

Original Article

Epidemiological investigation and risk factor analysis of chronic kidney disease among civil aviation employees in the capital

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Received February 2, 2025; Accepted August 11, 2025; Epub October 15, 2025; Published October 30, 2025

Abstract: Purpose: Chronic kidney disease (CKD) has become one of the most serious public health issues facing the world. The global prevalence of CKD ranges from 11% to 13%, and the prevalence remains persistently high. Additionally, as the prevalence of related conditions such as obesity, diabetes, and hypertension continues to rise, the kidney damage caused by these conditions contributes to an increase in CKD prevalence. Currently, there are very few epidemiological surveys on CKD in specific occupational groups both domestically and internationally. There are also few studies on the prevalence of CKD and its risk factors among aviation employees, and there are a lack of large-scale surveys. Recent data from small-scale health examinations in China have shown that the prevalence of hyperlipidemia, hypertension, diabetes, and obesity among aviation employees is increasing annually, highlighting the urgency of conducting an epidemiological survey on CKD among aviation employees. By analyzing the health examination data of civil aviation employees at a certain airport in the capital, this study aims to determine the prevalence of chronic kidney disease (CKD) among civil aviation employees at the airport and analyze related risk factors. This research provides support to ensure the safety of civil aviation operations and extend the professional lifespan of employees. Methods: Cross-sectional survey method was employed. A retrospective analysis was conducted on civil aviation employees at a certain airport in the capital city who underwent health examinations at the hospital's health examination center from January 2018 to December 2018. Inclusion criteria: (1) age ≥ 18 years old; (2) exclusion criteria: health examinees with incomplete routine urine and renal function test results. Data collection was conducted on the study population, including demographic information, routine urine, renal function, blood glucose, blood lipids, blood uric acid, and liver function tests. Based on the CKD diagnostic criteria established by the American Kidney Disease Foundation in 2002, the prevalence of CKD among civil aviation employees at a certain airport in the capital city was investigated, and logistic regression analysis was performed to identify the associated risk factors for CKD. Results: We considered 31,356 adults with complete data. The chronic kidney disease detection rate among employees of the Capital's civil aviation was 2.81%. Multivariate logistic regression analysis showed that males, age ≥ 60 , hypertension, diabetes, dyslipidemia, and hyperuricemia were independent risk factors for chronic kidney disease. Conclusion: 1. The prevalence of CKD among civil aviation employees at a certain airport in the capital is 2.81%, which is lower than the global and Chinese CKD prevalence rates. 2. Among aviation employees at a certain airport, the prevalence of major chronic diseases associated with CKD risk, such as hypertension, diabetes, dyslipidemia, and hyperuricemia, was relatively high. Male gender, age ≥ 60 years, hypertension, diabetes, dyslipidemia, and hyperuricemia were independent risk factors for increased CKD risk.

Keywords: Chronic kidney disease, risk factor, epidemiology, civil aviation employees

Introduction

Chronic kidney disease (CKD) is a severe public health problem; the global prevalence of CKD is 11%-13%. Since 2012, the sixth nationally representative cross-sectional study on chronic diseases and risk factors in China has updated

the prevalence of CKD among adults aged 18 and over in China to 8.2% [1].

CKD is defined as abnormalities of kidney structure or function, present for a minimum of 3 months, with implications for health. Chronic kidney disease occurs as a consequence of two

mechanisms: an initial trigger and a perpetuating mechanism. The initiating stimulus can be a baseline kidney issue (it is abnormal from development or it is injured along the way), an inflammatory or immune-mediated cause, or a toxic insult. This kidney damage is then perpetuated by the process of hyperfiltration and hypertrophy of remaining nephrons. These continued insults lead to sclerosis of nephrons and a further decrease in renal function [2]. However, the prevalence of diseases such as obesity, diabetes, and hypertension is increasing, which is partly the reason for the increasing burden. Therefore, early prevention and control of CKD is critical [3].

The relationship between occupation and CKD has attracted attention. Yet, there is little epidemiological evidence on the complex interaction between occupational risk factors and CKD, and the quantification of CKD burden related to occupational risk factors is unclear. Research on occupational risk factors focuses on nephrotoxic-related factors, including heavy welding fumes, silica compounds and grain dust, organic solvents [4, 5], and occupational environmental factors (such as psychosocial risk factors, heat exposure, and noise exposure) [5-7]. However, there are currently few epidemiological surveys on CKD in specific occupational groups both domestically and internationally. There are also few studies on the prevalence of CKD and its risk factors among aviation employees, and there is a lack of large-scale surveys.

Civil aviation employees are essential to the aviation transportation industry. They work quickly, for long periods, with irregular sleep and diet, lack of exercise, and work pressure, which introduces many adverse effects on their physical and mental health. Therefore, they are prone to chronic diseases affecting their health and career longevity. Physical health is associated with aviation safety. Recent small-scale health examination data in China have shown that the prevalence of hyperlipidemia, hypertension, diabetes, and obesity among aviation employees is increasing annually, highlighting the urgency of conducting an epidemiological survey on CKD among aviation employees. Assessing the CKD burden among civil aviation employees and analyzing common risk factors would facilitate early prevention and control of CKD in this population.

Methods

Study subjects

This study conducted a cross-sectional analysis using health examination data collected from January 2018 to December 2018 at the Health Examination Center of a specific hospital in the capital city, targeting all civil aviation employees aged 18 years or older from a particular airport who underwent health examinations (Table S1). (1) Inclusion criteria: The study population consisted of civil aviation employees from a certain airport in the capital city who underwent health examinations at the age of 18 or older. Their occupations included flight crew (pilots, flight attendants, aviation security officers, etc.), ground service personnel (aircraft maintenance technicians, security screeners, ground customer service representatives, etc.), and retired civil aviation employees. (2) Exclusion criteria: Health examination participants with incomplete results for routine urine tests and renal function tests were excluded.

