Community-based study on elderly CKD subjects and the associated risk factors

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ABSTRACT
Objective: To investigate the prevalence and risk factors for chronic kidney disease (CKD) among community elderly population in Shanghai, China, in order to provide early diagnosis and treatment of CKD, and improve the quality of life for elderly people.

Methods: In all, 24,886 residents (≥65 years old) were selected from community population in Changning District of Shanghai, China in 2014. They were interviewed and tested for reduced renal function estimated GFR by CKD-EPI equation. The associations among demographic characteristics, healthy characteristics (e.g., cardiovascular disease and hypertension), and indicators of kidney damage were examined.

Results: Approximately, 16.4% of the participants were CKD. The average of them was 74.9 ± 7.0 years old. Females had a significantly higher prevalence of CKD than males (17.6% vs. 14.9%). CKD patients were present in higher prevalence of female, hyperuricemia (29.6% vs. 18.7%), hypertension (45.1% vs. 40.3%), and cardiovascular disease (23.2% vs. 18.7%) than that of non-CKD population. CKD patients were present in lower prevalence of drinking than that of non-CKD population. The prevalence of CKD in female is 2.002 times than that of male. The prevalence of CKD increased 1.048 times with the age of each increase in 1 year old. The risk factors for CKD are age, female, hyperuricemia, cardiovascular disease, hypertension, hypercholesterolemia, and smoking.

Conclusions: The prevalence of CKD is high in the elderly population than that of adult CKD in Shanghai. The most risk factors for elderly CKD patients are similar to the adult population. But hypercholesterolemia as a risk fact of elderly CKD is different from adult CKD.

Introduction
Chronic kidney disease (CKD) is an increasing public health issue. The prevalence of chronic kidney disease (CKD) in Chinese adults was 10.8%. According to this estimate, there was more than 120 million adult population (≥18 years old) of CKD in China. The aging of urban population is becoming more and more serious in Shanghai. In particular, the elderly population CKD problems are gradually brought to us. Shanghai has the largest elderly population worldwide, and few studies have analyzed the risk of CKD in these old individuals. In this study, we investigated the risk facts of CKD in the elderly population.

Materials and methods
Data sources and ethics statement
We collected baseline information from the community health registry system in Changning District, Shanghai. Community hospitals are the primary health care sites of residents of China, and these hospitals perform activities such as chronic disease management. Community hospitals offer basic health services and build profiles for permanent residents with their consent. Furthermore, all the services at these hospitals are free according to health management services for the elderly in Changning by Changning District Aging Committee and Health Bureau. Residents were told that the physical examination information in their electronic profiles would be used for scientific research without their names, and all residents approved of this use. The profile consists of main parts: participant registration (name, gender, age, personal ID, and office address), anthropologic measurements (body height, body weight, and blood pressure), laboratory examination results (blood test results), health-related habits (alcohol consumption and smoking status), and a section for other health care issues (personal health history of chronic disease).
Participants

Because of the project of “Health examination for the elderly over 65 years old”, this cross-sectional study included 26,260 permanent residents with over the age of 65 years old who were household registered in Changning District, Shanghai, China. In all, 24,886 participants (94.8%) were underwent health examinations with complete data.

Measurements of risk factors for CKD

The physical examination and laboratory tests were performed by physicians at community hospitals following standard protocols. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m²). Blood samples were collected in the morning after an overnight fast of at least 8 h. Measurements of uric acid, triglyceride (TG), cholesterolemia (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting plasma glucose, and serum creatinine were taken.

Hematuria was confirmed by urine microscopy for RBC >3/HP after excluding for urinary tract infection and menstruation. Proteinuria was tested by urine routine test after excluding for urinary tract infection. The estimated glomerular filtration rate (eGFR) was calculated by CKD-EPI equation. eGFR (mL/min/1.73 m²) = 175 × SCR (mg/dL)⁻¹.234 × Age⁻⁰.179 × 0.79 (if female).² CKD is defined by NKF K/DOQI Guidelines.³

