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Awareness of chronic kidney disease and its risk factors in the former Soviet Union countries

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ABSTRACT

Purpose: Assessment of public knowledge of chronic kidney disease (CKD) is an essential step in development of CKD prevention and screening programs. Our aim was to estimate the level of public CKD knowledge and its predictors in the former Soviet Union countries using a validated questionnaire.

Materials and methods: This cross-sectional survey was conducted in 10 countries using an adapted validated online questionnaire. Descriptive statistics were used to describe participants' characteristics and assess public CKD knowledge level. A multiple linear regression analysis was performed to identify predictors of CKD knowledge.

Results: 2,715 participants satisfied the inclusion criteria. Respondents having higher level of education, living in countries belonging to the lower middle-income countries, having a personal history of diabetes and hypertension, and having a family history of kidney disease showed significantly better CKD knowledge.

Conclusions: The level of CKD knowledge among the population of post-Soviet states was found to be low, although some personal characteristics were associated with better CKD knowledge.

Keywords: CKD awareness, CKD knowledge, population-based survey

INTRODUCTION

According to kidney disease improving global outcomes, chronic kidney disease (CKD) is defined as structural kidney damage or decreased kidney function persistent for ≥3 months, with implications for health [1]. A comprehensive meta-analysis of 100 studies identified the worldwide CKD prevalence to be 13.4% for CKD stages 1-5 and 10.6% for CKD stages 1-3 [2]. These numbers are probably underestimated because CKD is rarely recognized at the early stages. While the global age-standardized CKD prevalence increased by 1.2% from 1990 to 2017, that change was larger for countries of Central Asia (Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Turkmenistan, Uzbekistan) represented by a 7.5% increase [3]. However, that difference from the global statistics does not seem to be dramatic compared to the age-standardized CKD mortality rate: A 60.9% increase in Central Asian countries versus the global 2.8% increase from 1990 to 2017 [3].

Progression of CKD leads to a kidney failure, requiring patients to receive kidney replacement therapy (KRT) that includes dialysis and kidney transplantation to sustain life. Besides very high morbidity and mortality rates in patients with kidney failure, this condition also puts an enormous burden on the public health. Comprehensive systematic review comprising data reported by 123 countries that represent 93.0% of world population reported that between 4.902 and 7.083 million people had kidney failure and needed KRT, whereas only 2.050 million people received it [4]. CKD is also associated with increased rates of cardiovascular diseases and deaths due to cardiovascular event. Therefore, it is hard to overestimate the importance of preventative measures and early diagnosis of CKD for delaying its' progression to later stages and prevention of CKD-related cardiovascular diseases.

Early hospital referral has been shown to delay initiation of KRT, improve patient survival, decrease length of hospitalization stay, and reduce both individual and public health costs [5-7]. The need for early referral becomes even more pronounced in view of increasing prevalence of major risk factors for CKD, including hypertension, diabetes, and obesity, to rise [8-10]. However, most people with CKD are not aware of their condition. National Kidney Foundation's kidney early evaluation program screenings (2000-2007) and the national health and nutrition examination survey (2005-2010) provided an unpromising conclusion that only 6-8% of people with CKD are aware of their disease. 37 million American people, who represent 15.0% of the US population, have CKD and as many as nine of 10 people with CKD do not know that they have it [11]. Studies conducted in other countries have confirmed overall global low CKD awareness with minor national and geographical variability [12].

Implementing screening programs intended to detect patients with CKD on earlier stages may help to slow the progression of renal impairment and decrease the incidence of kidney failure and kidney-related adverse outcomes. The strategy of screening people with risk factors of CKD had already been implemented in several countries [13]. However, solely implementing screening programs would have little effect if the public's understanding of their importance is poor. Low level of kidney health literacy and poor CKD awareness negatively affect public acceptance of the screening programs. Therefore, it is important to assess the public knowledge level before initiating development of screening programs. There was one study conducted in Australia that had similar aim to assess the CKD knowledge level of population and they have developed and validated a specific questionnaire [14]. It was found that public knowledge of CKD in Australia is poor. Studies conducted in other studies have also demonstrated poor level of CKD knowledge among their populations [15-18].

Poor CKD knowledge might not only negatively affect an acceptance of screening programs, but also it can be associated with negative health outcomes among CKD patients. The scoping review of 12 studies has demonstrated a correlation between CKD knowledge and health literacy as well as consequential association of low health literacy and poor CKD self-management behaviors [19]. Another systematic review of five cohort studies and 14,682 patients have also demonstrated an association between low health literacy and poor health outcomes, such as hospitalizations, cardiovascular events, and death among CKD patients [20].

In this study, we aim to assess the public knowledge of CKD across the post-Soviet states, particularly Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Ukraine, Uzbekistan using a validated translated questionnaire [14], as no previous similar studies assessing CKD awareness were conducted in these countries. Adopted questionnaire is provided in **Appendix A**.

