Effect of Marital Status on Depression and Mortality among Patients with Chronic Kidney Disease from National Health and Nutrition Examination Survey 2005–2014

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Keywords

Chronic kidney disease · Marital status · Depression · Mortality

Abstract

Background: The relationship between marital status and CKD is rarely studied. We aimed to explore the effect of marital status on the depression and mortality of patients with CKD. **Methods:** The data sources came from the NHANES database during 2005–2014 and 3,865 participants were included in this study. We used logistic regression models to examine the relationship between marital status and depression of CKD patients. The Cox proportional hazard models were used to evaluate the association between marital status and mortality of CKD patients. **Results:** In terms of depression in CKD patients, unmarried patients had a worse situation than married patients. Meanwhile, after adjusting the covariables, unmarried patients had increased risk of depression (OR = 1.26, 95% CI: 1.01–1.57) compared with married CKD patients, especially in males (OR = 1.45, 95% CI: 1.02–2.06) and patients with more than college education level (OR = 12.4, 95% CI: 3.75–41.02). There was a significant relationship between marital status and mortality of general CKD patients (HR = 1.36, 95% CI: 1.17–1.58). Moreover, mar-

riage showed a protective effect against death among male patients, patients with school graduate or less and more than college educational level, patients with high income, and patients in different estimated glomerular filtration rate groups. **Conclusions:** The use of large numbers of participants has revealed the effect of marital status on CKD patients. Unmarried ones had a higher risk of depression than married ones among CKD patients. Meanwhile, the risk of death was higher in unmarried ones than married ones among CKD patients in this study.

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Introduction

The prevalence of CKD is estimated to be 8–16% worldwide [1], and CKD affected 15% of the US population in 2018 [2]. Patients with CKD have a higher risk of substantial complications, including depression [3], cardiovascular disease [4], and death [5]. In addition to the treatment measures, many societal factors may also influence the mental health and mortality of CKD patients [6].

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Fig. 1. The screening process of this study.

Marital status is one of the most important social factors of people's lives, which affects various aspects of one's life, especially mental health [7]. A previous study showed that married people have better mental health than those who are single, widowed, separated, and divorced [8]. On the other hand, it is reported that 25% of patients with CKD had depression, which is 4 times higher than the prevalence in the general population [9]. However, few studies showed whether marital status effects on the depression of CKD patients.

Besides the mental health, marital status may have an influence on the mortality of general population as well [10]. It is well known to public that patients with CKD have a higher mortality risk than the general population, and the risk of mortality increased with the progression of CKD [11]. Meanwhile, the mortality of CKD was deeply related to medical treatment [12] and social support [13]. Marital status has often been regarded as a marker of social support, and also entails more economic resources, social support [14]. Thus, married people may

have a higher quality of life, healthier lifestyle, and behaviors [15] and better medical treatment [16] than the unmarried. However, whether the marital status has influence on mortality of CKD patients is unknown.

Relatively little is known about whether the marital status has effect on depression and mortality of patients with CKD. We thus conducted a study including more than 3,000 patients from National Health and Nutrition Examination Survey (NHANES) data from 2005 to 2014 to assess the effect of marital status on depression and mortality in CKD.

Methods

Participants

We performed an analysis of the NHANES database. The NHANES is a periodic survey conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC). NCHS performed the data accumulation with approval from the NCHS Ethics Review Board (protocol

#2005-06; protocol #2011-17), and all participants provided written informed consent. We used data from 2005 to 2014 (50,965 people). We restricted our analysis to nonpregnant individuals >18 years of age with marital status (26,157 subjects) and excluded from our analysis participants with missing information on hypertension, diabetes, history of smoke and drink, BMI, lipid markers, depression score, and information of mortality (4,141 subjects). 18,151 participants without CKD were included in our analysis. In addition, 3,865 patients with CKD [defined as an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m² (using the CKD Epidemiology Collaboration equation) [17] and/or a urinary albumin: Cr ratio >30 mg/g] in our analysis finally. See Figure 1 for detailed information.

Measures

Marital Status

Marital status was categorized into married, widowed, divorced, separated, never married, living with a partner, refused, and do not know in the primary file of NHANES. In this study, the people of married and living with partner groups were considered as married ones, and people of the widowed group, divorced group, separated group, and the never-married group were considered as unmarried ones.

