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Results of a community-based screening programme for chronic kidney disease and associated risk factors, (obesity, diabetes and hypertension) in a Samoan cohort

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ABSTRACT

Objectives In 2019, under the World Kidney Day theme of 'Kidney health for everyone everywhere', the National Kidney Foundation of Samoa undertook an extensive community screening campaign to detect the estimated prevalence of chronic kidney disease (CKD) and its associated risk factors in the community.

Setting Fifteen screening sites, with 11 urban and rural sites on the main island of Upolu, and 4 in different rural areas on the island of Savaii.

Participants All participants were self-referrals to the various screening sites. In total, 1163 Samoans were screened, with similar numbers from both urban and rural areas and similar numbers of female and male.

Screening activities All participants were screened for CKD using point of care serum creatinine determinations, with calculation of estimated glomerular filtration rate using the CKD-EPI formula and dipstix urinalysis. A standardised screening survey was used to capture demographic and medical history with associated risk factors of obesity, diabetes, using point of care determination of HbA1c and hypertension. Logistic regression was used to investigate the association of CKD with risk factors.

Results In total, 1163 people were screened for CKD within the month of March 2019. The prevalance of CKD (grades 1–5) was 44.5% (95% CI 41.6% to 47.4) with individual grade prevalence CKD 1: 3.7%, CKD 2: 6.1%, CKD 3: 30.7%, CKD 4: 2.9% and CKD 5: 1.0%. The prevalence of obesity (body mass index ≥32), diabetes and hypertension was 66.3%, 30.8% and 54.3%, respectively.

Conclusions This is the first paper to report the estimated prevalence of CKD in Samoa or any other Pacific Island nation. It reveals an urgent need for further studies on the epidemiology of CKD in Samoa, to develop country-specific prevention strategies to mitigate this growing burden and prevent subsequent CKD associated complications including development of kidney failure and premature death.

Strengths and limitaions of this study

- ► First comprehensive community screening programme to identify the prevalence of chronic kidney disease (CKD) in Samoa.
- ► Inclusion of urinalysis as part of the assessment of CKD.
- ► Validity of the CKD-EPI formula for Samoans not tested.
- ► A single measurement of estimated glomerular filtration rate and urinalysis for the identification of CKD.

INTRODUCTION

Samoa, an independant Pacific Island nation, separate to American Samoa, has been celebrating World Kidney Day (WKD) annually since 2013. Samoa consists of eight islands with the two main inhabited islands (Upolu and Savai'i) holding 99% of the almost 200 000 population.[1] Samoa has its own cultural beliefs in health with a strong traditional healer community and their own traditional medicines.[2 3] It is the only Polynesian Island nation running a successful largely government funded haemodialysis centre within the National Kidney Foundation of Samoa (NKFS). The NKFS was set up in 2005 as a state owned enterprise by the Samoan government and is mandated to detect and provide management for kidney diseases. This included, a haemodialysis unit which was set up initially with the support of the Singapore National Kidney foundation until 2007, and has since been run independantly with oversight from a nephrologist based in Auckland New Zealand.

Since the inception of its haemodialysis unit, the NKFS has seen a rapid rise in the demand for haemodialysis from six dialysis patients to now dialysing over 150 patients annually[4] Of concern to the NKFS, is that the leading causes of end stage kidney disease

(ESKD) in the patients accessing haemodialysis, being diabetes mellitus and hypertension, were largely preventable.[5] The NKFS has provided chronic kidney disease (CKD) screening activities since 2007. Initially, screening activities were centred around the dialysis centre patients and their families, and later extended into the main town of Apia and now rural village communities are being actively involved.

Samoa, like many other Pacific Island nations is experiencing an alarming burden of non-communicable diseases (NCDs). The Samoan Ministry of Health (MOH) performed the World Health Organisation's STEP studies in 2002 and 2012 and reported prevalences of obesity, diabetes and hypertension at worrying levels. In 2002 and 2012 the prevalances for obesity (body mass index, BMI ≥30) were 54.7% and 55.8%, for diabetes 22.1% and 45.8% and for hypertension 21.1% and 24.5%, respectively.[6 7] A review of the NKFS screening programme in 2014 reported a CKD prevalence (estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2) of 11.5% with a prevalence of its associated risk factors of obesity (BMI ≥30) at 67.8% and hypertension 33.4%.[8] A true prevalence of diabetes was unable to be evaluated as the screening programme only used a random finger prick blood sugar level to detect diabetes. There were problems identified in these early NKFS screening activites of missing and poorly collated data that suggested CKD prevalence was likely underestimated.[8]

As part of WKD celebrations in 2019, the NKFS undertook an expanded CKD screening campaign as part of their programme to raise kidney awareness. Advertising about this screening campaign, on various media platforms including the radio and television, commenced a month before the planned screening dates. This included partnering with a mobile phone company in Samoa to develop several short video clips relating to kidney health that were released on social media platforms during this time.