This study conducted a cross-sectional analysis using health examination data from all civil aviation employees aged ≥ 18 years who underwent health examinations at a certain hospital in Beijing from January 2018 to December 2018. A total of 40,600 cases were surveyed, among which 9,244 cases had missing key information such as urine protein or serum creatinine test results. Ultimately, 31,356 cases were included in the analysis.

Data collection

We recorded height, weight, blood pressure, age, gender, behavioral risk factors like smoking, and comorbidities such as hypertension, diabetes, and dyslipidemia. Laboratory tests including serum creatinine, blood urea, fasting blood glucose, serum total cholesterol, serum triglycerides, serum uric acid, etc., from all study participants. Serum creatinine (Serum creatinine, Scr) was used to estimate the glomerular filtration rate (Estimated Glomerular Filtration Rate, eGFR), and was collected from routine urine tests, etc.

CKD detection indicators and diagnostic criteria

1) Proteinuria: A qualitative test strip for urine protein showed 1+ or more. 2) Definition for

renal function decline: Serum creatinine was measured by the alkaline picrate method. According to the age, gender, and serum creatinine values of the subjects, the CKD-EPI formula recommended by the KDIGO guideline in 2002 was used to calculate eGFR, and $\text{eGFR} < 60 \text{ mL}/(\text{min } 1.73 \text{ m}^2)$ was defined as renal function decline. 3) CKD diagnostic criteria: Refer to the K/DOQI guidelines established by the National Kidney Foundation (NKF) in 2002 [8]: ① Kidney damage (abnormal kidney structure and function) with or without a decrease in glomerular filtration rate (GFR) for ≥ 3 months. Kidney damage refers to either of the following two conditions: abnormal pathological changes and the presence of markers of kidney damage, specifically abnormalities in blood or urine components and abnormal imaging findings; ② A decrease in estimated GFR (eGFR), defined as $\text{eGFR} < 60 \text{ mL}/(\text{min } 1.73 \text{ m}^2)$ for ≥ 3 months, with or without kidney damage. In this study population, the presence of either one or both of proteinuria and impaired renal function is sufficient for a diagnosis of CKD.

Other detection indicators and diagnostic criteria

(1) BMI: According to the Chinese adult weight determination, $\text{BMI} < 18.5 \text{ kg}/\text{m}^2$ is underweight, $18.5\text{-}23.9 \text{ kg}/\text{m}^2$ is normal, $24\text{-}27.9 \text{ kg}/\text{m}^2$ is overweight, and $\geq 28 \text{ kg}/\text{m}^2$ is obese ($\text{BMI} = \text{weight} [\text{kg}]/\text{height} [\text{m}]^2$). (2) Hypertension: Systolic blood pressure (SBP) $\geq 140 \text{ mmHg}$ and diastolic blood pressure (DBP) $\geq 90 \text{ mmHg}$ or a history of hypertension [9]. (3) Dyslipidemia: At least one of the following characteristics: 1) $\text{TC} \geq 6.22 \text{ mmol}/\text{L}$; 2) $\text{LDL-C} \geq 4.14 \text{ mmol}/\text{L}$; 3) $\text{HDL-C} < 1.04 \text{ mmol}/\text{L}$; 4) $\text{TG} \geq 2.26 \text{ mmol}/\text{L}$ [10]. (4) Diabetes: Fasting blood glucose (FBG) $\geq 7.0 \text{ mmol}/\text{L}$ or receiving diabetes treatment or previously diagnosed with diabetes [11]. (5) Hyperuricemia: Male $\text{SUA} > 420 \text{ }\mu\text{mol}/\text{L}$ ($7.0 \text{ mg}/\text{dL}$), female $> 360 \text{ }\mu\text{mol}/\text{L}$ ($6.0 \text{ mg}/\text{dL}$), or previously diagnosed with hyperuricemia [12].

Statistical methods

Measurement data were expressed as mean $\pm$ standard deviation; count data were expressed as frequency or percentage; mean comparison between the two groups was performed by *t*-test; prevalence comparison between males and females and different age groups was performed by row $\times$ column chi-square test (χ^2 test); multivariate logistic regression analysis

was used to analyze the possible risk factors related to CKD. $P < 0.05$ indicated statistical difference, expressed by odds ratio (odd ratio, OR) and 95% confidence interval (confidence intervals, CI).

Results

Essential characteristics of the survey population

The average age of the total population was 38.19 ± 15.92 years, with 16,565 males and 14,791 females. The male-to-female ratio was 1.12:1. Age segmentation: According to the age segmentation proposed by the World Health Organization, the youth group (18-44 years) accounted for 69.48%, the middle-aged group (45-59 years) accounted for 16.90%, the young-old group (60-74 years old) accounted for 10.89%, and the old group (≥ 75 years old) accounted for 2.73%. The age, BMI, SBP, DBP, FBG, TG, HDL-C, LDL-C, UREA, SCr, and UA of males were higher than those of females, and eGFR was lower than that of females, and the differences were statistically significant (all $P < 0.01$). Age, SBP, DBP, FBG, TG, HDL-C, UREA, SCr, UA, and eGFR indicators showed significant differences between the CKD and non-CKD groups ($P < 0.001$). However, the BMI, TC, and LDL-C indicators did not show significant differences between the CKD and non-CKD groups (Table 1).