Participants who currently required antihypertensive therapy to control their blood pressure or those with a systolic blood pressure (SBP) of 140 mmHg or greater and/or diastolic blood pressure (DBP) of 90 mmHg or greater at screening had to be reconfirmed after a third measurement (repeated every 15 min after rest) before they were accepted as hypertensive.⁴ Subjects with a diabetic history or those with fasting plasma glucose >7 mmol/L or non-fasting plasma glucose >11 mmol/L were categorized as diabetic.⁵ BMI of 30 or greater was defined as obesity, and those between 25 and 30 were considered overweight.⁶ Those with serum cholesterol >5.72 mmol/L and serum triglyceride >1.7 mmol/L at screening were noted to have hypercholesteremia and hypertriglyceridemia, respectively.⁷ Hyperuricemia is defined as normal purine diet status, >420 μmol/L (if male or menopausal female).⁸ Definition of smoking is according to the China disease prevention and control center in 2010 with the release of the global adult tobacco survey reported in China, current smokers (lifetime smoking at least 100 or more cigarettes) and former smokers (smoking less than 10 years).

Statistical analysis

The data are presented as mean ± SD for continuous variables and as proportions for categorical variables, and statistical significance of differences between genders was compared using t test for continuous variables and Chi-square test for categorical variables. Multivariate logistic regression models were used to estimate the odds ratio to determine the relationship between CKD and risk factors. In the multivariate logistic regression analysis, the dependent variable was CKD (1: yes, 0: no). All variables should be included in the analysis for female, BMI, age, high TG, high TC, hyperuricemia, low HDL-C, high LDL-C, drinking, smoking, hypertension, diabetes, cardiovascular disease, and MAP. Age and MAP were continuous variables. The remaining variables were classified variables (1: yes, 0: no, 1: female, 0: male). All statistical analyses were performed using SPSS 22.0 (SPSS Inc., Chicago, IL). A p value less than .05 was considered statistically significant.

Results

Clinical characteristics

A total of 11,216 males and 13,670 females were enrolled in this study. In all, 4078 cases (16.4%) of the participants were CKD patients. There were 1869 males and 2209 females. The average of them was 74.9 ± 7.0 years old. The average of non-CKD was 72.9 ± 6.3 years old. The average age of CKD had a significantly older than the ones of non-CKD (p < .05). Females had a significantly higher prevalence of CKD than males (17.6% vs. 14.9%, respectively; p < .05).

Characteristics of the study participants

CKD patients were present in higher prevalence of female, hyperuricemia, hypertension, and cardiovascular disease than that of non-CKD population (p < .05). CKD patients were present in lower prevalence of drinking than that of non-CKD population (p < .05). MAP of CKD was 101.2 ± 15.2 mmHg. MAP of non-CKD was 101.6 ± 14.8 mmHg. There was no difference of MAP between CKD and non-CKD patients (p > .05) (Table 1).

Risk factors for CKD

In the multivariate logistic regression analysis, it showed higher prevalence of CKD in female than male. In the case of other factors that are unchanged, the prevalence of CKD in female is 2.002 times (e⁰.⁶⁹⁴) than that of male (p < .05). The prevalence of CKD increased
1.048 times \((e^{0.047})\) with the age of each increase in 1 year old. The prevalence of CKD increased 1.000 times \((e^{0.010})\) with every increase in 1 mmHg MAP. The prevalence of CKD in hypercholesterolemia is 1.236 times \((e^{0.212})\) than that of non-hypercholesterolemia participants. The prevalence of CKD in hyperuricemia is 1.610 times \((e^{0.476})\) than that of non-hyperuricemia participants. The prevalence of CKD in cardiovascular disease is 1.221 times \((e^{0.200})\) than that of non-cardiovascular disease participants. The prevalence of CKD in hypertension is 1.242 times \((e^{0.217})\) than that of non-hypertension participants \((p < .05)\). The risk factors for elderly CKD are female, age, hyperuricemia, cardiovascular disease, hypertension, hypercholesterolemia, and smoking (Table 2).