This paper reports the results of this community screening survey and the estimated prevalence of CKD and its associated risk factors from its WKD screening campaign for 2019.

METHODS

Fifteen screening sites, active over the month of March 2019, were planned with eleven of these to be on the main island of Upolu in the urban areas and four of these in different rural areas on the island of Savaii. The urban sites chosen included sites close to the main bus depot and local produce market where people from rural areas frequent. The rural areas were in four different areas in Savaii. The objective was to screen participants from the four main census regions of residence.

There was a team containing at least one doctor and three nurses along with up to 10 volunteers at each screening activity. The screening team informed participants about the screening activity and explained how clinical measures were to be obtained and verbal consent to participate was obtained. A structured questionnaire was used to record name, sex, age, village, education level, occupation, smoking status and alcohol consumption. People were also asked about any known previous medical history and specifically if they had been diagnosed with diabetes mellitus and/or high blood pressure.

Clinical data collected included weight and height measurements to calculate BMI. Height and weight were measured with participants bare foot and in light clothing using a Seca213 stadiometer (Seca Hamburg, Germany) for height and a Seca762 mechanical personal scale (Seca Hamburg, Germany) for weight. BMI was then calculated using the formula weight (kg)/height (m^2). Obesity was diagnosed using the WHO criteria with BMI ≥30 kg/m^2 indicating obesity. Polynesian cutoffs for obesity (BMI ≥32 kg/m^2)[9] were also calculated for comparison. Blood pressure was collected using an Omron automatic blood pressure monitor (Omron, Kyoto Japan) using an appropriately sized cuff. Blood pressure was measured twice taken at least 5 min apart with the second reading recorded as the reading for the screening activity. Hypertension was recorded if patient self-reported a diagnosis, shared antihypertensive medication use or a systolic blood pressure (SBP) ≥140 mm Hg and/or the diastolic blood pressure (DBP) ≥90 mm Hg; or if a participant had only diabetes and SBP ≥130 mm Hg and/or DBP ≥80 mm Hg.

Point-of-care testing for serum creatinine used the Refloton plus system (Roche Diagnostics, Basel Switzerland) and eGFR was determined using the CKD-EPI formula (CKD Epidemiology collaboration). HbA1c (glycated haemoglobin) was measured on a finger prick sample using the A1cCare quantitative HbA1c Analyzer (Suwon-si South Korea). A spot urine sample was collected from participants and urinalysis was performed using the Siemens Multistix five urinalysis test strips (Siemens Healthcare, Erlangen Germany), with those with positive results recorded as 1+through to 3+proteinuria and/or haematuria. CKD was defined as an eGFR <60 mL/min/1.73 m^2 or an eGFR ≥60 mL/min/1.73 m^2 with proteinuria or haematuria on urinalysis, after menses in female participants was excluded. Women menstruating at time of screening were advised to return for a repeat test. Diabetes was diagnosed if the HBA1c was ≥6.5% (48.0 mmol/mol) and pre-diabetes as an HBA1c ≥5.8% and <6.5% (40.0 to <48.0 mmol/mol).[10] All data collection was recorded on an excel spreadsheet and stored on password-locked computers, in a secure location in the NKFS building. A copy of the data capture form is attached as online supplemental table 1.

Patient and public involvement

There was no participant involvement in the design, conduct or reporting of the results. The NKFS through their publicity campaigns will be reporting the results of this programme back to the community as well as the Samoan MOH via public forums, social media and local newspapers and television.

Statistics

Continuous and categorical variables are displayed as mean and SD and frequency and percentages, respectively. Prevalence was calculated using the total population of screened participants as the denominator during the campaign. The exact method for proportions was used to estimate the 95% CI for the prevalence. The age standardised prevalence was estimated using the Samoan population from the 2019 census as the standard population. Univariable and multivariable logistic regression analyses were used to estimate ORs and their 95% CIs for all risk factors on the outcome CKD occurrence. All variables were checked for collinearity. If collinearity was present, then only the variable with the strongest association with the outcome (univariability) was retained for the full model. All other variables were also included in the full model and then stepwise backward logistic regression was used to remove non-significant variables (using the likelihood ratio p value) after checking for the impact of confounding. Confounders were retained in the model regardless of significance that is, if the other model coefficients changed substantially indicating confounding. ORs and their 95% CIs are estimated from logistic regression models using a reference group for categorical variables. The likelihood ratio p value was calculated for each variable in the model to show whether the variable was important overall in the model. A sensitivity analysis was conducted to investigate the impact of using diabetes status rather than HbA1c and hypertension rather than blood pressure by refitting the model replacing separately the continuous version of each, for blood pressure both systolic and diastolic measures were included in the model. All analyses was completed using Stata V.16.[11]