MATERIALS AND METHODS

Data Collection Instrument

To assess the level of public awareness of CKD, we have employed a questionnaire, which was developed and validated by researchers, who aimed to determine the level of public knowledge of CKD in Australia [14]. The demographic component of the questionnaire was adapted to be suitable for the post-Soviet states under study, which are Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Ukraine, and Uzbekistan. The questionnaire consisted of two sections: a demographic section and a second section assessing the participant's knowledge of CKD. The demographic section included information on participant's gender, age, level of education, use of alcohol, use of tobacco, family history of kidney disease, personal history of hypertension, diabetes, heart problems, etc. The knowledge assessment component of the survey was made up of twenty-eight "true" or "false" questions focused on kidney function, tests of kidney function, risk factors for CKD, and symptoms of kidney disease. There was no response from participants contacted in Armenia and Belarus, thus both countries were excluded from the further study processes. The following steps were conducted in each country in the process of questionnaire translation to the Azerbaijani, Georgian, Kazakh, Kyrgyz, Russian, Tajik, Ukrainian and Uzbek languages:

(1) forward translation by two translators,

(2) their synthesis in one translation,

(3) two backward English translations, and

(4) translation verification by the expert committee.

Study Design

In this cross-sectional study each of the participating countries was represented by one nephrologist, who was responsible for the distribution of the recruitment message in their respective country. The recruitment message was distributed among the general public via social networks, messengers, and printed posters with QR code redirecting to qualtrics survey.

Ethical Issues

Anonymity of the respondents was created via survey settings in qualtrics. In the beginning of the survey, the respondents were asked to carefully read an informed consent. The participants were able to start the survey only if they have read and accepted the consent. Participants were allowed to ignore the questions to which they do not want to respond or finish the survey without answering all the questions if they wished to.

Study Subjects

The survey was conducted from February 2022 until April 2022. Subjects were included in the study if their age was ≥18 years. Subjects who failed to complete at least half of the survey were excluded from the study. In addition, people who reported "medicine, pharmaceuticals" as their occupation (n=1,025) were analyzed separately on bivariate tests and were excluded from the final multiple linear regression model to avoid confounding. Target sample size from each country was 385 people (95.0% confidence interval, 5.0% margin of error). However, several countries did not reach the target sample size (Ukraine n=262, Kyrgyzstan n=250, Azerbaijan n=167, Tajikistan n=96, and Georgia n=21), therefore it was decided to divide the respondents according to the 2021 World Bank income group classification. Azerbaijan, Kazakhstan, Russia and Georgia were included in upper-middle income group (UMIC, n=1,647), whereas Kyrgyzstan, Tajikistan, Ukraine and Uzbekistan were included in lower-middle income group (LMIC, n=1068).

Table 1. Characteristics of study participants

Variable	Values
Age (mean±SD, range)	38.1±12.6, 18-84
Gender n (%) (female)	1,871 (69.7)
Country n (%)	
Kazakhstan	1,069 (39.7)
Uzbekistan	440 (16.3)
Russia	387 (14.4)
Ukraine	262 (9.7)
Kyrgyzstan	250 (9.3)
Azerbaijan	167 (6.2)
Tajikistan	96 (3.6)
Georgia	21 (0.8)
Belarus	3 (0.1)
Armenia	1 (0.04)
Country income type n (%) (UMIC)	1,647 (60.7)
Education n (%)	
Master's/PhD	917 (34.0)
Bachelor's degree	1,013 (37.6)
College	403 (15.0)
High school	268 (9.9)
Other	57 (2.1)
Primary school	37 (1.4)
Occupation n (%)	
Medicine/pharmaceuticals	1,025 (38.0)
Science/education	416 (15.4)
Residence n (%) (urban)	2,218 (82.1)
Smoking n (%)	
Yes, <1 pack per day	305 (11.3)
Yes, >1 pack per day	113 (4.2)
Alcohol n (%)	
Weekly basis	227 (8.4)
Daily basis	20 (0.7)
Family history of kidney failure n (%) (yes)	485 (17.9)
Presence of medical conditions/illnesses n (%)	
Arterial hypertension	519 (19.2)
Diabetes mellitus	156 (5.8)
Heart problem	192 (7.1)
Stroke	51 (1.9)

Note. LMIC: Lower middle-income countries; SD: Standard deviation; & UMIC: Upper middle-income countries

Data Collation and Analysis

Data analysis was performed using STATA software version 16.0. p-values lower than 0.05 were considered statistically significant. Descriptive statistics was used to analyze the demographic characteristics of the respondents; qualitative variables were described by absolute numbers and frequencies; quantitative variables were represented by mean values and standard deviations. The knowledge section contained 28 "true/false/I do not know" questions. One point was assigned for each correctly answered question. If the respondent answered incorrectly, chose "I do not know" answer choice or missed the question, no points were assigned. Total score was calculated as the sum of the points the respondent got with the maximum possible 28 points. The total knowledge score was found to be normally distributed. Bivariate analyses, which included independent t-test and one-way ANOVA test, were used to find the association between sociodemographic characteristics and total knowledge score. A multiple linear regression analysis was then performed after the assumptions of normality, linearity, multicollinearity, and homoscedasticity were confirmed.

