84.1)	193 (12.3) (10.3 to 14.6)	56 (3.0) (2.3 to 4.0)	31 (1.7) (1.0 to 2.7)	19 (–) –
Bangladesh	758	566 (74.7) (71.4 to 77.7)	143 (18.9) (16.1 to 21.8)	33 (4.4) (3.0 to 6.1)	9 (1.2) –	7 (0.9) –
Georgia	927	695 (75.0) (72.1 to 77.7)	106 (11.4) (9.5 to 13.7)	78 (8.4) (6.7 to 10.4)	28 (3.0) (2.0 to 4.3)	20 (2.2) (1.3 to 3.3)

Data are expressed as number (percentage) (CI). CIs are not presented when relative SE>30% because of unreliable estimates.

suggests that these data may reflect patterns throughout the developing world. Of note, although formal comparison across different populations is prevented by different inclusion criteria and sampling strategies, use of the same cut-off points for clinical and laboratory parameters and the same web-based database for data entry and centralised data monitoring make the present analysis a unique opportunity to study prevalence of CKD and CVD in countries with different incomes.

Owing to limited resources, laboratories in developing countries were not calibrated according to the National Kidney Disease Education Program. However, each site made calibrations for creatinine measurement according to guidelines suggested by the manufacture, which should have prevented major bias in our findings. Some authors have advocated to repeat renal function measurements in screening programmes to prevent overestimation of disease prevalence.[22] However, in low-income countries, repeated measurements on a standard basis would unnecessarily increase costs and could be burdened by high rate of non-compliance, which, on its turn, could reduce the number of subjects identified with renal abnormalities. In addition, the primary goal of any screening programme is to avoid false negative results that might affect the identification of subjects at risk, whereas the risk of false-positive results is of relatively limited importance since subjects erroneously identified with albuminuria can be correctly characterised at follow-up evaluation. Therefore, different assays to measure albuminuria should be titrated to single resources. Consistently, a pilot phase of National Kidney Foundation Kidney Early Evaluation Program in México City and Jalisco State[25] reporting prevalence of eGFR<60 ml/min/1.73 m^2 and albuminuria close to the ones we found in high-risk subjects from Georgia and Bangladesh, evaluated albuminuria levels once and used the same cut-off points considered in our analyses.

Finally, an issue of the present study was the use of GFR-predicting equations that may not fully fit to different ethnicities, thus some participants from these countries might have been misclassified with respect to the presence of eGFR<60 ml/min/1.73 m^2. This could account for the variability across different countries. On the contrary, performance of formulas is poor for high levels of GFR, whereas they tend to improve for lower values. Thus, risk of misclassification of subjects below the threshold of 60 ml/min/1.73 m^2 is reasonably low. Notably, since no ad hoc formulas are available to estimate GFR more precisely in considered populations, such ISN screening programmes might offer the unique opportunity to implement formulas to fit best different ethnicities.

CONCLUSIONS

We found that impaired kidney function and microalbuminuria/proteinuria are common within the general population, both in low-income countries and in the USA. Although screening programmes focusing on high-risk subjects seem to be more cost-effective than general population screenings, overall these data demonstrate the feasibility of projects for early detection of CKD in low-income nations. In the light of major impact of renal abnormalities on CVD, these programmes are urgently warranted and should be implemented according to single-nation characteristics. Prospective studies are ongoing[26] and will allow quantifying the benefits of such prevention strategies.

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APPENDIX

Screening programme in emerging countries—study organisation

Nepal

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