**Table 1.** Characteristics of the study participants.

| Characteristic            | CKD       | Non-CKD   | \(\chi^2\) | \(p\) |
|--------------------------|-----------|-----------|-------------|------|
| Number                   | 4078      | 20,808    |             |      |
| Male/female              | 1669/2409 | 9547/11,261| 159.16      | <.000|
| Age (years)              | 74.9 ± 7.0| 72.9 ± 6.3| -13.51      | <.000|
| 30 > BMI > 25 (kg/m²)    | 1003 (24.6%)| 6520 (31.3%)| 5.92  | .205 |
| BMI ≥ 30 (kg/m²)         | 134 (3.3%)| 1065 (5.1%)| 6.21  | .356 |
| High TG (mmol/L)         | 740 (18.1%)| 6809 (32.7%)| 1.06  | .303 |
| High TC (mmol/L)         | 1021 (25.0%)| 9663 (46.4%)| 0.05  | .831 |
| Hyperuricemia (µmol/L)   | 1207 (29.6%)| 3891 (18.7%)| 81.58 | <.000|
| Low HDL-C (mmol/L)       | 1110 (27.2%)| 11,093 (53.3%)| 0.05  | .824 |
| High LDL-C (mmol/L)      | 130 (3.2%)| 1371 (6.6%)| 0.36  | .546 |
| High fasting plasma glucose (mmol/L) | 351 (8.6%)| 3179 (15.3%)| 0.86  | .354 |
| Smoking                  | 224 (5.5%)| 2231 (10.7%)| 0.19  | .660 |
| Drinking                 | 79 (1.9%)| 1116 (5.4%)| 11.23 | .001 |
| Hypertension             | 1841 (45.1%)| 8384 (40.3%)| 17.08 | <.000|
| Diabetes                 | 629 (15.4%)| 5741 (27.6%)| 1.84  | .175 |
| Cardiovascular disease   | 945 (23.2%)| 3894 (18.7%)| 31.28 | <.000|

**Table 2.** The risk factors for chronic kidney disease.

| Component                      | \(b\)   | \(SE\)  | \(z\)    | \(p\)  |
|--------------------------------|---------|---------|----------|-------|
| Gender, female                 | 0.694   | 0.081   | 8.522    | <.000 |
| 25 ≤ BMI < 30 (kg/m²)          | 0.056   | 0.132   | 0.423    | .672  |
| 30 ≤ BMI (kg/m²)               | 0.141   | 0.144   | 0.979    | .328  |
| Age (years)                    | 0.047   | 0.005   | 8.976    | <.000 |
| High TG (mmol/L)               | 0.028   | 0.077   | 0.367    | .714  |
| High TC (mmol/L)               | 0.212   | 0.079   | 2.701    | .007  |
| Hyperuricemia (µmol/L)         | 0.476   | 0.079   | 6.053    | .000  |
| Low HDL-C (mmol/L)             | 0.011   | 0.133   | 0.086    | .931  |
| High LDL-C (mmol/L)            | 0.038   | 0.121   | 0.317    | .751  |
| Drinking                       | -0.098  | 0.172   | -0.570   | .569  |
| Smoking                        | 0.587   | 0.121   | 4.846    | .000  |
| Hypertension                   | 0.217   | 0.095   | 2.288    | .022  |
| Diabetes                       | 0.021   | 0.102   | 0.202    | .840  |
| Cardiovascular disease         | 0.200   | 0.082   | 2.424    | .015  |
| MAP (mmHg)                     | 0.010   | 0.004   | 2.635    | .008  |

**Discussion**

Aging is an important risk factor for the occurrence and development of CKD.9–11 With the aging of the world population, there will be more and more elderly CKD patients. This is the first large-scale study in Shanghai on surveillance of community elderly CKD patients. Our objective is to examine the elderly CKD prevalence and the associated risk facts of elderly CKD patient in Shanghai. In short, our objective is to more effectively managing the elderly CKD patients.

The epidemiological screening of the population in Shanghai, examining those aged 18 and above, revealed 11.8% of CKD.12 In this study, our studied subjects are aged 65 years and above. After studying 24,886 cases, it is clear that the prevalence of elderly community CKD in Shanghai is 16.4%. The average age of CKD was significantly older than the ones of non-CKD. Females had a significantly higher prevalence of CKD than males (17.6% vs. 14.9%). The prevalence of elderly CKD is higher than the adult CKD. In our study, we use the formula of CKD-EPI to calculate the eGFR. We used the definition of CKD recommended by K/DOQI to categorize all the participants with kidney damage by proteinuria, hematuria, and decreased renal function.