Depression Outcomes

Participants were assessed for depression based upon their self-ratings on a PHQ-9 questionnaire for symptoms within the prior 2 weeks [18]. This questionnaire is widely used to assess the prevalence and severity of depressive symptoms because it is valid and reliable [19]. Nine questions are scored on a scale of 0–3 for each frequency question of how often the symptom arose, the zero represents not at all, 1 represents several days, 2 represents more than half the days, and 3 represents to nearly all days. The sum of all 9 questions was used as a quantitative measure of depression along with the cutoff of ≥10 as applied elsewhere [20].

Covariates

Covariates used in the adjusted analyses were age, sex, race (Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black and other), citizen living (yes or no), education level (high school graduate, some college or associate's degree, and college graduate and above), and category of income (low, middle, and high), hypertension (yes, prehypertension, and no), diabetes (yes, prediabetes, and no), physical activity (vigorous, moderate, and none), alcohol drinking status (current drinker, past drinker, and never drinker), smoking status (never smoker, current smoker, or former smoker), category of BMI (obese, overweight, normal weight, and underweight), eGFR (mL/min/1.73 m²), high-density lipoprotein cholesterol (HDL-c) (mmol/L), total cholesterol (TC) (mmol/L), triglyceride (TG) (mmol/L), and uric acid (mmol/L).

The income was classified by the family monthly poverty level index, <1.30 referring to as low income, 1.30–1.85 referring to as middle income, and >1.85 referring to as high income. Hypertension was defined as systolic blood pressure (BP) ≥140 mm Hg or diastolic BP ≥90 mm Hg or used antihypertensive medications before the measurement. Prehypertension was defined as a systolic BP between 120 and 129 mm Hg or diastolic BP of 80–89 mm Hg [21]. Diabetes was defined as a fasting blood glucose concentration ≥7 mmol/L, or treatment with insulin or any oral hypoglycemic agent. Participants with fasting blood glucose concentration of

5.6–6.9 mmol/L were considered as prediabetes [22]. The BMI was sorted as 4 groups, obese (≥25.0 kg/m²), overweight (23.0–24.9 kg/m²), normal weight (18.5–22.9 kg/m²), and underweight (<18.5 kg/m²).

Mortality

The primary outcome was time to death. Mortality status was determined by NHANES-linked National Death Index public access files through December 31, 2015.

Statistical Analysis

All calculations took into account the complex survey design of the NHANES database and were analyzed according to the CDC analytic recommendations [23]. Standard description statistics were reported for each marital status group, median and quartile for numerical variables, and percent (*n*) for categorical variables. Subgroups were grouped by sex, educational level, income, and eGFR with the cutoff of 60 mL/min/1.73 m². Since the depression score was nonnormal distribution, the nonparametric test was used to compare the value of depression score between different marital statuses in the different subgroups. The associations of marital status and renal function with depression outcomes were assessed using logistic regression for depression defined by depression sum score ≥10. Three models were calculated, model 1 was nonadjusted, model 2 adjusted for age, sex, race/ethnicity, citizen living, education level, and category of income, and model 3 adjusted for previously mentioned variables plus hypertension, diabetes, physical activity, alcohol consumption, smoking status, BMI, eGFR, HDL-c, TC, TG, and uric acid. Cox proportional hazard models were performed to assess the association between marital status and all-cause mortality, model 1 was nonadjusted, model 2 adjusted for age, sex, race/ethnicity, citizen living, education level, and category of income, and model 3 adjusted for previously mentioned variables plus hypertension, diabetes, physical activity, alcohol consumption, smoking status, BMI, eGFR, HDL-c, TC, TG, uric acid, and depression score. A two-sided *p* value <0.05 was considered statistically significant. Analyses were performed using SPSS software (version 25.0 for Windows; SPSS, Chicago, IL, USA). And the survival curves of CKD patients were performed by GraphPad Prism 6.

Result

Description of CKD Patients

The median age of CKD patients was 67 (quartile 54–78) years old, and 48.0% were male. 57.0% of patients' educational level was high school graduate or less. Meanwhile, 47.5% of them were high-income group. There were total of 2,092 (54%) married ones in CKD patients. Compared with married ones, unmarried ones were more likely to be older, female, nonHispanic black, citizen living, lower educational level, lower income, hypertension, nondiabetes, less physical activity, noncurrent alcohol drinker, current smoker, and less obese. Meanwhile, unmarried ones had a higher value of HDL-C and TC and lower value of TG and UC than married ones (Table 1).