RESULTS

A total of 1163 people were screened with 1138 tested for CKD. The mean (±SD) age of participants was 50.5±14.5 years. The mean (±SD) SBP and DBP were 134±21.3 and 85±13.9 mm Hg, respectively. The mean BMI (+SD) was 35.4 kg/m^2±7.4, mean HbA1c 6.2%±2.1% and mean waist circumference 108.5 cm ±14.6 cm. There was an equal number of people from rural (50.1%) and urban (49.1%) regions and equal proportions of males (49.8%) and females (50.2%) screened. 18.1% of the screened population were current smokers, 31.6% were in paid employment and 79.5% had completed some level of formal education (table 1).

The estimated overall prevalence of CKD in this population, was 44.5% (95% CI 41.6% to 47.4%)with 22% of those diagnosed with CKD having proteinuria and/or haematuria and an eGFR >60 mL/min/1.72 m^2 (CKD grade 1 and 2). Proteinuria was detected in 8.3% of the total participants and haematuria in 9.4%. The estimated prevalence of the different CKD stages were CKD-1: 3.7% (95% CI 2.7% to 4.9%), CKD-2G: 6.1% (95% CI 4.8% to 7.6%), CKD-3G: 30.7% (95% CI 28.1% to 33.4%),CKD-4 G: 2.9% (95% CI 2.0% to 4.1%) and CKD-5G: 1.0% (95% CI 0.5% to 1.8%). In the those who were screened, diabetes prevalence was 30.8% (95% CI 28.1% to 33.5%) with 14.4% defined as pre-diabetic. The prevalence of hypertension and obesity (Polynesian cut-off) was 54.3% (95% CI 51.4% to 57.2%) and 66.3% (95% CI 63.5% to 69.0%), respectively (table 1).

In those diagnosed with CKD, 52.2% (95% CI 47.8% to 56.6%) were female, 57.2% (95% CI 52.9% to 61.6%) were 55 years and older, 34.4% (95% CI 30.3% to 38.7%) were diabetic, 60.5% (95% CI 56.2% to 64.8%) were hypertensive and 64.2% (95% CI 59.9% to 68.4%) were obese (online supplemental tables 2–5). The age-standardised prevalence for total CKD in the Samoan population is 31.8%.

In the adjusted model, (table 2) increasing age was a strong predictor for CKD (55–65 years adjOR 3.1 (95% CI 1.93 to 5.07), ≥65 years adjOR 7.9 (95% CI 4.62 to 13.56)) compared with the age group of 25–35 years) likelihood ratio probability (LRp)<0.001). Diabetes and hypertension, while being predictors for CKD in the unadjusted model (OR 1.6 (95% CI 1.24 to 1.99) and 1.3 (95% CI 1.02 to 1.74) LRp 0.002 and 0.138, respectively) lost this association in the adjusted model (adjOR 1.1 (95% CI 0.87 to 1.52) LRp 0.332 and 0.9 (95% CI 0.87 to 1.52) LRp 0.332 and 0.864, respectively). In this cohort, smoking was associated with a lower risk for CKD in both the unadjusted (OR 0.6(95% CI 0.43 to 0.86), LRp 0.033) and adjusted models (adjOR 0.7 (95% CI 0.46 to 0.96), LRp 0.153). Polynesian BMI categories had a decreased association with CKD in the unadjusted model in the obese (BMI ≥32) category (OR 0.6 (95% CI 0.41 to 0.94) LRp 0.165) but lost this association in the adjusted model (adjOR 0.7 (95% CI 0.44 to 1.14). Sex and location were not associated with CKD in both models.

The results for other factors in the model did not alter substantially when the sensitivity analyses was undertaken by using the continuous HbA1c and blood pressure measures. When HbA1c was included in the model it was not associated with CKD (adjOR: 1.0 (95% CI 0.90 to 1.02) LRp 0.189). When blood pressure was included in the model, SBP had a small association with CKD (adjOR: 1.007 (95% CI 1.000 to 1.013) LRp 0.039) and DBP was not associated (adjOR 1.005 (95% CI 0.995 to 1.014) LRp 0.3310).