RESULTS

Overview of Characteristics of Participants

In total 3,239 responses were collected. Reasons for exclusion from analysis were unwillingness to provide consent (n=40), age <18 years old (n=13) and completion of a survey to less than a half (n=471). In total, 2,715 responses were analyzed. Mean age of the participants was 38.1±12.6 years ranging from 18 to 84 years, 69.7% of them were female and 37.6% of people reported to have bachelor's degree and 34.0% of people reported to have master's or PhD degrees. More than a half (61.1%) of respondents were from UMIC and the others were from LMIC. 38.0% of respondents were healthcare/pharmaceutical workers and they were excluded from the bivariate analyses and final regression model. Most participants lived in urban areas (82.1%) and 67.2% of participants were married or lived with a partner. A family history of kidney failure was reported by 17.9% of participants. 84.5% of people reported that they do not smoke and 54.1% answered that they never consumed alcohol. 19.2% of people had hypertension, 5.8% of people reported having diabetes mellitus, 7.1% reported having heart related disease and 1.9% had a history of stroke. A summary of characteristics of study participants is presented in **Table 1**.

A more detailed description of personal characteristics is presented in **Appendix B**. The general characteristics of the respondents over the former Soviet Union countries depicted in **Appendix F**.

Overview of Awareness Scores

The mean knowledge score of population before the exclusion of healthcare and pharmaceutical workers was 15.8 (±5.6) ranging from zero to 28. The mean knowledge score of general public (healthcare/pharmaceutical workers excluded) was 13.8 (±5.2) ranging from zero to 26. The healthcare/pharmaceutical workers group showed statistically significant better knowledge than general public in each question.

A large proportion of general public correctly believes that urine production (72.1%) and blood filtration (67.6%) are the functions of kidney, however, only 15.3% and 18.9% of respondents knew that kidneys do not maintain sugar level and do not participate in the breakdown of protein, respectively. In addition, knowledge of the fact that kidneys help keeping bones healthy is relatively low among general public (31.1%). While 91.3% of people correctly answered that urinalysis is used to determine kidney health, only 54.2% knew that a fecal test is not used as a diagnostic tool for kidney diseases. 73.6% and 60.8% of the general public correctly identified excessive alcohol consumption and obesity respectively as risk factors for CKD, however only 11.6% of the general public and 15.7% of the healthcare/pharmaceutical workers correctly identified excess stress as not a CKD risk factor. It is also remarkable that only 4.5% of general public and 10.3% of healthcare/pharmaceutical workers knew that flank pain is not a symptom of advanced stages of CKD. The percentages of correct responses to each question as well as their comparison between healthcare/pharmaceutical workers and general public are summarized in **Table 2**.

Table 2. Mean knowledge scores & proportion of correct answers in knowledge section among all participants & comparison between medicine/pharmaceutical workers & general public

		AP	M/PW	GP	
Mean knowledge score±SD (max=28)		15.8±5.6	19.1±4.5	13.8±5.2	
Question	**RA**	**CR (%) n=2,715**	**CR (%) n=1,025**	**CR (%) n=1,690**	**p***
1. A person can lead a normal life with one healthy kidney	True	64.9	78.4	56.6	**<0.001**
2. Herbal supplements can be effective in treating chronic kidney disease	False	30.1	40.6	23.7	**<0.001**
3. Certain medications can help to slow-down the worsening of chronic kidney disease	True	64.1	77.4	56.0	**<0.001**
What functions do the kidney perform in our body?					
4. The kidneys make urine	True	77.8	87.2	72.1	**<0.001**
5. The kidneys clean blood	True	75.1	87.5	67.6	**<0.001**
6. The kidneys help to keep blood sugar level normal	False	26.0	37.8	18.9	**<0.001**
7. The kidneys help to maintain blood pressure	True	74.0	89.4	64.7	**<0.001**
8. The kidneys help to breakdown protein in the body	False	24.4	39.3	15.3	**<0.001**
9. The kidneys help to keep the bones healthy	True	42.0	59.9	31.1	**<0.001**
Which of the following are commonly used to determine the health of your kidneys?					
10. A blood test	True	72.9	83.0	66.8	**<0.001**
11. A urine test	True	93.3	96.6	91.3	**<0.001**
12. A faecal (poo) test	False	63.0	77.4	54.2	**<0.001**
13. Blood pressure monitoring	True	67.6	85.3	56.9	**<0.001**
What are the risk factors for chronic kidney disease?					
14. Diabetes	True	64.3	83.8	52.5	**<0.001**
15. Being female	False	44.0	50.9	39.8	**<0.001**
16. High blood pressure	True	65.0	84.4	53.2	**<0.001**
17. Heart problems such as heart failure or heart attack	True	49.1	69.9	36.6	**<0.001**
18. Excess stress	False	13.2	15.7	11.6	**<0.001**
19. Obesity	True	67.5	78.4	60.8	**<0.001**
20. Smoking	True	58.9	67.6	53.6	**<0.001**
21. Excessive alcohol use	True	77.2	83.2	73.6	**<0.001**
22. Long term analgesic (pain medicine) use	True	62.6	70.4	57.9	**<0.001**
What are the signs and symptoms that a person might have if they have advanced chronic kidney disease or kidney failure?					
23. Water retention (excess water in body)	True	83.7	90.2	79.6	**<0.001**
24. Fever	False	21.5	33.9	14.0	**<0.001**
25. Nausea/vomiting	True	55.5	68.9	47.3	**<0.001**
26. Loss of appetite	True	59.3	75.9	49.4	**<0.001**
27. Increased fatigue (tiredness)	True	77.4	86.3	71.9	**<0.001**
28. Flank pain	False	6.7	10.3	4.5	**<0.001**