Table 1. Baseline characteristics of the CKD population according to marriage status

	All N = 3,865	Married N = 2,092	Unmarried N = 1,773	p value
Age, years	67 (54–78)	66 (53–76)	69 (55–80)	<0.001
Gender, N (%)				
Men	1,856 (48.0)	1,225 (66.0)	631 (34.0)	<0.001
Women	2,009 (52.0)	867 (43.2)	1,142 (56.8)	
Race/ethnicity, N (%)				
Mexican American	474 (12.3)	278 (13.3)	196 (11.1)	0.001
Other Hispanic	293 (7.6)	159 (7.8)	134 (7.6)	
Non-Hispanic white	2,015 (52.1)	1,152 (55.1)	863 (48.7)	
Non-Hispanic black	863 (22.3)	362 (17.3)	501 (28.3)	
Other race – including multiracial	220 (5.7)	141 (6.7)	79 (4.5)	
Citizen living, N (%)				
Yes	3,554 (92.0)	1,895 (90.6)	1,659 (93.6)	0.001
No	311 (7.7)	198 (9.4)	113 (6.4)	
Education, N (%)				
High school graduate or less	2,204 (57.0)	1,120 (53.5)	1,084 (61.1)	<0.001
College	1,008 (26.1)	540 (25.8)	468 (26.4)	
More than college	653 (16.9)	432 (20.7)	221 (12.5)	
Category of income, N (%)				
Low	1,388 (35.9)	583 (27.9)	805 (45.6)	<0.001
Middle	641 (16.6)	343 (16.4)	298 (16.8)	
High	1,836 (47.5)	1,166 (55.7)	670 (37.8)	
Hypertension, N (%)				
Yes	2,793 (2,793)	1,474 (70.5)	1,319 (74.4)	0.010
Prehypertension	537 (537)	309 (14.8)	228 (12.9)	
No	535 (535)	309 (14.8)	226 (12.7)	
Diabetes, N (%)				
Yes	1,318 (34.1)	721 (34.5)	597 (33.7)	0.384
Prediabetes	875 (22.6)	482 (23.0)	393 (22.2)	
No	1,672 (43.3)	889 (42.5)	783 (44.2)	
Physical activity, N (%)				
Vigorous	737 (19.1)	448 (21.4)	289 (16.3)	<0.001
Moderate	1,413 (36.6)	772 (36.9)	641 (36.2)	
None	1,715 (44.4)	872 (41.7)	843 (47.5)	
Alcohol consumption, N (%)				
Current drinker	2,187 (56.6)	1,241 (59.3)	946 (53.4)	0.001
Past drinker	688 (17.8)	342 (16.3)	346 (19.5)	
Never	990 (25.6)	509 (24.3)	481 (27.1)	
Smoking status, N (%)				
Current smoker	662 (17.1)	319 (15.2)	343 (19.3)	0.057
Past smoker	1,402 (36.3)	796 (38.0)	606 (34.2)	
Never	1,800 (46.6)	976 (46.7)	824 (46.5)	
BMI, kg/m ²				
Obese (≥25.0 kg/m ²)	2,902 (75.1)	1,601 (76.5)	1,301 (73.4)	0.001
Overweight (23.0–24.9 kg/m ²)	400 (10.3)	226 (10.8)	174 (9.8)	
Normal weight (18.5–22.9 kg/m ²)	486 (12.6)	226 (10.8)	252 (14.2)	
Underweight (<18.5 kg/m ²)	77 (2.0)	31 (1.5)	46 (2.6)	
eGFR, mL/min/1.73 m ²	59 (49–92)	59 (50–92)	59 (48–92)	0.272
HDL-c, mmol/L	1.3 (1.1–1.6)	1.2 (1.0–1.5)	1.3 (1.1–1.6)	<0.001
TC, mmol/L	4.9 (4.2–5.7)	4.8 (4.1–5.6)	4.9 (4.2–5.8)	0.004
TG, mmol/L	1.6 (1.0–2.4)	1.6 (1.1–2.5)	1.5 (1.0–2.3)	<0.001
Uric acid, mmol/L	357 (292–422)	357 (297–428)	351 (286–422)	0.004

Values for categorical variables are given as count (percentage); values for continuous variables are given as median (interquartile range). eGFR, estimated glomerular filtration rate; HDL-c, high-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride.

