BMJ Open

Urban–rural health disparity among patients with chronic kidney disease: a cross-sectional community-based study from 2012 to 2019

Yi-Lien Wu,[1,2] Yun-Chun Wu,[3] Andrei R Akhmetzhanov,[3,4] Mei-Yi Wu,[5,6] Yuh-Feng Lin,[7,8] Chia-Chin Lin [2,9]

To cite: Wu Y-L, Wu Y-C, Akhmetzhanov AR, *et al*. Urban–rural health disparity among patients with chronic kidney disease: a cross-sectional community-based study from 2012 to 2019. *BMJ Open* 2024;**14**:e082959. doi:10.1136/bmjopen-2023-082959

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-082959).

Received 08 December 2023
Accepted 27 June 2024

For numbered affiliations see end of article.

Correspondence to
Professor Chia-Chin Lin; cclin@hku.hk

ABSTRACT

Objectives The incidence of chronic kidney disease (CKD) is increasing owing to the ageing population, resulting in an increased demand for dialysis and kidney transplantation, which can be costly. Current research lacks clarity regarding the relationship between residence setting and CKD prevalence or its related risk factors. This study explored the urban–rural disparities in CKD prevalence and risk factors in Taiwan. Our findings will aid the understanding of the distribution of CKD and the design of more effective prevention programmes.

Design This cross-sectional community-based study used the Renal Value Evaluation Awareness and Lift programme, which involves early screening and health education for CKD diagnosis and treatment. CKD prevalence and risk factors including alcohol consumption, smoking and betel nut chewing were compared between urban and rural areas.

Setting Urbanisation levels were determined based on population density, education, age, agricultural population and medical resources.

Participants A total of 7786 participants from 26 urban and 15 rural townships were included.

Results The prevalence of CKD was significantly higher in rural (29.2%) than urban (10.8%) areas, representing a 2.7-fold difference (p<0.0001). Risk factors including diabetes (rural vs urban: 21.7% and 11.0%), hypertension (59.0% vs 39.9%), hyperuricaemia (36.7% vs 18.6%), alcohol consumption (29.0% vs 19.5%), smoking (15.9% vs 12.0%), betel nut chewing (12.6% vs 2.8%) and obesity (33.6% vs 19.4%) were significantly higher (p<0.0001) in rural areas.

Conclusions The prevalence of CKD is three times higher in rural versus urban areas. Despite >99% National Health Insurance coverage, disparities in CKD prevalence persist between residential areas. Targeted interventions and further studies are crucial for addressing these disparities and enhancing CKD management across different settings.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study used a large sample size and cross-sectional community-based approach to contribute to the existing body of knowledge on chronic kidney disease (CKD) prevalence and risk factors, particularly among asymptomatic individuals who may not seek or have limited access to medical care.
⇒ Our study exhibits strength by using estimated glomerular filtration rate and urine protein/creatinine ratio to define CKD stages, enabling the inclusion of early-stage CKD patients, in contrast to previous studies, including those using Taiwan National Health Insurance database data, which often excluded individuals with early-stage CKD.
⇒ Our study collected data on various CKD-related risk factors, such as alcohol intake, smoking, betel nut chewing, over-the-counter medicine use, Chinese medicine use and obesity, employing a comprehensive approach to estimate potential urban–rural differences in CKD prevalence.
⇒ A limitation of our study is the use of convenience sampling for participant recruitment, which may introduce potential selection bias; nevertheless, the consistent application of this method in both urban and rural areas support the reliability of our estimated CKD prevalence disparity ratios.
⇒ The study's reliance on cross-sectional screening data to define CKD stages, lacking access to complete follow-up data that may lead to an overestimation of CKD prevalence because the diagnosis typically requires two tests over a 3-month period.

INTRODUCTION

The global prevalence of chronic kidney disease (CKD) has remained stable for three decades; however, its crude prevalence has increased significantly owing to an ageing population, rising from 26.4% to 32.6% between 1990 and 2017.[1] This has heightened the demand for dialysis and kidney transplantation. Although dialysis can prolong the life of patients with CKD, the associated costs are prohibitive. In Taiwan, end-stage renal disease affected 0.3% of the population in 2017 and accounted for more than 7% (equivalent to US$1.5 billion) of healthcare expenditures for dialysis.[2] With the Taiwanese population aged >80 years projected to increase 2.5-fold by 2050,[3] the demand for dialysis is expected

to increase, underscoring the urgent need for strategies to reduce the incidence of CKD and delay the progression of kidney function decline.