Note. RA: Right answer; CR: Correct responses; M/PW: Medicine/pharmaceutical workers; AP: All participants; GP: General public; *p-values for comparison of M/PW & GP; & SD: Standard deviation

Table 3. Differences in total knowledge scores between different subgroups

	Mean score±SD (max=28)	p-value
Gender		
Male	13.5±5.4	0.140
Female	13.9±5.1	
Residence		
Urban	14.0±5.1	**0.041**
Rural	13.3±5.4	
Income type of country		
LMIC	14.3±5.5	**0.004**
UMIC	13.6±5.0	

Note. LMIC: Lower middle-income countries; SD: Standard deviation; & UMIC: Upper middle-income countries

Regression Analysis and Correlation of Knowledge Scores

Bivariate analysis using an independent t-tests showed that urban residents (14.0±5.1) had significantly higher mean total knowledge score compared to the rural residents (13.3±5.4, p=0.041) and people living in the countries belonging to LMIC group had significantly higher CKD knowledge score (14.3±5.5) than those living in UMIC (13.6±5.0, p=0.004). There was no statistically significant difference in knowledge between male and female participants. Bivariate analysis using ANOVA tests showed that total knowledge score was significantly associated with education level, smoking habits, family history of kidney diseases, personal history of arterial hypertension, DM, and heart disease (p<0.05). Marital status, alcohol use frequency and personal history of stroke were not associated with total knowledge score. In overall, bivariate tests showed that people with master's/PhD degrees, living in urban areas and in countries belonging to LMIC (Kyrgyzstan, Tajikistan, Ukraine, and Uzbekistan), nonsmokers and people smoking less than one pack per day, people with personal history of arterial hypertension and DM have significantly higher total knowledge scores.

For more details, see **Table 3** and **Appendix C**. The comparison of correct response percentages between all respondents of UMIC and LMIC groups are shown in **Appendix D**. The comparison of correct response percentages between general public (healthcare workers excluded) of UMIC and LMIC groups are presented in **Appendix E**.

Univariate linear regression showed that income type of country, education, smoking frequency, family history of kidney failure, personal history of arterial hypertension and DM were significantly associated with a higher final CKD knowledge score after the model was adjusted for age, gender, residence, occupation, and personal history of heart diseases (**Table 4**).

Table 4. Unadjusted & adjusted multiple linear regression models between total knowledge score & personal characteristics (R^2 of adjusted model=0.0528, p<0.05)

Participant's characteristic	Unadjusted model ß coefficient (95% CI)	p-value	Adjusted model ß coefficient (95% CI)	p-value
Age	0.002 (-0.02 to 0.03)	0.872		
Gender (male vs. female)	-0.230 (-0.89 to 0.42)	0.482		
Residence (urban vs. rural)	0.570 (-0.20 to 1.34)	0.147		
Occupation	0.060 (-0.07 to 0.19)	0.376		
Income type of country (UMIC vs. LMIC)	-1.360 (-2.00 to -0.71)	**<0.001**	-1.260 (-1.90 to -0.64)	**<0.001**
Education	0.430 (0.17 to 0.70)	**0.001**	0.450 (0.19 to 0.72)	**0.001**
Smoking	0.450 (0.02 to 0.89)	**0.039**	0.390 (-0.03 to 0.81)	0.067
Family history of kidney disease	0.770 (0.25 to 1.30)	**0.004**	0.760 (0.24 to 1.28)	**0.004**
Hypertension	0.670 (0.09 to 1.24)	**0.023**	0.660 (0.10 to 1.22)	**0.020**
Diabetes mellitus	0.910 (0.13 to 1.69)	**0.022**	0.970 (0.20 to 1.75)	**0.014**
Heart diseases	0.220 (-0.46 to 0.89)	0.531		

Note. CI: Confidence interval; LMIC: lower middle-income countries; & UMIC: upper middle-income countries

Table 5. Multiple regression analysis between total knowledge score & personal characteristics (R^2=0.0698, F=8.83, p<0.05)

Participant's characteristics	ß coefficient	p-value
Country		
LMIC		
UMIC	-0.92 (-1.45 to -0.39)	**0.001**
Education		
Primary school		
High school	0.08 (-1.71 to 1.87)	0.203
College	1.15 (-0.62 to 2.91)	0.932
Bachelor's degree	1.47 (-0.22 to 3.18)	0.089
Master's/PhD	2.72 (0.98 to 4.46)	**0.002**
Other	2.17 (-0.20 to 4.53)	0.072
Smoking		
≥1 pack per day		
<1 pack per day	1.92 (0.58 to 3.26)	**0.005**
Not smoker	1.14 (-0.05 to 2.34)	0.061
Family history of kidney disease		
Yes		
No	-0.41 (-1.03 to 0.21)	0.198
I do not know	-1.52 (-2.39 to -0.66)	**0.001**
Hypertension		
Yes		
No	-0.82 (-1.44 to -0.21)	**0.008**
I do not know	-2.00 (-3.05 to -1.04)	**<0.001**
Diabetes mellitus		
Yes		
No	-0.97 (-1.98 to 0.05)	0.064
I do not know	-1.82 (-3.11 to -0.53)	**0.006**

Note. LMIC: Lower middle-income countries & UMIC: Upper middle-income countries

However, in the multiple linear regression only income type of the country, education, personal history of arterial hypertension retained their significance (**Table 5**).