DISCUSSION

The estimated CKD prevalence of 44.5% is alarming for a country with an estimated population of 200 000 as is the age-standardised total CKD prevalence of 31.8%. It is almost three times the global prevalence of CKD (11%–13%) as described by Hill *et al*.[12] In a recent prevalence study focusing on CKD in Samoans living in Auckland New Zealand, we found a prevalence of 16.4% in the total study group but in those Samoans who had actually had their kidney function tested, the prevalence of CKD was 33.4%.[13] This has serious implications for Samoans living in Samoa or New Zealand, as this CKD burden runs

Table 1 Prevalence and characteristics of participants in a NKFS chronic kidney disease screening campaign over March 2019

	Screening participants	No CKD	CKD
Characteristics	**N (%*) (95% CI)**	**n (%†) (95% CI)**	**n_1 (%‡) (95% CI)**
All patients	1163 (100.0)	621 (53.4) (50.5 to 56.3)	517 (44.5) (41.6 to 47.4)
	Mean±SD	Mean±SD	Mean±SD
Age (years)	50.5±14.5	46.5±13.2	55.5±14.4
eGFR (mL/min/1.73 m^2)	68.7±22.6	80.6±16.1	54.3±20.8
Hba1c (%)	6.2±2.1	6.2±2.2	6.2±1.9
BMI (kg/m^2)	35.4±7.4	35.5±7.0	35.3±7.9
SBP (mm Hg)	134.8±21.3	132.1±18.9	138.2±23.5
DBP (mm Hg)	85.8±13.9	85.4±12.4	86.3±15.5
Waist circumference (cm)	108.7±14.6	108.1±13.7	109.5±15.7
Sex			
Female	584 (50.2) (47.3 to 53.1)	301 (51.5) (47.4 to 55.7)	270 (46.2) (42.1 to 50.4)
Male	579 (49.8) (46.9 to 52.7)	320 (55.3) (51.1 to 59.4)	247 (42.7) (38.6 to 46.8)
Age group (years)			
15 ≤age <25	54 (4.6) (3.5 to 6.0)	35 (64.8) (50.6 to 77.3)	16 (29.6) (18.0 to 43.6)
25 ≤age < 35	138 (11.9) (10.1 to 13.9)	96 (69.6) (61.2 to 77.1)	37 (26.8) (19.6 to 35.0)
35 ≤age < 45	185 (15.9) (13.9 to 18.1)	122 (65.9) (58.6 to 72.7)	58 (31.4) (24.7 to 38.6)
45≤age < 55	311 (26.7) (24.2 to 29.4)	195 (62.7) (57.1 to 68.1)	110 (35.4) (30.1 to 41.0)
55≤age < 65	277 (23.8) (21.4 to 26.4)	125 (45.1) (39.2 to 51.2)	149 (53.8) (47.7 to 59.8)
Age≥65	198 (17.0) (14.9 to 19.3)	48 (24.2) (18.4 to 30.8)	147 (74.2) (67.6 to 80.2)
CKD			
0		621 (53.4) (50.5 to 56.3)	
CKD Stage 1			43 (3.7) (2.7 to 4.9)
CKD Stage 2G			71 (6.1) (4.8 to 7.6)
CKD Stage 3G			357 (30.7) (28.1 to 33.4)
CKD Stage 4G			34 (2.9) (2.0 to 4.1)
CKD Stage 5G			12 (1.0) (0.5 to 1.8)
Missing	25 (2.1) (1.4 to 3.2)		
BMI categories			
18.5≤BMI < 25	64 (5.5) (4.3 to 7.0)	31 (48.0) (35.8 to 61.3)	32 (50.0) (37.2 to 62.8)
25≤BMI < 30	196 (16.9) (14.7 to 19.1)	103 (52.6) (45.3 to 59.7)	93 (47.4) (40.3 to 54.7)
30≤BMI < 35	310 (26.7) (24.1 to 29.3)	163 (52.6) (46.9 to 58.3)	141 (45.5) (39.8 to 51.2)
35≤BMI < 40	289 (24.9) (22.4 to 27.4)	170 (58.8) (52.9 to 64.6)	116 (40.1) (34.4 to 46.0)
BMI≥40	283 (24.3) (21.9 to 26.9)	145 (51.2) (45.3 to 57.2)	127 (44.9) (39.0 to 50.9)
Missing	21 (1.8) (1.1 to 2.7)	9 (42.9) (21.8 to 66.0)	8 (38.1) (18.1 to 61.6)
Polynesian BMI categories			
BMI <26	101 (8.7) (7.1 to 10.5)	44 (43.6) (33.7 to 53.8)	56 (55.4) (45.2 to 65.3)
26≤BMI < 32	270 (23.2) (20.8 to 25.8)	146 (54.1) (47.9 to 60.1)	121 (44.8) (38.8 to 51.0)
BMI≥32	771 (66.3) (63.5 to 69.0)	422 (54.7) (51.1 to 58.3)	332 (43.1) (39.5 to 46.6)
Missing	21 (1.8) (1.1 to 2.7)	9 (42.9) (21.8 to 66.0)	8 (38.1) (18.1 to 61.6)
Diabetes			
No diabetes	585 (50.3) (47.4 to 53.2)	332 (56.8) (52.6 to 60.8)	253 (43.2) (39.2 to 47.4)
Diabetes	358 (30.8) (28.1 to 33.5)	175 (48.9) (43.6 to 54.2)	178 (49.7) (44.4 to 55.0)
Pre-diabetes	144 (12.4) (10.5 to 14.4)	84 (58.3) (49.8 to 66.5)	60 (41.7) (33.5 to 50.2)