The development of CKD is commonly associated with diabetes,[4] hypertension,[5] hyperuricaemia,[6] obesity,[7] cigarette smoking[8] and betel nut chewing (specific to Taiwan).[9] Addressing these factors through lifestyle changes such as intensive glucose control,[10] optimal blood pressure management,[11] dietary protein restriction,[12 13] uric acid-lowering therapy[14] and smoking cessation[15] slow the deterioration of kidney function and improve health outcomes of patients with CKD. Social determinants of health may also increase the risk of CKD incidence and progression; however, they are often overlooked by the medical and public health systems.

Residential area is a social determinant of CKD development. Although geography alone is not responsible for poor health outcomes, it often intersects with race, poverty and access to healthcare. In rural areas, limited healthcare access due to long distances to facilities and fewer providers may lead to poor health outcomes,[16–18] especially for residents with a low socioeconomic status who may struggle to afford medical expenses. For example, in Canada, the prevalence of CKD and diabetes is higher among rural residents, particularly Indigenous people, compared with urban residents.[19 20] Similar findings have been observed in populations from Cameroon, Malawi, India and China.[21–24] However, in Taiwan, a prior study reported a higher prevalence of CKD in urban areas.[25] Notably, this study used data from the National Health Insurance (NHI) database, focusing exclusively on individuals with access to healthcare or advanced-stage CKD. This approach may introduce bias by systematically under-representing CKD patients in rural areas, where individuals might have a shorter life expectancy and reduced access to healthcare.

Therefore, knowledge is limited regarding the prevalence of CKD in rural communities with restricted access to healthcare. This study aimed to compare the prevalence of CKD in urban and rural areas of Taiwan using data from the Renal Value Evaluation Awareness and Lift (ReVEAL) programme. The ReVEAL programme included early screening and health education, in 41 townships in Taiwan with varying urban and rural characteristics. Investigating CKD prevalence and associated geographical and sociodemographic factors can help to estimate the future burden of CKD, thereby helping policy-makers understand CKD distribution and informing the design of targeted and efficient prevention programmes.

MATERIALS AND METHODS

Study population

The ReVEAL programme was a community screening initiative conducted in 2012–2019. It used a convenience sampling approach and used the first-time data point for each participant (online supplemental table 1). Screening information was disseminated by local governors, health units, partner groups and the local media. We actively worked to ensure that our message reached every corner of the community to allow everyone aged 20 years or older, excluding those with serious mental illnesses, to participate. Screening procedures were conducted at various locations such as community centres, schools, churches and parks. In our study, the process of estimating the sample size involved the following steps. Initially, we defined the primary outcome variable and formulated the research hypothesis, with the aim of detecting a significant difference in mean scores between two groups using a two-sample t-test. The selected significance level (α) was established at 0.05, and the desired power ($1-\beta$) was set at 0.80. Subsequently, we set the assumed prevalence rates for CKD at 10% for urban areas and 15% for rural areas, aligning with our hypothesis suggesting a potential disparity in prevalence between these two settings. This distinction was grounded in a review of existing literature.[26 27] Following the calculations by using an online tool, the required sample size for our study was at least to be 683 (https://select-statistics.co.uk/calculators/sample-size-calculator-two-proportions/).

Definition of urban and rural areas

To define urban and rural areas in Taiwan, this study used township urbanisation levels based on factors such as population density, the proportion of the population with a college degree or above, the proportion of the population >65 years of age, the proportion of agricultural workers and the number of doctors per 100 000 people.[28] Previous studies used this stratification.[29–31] Adopting the same stratification, we further implemented levels 1–4 for urban areas and levels 5–7 for rural areas (online supplemental table 2). Our analysis included data from 41 townships comprising 26 urban and 15 rural areas. In our study, we used current living location rather than using their address in the official household registration system because the previous study has shown that around 19.4% of the population encounters differences between their address in the official household registration system and actual places of residence, and this inconsistency is particularly noticeable in specific areas.[32]

Definition of risk factors

In this study, the risk factors were defined as follows: alcohol use as currently or ever having consumed alcohol; smoking as currently or ever having smoked; betel nuts as currently or ever having chewed betel nuts and over-the-counter medications as medicines not prescribed by a physician, such as liver-protecting pills, kidney-protecting pills, diet pills and pain relievers. An oversized waist was defined as a waist circumference of >90 cm for men and >80 cm for women.

ReVEAL programme

The ReVEAL programme in Taiwan aims to detect CKD early using a screening and health education programme

comprising: (1) individual questionnaire interviews; (2) health examinations and (3) health education lectures. The details of each component are as follows.

Individual questionnaire interview

Individual interviews were conducted using a questionnaire that included demographic questions and questions about risk factors such as alcohol intake, smoking, betel nut chewing, and the use of over-the-counter and Chinese medicines. The participants were also asked about their self-reported disease history, including CKD, hypertension, diabetes mellitus (DM), hyperuricaemia and hyperlipidaemia.