DISCUSSION

Our study revealed a low level of CKD knowledge among the populations of post-Soviet Union countries, with limited understanding of kidney functions, diagnostic methods, risk factors, symptoms, and treatment options. Factors such as education level, personal history of diabetes or hypertension, smoking habits, and income type of country were associated with variations in CKD knowledge scores.

First, there is poor knowledge about some functions the kidneys perform in the human body–only 31.1% of people knew that the kidneys are involved in keeping the bones healthy and only 18.9% and 15.3% of people correctly believed that kidneys do not regulate the level of sugar and protein in the organism. These findings were similar to those reported in [14, 15, 17], which conducted surveys among the general public in Australia, Saudi Arabia, and India, respectively. On the other hand, more than 64.0% of respondents in our study knew that kidneys participate in urine production, blood filtering and regulation of blood pressure.

Early screening methods are essential for diagnosing the disease on its' earlier stages. These include blood test to estimate GFR by using blood creatinine level, urine test for protein and measurement of blood pressure. The knowledge about diagnostic methods among the participants was moderate–all questions in that section were answered correctly by more than a half of participants, and 56.9% of people knew that blood pressure monitoring is also used as a diagnostic tool. That result is higher compared to the Australian research, where only 20.3% of participants answered that question correctly [14].

Knowledge of CKD risk factors was also found to be limited. In our study, only a half of participants knew that hypertension and diabetes are the risk factors for CKD. The public knowledge of diabetes being a CKD risk factor was also found to be poor in studies conducted in Southwest Nigeria (20.0%) and Hong Kong (44.0%), however in Saudi Arabia (69.2%) and India (71.2%) the knowledge was significantly better [15-18]. But proportion of respondents in our study who correctly chose hypertension (53.0%) was higher than in the Australian, Indian, Southwest Nigerian and Hong Kong populations. Most participants incorrectly identified female gender and excess stress as CKD risk factors similarly to the other populations (Australian, Saudi Arabian, and Indian) [14, 15, 17]. Knowledge that smoking and excessive painkiller use can contribute to CKD occurrence was also poor, with slightly more than a half of total responses being correct. A study conducted in Thailand reported that only 60.0% of study population were aware about nephrotoxic effect of NSAIDs [21].

The most commonly known symptoms of advanced CKD were water retention (79.6%) and fatigue (71.9%), similarly to the previous studies [14, 15, 17]. Fever was incorrectly believed to be a symptom of advanced CKD in our (14.0% correct answers) and the three aforementioned studies (15.2%, 15.9%, and 25.4%) and only 4.5% of people answered that flank pain is not a symptom of advanced CKD.

Although CKD is usually detected on its' advanced stages, there are existing strategies that can slow down the progression of the disease, which include medications, such as

ACE inhibitors and ARBs, good control of the underlying chronic conditions such as hypertension, diabetes, and avoiding nephrotoxic substances, which include tobacco smoking, NSAIDs and some herbal supplements [22,23]. Unfortunately, 44.0% of participants in our study did not know that progression of CKD can be slowed down with certain medications and only 23.7% of participants knew that herbal supplements are not effective against CKD. The misconception about the effectiveness of herbal supplements was similarly observed among Australian and Indian populations, with only 23,4% and 20,11% of answers being correct, respectively [14, 17].

In our study, higher level of education of participants was associated with higher CKD knowledge scores that supports the findings of other studies, where similar trend was observed [14-18]. Among all demographic subgroups of people, participants with master’s or PhD degree showed the second highest mean CKD knowledge score (15.0±4.8) that is slightly less than the result of people with personal history of diabetes. Better CKD knowledge scores of participants with diabetes were also reported by other studies that are consistent with our results showing that personal history of DM is the strongest predictor of better CKD knowledge (15.2±5.1) [15, 18]. Personal history of hypertension was similarly associated with higher total knowledge scores but to the best of our knowledge only one study [15] reported such association. This can be because people, who are aware of their own chronic condition, particularly hypertension and diabetes, tend to read more and receive explanations from doctors about their condition and its possible complications. In contrast to the findings of [14, 15], we have not observed an effect of marital status of the participants on the total CKD knowledge score. Although such association was not observed in similar studies conducted in other countries, in our study participants who smoked more than one pack per day were less knowledgeable than those who smoked less than one pack per day or do not smoke at all. This may be because people who associate smoking with health problems either avoid smoking completely or try to smoke less. Another identified factor associated with better CKD knowledge was the income level of the country of the responders’ residence. Surprisingly, people from countries belonging to LMIC held better CKD knowledge than participants from the upper-middle income countries. Although the percentage of healthcare/pharmaceutical workers among the participants from lower-middle income countries was higher, this factor should not have been significant as those participants were deliberately excluded from the analysis. However, we still observe differences between lower middle income and upper middle income countries in the percentages of participants with master’s/PhD degree (25.4% vs. 22.2%, respectively), with a family history of kidney disease (23.8% vs. 18.7%, respectively), with a personal history of hypertension (27.7% vs. 20.9%, respectively) and with a personal history of diabetes (8.5% vs. 5.7%, respectively), which could potentially explain observed differences in CKD knowledge between the two groups.