Continued

Table 1 Continued

Characteristics	Screening participants N (%*) (95% CI)	No CKD n (%†) (95% CI)	CKD n_1 (%‡) (95% CI)
Missing	76 (6.5) (5.2 to 8.1)	30 (39.5) (28.4 to 51.4)	26 (34.2) (23.7 to 46.0)
Hypertension			
No Hypertension	531 (45.7) (42.8 to 48.6)	314 (59.1) (54.8 to 63.3)	204 (38.6) (34.4 to 42.9)
Hypertension	632 (54.3) (51.4 to 57.2)	307 (48.6) (44.6 to 52.6)	313 (49.5) (45.6 to 53.5)
Proteinuria			
No proteinuria	1027 (88.3) (86.3 to 90.1)	602 (58.6) (55.5 to 61.6)	407 (39.6) (36.6 to 42.7)
Proteinuria	97 (8.3) (6.8 to 10.1)	0	97 (100.0) (96.3 to 100.0§)
Missing	39 (3.4) (2.4 to 4.6)	19 (48.7) (32.4 to 65.2)	13 (33.3) (19.1 to 50.2)
Haematuria			
No haematuria	1015 (87.3) (85.2 to 89.1)	602 (59.3) (56.2 to 62.4)	395 (38.9) (35.9 to 42.0)
haematuria	109 (9.4) (7.8 to 11.2)	0	109 (100.0) (96.7 to 100.0§)
Missing	39 (3.3) (2.4 to 4.6)	19 (48.7) (32.4 to 65.2)	13 (33.3) (19.1 to 50.2)
Smoking Status			
Never smoked	910 (78.2) (75.8 to 80.6)	465 (51.1) (47.8 to 54.4)	423 (46.5) (43.2 to 49.8)
Current smoker	211 (18.1) (16.0 to 20.5)	134 (63.5) (56.6 to 70.0)	74 (35.1) (28.6 to 41.9)
Ex-smoker	32 (2.8) (1.9 to 3.9)	19 (59.4) (40.6 to 76.3)	13 (40.6) (23.7 to 59.4)
Missing	10 (0.8) (0.4 to 1.6)	3 (30.0) (6.7 to 65.2)	7 (70.0) (34.7 to 93.3)
Location			
Rural	583 (50.1) (47.2 to 53.0)	305 (52.3) (48.2 to 56.4)	260 (44.6) (40.5 to 48.7)
Urban	571 (49.1) (46.2 to 52.0)	310 (54.3) (50.1 to 58.4)	254 (44.5) (40.4 to 48.7)
Missing	9 (0.8) (0.4 to 1.5)	6 (66.7) (29.9 to 92.5)	3 (33.3) (7.4 to 70.1)
Profession			
Not in paid employment	556 (47.8) (44.9 to 50.7)	280 (50.4) (46.1 to 54.6)	267 (48.0) (43.8 to 52.3)
Employed	368 (31.6) (29.0 to 34.4)	236 (64.1) (59.0 to 69.0)	122 (33.2) (28.4 to 38.2)
Retired	21 (1.8) (1.1 to 2.7)	5 (23.8) (8.2 to 47.2)	16 (76.2) (52.8 to 91.8)
Student	11 (0.9) (0.5 to 1.7)	8 (72.7) (39.0 to 94.0)	3 (27.3) (6.0 to 61.0)
Missing	207 (17.8) (15.6 to 20.1)	92 (44.4) (37.6 to 51.5)	109 (52.7) (45.6 to 59.6)
Education level			
Primary	15 (1.3) (0.7 to 2.1)	7 (46.7) (21.3 to 73.4)	8 (47.3) (43.4 to 51.2)
Secondary	664 (57.1) (54.2 to 60.0)	338 (50.9) (47.0 to 54.8)	314 (33.9) (30.3 to 37.6)
Tertiary	245 (21.1) (18.8 to 23.5)	158 (64.5) (58.1 to 70.5)	78 (31.8) (26.1 to 38.1)
Missing	239 (20.5) (18.3 to 23.0)	118 (49.4) (42.9 to 55.9)	117 (49.0) (42.5 to 55.5)