Health examination

The health examination involved physical measurements and the collection of blood and urine samples to test for glucose, total cholesterol, triglycerides, uric acid, and serum creatinine levels and urine protein/creatinine ratio (UPCR).[33] Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease formula.[34] A UPCR of 150 mg/g was used to convert to the equivalent UACR of 30 mg/g.[35] These values were used to determine CKD stages following the Kidney Disease Improving Global Outcomes guidelines.[36] Stage I was defined as a UPCR≥150 mg/g with an eGFR≥90 mL/min/1.73 m^2, stage II as a UPCR≥150 mg/g with an eGFR of 60–89 mL/min/1.73 m^2, stage III as an eGFR of 30–59 mL/min/1.73 m^2, stage IV as an eGFR of 15–29 mL/min/1.73 m^2 and stage V as an eGFR<15 mL/min/1.73 m^2.

Case definitions

Following the survey and health examination, the following case definitions were used to summarise the demographic statistics. An oversized waist was defined as a waist circumference of >90 cm for men and >80 cm for women. Obesity was defined as a body mass index ≥27 kg/m^2. Proteinuria was defined as a UPCR≥150 mg/g. CKD was defined as an eGFR<60 mL/min/1.73 m^2 or a UPCR≥150 mg/g. DM was defined as a fasting blood glucose level of ≥126 mg/dL or self-reported DM. Hypertension was defined as a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg or self-reported hypertension. Hyperuricaemia was defined as a blood uric acid level of ≥7.5 mg/dL for men and ≥6 mg/dL for women or self-reported gout. Hyperlipidaemia was defined as a blood cholesterol level ≥200 mg/dL, blood triglyceride level ≥150 mg/dL or self-reported hyperlipidaemia.

Health education lecture

Health education lectures were conducted by a team of nephrologists, CKD health educators and dietitians. The main goal was to raise the participants' awareness of kidney disease, kidney function, the importance of proper dietary habits and encourage them to seek medical attention if abnormal kidney function was suspected. The participants were given a report after the examination; if they had abnormal renal function, nursing staff referred them for medical treatment. This health education lecture was an important aspect of the programme, as it provided valuable information that could help prevent or manage kidney disease.

Statistical analyses

Descriptive statistics were used to summarise the participants' clinical characteristics. Continuous variables are described as mean and SD, whereas categorical variables are presented as absolute value and percentage. The clinical characteristics were compared between urban and rural participants using t-tests for continuous variables and χ^2 tests for categorical variables. Statistical significance was set at $p<0.05$. The age-standardised prevalence of CKD was calculated using the 2018 Taiwanese population structure as the standard population. Multivariate logistic regression was used to investigate the differences in CKD risk between rural and urban areas. The age-dependent prevalence of CKD was fitted to the data using a Gaussian process within a Bayesian framework. SAS software (V.9.4; SAS Institute Inc) was used to perform the multivariate logistic regression analysis. The Bayesian parameter estimation of the Gaussian process was implemented in Stan (V.2.31.0; https://mc-stan.org/) using the cmdstanpy interface in Python. The Python packages Altair (V.4.2.2; https://altair-viz.github.io/) and Matplotlib (V.3.7.1; https://matplotlib.org/) were used to generate figures. The reproducible code used in this study is available at https://github.com/Luluchun/ReVEALprogram.

Sensitivity analyses

We performed a sensitivity analysis to evaluate the effect of excluding records without ID numbers on our results. Specifically, we compared outcomes when both excluding and including these records. We considered records without ID numbers as distinct individual baseline data, and our analysis aimed to determine if the exclusion had an impact on the overall results.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

RESULTS

Descriptive statistics

Among the 10 647 records initially collected in 2012–2019, 636 records were excluded due to the lack of eGFR or Proteinuria data, 530 records were excluded due to the absence of an ID number and 8 records were excluded due to individuals being under 20 years old. Therefore, we had 9473 records (corresponding to 7786 individuals) with complete data. We used the baseline data from these individuals for our analysis. Specifically, our analysis included a total of 7786 participants: 6527 from 25 urban townships and 1259 from 16 rural townships (figure 1; see geographical distribution in online supplemental figure 1).