Considering low level of CKD knowledge among populations of post-Soviet Union nations, it is highly recommended to raise the public CKD awareness in those countries. Health care providers and health policy makers should cooperate to organize and implement nation-wide educational strategies to improve kidney health literacy both in the general population and in the subgroups of individuals at high risk of CKD. Based on our study results, it is also recommended to put more focus on individuals with lower educational attainment, having no chronic conditions such as diabetes and hypertension, heavy smokers and those without kidney disease in family history, as they demonstrated significantly lower level of CKD knowledge.

Our study has several limitations. Firstly, we failed to overcome difficulties associated with the data collection process in eight countries simultaneously. As a result, several countries did not reach the target sample size, but rather than discarding a large number of responses we decided to divide the countries into two groups according to their income type. In addition to that, respondents in our study may not correctly represent the population in the studied countries because of the recruitment strategy, which favored the enrollment of participants who were in contact with doctors responsible for survey distribution. That could be a reason for large percentage of healthcare workers among the respondents. Our study population was also overrepresented by female respondents (almost 70.0%) that could be a source of gender bias. One study [24] examined how various demographic factors influenced the response rates of online surveys. The results showed a significant relationship between gender and online survey participation, with female faculty members contributing to a greater extent in the dataset of respondents. Author believes that difference could be explained by variations in values of males and females. It is argued that females are more likely to possess or value characteristics such as empathy or emotional closeness, while males are more inclined to possess more separative qualities. Another limitation is a potential selection bias. Our survey was online, and people of older age or without Internet access had lower chances to participate in our survey. The fourth limitation is a response bias, because there were some sensitive questions about alcohol use and smoking and the prevalence of smokers and alcohol consumers deviated from the global statistics significantly. Our study was also prone to acquiescence bias, because there was a tendency among the participants towards answering “true” to all questions in the Knowledge section, that could be easily observed from the distribution of answers. The questions, where the right answer was “false”, were correctly answered by 22.8% of respondents on average in contrast to 60.0% for the questions with the correct answer “true”.

CONCLUSIONS

This is a first population-based large survey study involving a population of post-Soviet countries and assessing the awareness of CKD and its risk factors. Although some personal characteristics were associated with a higher CKD knowledge score, the overall level of CKD knowledge among the population of former Soviet Union countries was found to be low. Increasing the awareness of CKD among studied populations may facilitate further implementation of CKD prevention and screening programs.

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Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Table A1. Chronic kidney disease knowledge questionnaire developed & validated by [14] (for sections, 1-5, please answer 'true', 'false' or 'I do not know' to the following questions)

No	Question	True	False	I do not know
Section 1.				
1	A person can lead a normal life with one healthy kidney.	□	□	□
2	Herbal supplements can be effective in treating chronic kidney disease.	□	□	□
3	Certain medications can help to slow-down the worsening of chronic kidney disease.	□	□	□
Section 2. What functions do the kidney perform in our body?				
4	The kidneys make urine.	□	□	□
5	The kidneys clean blood.	□	□	□
6	The kidneys help to keep blood sugar level normal.	□	□	□
7	The kidneys help to maintain blood pressure.	□	□	□
8	The kidneys help to breakdown protein in the body.	□	□	□
9	The kidneys help to keep the bones healthy.	□	□	□
Section 3. Which of the following are commonly used to determine the health of your kidneys?				
10	A blood test.	□	□	□
11	A urine test.	□	□	□
12	A faecal (poo) test.	□	□	□
13	Blood pressure monitoring.	□	□	□
Section 4. What are the risk factors for chronic kidney disease?				
14	Diabetes.	□	□	□
15	Being female.	□	□	□
16	High blood pressure.	□	□	□
17	Heart problems such as heart failure or heart attack.	□	□	□
18	Excess stress.	□	□	□
19	Obesity.	□	□	□
Section 5. What are the signs and symptoms that a person might have if they have advanced chronic kidney disease or kidney failure?				
20	Water retention (excess water in the body).	□	□	□
21	Fever.	□	□	□
22	Nausea/vomiting.	□	□	□
23	Loss of appetite.	□	□	□
24	Increased fatigue (tiredness).	□	□	□

Thank you very much for your time and participation in this questionnaire!