In our study, elderly CKD patients had a higher prevalence of hyperuricemia, hypertension, and cardiovascular disease than that of non-CKD participants. The risk factors for elderly CKD are female, age, hyperuricemia, cardiovascular disease, hypertension, hypercholesterolemia, and smoking. The factors independently associated with kidney damage were age, sex, hypertension, diabetes, history of cardiovascular disease, hyperuricemia, area of residence, and economic status on Chinese CKD population.1 In Shanghai, age, central obesity, hypertension, diabetes, anemia, hyperuricemia, and nephrolithiasis are positively correlated with the development of CKD.12 Age, female, cardiovascular disease, hyperuricemia, and hypertension as the risk factors for elderly CKD patients are similar to the adult CKD. Hypercholesterolemia as the risk fact of elderly CKD patients is different from the adult CKD.
Hypertension and CKD often reinforce each other. Hypertension is an important risk factor for the progression of CKD and the complication of cardiovascular disease. Elderly CKD patients have a higher prevalence of hypertension than that of non-CKD participants (45.1% vs. 40.3%). In our study, MAP of CKD was 101.2 ± 15.2 mmHg. MAP of non-CKD was 101.6 ± 14.8 mmHg. There was no difference of MAP between CKD and non-CKD. But in the multivariate logistic regression analysis, hypertension is one of the risk factor for CKD. Also the prevalence of CKD increased 1.000 times with every increase in 1 mmHg MAP. In the retrospective analysis of 1866 cases of eGFR <30 elderly patients of Drawz study, it showed baseline systolic blood pressure is an independent risk factor for patients with ESRD. It is the lowest all-cause mortality of elderly patients with CKD to control the systolic blood pressure in the 130–150 mmHg and diastolic blood pressure in the 70–90 mmHg. So control of blood pressure makes benefit to elderly CKD patients.

In our study, hypercholesterolemia is one of the risk factors for elderly CKD. It is different from the adult CKD population. In 1982, Ruan puts forward the theory of lipid nephrotoxicity. Dyslipidemia has been known as the independent risk factor for glomerulosclerosis. It is generally accepted that the hypercholesterolemia is considered independent risk factor to coronary heart disease. In our study, both hypercholesterolemia and cardiovascular disease are the risk factors for elderly CKD patients. The prevalence of CKD in hypercholesterolemia is 1.236 times ($e^{0.212}$) than that of non-hypercholesterolemia participants. The prevalence of CKD in cardiovascular disease is 1.221 times ($e^{0.200}$) than that of non-cardiovascular disease participants. Cardiovascular disease is also one of the complications of CKD. Hypercholesterolemia is also an important cause of atherosclerosis, glomerulosclerosis, and cardiovascular disease. As cardiovascular disease is one of the risk factors for elderly CKD patient, dyslipidemia is more likely to occur in the elderly population. Therefore, we need to pay more attention to hypercholesterolemia in elderly patients with CKD.

CKD is also related to the lifestyle of smoking and other unhealthy lifestyle. Non-CKD participants have a higher drinking and smoking than that of elderly CKD (5.4% vs. 1.9%, 10.7% vs. 5.5%). Drinking and smoking are common in many populations. Smoking significantly increases the risks for vascular and non-vascular morbidity and for mortality in patients with CKD. Urinary albumin excretion in patients with diabetic nephropathy was increased by smoking, especially in heavy smoking. Also the risk of CKD was increased. Smoking has significant kidney toxicity. It can increase the urinary albumin excretion rate to damage the renal function. And then it increased the risk of ESRD. There are more smokers in decreased eGFR population. In our study, smoking is one of the risk factors for elderly CKD population. It is necessary for elderly CKD patients to quit smoking for their health.

In our study, elderly CKD has a higher prevalence of hyperuricemia than that of non-CKD participants (29.6% vs. 18.7%). Also hyperuricemia is a risk fact of elderly CKD. In the Cardiovascular Health Study, the uric acid of the elderly population (aged over 65 years) is closely related to the basic level of renal function. Uric acid levels are associated strongly with prevalent CKD. According to the limited-access data of 13,338 participants with intact kidney function in two community-based cohorts, baseline uric acid level was associated with increased risk of incident kidney disease. Therefore, elevated serum uric acid level is a modest, independent risk factor for incident kidney disease in the general population. Hyperuricemia is an independent risk factor for CKD in middle-aged and elderly Taiwanese adults, eGFR negatively correlated with serum uric acid level.

In conclusion, the elderly CKD patients have a higher prevalence than adult CKD ones in Shanghai. The risk factors for elderly CKD are similar to the adult CKD patients. As more and more elderly population are suffering from hyperuricemia, hypertension, and cardiovascular disease, it is important to intervene the risk factors for CKD to delay the progress of CKD on elderly population. It is also very important to treat the hypercholesterolemia in elderly CKD population. It may effectively delay the progression of CKD.

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Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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