CKD detection

The proteinuria, eGFR decline, and CKD rates in the total population were 2.24%, 0.77%, and 2.81%, respectively. The detection rates of proteinuria in males were higher than in females; the differences between gender and age groups were statistically significant ($P < 0.01$); the detection rates of eGFR decline in the differences between gender and age groups were statistically significant ($P < 0.001$). The detection rates of CKD in males were higher than in females, and the differences between gender and age groups were statistically significant ($P < 0.001$) (Table 2).

The detection status of major chronic diseases and the indicators of kidney damage in individuals with these diseases, as well as the detection status of CKD

The rates of hypertension, diabetes, dyslipidemia, and hyperuricemia were 28.15%, 9.64%,

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Table 1. Demographic and biochemical characteristics among the surveyed population

Characteristics	Gender				CKD		
	Total count (n=31356)	Female (n=14791)	Male (n=16565)	P value	NO (n=30476)	YES (n=880)	P value
	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation		Mean ± Standard Deviation	Mean ± Standard Deviation	
AGE (year)	38.19±15.92	36.61±15.48	39.60±16.18	< 0.001	37.94±15.59	46.79±23.31	< 0.001
BMI (kg/m ²)	24.22±3.97	120.84±16.86	129.51±15.91	< 0.001	24.22±3.97	24.77±4.56	0.003
SBP (mmHg)	125.65±16.90	120.84±16.86	129.51±15.91	< 0.001	125.36±16.62	135.56±22.38	< 0.001
DBP (mmHg)	75.12±11.35	71.72±10.35	77.83±11.38	< 0.001	75.03±11.26	77.93±13.77	< 0.001
FBG (mmol/L)	5.46±1.32	5.32±1.11	5.57±1.45	< 0.001	5.44±1.27	6.38±2.40	< 0.001
TC (mmol/L)	4.92±0.98	4.93±0.99	4.92±0.97	0.622	4.92±0.97	5.04±1.25	0.028
TG (mmol/L)	1.55±1.28	1.26±0.90	1.78±1.48	< 0.001	1.53±1.25	2.77±2.15	< 0.001
HDL-C (mmol/L)	1.41±0.33	1.56±0.33	1.30±0.28	< 0.001	1.41±0.33	1.32±0.38	< 0.001
LDL-C (mmol/L)	2.72±0.62	2.66±0.63	2.76±0.62	< 0.001	2.72±0.62	2.73±0.71	0.616
UREA (mmol/L)	4.79±1.29	4.40±1.19	5.14±1.27	< 0.001	4.76±1.23	5.93±2.33	< 0.001
Scr (μmol/L)	69.59±14.83	58.80±8.97	79.22±12.16	< 0.001	69.12±13.64	85.65±33.64	< 0.001
UA (μmol/L)	333.68±88.75	280.71±62.01	382.09±81.58	< 0.001	332.71±88.29	366.95±97.64	< 0.001
eGFR (ml/min)	108.23±16.18	112.07±15.72	104.81±15.80	< 0.001	108.72±15.31	91.50±30.25	< 0.001

P values among gender. P values among CKD with or without. Variables are presented as mean ± standard deviation (SD). BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; Scr, serum creatinine; UA, uric acid; eGFR, estimated glomerular filtration rate; CKD, chronic kidney diseases.

Table 2. Prevalence of CKD diagnostic indicators among survey participants by gender and age groups

Item	Total N (%)	Proteinuria N (%)	Reduced eGFR N (%)	CKD N (%)
Gender				
Male	16565 (52.83)	410 (2.48)	172 (1.04)	534 (3.22)
Female	14791 (47.17)	292 (1.97)	69 (0.47)	346 (2.34)
<i>P</i> value		0.003	< 0.001	< 0.001
Age (year)				
18-44	21787 (69.48)	453 (2.08)	6 (0.28)	455 (2.09)
45-59	5298 (16.90)	91 (1.72)	18 (0.34)	99 (1.87)
60-74	3415 (10.89)	99 (2.90)	86 (2.52)	158 (4.63)
≥ 75	856 (2.73)	59 (6.89)	131 (15.30)	168 (19.63)
<i>P</i> value		< 0.001	< 0.001	< 0.001
Total Number	31356	702 (2.24)	241 (0.77)	880 (2.81)

P values among gender. *P* values among age groups. Variables are number (percentage). eGFR, estimated glomerular filtration rate; CKD, chronic kidney diseases.

53.87%, and 20.90%, respectively. Among them, hypertension, diabetes, dyslipidemia, and hyperuricemia had gender differences, and males were significantly higher than females ($P < 0.001$). The detection rates of proteinuria, eGFR decline, and CKD in each major chronic disease group were higher than those in each non-chronic disease compared with non-hypertensive, non-diabetic, non-dyslipidemic, and non-hyperuricemia subjects, regardless of gender, hypertensive, diabetic, dyslipidemia, and hyperuricemia subjects had significantly higher detection rates of proteinuria, eGFR decline, and CKD ($P < 0.001$) (Table 3).

CKD-related risk factor analysis

Through univariate logistic regression analysis of factors associated with CKD: the risk of developing CKD is significantly higher in men than in women, and the risk of CKD increases with age and BMI. Coexisting conditions such as hypertension, diabetes, dyslipidemia, and hyperuricemia are also factors associated with an increased risk of CKD. However, smoking is not significantly associated with the risk of CKD ($P > 0.05$). Variables with $P < 0.1$ in the univariate logistic regression analysis were included in the multivariate logistic regression analysis. The results showed that the independent risk factors for CKD were being male, age ≥ 60 years, and having hypertension, diabetes, dyslipidemia, or hyperuricemia (Table 4).