APPENDIX B

Table B1. Characteristics of study participants

Variable	Values	Variable	Values	Variable	Values
Age (mean±SD, range)	38.1±12.6, 18-84	**Education**	**n (%)**	**Alcohol**	**n (%)**
Gender	**n (%)**	Master's/PhD	917 (34.0)	Never	1,462 (54.1)
Male	814 (30.3)	Bachelor's degree	1,013 (37.6)	Monthly basis	536 (19.8)
Female	1,871 (69.7)	College	403 (15.0)	Other	456 (16.9)
Total	2,685 (100.0)	High school	268 (9.9)	Weekly basis	227 (8.4)
Country	**n (%)**	Other	57 (2.1)	Daily basis	20 (0.7)
Kazakhstan	1,069 (39.7)	Primary school	37 (1.4)	Total	2,701 (100.0)
Uzbekistan	440 (16.3)	Total	2,695 (100.0)	**FH of kidney failure**	**n (%)**
Russia	387 (14.4)	**Occupation**	**n (%)**	No	1,939 (71.6)
Ukraine	262 (9.7)	Medicine/pharmaceuticals	1,025 (38.0)	Yes	485 (17.9)
Kyrgyzstan	250 (9.3)	Science/education	416 (15.4)	I do not know	283 (10.6)
Azerbaijan	167 (6.2)	I do not work	398 (14.8)	Total	2,707 (100.0)
Tajikistan	96 (3.6)	Trade/sales	207 (7.7)	**Medical conditions/illnesses**	
Georgia	21 (0.8)	Public service	171 (6.3)	**Arterial hypertension**	**n (%)**
Belarus	3 (0.1)	Manufacturing	139 (5.2)	No	2,019 (74.6)
Armenia	1 (0.04)	Transport/logistics	53 (2.0)	Yes	519 (19.2)
Total	2,696 (100.0)	Other	290 (10.7)	I do not know	170 (6.3)
Income	**n (%)**	Total	2,699 (100.0)	Total	2,708 (100.0)
UMIC	1,647 (61.1)	**Marital status**	**n (%)**	**DM**	**n (%)**
LMIC	1,049 (38.9)	Married/living with a partner	1,810 (67.2)	No	2,366 (87.4)
Total	2,715 (100.0)	Single/never married	650 (24.1)	I do not know	185 (6.8)
Nationality	**n (%)**	Divorced/separated/widowed	235 (8.8)	Yes	156 (5.8)
Kazakh	706 (26.4)	Total	2,695 (100.0)	Total	2,707 (100.0)
Uzbek	623 (23.3)	**Residence**	**n (%)**	**Heart problem**	**n (%)**
Russian	441 (16.5)	Urban	2,218 (82.1)	No	2,292 (84.6)
Ukrainian	262 (9.8)	Rural	484 (17.9)	I do not know	225 (8.3)
Kyrgyz	215 (8.0)	Total	2,702 (100.0)	Yes	192 (7.1)
Azerbaijani	171 (6.4)	**Smoking**	**n (%)**	Total	2,709 (100.0)
Tajik	114 (4.3)	No	2,283 (84.5)	**Stroke**	**n (%)**
Georgian	17 (0.6)	Yes, <1 PPD	305 (11.3)	No	2,595 (95.7)
Belorussian	11 (0.4)	Yes, >1 PPD	113 (4.2)	I do not know	65 (2.4)
Armenian	7 (0.3)	Total	2,701 (100.0)	Yes	51 (1.9)
Other	107 (4.0)			Total	2,711 (100.0)
Total	2,674 (100.0)				

Note. DM: Diabetes mellitus; FH: Family history; LMIC: Lower middle-income countries; PPD: Pack per day; & UMIC: Upper middle-income countries

APPENDIX C

Table C1. Associations between total knowledge scores & personal characteristics of respondents

	Mean score±SD (max=28)	F	p-value	Post-hoc comparison test
Education				
Primary school education	12.3±5.4	8.50	**<0.001**	Master's/PhD > bachelor's degree, college, high school
High school education	12.5±5.6			
College degree	13.5±5.3			
Bachelor's degree	13.8±5.0			
Master's degree or PhD	15.0±4.8			
Other	14.4±5.7			
Occupation				
Manufacturing	13.6±5.2	3.74	**0.001**	Science/education>other, trade/sales
Public service	13.9±5.4			
Science/education	14.6±5.0			
Trade/sales	13.1±5.0			
Transport/logistics	13.1±5.7			
Other	13.1±4.8			
I do not work	14.0±5.4			
Marital status				
Single/never married	13.8±5.1	0.02	0.978	No significant difference between means
Married or living with a partner	13.8±5.1			
Divorced/separated/widowed	13.8±5.7			
Smoking				
No	13.8±5.2	5.47	**0.004**	Yes, less than 1 pack/d, no>yes, 1 pack/d o
<1 PPD	14.4±4.9			
≥1 PPD	12.2±5.9			
Alcohol				
Never	13.6±5.4	1.09	0.359	No significant difference between means
Monthly	14.2±5.2			
Weekly	13.8±4.6			
Daily	12.9±6.0			
Other	14.1±4.8			
Family history of kidney disease				
Yes	14.5±4.8	12.82	**<0.001**	Yes, no>I do not know
No	13.9±5.3			
I do not know	12.3±5.2			
Personal history of arterial hypertension				
Yes	14.7±5.0	16.08	**<0.001**	Yes>no>I do not know
No	13.8±5.2			
I do not know	11.9±5.2			
Personal history of DM				
Yes	15.2±5.1	9.42	**<0.001**	Yes>no>I do not know
No	13.9±5.1			
I do not know	12.5±5.5			
Personal history of heart disease				
Yes	14.3±5.0	6.39	**0.002**	Yes=no>I do not know
No	13.9±5.2			
I do not know	12.6±5.3			
Personal history of stroke				
Yes	13.9±4.8	2.69	0.068	No significant difference between means
No	13.9±5.2			
I do not know	12.2±5.5			

Note. DM: Diabetes mellitus; PPD: Pack per day; & SD: Standard deviation

APPENDIX D

Table D1. Comparison of correct response percentages between all respondents of UMIC & LMIC groups