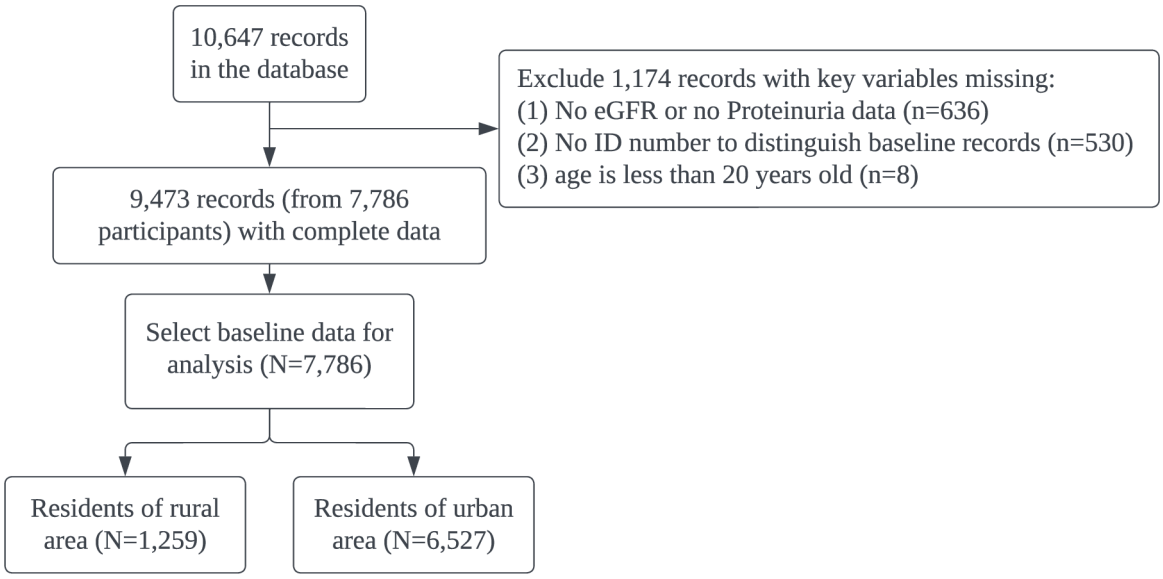

Figure 1 Flow chart of participant enrolment process. ID, identification; eGFR, estimated glomerular filtration rate.

The rural participants were older than their urban counterparts (mean age: 61.6 vs 57.3 years, p<0.0001); had lower educational attainment (66.0% with <12 years of education: 66.0% vs 23.3%, p<0.0001) and had higher rates of alcohol use (29.0% vs 19.5%, p<0.0001), smoking (15.9% vs 12.0%, p=0.0001) and betel nut use (12.6% vs 2.8%, p<0.0001) (table 1). More participants in rural areas reported taking over-the-counter medications including for weight loss, kidney, liver and painkiller (11.0% vs 8.8%, p=0.01), over-the-counter medications restricted to kidney, liver, painkiller related (10.9% vs 8.4%, p=0.005) and Chinese medicine (25.6% vs 20.5%, p<0.0001). The proportion of participants with an oversized waist was higher in rural versus urban areas (59.6% vs 38.4%, p<0.0001), as was the prevalence of obesity (33.6% vs 19.4%, p<0.0001). The prevalence of

Table 1 Demographic characteristics of study population stratified by urbanisation level

Variable	Total (N=7786)	Urban (N=6527)	Rural (N=1259)	P value
Age	58.0±13.5	57.3±13.2	61.6±14.4	<0.0001
Male	2789 (35.8)	2327 (35.6)	462 (36.6)	0.5
Less than 12 years of education	2321 (30.2)	1500 (23.3)	821 (66.0)	<0.0001
Alcohol intake (ever)	1616 (21.0)	1257 (19.5)	359 (29.0)	<0.0001
Smoking (ever)	971 (12.3)	774 (12.0)	197 (15.9)	0.0001
Betel nut chewing (ever)	340 (4.4)	184 (2.8)	156 (12.6)	<0.0001
Over-the-counter medicines (ever) including for weight loss, kidney, liver and painkiller	684 (9.1)	551 (8.8)	133 (11.0)	0.01
Over-the-counter medicines (ever) restricted to kidney, liver, painkiller related	661 (8.8)	529 (8.4)	132 (10.9)	0.0051
Chinese medicines (ever)	1626 (21.3)	1312 (20.5)	314 (25.6)	<0.0001
Oversized waist	3176 (41.9)	2442 (38.4)	734 (59.6)	<0.0001
Obesity	1163 (21.7)	1221 (19.4)	412 (33.6)	<0.0001
Proteinuria	777 (10.0)	504 (7.7)	273 (21.7)	<0.0001
CKD	1070 (13.7)	702 (10.8)	368 (29.2)	<0.0001
DM	989 (12.7)	716 (11.0)	273 (21.7)	<0.0001
Hypertension	3347 (43.0)	2604 (39.9)	743 (59.0)	<0.0001
Hyperuricaemia	1679 (21.6)	1217 (18.6)	462 (36.7)	<0.0001
Hyperlipidaemia	4003 (51.4)	3324 (50.9)	679 (53.9)	0.05

CKD, chronic kidney disease; DM, diabetes mellitus.