Discussion

This study is the first to report the prevalence of chronic kidney disease (CKD) among employees of the civil aviation at a certain airport in the capital based on a large-scale health examination, with a prevalence rate of 2.81%, which is lower than the 14.00% reported by the U.S. Centers for Disease Control and Prevention (CDC) for adults in the United States in 2023. It is also lower than the CKD prevalence rate of 14.30% among adults aged 20-60 in Odisha, India [13] and the overall CKD prevalence rate of 15.14% among adults in Iran [14]. It is

also lower than the CKD prevalence rate of 10.80% among Chinese adults reported in 2012 [15], and the updated CKD prevalence rate of 8.2% among Chinese adults aged 18 and older in the sixth round of the China Chronic Disease and Risk Factor Surveillance since 2012 [1]. This rate is significantly lower than the CKD prevalence rate of 18.70% among the elderly population (aged 40 and older) in four communities in Shijingshan District, Beijing, China [16]. However, there are currently no studies on the prevalence of CKD among civil aviation employees. Our study results indicate that the prevalence of CKD among civil aviation employees at a specific airport in the capital is significantly lower than that in economically developed countries such as the United States, economically growing countries such as Odisha Province in India, and developing countries such as Iran, as well as lower than the national baseline prevalence in China and the prevalence level among adult populations in communities in Beijing, a first-tier city in China.

Currently, there are few epidemiological studies on CKD in specific occupational groups both domestically and internationally. A study conducted at the La Paz Center in Nicaragua, Central America, targeting brickmakers reported a CKD prevalence rate of 12.1% among brickmakers, which is relatively high. This finding aligns with the hypothesis that occupational

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Table 3. General characteristics of gender and kidney damage indicators among survey participants with major chronic diseases

Items		Total (n=19571)	Gender		Proteinuria	Reduced eGFR	CKD
			Male (n=11055)	Female (n=8516)			
Hypertension N (%)	Yes	510 (28.15)	3645 (32.97)	1865 (21.90)	227 (4.12)	190 (3.45)	368 (6.68)
	No	14061 (71.85)	7410 (69.03)	6651 (78.10)	153 (1.09)	46 (0.33)	187 (1.33)
	P value		< 0.001		< 0.001	< 0.001	< 0.001
Diabetes N (%)	Yes	1887 (9.64)	1286 (11.63)	601 (7.06)	143 (7.58)	86 (4.56)	197 (10.44)
	No	17684 (90.36)	9769 (88.37)	7915 (92.94)	237 (1.34)	150 (0.85)	358 (2.02)
	P value		< 0.001		< 0.001	< 0.001	< 0.001
Dyslipidemia N (%)	Yes	10543 (53.87)	6590 (59.61)	3953 (46.42)	251 (2.38)	163 (1.55)	371 (3.52)
	No	9028 (46.13)	4465 (40.39)	4563 (53.58)	129 (1.43)	73 (0.81)	184 (2.04)
	P value		< 0.001		< 0.001	< 0.001	< 0.001
Hyperuricemia N (%)	Yes	3971 (20.90)	2978 (26.94)	993 (11.66)	128 (3.25)	129 (3.25)	214 (5.39)
	No	15600 (79.71)	8077 (73.06)	7523 (88.34)	252 (1.62)	107 (0.69)	341 (2.19)
	P value		< 0.001		< 0.001	< 0.001	< 0.001

P value among chronic diseases with or without. Variables are number (percentage). eGFR, estimated glomerular filtration rate; CKD, chronic kidney diseases.

Table 4. Logistic regression analysis of CKD risk factors in survey participants

Risk factor	Univariate analysis		Multivariate analysis	
	COR value (95% CI)	P value	AOR value (95% CI)	P value
Gender				
Female	Referent		Referent	
Male	2.43 (1.94-3.04)	< 0.001	1.80 (1.42-2.28)	< 0.001
Age grouping				
18-44	Referent		Referent	
45-59	1.67 (1.20-2.30)	0.002	1.07 (0.76-1.51)	0.689
60-74	4.48 (3.40-5.89)	< 0.001	2.39 (1.76-3.25)	< 0.001
≥ 75	20.82 (15.61-27.76)	< 0.001	9.41 (6.74-13.13)	< 0.001
BMI				
Normal weight index	Referent		Referent	
Overweight	1.87 (1.48-2.37)	< 0.001	1.00 (0.78-1.30)	0.973
Obese	2.26 (1.73-2.95)	0.003	1.12 (0.83-1.51)	0.465
Hypertension				
No	Referent		Referent	
Yes	6.48 (5.17-8.12)	< 0.001	2.64 (2.04-3.42)	< 0.001
Diabetes				
No	Referent		Referent	
Yes	5.75 (4.68-7.07)	< 0.001	2.57 (2.04-3.22)	< 0.001
Dyslipidemia				
No	Referent		Referent	
Yes	1.85 (1.50-2.28)	< 0.001	1.49 (1.19-1.86)	< 0.001
Hyperuricemia				
No	Referent		Referent	
Yes	2.58 (2.11-3.16)	< 0.001	2.20 (1.76-2.73)	< 0.001
Smoking history				
No	Referent		Referent	
Yes	0.89 (0.51-1.55)	0.675		

AOR estimated from the stepwise multivariate logistic regression model with all the above variables added except smoking history. CI, confidence interval; OR, odds ratio; CKD, chronic kidney diseases; COR, crude OR; AOR, adjusted OR.

heat exposure is a risk factor for kidney disease in the region [17]. A cross-sectional study on CKD among sugarcane workers in Cameroon showed that the overall prevalence of CKD was 3.4%, with the prevalence of CKD being low, possibly related to the implementation of heat stress and dehydration prevention measures [18]. The prevalence of chronic kidney disease among teachers in Cape Town, South Africa, was 6.1%, and CKD was associated with diabetes and higher diastolic blood pressure [19]. A study in Iran showed that the prevalence of $\text{GFR} < 60 \text{ mL/min/1.73 m}^2$ among commercial drivers was 4%. Advanced age and hypertension were risk factors for CKD among commercial drivers [20]. Among occupational male long-distance drivers in Lagos, Nigeria, with cardiovascular disease risk, the prevalence of CKD was as high as 51.7% [21]. There are significant differences in the prevalence of CKD among different occupational groups. Non-traditional risk factors (such as heat exposure and dehydration) may have a significant impact on the prevalence of CKD in occupational groups, but common risk factors (such as diabetes and hypertension) have a more obvious impact on CKD in occupational groups.