Question number	Correct responses (%) (n=1,068)	Correct responses (%) (n=1,647)	p-value
	LMIC	UMIC	
1	72.0	60.2	**<0.001**
2	28.1	31.3	0.072
3	67.1	62.1	**0.008**
4	81.3	75.6	**<0.001**
5	81.7	70.9	**<0.001**
6	29.1	24.0	**0.003**
7	80.2	70.0	**<0.001**
8	27.7	22.2	**0.001**
9	46.9	38.7	**<0.001**
10	77.4	70.0	**<0.001**
11	92.1	94.1	0.051
12	60.6	64.5	**0.040**
13	73.2	64.0	**<0.001**
14	72.9	58.8	**<0.001**
15	45.3	43.1	0.257
16	72.1	60.4	**<0.001**
17	52.6	46.9	**0.003**
18	14.1	12.5	0.219
19	64.7	69.3	**0.013**
20	56.4	60.5	**0.031**
21	74.5	79.0	**0.007**
22	61.1	63.6	0.174
23	86.1	82.0	**0.005**
24	22.5	20.9	0.326
25	63.7	50.2	**<0.001**
26	68.8	53.3	**<0.001**
27	81.0	75.0	**<0.001**
28	6.1	7.1	0.300

Note. LMIC: Lower middle-income countries & UMIC: Upper middle-income countries

APPENDIX E

Table E1. Comparison of correct response percentages between general public (healthcare workers excluded) of UMIC & LMIC groups

Question number	Correct responses (%) (n=521)	Correct responses (%) (n=1,169)	p-value
	LMIC	UMIC	
1	65.3	52.8	**<0.001**
2	21.5	24.6	0.161
3	57.6	55.4	0.393
4	76.0	70.4	**0.018**
5	73.7	64.9	**<0.001**
6	20.0	18.4	0.446
7	70.4	62.1	**0.001**
8	15.2	15.4	0.902
9	37.8	28.1	**<0.001**
10	72.0	64.5	**0.003**
11	87.9	92.8	**0.001**
12	47.8	57.1	**<0.001**
13	61.2	55.0	**0.017**
14	61.4	48.5	**<0.001**
15	38.6	40.3	0.507
16	58.7	50.7	**0.002**
17	38.6	35.7	0.252
18	10.8	12.0	0.467
19	53.4	64.2	**<0.001**
20	49.1	55.6	**0.014**
21	67.4	76.4	**<0.001**
22	54.3	59.5	**0.048**
23	82.5	78.4	**0.049**
24	14.2	14.0	0.887
25	58.9	42.2	**<0.001**
26	61.0	44.1	**<0.001**
27	76.4	69.9	**0.006**
28	5.2	4.2	0.364

Note. LMIC: Lower middle-income countries & UMIC: Upper middle-income countries

APPENDIX F

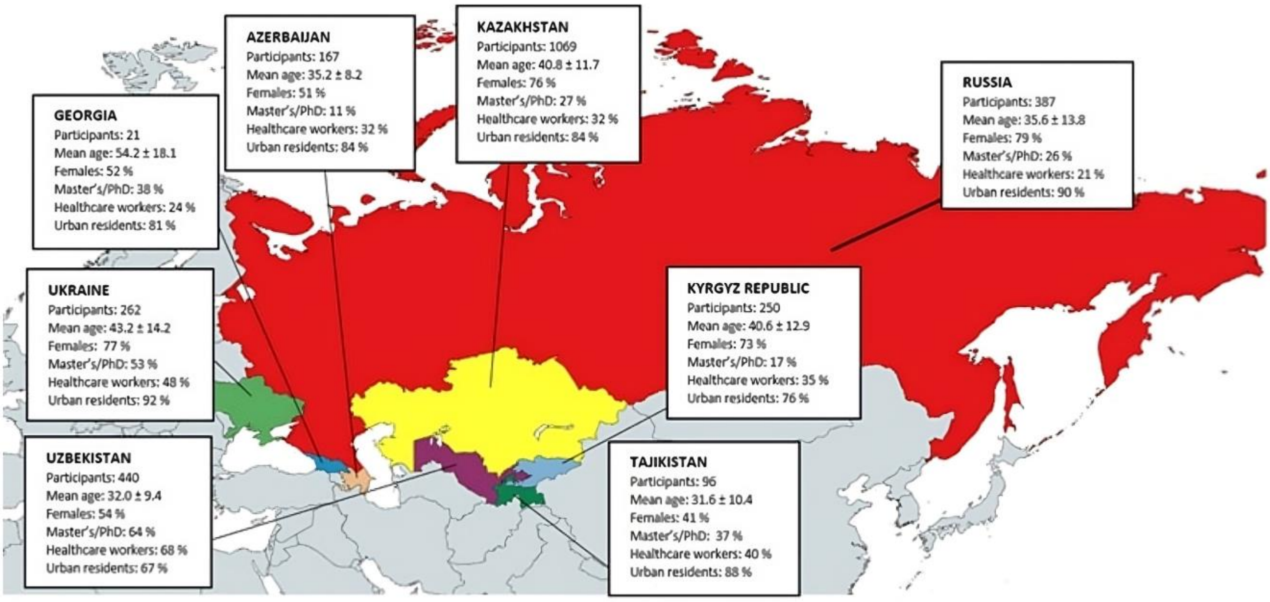

Figure F1. Map representation of demographic characteristics of study participants