Table 2 Crude and age-standardised prevalence of chronic kidney disease (CKD) stratified by CKD stage and urbanisation level

	All CKD cases	Cases stratified by CKD stage				
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Crude prevalence	13.7 (13.0 to 14.5)	3.3 (2.9 to 3.8)	3.9 (3.5 to 4.4)	5.8 (5.3 to 6.3)	0.5 (0.4 to 0.7)	0.2 (0.1 to 0.3)
Urban areas	10.8 (10.0 to 11.5)	2.7 (2.4 to 3.2)	2.9 (2.5 to 3.3)	4.6 (4.1 to 5.1)	0.3 (0.2 to 0.5)	0.1 (0.1 to 0.3)
Rural areas	29.2 (26.7 to 31.8)	6.3 (5.1 to 7.8)	9.0 (7.5 to 10.8)	11.8 (10.1 to 13.7)	1.7 (1.0 to 2.5)	0.3 (0.1 to 0.8)
Age-standardised prevalence	11.1 (10.2 to 12.0)	4.1 (3.4 to 4.8)	2.6 (2.3 to 3.0)	3.9 (3.5 to 4.3)	0.4 (0.3 to 0.5)	0.1 (0.0 to 0.2)
Urban areas	9.2 (8.3 to 10.1)	3.2 (2.6 to 3.9)	2.0 (1.7 to 2.4)	3.5 (3.0 to 4.0)	0.3 (0.2 to 0.5)	0.2 (0.0 to 0.3)
Rural areas	20.8 (17.5 to 24.2)	8.6 (5.8 to 11.5)	6.0 (4.5 to 7.5)	5.3 (4.3 to 6.3)	0.8 (0.4 to 1.1)	0.3 (0.2 to 0.5)

The 2018 Taiwanese population was used as the reference population. Values are shown as percentage (95% CI).

DM (21.7% vs 11.0%, p<0.0001), hypertension (59.0% vs 39.9%, p<0.0001) and hyperuricaemia (36.7% vs 18.6%, p<0.0001) was found to be significantly higher in rural areas compared with urban areas. However, there was no statistically significant difference in the prevalence of hyperlipidaemia between urban and rural areas (53.9% vs 50.9%; p=0.05).

Values are shown as mean±SD or n (%), as appropriate. The case definitions of oversized waist, obesity, proteinuria, CKD, DM, hypertension, hyperuricaemia and hyperlipidaemia are described in the Methods section.

Prevalence and risk of CKD among residents of rural versus urban areas

The crude prevalence of CKD was estimated as 13.7% overall, 29.2% among rural residents and 10.8% among urban residents, representing a 2.7-fold increase in prevalence in rural vs urban areas. After the adjustment for age, the prevalence of CKD changed only slightly and remained high in rural areas (20.8% and 9.2% among rural and urban residents, respectively). Age-standardised prevalence stratified by CKD stage was higher in rural versus urban areas (table 2). The age-specific prevalence of CKD was significantly higher among rural versus urban residents across all age groups (figure 2A).

Among participants with abnormal renal function, 11.4% reported a history of CKD. The CKD awareness rate was generally low, with only 9.0% and 12.6% of those living in rural versus urban areas being aware of their health condition (table 3). However, the awareness rate was highly dependent on CKD stage, ranging from 2.0% in participants with stage 1 CKD to 61.5% in participants with stage 5 CKD.

The age-specific prevalence of comorbidities (DM, hyperuricaemia and hypertension) was higher in rural versus urban areas among men and women in all age groups (figure 2B). An age-specific prevalence was higher in the older age groups, except for hyperuricaemia, in rural areas. Notably, the highest age-specific prevalence of hyperuricaemia was observed in rural residents in the younger age group. Overall, alcohol consumption, betel nut consumption, obesity and smoking were more prevalent in rural areas across all age groups and for both sexes. However, the prevalence was notably higher among men compared with women, except for obesity. In rural areas, the prevalence of obesity was similar for both men and women, although among older women, it was slightly higher compared with men (figure 2C).

The crude OR for CKD in rural versus urban areas was estimated at 3.4 (95% CI 3.0 to 4.0) (online supplemental table 3). After the adjustment for age, sex and education (<12 vs ≥12 years), the adjusted OR was 2.7 (95% CI 2.3 to 3.1). Further adjustment for age, sex, education, DM, hypertension and hyperuricaemia resulted in an adjusted OR of 2.2 (95% CI 1.8 to 2.6) while the adjustment for obesity led to an OR of 2.1 (95% CI 1.8 to 2.5). Finally, after the adjustment for over-the-counter medicine and Chinese medicine use, the adjusted OR was 2.1 (95% CI 1.8 to 2.6).

Sensitivity analysis

This study excludes 530 records from participants who did not provide the ID number. Since we used their ID number to confirm whether the records were baseline or follow-up records, we decided to exclude those records without the ID number for the analysis of this study. To further investigate whether this exclusion criteria would affect results, we conducted sensitivity analysis to compare the results including those without ID while taking those records as individual data from the baseline. Their results showed a similar pattern to our main findings (online supplemental table 4).