Our study found that the prevalence of decreased eGFR among civil aviation employees at a specific airport in the capital was 0.77%, which was lower than the prevalence of eGFR among the elderly population (aged 40 and above) in four communities in the Shijingshan district of Beijing, China, which was 5.20% [16].

Our survey results indicate that the prevalence of proteinuria among civil aviation employees at a certain airport in the capital is 2.24%, which is lower than the prevalence of albuminuria among the elderly population (aged 40 and above) in four communities in Shijingshan District, Beijing, China, which is 6.20%. This study used enzyme-linked immunosorbent assay (ELISA) or immunoturbidimetry to detect urinary microalbumin [16], which is more sensitive than proteinuria detection in routine urine tests. Our study used routine urine tests to detect proteinuria prevalence, and the prevalence rates in Hong Kong, China, which used the same or similar detection methods (urine dipstick tests for protein), were 2.70%-3.12% [22], which are comparable.

The overall prevalence of CKD, the prevalence of reduced eGFR, and the prevalence of proteinuria were all low in this study population. This may be attributed to the following factors: (1) Differences in the study population. The employees of the civil aviation at a certain airport in the capital are part of China's occupational population, who undergo rigorous health examinations upon employment and are thus a healthy group. Additionally, civil aviation employees in China have a good educational background and access to adequate medical care, which may contribute to the lower prevalence of CKD. (2) Differences in age distribution. Unlike the age distribution of the general population, the civil aviation employees at a certain airport in the capital are a young occupational group, primarily consisting of individuals aged 18-44, accounting for 69.48% of the population. (3) Differences in proteinuria detection methods. Pathological proteinuria is an important manifestation of kidney damage, but in the early stages of kidney damage (especially diabetic nephropathy, hypertensive kidney damage, and hyperuricemic kidney damage), proteinuria is primarily characterized by microalbuminuria (30-300 mg/24 h), which exists before proteinuria is detected by routine urine analysis using dry chemistry methods. Therefore, this study used dry chemistry methods to detect proteinuria without testing for albuminuria, which may lead to missed diagnoses. (4) Different diagnostic criteria. Unlike other studies, this study did not include hematuria as a diagnostic criterion for CKD. Since hematuria can be caused by various factors such as urinary tract infections or tumors, if urine red blood cell phase examination and red blood cell morphology are not performed, relying solely on hematuria as a marker of kidney damage in CKD during physical examinations has poor specificity, potentially overestimating the prevalence of glomerular hematuria and, consequently, the prevalence of CKD. Removing hematuria yields a CKD prevalence rate that is closer to the actual value.

Our study also found that among the major chronic diseases affecting civil aviation employees at a certain airport in the capital, dyslipidemia had the highest prevalence rate of 53.87%, which was significantly higher than the overall prevalence rate of dyslipidemia among adults aged 18 and above in China in 2016

(34.00%) [23]. The main reason for dyslipidemia may be the unreasonable diet (high fat, high calorie), unhealthy lifestyle habits, and lack of physical exercise of airport civil aviation employees, coupled with long-term high mental stress and heavy tasks (especially pilots), resulting in the accumulation of energy intake in the body. Some authors have found that dyslipidemia is related to the incidence of CKD [24]. Followed by hypertension (28.15%), higher than the 24.7% prevalence of hypertension among Chinese adults (18-69 years old) in the sixth national survey results in 2018 [25]. Internationally recognized risk factors for the onset of hypertension include overweight/obesity and high-salt diets. However, the rise in blood pressure may be related to the high work pressure of employees of the Capital's civil aviation. We found that the prevalence of diabetes was the lowest (9.64%), lower than the 12.80% total prevalence of diabetes among Chinese adults aged 18 and over according to the 2018 American Diabetes Association diagnostic criteria [26]. However, the prevalence of CKD among diabetic patients was the highest (10.44%), followed by the prevalence of CKD among hypertensive patients (6.68%) and the prevalence of CKD among patients with hyperuricemia and dyslipidemia (5.39% and 3.52%, respectively). Consistent with previous studies that identified hypertension and diabetes as the main risk factors for CKD [27, 28]. In addition, hyperuricemia is also related to CKD [29]. Therefore, early CKD screening should be carried out among chronic disease patients (especially diabetic and hypertensive patients), and urine microalbumin detection should be performed for this group of people, which can increase the chance of early diagnosis and treatment, and improve the awareness of medical staff on early CKD screening. Attention should be paid to preventing and treating common chronic diseases among civil aviation employees (especially pilots).