*%= (N/1163)x100.
†%=(n/1163)x100.
‡%=(n_1/N)x100.
§One-sided, 97.5% CI.
BMI, body mass index; CKD, chronic kidney disease; DBP, diastolic blood pressure; NKFS, National Kidney Foundation of Samoa; SBP, systolic blood pressure.

parallel with high rates of NCDs and associated with high rates of morbidity and mortality, in particular premature mortality. The impact of migration on Samoans is well studied with several studies showing a marked increased health risk when they have migrated to developed countries, which is largely attributed to different lifestyles and diets.[14–16] However, the high CKD prevalence in Samoan residents in Samoa suggests that these changes associated with urbanisation and westernisation are now critical in Pacific Island countries causing similar poor health outcomes in these countries.

The prevalence of CKD in this 2019 screeening programme is almost four times that observed in 2014, with the prevalence of CKD stages 3G–5G at 34.7% in this survey compared with 11.5% in 2014.[8] The 2014 study did not report earlier grades (CKD stages 1 and 2) of CKD

Table 2 Unadjusted and adjusted ORs for associations between CKD and associated risk factors

	Unadjusted OR		Adjusted OR*	
Characteristics	OR (95% CI)	Likelihood p value	OR (95% CI)	Likelihood p value
Age groups		<0.001		<0.001
15 ≤age <25	1.2 (0.59 to 2.39)		1.2 (0.56 to 2.36)	
25 ≤age <35	Reference		Reference	
35 ≤age <45	1.2 (0.75 to 2.02)		1.2 (0.74 to 2.02)	
45 ≤age <55	1.5 (0.94 to2.29)		1.5 (0.92 to 2.34)	
55 ≤age <65	3.1 (1.98 to 4.84)		3.1 (1.93 to 5.07)	
age ≥65	7.9 (4.82 to 13.10)		7.9 (4.62 to 13.56)	
BMI categories (Poly cut-off)		0.165		0.335
BMI <26	Reference		Reference	
26 ≤BMI <32	0.7 (0.41 to 1.03)		0.6 (0.38 to 1.04)	
BMI ≥32	0.6 (0.41 to 0.94)		0.7 (0.44 to 1.14)	
BMI categories		0.534		
18.5 ≤BMI <25	Reference			
25 ≤BMI <30	0.9 (0.50 to 1.54)			
30 ≤BMI <35	0.8 (0.49 to 1.44)			
35 ≤BMI <40	0.7 (0.38 to 1.14)			
BMI≥40	0.8 (0.49 to 1.47)			
Diabetes		0.138		0.864
No diabetes	Reference		Reference	
Diabetes	1.3 (1.02 to 1.74)		0.9 (0.69 to 1.27)	
Pre-diabetes	0.9 (0.65 to 1.36)			
Hypertension		0.002		0.332
No hypertension	Reference		reference	
Hypertension	1.6 (1.24 to 1.99)		1.1 (0.87 to 1.52)	
Smoking status		0.005		0.031
Never smoked	reference		reference	
Ex-smoker	0.7 (0.37 to 1.54)		0.7 (0.30 to 1.42)	
Current smoker	0.6 (0.44 to 0.83)		0.7 (0.49 to 0.95)	
Sex		0.207		0.065
Male	reference		reference	
Female	1.2 (0.92 to 1.47)		1.3 (0.98 to 1.66)	
Location		0.719		0.580
Urban	reference		reference	
Rural	1.0 (0.82 to 1.32)		0.9 (0.73 to 1.22)	
Education		<0.001		
Primary	reference			
Secondary	0.8 (0.29 to 2.27)			
Tertiary	0.4 (0.15 to 1.23)			
Profession		<0.001		
No formal employment	reference			
Employed	0.5 (0.42 to 0.71)			
Retired	3.4 (1.21 to 9.29)			
Student	0.4 (0.10 to 1.50)			
Waist circumference		0.085		

Continued

Table 2 Continued

Characteristics	Unadjusted OR		Adjusted OR*	
	OR (95% CI)	Likelihood p value	OR (95% CI)	Likelihood p value
per 1 cm	1.0 (1.00 to 1.01)			

*Adjusted for age in 10-year categories, BMI categories (Polynesian cut-off), diabetes, hypertension, smoking status, sex and location. Education, profession, and waist circumference excluded due to collinearity. No variables removed on stepwise backward logistical regression.
BMI, body mass index; CKD, chronic kidney disease.

and was predominantly an urban population around the capital of Apia. The increased prevalence may be due to a number of factors including the wider screening of both rural and urban Samoan communities, and an increased awareness of CKD as the NKFS had invested considerably in health promotion nationally in the leadup to the screening campaign. In addition, by adding urinalysis to the screening, this allows the wider capture of earlier stages of CKD.