DISCUSSION

This study found that the overall crude prevalence of CKD was nearly three times higher among residents of rural versus urban areas in Taiwan. This estimate persisted across all CKD stages and was adjusted to a twofold increase after age standardisation. Despite Taiwan's NHI system covering >99% of the population for more than two decades, disparities persist in the prevalence of CKD between urban and rural areas. In addition to this key finding, our study identified urban–rural differences in

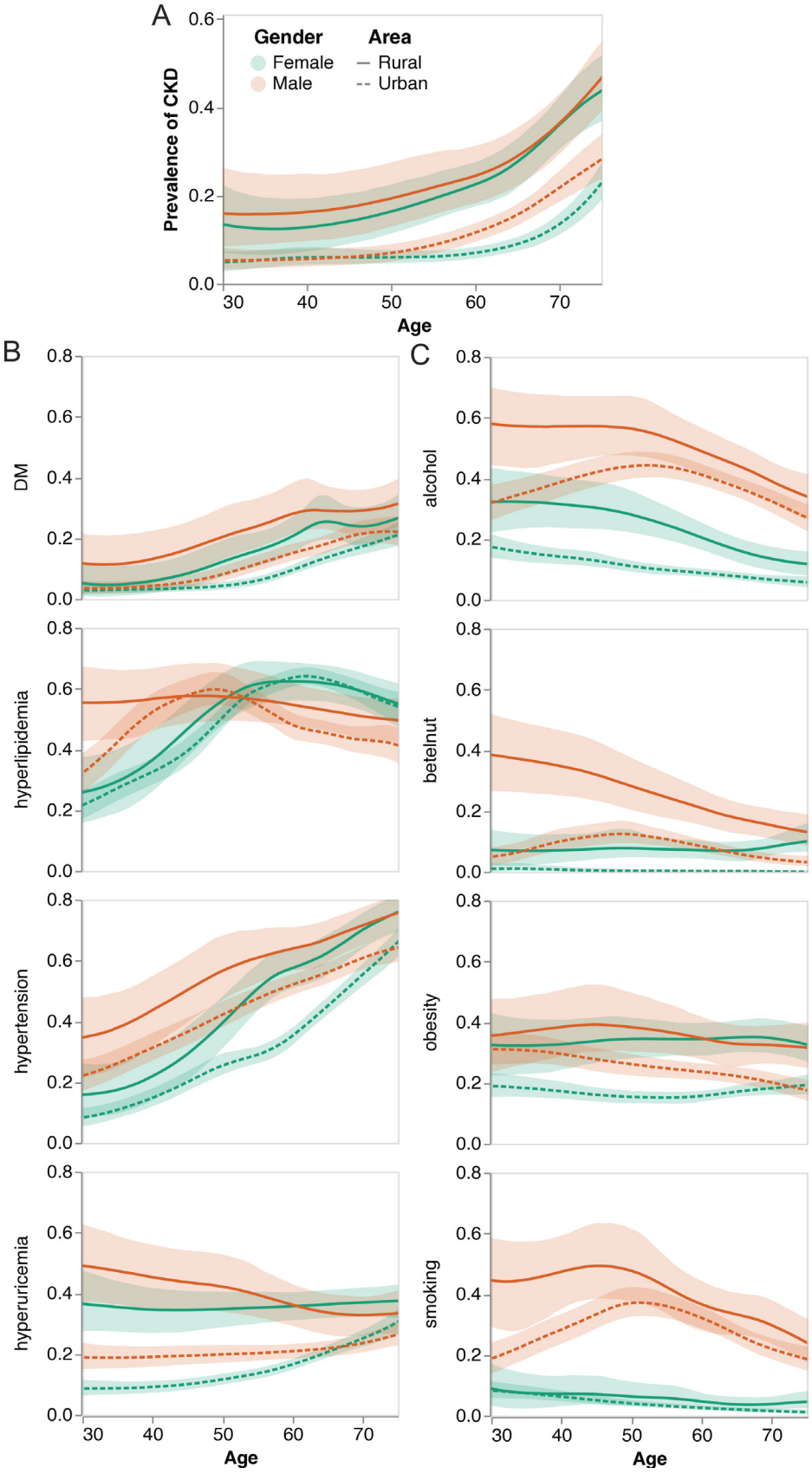

Figure 2 (A) Prevalence of CKD stratified by age, sex and urbanisation level compared with other chronic diseases (B) and related risk factors (C). Chronic diseases include DM, hyperlipidaemia, hyperuricaemia and hypertension. Risk factors included alcohol intake, betel nut consumption, obesity and smoking history. The lines indicate the median of the posterior distribution while the shaded areas indicate the 95% CI.