This study found through multivariate logistic regression analysis that male gender, age ≥ 60 years, hypertension, diabetes, dyslipidemia, and hyperuricemia are independent risk factors for chronic kidney disease (CKD). The prevalence of CKD is higher in men than in women, which may be related to the higher prevalence of chronic diseases such as hypertension, diabetes, dyslipidemia, and hyperuricemia in men

compared to women. Additionally, the prevalence of proteinuria and eGFR decline is also higher in men than in women. Previous studies have suggested that aging is a classic risk factor for CKD [16, 30]. As age increases, changes occur in kidney morphology and function, and kidney reserve function also decreases. This study also found that the risk of CKD in individuals with hypertension, diabetes, dyslipidemia, and hyperuricemia was 1.50-2.64 times higher than in those without these chronic diseases. Additionally, obesity can lead to compensatory ultrafiltration to meet the metabolic demands of weight gain, and increased glomerular pressure can damage the kidneys. Increasing evidence suggests that obesity is a driving factor in CKD progression, with complex mechanisms involving hemodynamic changes, inflammation, oxidative stress, and activation of the renin-angiotensin-aldosterone system (RAAS) [31]. Excessive alcohol consumption and smoking are also associated with increased CKD risk [32]. However, this study found a significant association between BMI and the risk of CKD in univariate analysis, but multivariate analysis did not reveal an independent association between obesity and CKD. Similarly, no independent association between smoking and CKD was observed in this study, which is inconsistent with previous research. This discrepancy may be attributed to differences in the study population, including a lower proportion of obese individuals, variations in demographic characteristics, sample size, and regional differences in the prevalence of chronic diseases. It may also be related to the characteristics of obesity-related kidney disease, where early manifestations are primarily characterized by microalbuminuria, and eGFR may be elevated due to early compensatory mechanisms rather than renal function decline [33, 34]. Since we used urine protein testing instead of urine microalbumin testing, this may have led to an underestimation of the risk of CKD associated with obesity. Additionally, it may be related to the stringent requirements for aviation-related occupational populations (such as body image standards and smoking restrictions in work areas). The results suggest that it is important to prioritize the prevention and control of hypertension, diabetes, hyperuricemia, and dyslipidemia among aviation employees, and to emphasize the importance of urine microalbumin

testing for this population to enable early detection of CKD.

This study utilized data collected prior to the COVID-19 pandemic, and the results are generally accurate. Among civil aviation employees at a certain airport in the capital, flight crew members (pilots, flight attendants, etc.) account for approximately 12% of the workforce. Due to privacy concerns, it was not possible to further distinguish and compare the prevalence of chronic kidney disease (CKD) and differences in risk factors between flight crew members and ground service personnel.

In summary, the prevalence of CKD among civil aviation employees at a certain airport in the capital is 2.81%, which is lower than the global and Chinese CKD prevalence rates. Among aviation employees at a specific airport, the prevalence of major chronic diseases associated with CKD risk, such as hypertension, diabetes, dyslipidemia, and hyperuricemia, was relatively high. Male gender, age ≥ 60 years, hypertension, diabetes, dyslipidemia, and hyperuricemia were independent risk factors for increased CKD risk.

Disclosure of conflict of interest

None.

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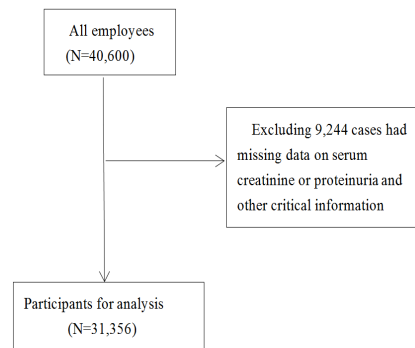
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Table S1. STROBE Statement-Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Epidemiological investigation and risk factor analysis of chronic kidney disease among civil aviation employees in the Capital (b) We considered 31,356 adults with complete data. The detection rate of chronic kidney disease among employees of the Capital's civil aviation was 2.81%. Multivariate logistic regression analysis showed that males, age ≥ 60 , hypertension, diabetes, dyslipidemia, and hyperuricemia were independent risk factors for chronic kidney disease.	1 1
Introduction			
Background/ rationale	2	The relationship between occupation and chronic kidney disease (CKD) has attracted substantial. There is little epidemiological evidence of the interaction between occupational risk factors and CKD. The quantification of CKD burden-related occupational risk factors needs to be clarified. There are few epidemiological surveys on occupational groups in China or elsewhere. There is no known study with civil aviation employees in the Capital; their health is associated with aviation safety. It is necessary to assess the CKD burden among civil aviation employees and analyze common risk factors, which is beneficial for the early prevention and control of CKD in this population.	2
Objectives	3	It is necessary to assess the CKD burden among civil aviation employees and analyze common risk factors, such as hypertension and diabetes, which is beneficial for the early prevention and control of CKD in this population.	2
Methods			
Study design	4	This study was designed as a cross-sectional study.	3
Setting	5	The participants were employees of the Capital's civil aviation who underwent health check-ups at a hospital health examination center and were ≥ 18 from January to December 2018. The occupations involved flight crew (pilots, flight attendants, aviation security officers), ground crew (aircraft maintenance technicians, security inspectors, ground service staff), and retired airport civil aviation employees. The survey included demographic information such as height, weight, blood pressure, age, gender, behavioral risk factors like smoking, and comorbidities such as hypertension, diabetes, and dyslipidemia. Laboratory tests included serum creatinine, urea, uric acid, fasting blood glucose, serum total cholesterol, and serum triglycerides from all subjects.	3
Participants	6	(a) 40,600 cases were investigated, of which 9,244 cases had missing data on serum creatinine or proteinuria and other critical information, and finally 31,356 cases were included in the analysis.	3
Variables	7	Proteinuria: A qualitative test strip for urine protein showed 1+ or more. Definition for renal function decline: Serum creatinine was measured by the alkaline picrate method. According to the age, gender, and serum creatinine values of the subjects, the CKD-EPI formula recommended by the KDIGO guideline in 2002 was used to calculate eGFR, and $eGFR < 60 \text{ ml}/(\text{min } 1.73 \text{ m}^2)$ was defined as renal function decline. CKD diagnostic criteria: The definition and diagnostic criteria of CKD refer to the K/DOQI guideline formulated by the American Kidney Foundation. In this survey, the occurrence of proteinuria, renal function decline, or both items can be diagnosed as CKD (those who were found to have positive proteinuria and reduced eGFR in the annual physical examination were traced back to the previous year's physical examination results according to the employee physical examination ID number and reconfirmed).	3-4
Data sources/ measurement	8*	The glomerular filtration rate (eGFR) is based on SCr, extract fasting venous blood, centrifuge and separate serum, tested by trained laboratory technicians. Collecting 5 ml of morning urine samples from all subjects and testing urine routine.	4