There is a major limitation with the use of any formulae to determine eGFR in the Samoan community. All formulae currently use a standardised correction for body surface area (BSA −1.73 m2 in the CKD EPI formula). Given the large size of Samoan people (BMI 35.4±7.4 kg/m^2) the CKD EPI formula is almost certainly overestimating the prevalence of CKD especially in the earlier CKD stage 2G–3G. However, there is no validated conversion factor for the CKD-EPI formula suitable for Samoans or any Pacific people. Previously the CKD-EPI formula had a correction factor for race (African-Americans) but this correction was not validated for other ethnic groups.[17] The recommendations of joint task force of the NKF-ASN that a modification to the CKD-EPI formula on the basis of race should be remove has now been adopted.[18] Hence while the increased size of the Samoan population may or may not affect the determination of the eGFR, which we accept as a limitation, we do not believe correcting the data for BSA, adds any additional value to this community survey. Despite this, we still believe the increased prevalence of CKD identified in this community screening programme is a real finding.

Compared with the earlier screening,[6 7] the prevalence of obesity and hypertension have increased. However, the prevalence of diabetes found in this WKD screening study (30.8%) is lower than the prevalence documented in the 2014 screening.[7] The previous studies used presumed fasting (but which were not validated) blood sugar levels (≥6.1 mmol/L) from finger prick blood tests to define diabetes whereas the NKFS screening study used point of care HbA1c testing which is recognised as the gold standard for diabetes diagnostic testing.[19] This is the first study in Samoa to use HbA1c testing and the prevalence of 30.8% is likely to reflect the current Samoan prevalence of diabetes. The increasing trends of diabetes and hypertension, have been monitored closely in Samoa[6 7 20 21] and have seen the development of MOH policies to address these health issues, which may also have contributed to the difference seen in the prevalence of diabetes.

The results of the adjusted regression models showing a reduced association with diabetes, hypertension, obesity, smoking and CKD, after strong unadjusted associations, were not expected. Diabetes and hypertension have been strongly associated with CKD in studies elsewhere in both adjusted and unadjusted models,[22–27] however, these studies have been in different populations and in models with different variables often excluding one or the other. Also in previous studies in Pacific people (predominantly Samoan) living in Auckland New Zealand, it has been demonstrated that there is a high concordence of CKD within Pacific (predominantly Samoan) families, even when controlled for diabetes and hypertension, suggesting other familial or ethnic factors may be important.[28] This study was not able to determine causal effects nor determine which comorbodity came first with respect to diabetes, hypertension and obesity leading to CKD thus it is possible one or more of these may contribute to CKD. This is an area for further investigation.

Previous studies looking at smoking and CKD have shown increased risk of CKD associated with the duration and quantity of smoking.[29] Smoking's negative association with CKD needs further investigation and may be a reflection of the greater impact of the other assumed risk factors such as obesity and diabetes within this particular population. Misclassification is another possibility, as participants may have been unwilling to share if they smoked. There is a stigma associated with smoking in Samoa within families, many disapproving of family members especially women and youth smoking.[30] There is also a misunderstanding with some people associating smoking only with tailor made cigarettes and not 'tapa'a Samoa', the local tobacco.

The information gathered on the indicators for CKD suggest testing for CKD using urinalysis and eGFR needs to occur in high risk groups which include increasing age (45 years and onwards), and in people with diabetes and hypertension. Using a urine dipstick to determine proteinuria will underestimate the true prevalence of CKD detected out in the community, as it would have been expected that most diabetics with nephropathy would have had an elevated urinary albumin/creatinine ratio despite a negative urine dipstick test for proteinuria. A repeat urinalysis would also have been of values

as albuminuria may resolve in around 35% of patients on rechecking.[31] However, in a resource-limited country such as Samoa, dipstick analysis for proteinuria remains the most cost effective screening test. Of note, 59.7% of participants with proteinuria had an eGFR >60 mL/min/1.73 m^2 and thus demonstrates the importance of proteinuria tesing during screening. A switch to urine albumin:creatinine ratio point of contact testing in further studies will be beneficial and may reveal a higher CKD burden. While women were asked about menses (to exclude a false positive test for haematuria), it is possible women may not have shared this information as culturally, menses is a sensitive subject particularly when interacting with males.