Table 3 Percentage of participants with chronic kidney disease (CKD) stratified by stage and awareness of the diagnosis

Awareness	All CKD	CKD stages				
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Total	120/1055 (11.4%)	5/254 (2.0%)	15/300 (5.00%)	71/446 (15.9%)	21/42 (50.0%)	8/13 (61.5%)
Urban areas	87/690 (12.6%)	3/175 (1.7%)	10/187 (5.3%)	56/297 (18.9%)	11/21 (52.4%)	7/10 (70.0%)
Rural areas	33/365 (9.0%)	2/79 (2.5%)	5/113 (4.42%)	15/149 (10.1%)	10/21 (47.6%)	1/3 (33.3%)

CKD-related risk factors, suggesting that urban–rural disparities in CKD prevalence may continue in the future.

The overall age-standardised prevalence of CKD (11.1%) estimated here falls within the range of 9.8%–15.5% reported in other studies in Taiwan.[26 27 37] However, one study reported a higher prevalence of CKD among the residents of urban areas in Taiwan,[25] which contradicts our results. A possible explanation for this discrepancy is the inability to identify CKD cases. First, it was based on data from patients who sought medical advice and were diagnosed with CKD at the hospital. However, many patients with CKD remain undiagnosed without active screening, owing to the low awareness of CKD, particularly in rural areas, or the asymptomatic nature of CKD in its early stages. In our study, only 11.4% of the participants with CKD were aware of their condition, a finding that is consistent with previous research in Taiwan.[38 39] Second, rural areas in Taiwan have fewer nephrologists per capita than urban areas, leading to lower CKD awareness and delayed CKD diagnoses. Consequently, the cited study[25] may have underestimated the prevalence of CKD in rural areas. Furthermore, based on this comparison, we assert that using claims data to compare CKD prevalence between rural and urban areas is inappropriate. Claims data primarily reflect hospital visit behaviour and only capture advanced disease stages. For diseases like CKD, early-stage awareness is often lacking, and accurate diagnosis relies on laboratory data confirmation. Therefore, active screening remains essential when investigating this topic to avoid misguided health policy decision-making.

Although the NHI system in Taiwan features improved access to medical services,[40] our study found that a disparity persists in the prevalence of CKD in urban versus rural areas. Efforts have been made to reduce this disparity through the implementation of integrated delivery systems (IDSs) in rural areas. While IDSs aim to encourage doctors to provide medical services in rural areas, its impact on narrowing the urban–rural gap has been limited.[41] Taiwan has observed statistically significant urban–rural inequality in the rates of CKD and other health complications, including heart failure, stroke, end-stage kidney disease and DM-related amputations.[30 31] The Global Burden of Disease report of 2015 highlighted the high rate of dialysis in Taiwan and identified areas where the quality of healthcare for patients with CKD could be improved.[41 42]

Moreover, recent research has emphasised that rurality can pose unique challenges for paediatric nephrology patients worldwide, leading to barriers accessing kidney replacement therapy options.[43] This is exacerbated by the uneven distribution of paediatric nephrologists in under-resourced and rural areas. It also discusses the variable adoption of telehealth in different regions during the SARS-CoV-2 pandemic and clinicians' perceptions of telemedicine in clinical encounters. Telehealth is recognised as a valuable tool for expanding the geographical reach of medical services as it can improve healthcare accessibility in rural and underserved areas. Following expert recommendations, the Taiwanese government began building a telemedicine infrastructure in 2021 to enhance healthcare accessibility for people living in rural or underserved areas. Although telemedicine has its limitations, such as the inability to fully replace clinical functions (eg, biochemical tests), it can still improve healthcare accessibility. However, active CKD screening in rural areas remains essential and cannot be replaced by telemedicine; thus, this problem requires further investigation.

Strengths and limitations

Our study has several strengths. First, we used eGFR and UPCR to define the CKD stages, which allowed us to include patients with early-stage CKD, who were often excluded from previous studies, including those that used data from the Taiwan NHI database. Second, we determined each participant's current residential area to discern the difference in CKD prevalence between urban and rural areas instead of relying on the site of medical care. And finally, we collected data on various CKD-related risk factors, such as alcohol intake, smoking, betel nut chewing, over-the-counter medicine use, Chinese medicine use and obesity, which can help estimate potential future urban–rural differences in CKD prevalence.