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Bias	9	Researchers strictly control the inclusion and exclusion criteria of research subjects. Researchers develop detailed data collection methods to ensure the authenticity and completeness of the data. Choose appropriate statistical methods, rigorously investigate the scientific attitudes of the design and researchers.	
Study size	10	This study surveyed on employees of the Capital's civil aviation who underwent health check-ups at a hospital health examination center and were ≥ 18 from January to December 2018.	
Quantitative variables	11	Basic characteristics of the survey population. CKD detection rate. The detection status of major chronic diseases and the indicators of kidney damage in individuals with these diseases, as well as the detection status of CKD. CKD-related risk factor analysis.	5-6
Statistical methods	12	(a) Measurement data were expressed as mean $\pm$ standard deviation; count data were expressed as frequency or percentage; mean comparison between two groups was performed by t-test; prevalence comparison between male and female and different age groups was performed by row $\times$ column chi-square test (χ^2 test); multivariate logistic regression analysis was used to analyze the possible risk factors related to CKD, $P < 0.05$ indicated statistical difference, expressed by odds ratio (odd ratio, OR) and 95% confidence interval (confidence intervals, CI). (b) Mean comparison between two groups was performed by t-test; prevalence comparison between male and female and different age groups was performed by row $\times$ column chi-square test (χ^2 test). (c) According to the number and proportion of missing values: if there are few missing values, deletion method can be considered; if there are many missing values, methods such as imputation or regression need to be considered. (d) This study is a census of employees of the Capital's civil aviation who underwent health check-ups at a hospital health examination center and were ≥ 18 from January to December 2018. (e) First, use single factor logistic regression analysis, followed by multiple factor Logistic regression analysis to control for potential confounding factors.	5-6 5-6 6
Results			
Participants	13*	(a) 40,600 cases were investigated, of which 9,244 cases had missing data on serum creatinine or proteinuria and other critical information, and finally 31,356 cases were included in the analysis. (b) This study is a retrospective study that collected previous data for analysis and Research. (c) Flow of the participants' selection procedure	3