Of interest, the finding that 9.4% of the population had microhaematuria, raises the possibility of undiagnosed glomerulonephritis contributing to the increased prevalence of CKD. Samoa's very limited health resources prevents any further investigations of causes of underlying CKD. There are no nephrologists or pathologists, so renal biopsies are not feasible, and the sole laboratory attached to the main hospital also has very limited resources for investigations. Studies from New Zealand have shown Pacific people aged 15–44 years old had higher rates of ESKD due to glomerulonephritis compared with non-Māori non Pacific or Māori.[32] Also, in the only biopsy -proven study of glomerulonephritis, that included Pacific people, demonstrated a higher incidence of membranoproliferative glomerulonephritis and focal segmental glomerulonephritis but low rates of mesangial IgA glomerulonephritis in Pacific people (most of whom were Samoan) living in New Zealand.[33]

Samoa has no clinical guidelines nor a national screening programme to help detect CKD. The Samoan MOH in 2015, contextualised and piloted the WHO's package of essential NCDs interventions which was developed around a community service to detect early NCDs and refer as appropriate. However since then, this has only been rolled out in 17 of 431 villages in Samoa suggesting a more pro-active stance on screening is required.[34] Such programmes would allow early intervention to prevent development and progression of CKD. Also impacting on this is a primary healthcare system that is not fully developed and largely delivered through the secondary hospital services.[35 36]

The NKFS (a state owned organisation) has developed an organisation-based screening programme which has been refined to a point where they are able to detect CKD with point of care screening in the community and they have been implementing this regularly both in rural and urban areas over the past 5 years. This is the first detailed analysis of this programme.

The design of the screening programme is a strength in this study ensuring the required information was collected. There were, however, several limitations. First, this study only looked at one test result for eGFR and urinalysis and therefore these results reflect an estimation of CKD prevalence. Selection bias is a consideration if only those with an invested interest in being tested for CKD because either having a family member diagnosed or themselves feeling unwell may present. However, the screening programme was open to all people living in Samoa, with no restrictions placed on any adults who wished to participate. Recall bias was a possibility, as participants were asked questions about past medical history that they may not recall due possibly to low health literacy and observation bias leading to misclassification. Missing values limit the interpretation of data. Reasons for the different missing values identified, include staff errors in documenting or acquiring demographic and clinical information; machine error with the point of care devices and inability of the participant to provide a sample. Also, with respect to haematuria, while women were asked about menses, it is possible women may not have shared this information as culturally, menses remains a sensitive subject particularly when interacting with males.

It was also noted anecdotally among the staff, that some participants had health literacy issues which may have affected the responses to the health questions. Of those with missing data, there were 22 of 1163 (1.9%) people without point of care testing. They were still able to have their blood pressure, BMI and proteinuria measured. Eight of these 22 had HbA1c testing with two identified as diabetic, eleven were found to have high blood pressure and sixteen categorised as obese. With CKD risk factors prevalent in this small group it is possible some of these 22 participants may have undetected CKD. This screening programme was cross sectional and thus difficult to untangle causal relationships or direction with respect to risk factors and CKD. A longitudinal study following individuals to determine development of risk factors and/or CKD would be needed to further evaluate this.

Evaluating access to healthcare in rural vs urban areas is critical as chronic diseases often expose inequities in health associated with access to healthcare. An evaluation of the current healthcare system and in particular primary care services in Samoa is needed. Several studies in Samoa have highlighted areas for improvement in the current primary healthcare system which included delivery of curative care as opposed to preventative care, few healthworkers trained in primary care and financial investment.[37–39] The continued use and importance of traditional healers and Samoan beliefs around sickness and health and how this influences engagement with the western health system should also be investigated and navigated sensitively.

This study has highlighted important factors for the NKFS organisation to consider as they move forward with respect to identifying those at risk for CKD and introducing strategies to target the associated risk factors of obesity, diabetes and hypertension. Such planning needs to incorporate aggressive management plans for people identified with CKD and/or risk factors with ongoing follow-up and continuity of care. It is evident that future planning needs to focus more on prevention targeting both men and women and at younger ages most likely

in school age years. Planning and implementation need to be delivered both in rural and urban communities addressing the unique complexities of each community. In addition to screening, health education to develop awareness around CKD and associated risk factors will be important. This will involve working closely with the MOH.

In summary, this study demonstrates a high burden of CKD and related NCDs in Samoa. This is likely a similar picture in other Pacific Island nations. There is a need for further research to understand better the associations of the risk factors for CKD in Samoa and to continue to document CKD prevalence with repeated testing on a regular basis. Knowing the burden of earlier CKD stages, supporting earlier intervention and addressing health literacy are key areas for the NFKS as they plan future activities to address this growing CKD concern. The goal is to have CKD recognised as an important NCD with a national focus on management.

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Ethics approval Approval for this screening activity was obtained from the NKFS board and NKFS research committee. It was designed to inform the activities of the NKFS as they reviewed their strategic plan for the next four4 years as well as to provide information on the extent of CKD to the Ministry of HealthMOH and the Samoan government.

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