Our study also has some limitations. First, the participants were recruited using convenience sampling, which may have introduced selection bias. However, we used the same method in urban and rural areas to estimate the disparity ratio of CKD prevalence; therefore, our findings are unlikely to be biased. Second, we used only cross-sectional screening data to define CKD stage and did not have access to complete follow-up data. Therefore, the prevalence of CKD may have been overestimated because the diagnosis required two tests over a 3-month period. However, it is worth noting that similar limitations are encountered in other community screening initiatives. Third, during the data analysis process, we excluded 1174 (11%) records. These exclusions primarily consisted of

530 (5%) records without ID numbers and 636 (6%) records lacking essential eGFR or UPCR data. The missing data could be attributed to reasons such as data privacy concerns (individuals not wanting to provide their ID numbers), forgetfulness (participants may not have brought their IDs) and in the case of females, missing UPCR due to menstruation (as urine samples may contain blood during this time). Additionally, some participants were reluctant to undergo blood examinations or had a fear of blood extraction. The voluntary nature of our screening programme allowed participants to decide whether to provide these data. However, we conducted a sensitivity analysis, and it showed consistent findings with our primary results, mitigating concerns regarding this exclusion. Although we are unable to provide coverage of this study in Taiwan, we conducted a comparative analysis of smoking prevalence using data from the National Health Interview Survey (NHIS) in Taiwan for 2009 and 2013 (online supplemental table 5). Despite the higher average age of our study participants compared with the NHIS population, we specifically focused on the same age group (over 65 years old) for a meaningful comparison. In NHIS 2009 and 2013, the smoking rates for males over 65 were 24% and 19%, respectively. Our current study reports a slightly lower rate of 22.3%. For females over 65, NHIS recorded rates of 1.4% and 1.6% in 2009 and 2013 while our study found a higher rate of 2.3%. Therefore, the findings suggested that concerns about the generalisability and absence of a formal sampling approach in our study may be alleviated, given the consistency of results with established national survey data. Finally, our study did not include information on income or race or ethnicity, which may have affected the differences in CKD prevalence between urban and rural areas. A study in Canada reported that racial disparities in CKD prevalence and differences in residential patterns may be related to the differences in CKD prevalence between urban and rural areas.[19] Thus, it would be beneficial to include race as a factor in future studies of CKD in Taiwan to explore its potential impact.

CONCLUSIONS

As early-stage CKD is asymptomatic and renal function deterioration is irreversible, it is essential to implement early screening programmes to increase public awareness, especially in areas with limited resources. In such resource-constrained settings, our focus extends beyond merely promoting kidney disease prevention and emphasises the critical importance of health promotion by targeting risk factors associated with CKD. The ReVEAL programme not only included kidney function screening and related risk factor assessments but it also featured education on CKD symptoms, long-term consequences of CKD deterioration and ways to reduce risk factors. Our results will guide the continuation of the ReVEAL programme in areas where it is needed and promotion of the health of patients with CKD risk factors.

Author affiliations
[1]Taiwan Kidney Foundation, New Taipei City, Taiwan
[2]School of Nursing, College of Nursing, Taipei Medical University, Taipei, Taiwan
[3]Institute of Epidemiology and Preventive Medicine, National Taiwan University College of Public Health, Taipei, Taiwan
[4]Global Health Program, National Taiwan University College of Public Health, Taipei, Taiwan
[5]Department of Nephrology, Department of Internal Medicine, Taipei Medical University Shuang Ho Hospital Ministry of Health and Welfare, New Taipei City, Taiwan
[6]Division of Nephrology, Department of Internal Medicine, School of Medicine, Taipei Medical University College of Medicine, Taipei, Taiwan
[7]Graduate Institute of Clinical Medicine, Taipei Medical University, Taipei, Taiwan
[8]Division of Nephrology, Department of Internal Medicine, Taipei Medical University Shuang Ho Hospital Ministry of Health and Welfare, New Taipei City, Taiwan
[9]The University of Hong Kong, Hong Kong, Hong Kong

X Andrei R Akhmetzhanov @aakhmetz

Acknowledgements We thank the individuals involved in the ReVEAL programme and the Taiwan Kidney Foundation for their invaluable support. We thank Russell Shean for proofreading the manuscript. We would like to thank Editage (www.editage.com.tw) for English language editing.

Contributors Y-LW, M-YW, Y-FL and C-CL were responsible for research ideas and study design. Y-LW was responsible for the data acquisition. Y-LW, Y-CW and ARA were responsible for the data analysis and interpretation. Y-CW and ARA were responsible for the statistical analysis. Y-LW and Y-CW wrote the original manuscript. Y-LW is the guarantor of the study and had access to the data. All authors reviewed and approved the final version of the manuscript.

Funding This project was funded by the Taiwan Kidney Foundation (grant no. ReVEAL0001).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Institutional Ethics Committee of the Office of Human Research at Taipei Medical University (201208026 and N201805013). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The data required to reproduce the results of this study are available from the Taiwan Kidney Foundation (Contact person: Y-LW; Email: elaine@tckdf.org.tw) on reasonable request.

ORCID iD

Chia-Chin Lin http://orcid.org/0000-0001-9551-0991

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