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Descriptive data	14*	(a) A total of 40,600 cases were surveyed, and the final dataset, which includes 31,356 fully complete cases, was included in the analysis. The average age of the total population was (38.19 ± 15.92 years), with 16,565 males and 14,791 females. The male-to-female ratio was 1.12:1. Age segmentation: According to the age segmentation proposed by the World Health Organization: the youth group (18-44 years) accounted for 69.48%, the middle-aged group (45-59 years) accounted for 16.90%, the young-old group (60-74 years old) accounted for 10.89%, and the old group (≥ 75 years old) accounted for 2.73%. The age, BMI, SBP, DBP, FBG, TG, HDC-L, LDC-L, UREA, SCr, and UA of males were higher than those of females, and eGFR was lower than that of females, and the differences were statistically significant (all P < 0.01). A binary logistic regression analysis with CKD as the dependent variable (YES = 1, NO = 0) set the probability standard for covariate introduction at 0.1. After adjusting for gender, age, BMI, hypertension, diabetes, dyslipidemia, hyperuricemia, and smoking history, the multivariate logistic regression analysis identified male gender, age ≥ 60 years, hypertension, diabetes, dyslipidemia, and hyperuricemia as independent factors associated with CKD. (b) There were no missing data in the logistic regression analysis of risk factor. For CKD among 19571 participants.				5-6																																																																	
Outcome data	15*	The detection rates of proteinuria, eGFR decline, and CKD in the total population were 2.24%, 0.77%, and 2.81%, respectively. The detection rates of hypertension, diabetes, dyslipidemia, and hyperuricemia were 28.15%, 9.64%, 53.87%, and 20.90%, respectively. A binary logistic regression analysis with CKD as the dependent variable (YES = 1, NO = 0) set the probability standard for covariate introduction at 0.1. After adjusting for gender, age, BMI, hypertension, diabetes, dyslipidemia, hyperuricemia, and smoking history, the multivariate logistic regression analysis identified male gender, age ≥ 60 years, hypertension, diabetes, dyslipidemia, and hyperuricemia as independent factors associated with CKD.				5-6																																																																	
Main results	16	<table><tr><td colspan="2">(a) Risk factor</td><td colspan="2">value (95% CI)</td><td>value (95% CI)</td></tr><tr><td>Gender</td><td>Male</td><td>2.65 (2.11-3.33)</td><td>After adjusting</td><td>1.92 (1.51-2.45)</td></tr><tr><td rowspan="4">Age grouping</td><td>45-59</td><td>1.61 (1.56-2.23)</td><td>After adjusting</td><td>1.04 (0.74-1.47)</td></tr><tr><td>60-74</td><td>4.30 (3.24-5.69)</td><td>After adjusting</td><td>2.35 (1.72-3.21)</td></tr><tr><td>≥75</td><td>19.73 (14.70-26.49)</td><td>After adjusting</td><td>9.18 (6.54-12.90)</td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td rowspan="3">BMI</td><td>normal weight index</td><td>3.86 (0.95-16.69)</td><td>After adjusting</td><td>1.36 (0.33-5.63)</td></tr><tr><td>Overweight</td><td>6.92 (1.71-28.10)</td><td>After adjusting</td><td>1.35 (0.33-5.60)</td></tr><tr><td>Obese</td><td>8.45 (2.08-34.34)</td><td>After adjusting</td><td>1.53 (0.37-6.38)</td></tr><tr><td>Hypertension</td><td>Yes</td><td>6.21 (4.95-7.80)</td><td>After adjusting</td><td>2.53 (1.96-3.28)</td></tr><tr><td>Diabetes</td><td>Yes</td><td>5.51 (4.48-6.78)</td><td>After adjusting</td><td>2.56 (2.03-3.21)</td></tr><tr><td>Dyslipidemia</td><td>Yes</td><td>1.89 (1.53-2.33)</td><td>After adjusting</td><td>1.58 (1.26-2.00)</td></tr><tr><td>Hyperuricemia</td><td>Yes</td><td>2.80 (2.28-3.43)</td><td>After adjusting</td><td>2.27 (1.82-2.83)</td></tr><tr><td>smoking history</td><td>Yes</td><td>0.86 (0.49-1.51)</td><td>After adjusting</td><td></td></tr></table> A binary logistic regression analysis with CKD as the dependent variable (YES = 1, NO = 0) set the probability standard for covariate introduction at 0.1. After adjusting for gender, age, BMI, hypertension, diabetes, dyslipidemia, hyperuricemia, and smoking history, the multivariate logistic regression analysis identified male gender, age ≥ 60 years, hypertension, diabetes, dyslipidemia, and hyperuricemia as independent factors associated with CKD. According to literature reports: the prevalence of CKD varies among different occupational groups, and uncommon risk factors may significantly impact the CKD prevalence in certain groups. However, the influence of common risk factors (such as diabetes and hypertension) on CKD prevalence in some occupational groups is more definitive. It is necessary to assess the CKD burden among civil aviation employees and analyze common risk factors, such as hypertension and diabetes, which is beneficial for the early prevention and control of CKD in this population.				(a) Risk factor		value (95% CI)		value (95% CI)	Gender	Male	2.65 (2.11-3.33)	After adjusting	1.92 (1.51-2.45)	Age grouping	45-59	1.61 (1.56-2.23)	After adjusting	1.04 (0.74-1.47)	60-74	4.30 (3.24-5.69)	After adjusting	2.35 (1.72-3.21)	≥75	19.73 (14.70-26.49)	After adjusting	9.18 (6.54-12.90)					BMI	normal weight index	3.86 (0.95-16.69)	After adjusting	1.36 (0.33-5.63)	Overweight	6.92 (1.71-28.10)	After adjusting	1.35 (0.33-5.60)	Obese	8.45 (2.08-34.34)	After adjusting	1.53 (0.37-6.38)	Hypertension	Yes	6.21 (4.95-7.80)	After adjusting	2.53 (1.96-3.28)	Diabetes	Yes	5.51 (4.48-6.78)	After adjusting	2.56 (2.03-3.21)	Dyslipidemia	Yes	1.89 (1.53-2.33)	After adjusting	1.58 (1.26-2.00)	Hyperuricemia	Yes	2.80 (2.28-3.43)	After adjusting	2.27 (1.82-2.83)	smoking history	Yes	0.86 (0.49-1.51)	After adjusting		5-6
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Other analyses	17	The detection rates of hypertension, diabetes, dyslipidemia, and hyperuricemia were 28.15%, 9.64%, 53.87%, and 20.90%, respectively. Among them, hypertension, diabetes, dyslipidemia, and hyperuricemia had gender differences, and males were significantly higher than females ($P < 0.001$). The detection rates of proteinuria, eGFR decline, and CKD in each major chronic disease group were higher than those in each non-chronic disease compared with non-hypertensive, non-diabetic, non-dyslipidemic, and non-hyperuricemia subjects, regardless of gender, hypertensive, diabetic, dyslipidemia, and hyperuricemia subjects had significantly higher detection rates of proteinuria, eGFR decline, and CKD ($P < 0.001$)	5
Discussion			
Key results	18	The prevalence of CKD among employees of the Capital's civil aviation was surprisingly low. However, the prevalence of chronic diseases such as hypertension, diabetes, dyslipidemia, and hyperuricemia among employees of the Capital's civil aviation was high, posing a risk of CKD increase. Discuss the importance of improving screening methods and emphasizing the screening of high-risk populations for early identification of chronic kidney disease.	7-10
Limitations	19	This study used data from before the COVID-19 pandemic, and the results were generally accurate. The limitation is that the proportion of flight personnel (pilots, flight attendants) among employees of the Capital's civil aviation is about 12%, and due to privacy protection, the differences in CKD prevalence and risk factors between flight personnel and ground personnel could not be further distinguished and compared.	10
Interpretation	20	This study is the first large-scale report of the epidemiological data of chronic kidney disease among civil aviation employees. There have been few related studies in the past.	7
Generalisability	21	This study was intended to enhance the awareness of medical personnel on early chronic kidney disease screening, laying the foundation for extending the career life of employees (especially pilots) and ensuring aviation safety.	
Other information			
Funding	22	This study was not supported by any sponsor or funder.	

*Give information separately for exposed and unexposed groups. Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.