Table 2. The depression score of CKD patients according to gender, eGFR, education level, and income

	N (%)	All patients, N = 3,865			p value
		all	married	unmarried	
All	3,865 (100.0)	2.0 (0.0–5.0)	2.0 (0.0–4.0)	2.0 (0.0–6.0)	<0.001
Gender					
Men	1,856 (48.0)	1.0 (0.0–4.0)	1.0 (0.0–4.0)	2.0 (0.0–5.0)	0.001
Women	2,009 (52.0)	2.0 (0.5–6.0)	2.0 (0.0–5.0)	3.0 (1.0–6.0)	0.009
Category of education level					
High school graduate or less	2,204 (57.0)	2.0 (0.0–6.0)	2.0 (0.0–5.0)	3.0 (0.0–7.0)	<0.001
College	1,008 (26.1)	2.0 (0.0–5.0)	2.0 (0.0–4.0)	2.0 (0.0–5.0)	0.020
More than college	653 (16.9)	1.0 (0.0–3.0)	1.0 (0.0–3.0)	2.0 (0.0–5.0)	<0.001
Category of income					
Low	1,388 (35.9)	3.0 (0.0–7.0)	2.0 (0.0–7.0)	3.0 (0.0–8.0)	0.039
Middle	641 (16.6)	2.0 (0.0–5.0)	2.0 (0.0–5.0)	2.0 (0.0–6.0)	0.019
High	1,836 (47.5)	1.0 (0.0–4.0)	1.0 (0.0–3.0)	2.0 (0.0–4.0)	0.001
Category of eGFR					
eGFR >60 mL/min/1.73 m ²	1,893 (48.98)	2.0 (0.0–6.0)	2.0 (0.0–5.0)	2.0 (0.0–6.0)	<0.001
eGFR <60 mL/min/1.73 m ²	1,972 (51.02)	2.0 (0.0–5.0)	1.0 (0.0–4.0)	2.0 (0.0–6.0)	<0.001

Values for categorical variables are given as count (percentage); values for continuous variables are given as median (interquartile range). Participants with depression score ≥ 10 were defined as having depression. eGFR, estimated glomerular filtration rate.

The Situation of Depression among CKD Patients

The percentage of depression in CKD patients was 10.9%, which was higher than 8.8% in normal population (see online suppl. Table 1; for all online suppl. material, see www.karger.com/doi/10.1159/000515440). The depression score of CKD patients according to marital status is presented in Table 2. The median of depression score was 2.0 (quartile 0.0–5.0) in total CKD patients. The depression sum scores for unmarried ones were higher than married ones in total. Furthermore, each subgroup showed the similar result like general CKD patients. Table 3 showed the results of the binary logistic models of depression and married status. In CKD patients, unmarried ones showed a higher risk to have depression than married ones (OR = 1.26, 95% CI: 1.01–1.57). There was also a significant association between marital status and depression in some subgroups of CKD patients. Unmarried male patients with CKD were more likely to have depression than married ones (OR = 1.45, 95% CI: 1.02–2.06), while the female group did not have this similar result. Meanwhile, in participants with more than college educational level, unmarried was significantly associated with an increased risk of depression (OR = 12.4, 95% CI: 3.75–41.02). However, there was no relationship between marital status and depression in other educational level groups. At the

same time, none subgroup grouped by eGFR or income showed significant association between depression and marital status.

Marital Status and Mortality in CKD Patients

There were total 802 (20.8%) deaths among CKD patients. Figure 2 showed that the cumulative survival rate in unmarried ones was significantly lower than that married ones ($p < 0.001$). The results of cox proportional hazards models to assess the association between marital status and all-cause mortality are shown in Table 4. Among patients with CKD, there was a significant difference of all-cause mortality between patients with different marital statuses. Moreover, marital status was significant associated with all-cause mortality in some subgroups. Unmarried male patients had a threat to death than married ones (HR = 1.64, 95% CI: 1.35–2.00), while there was no significant relationship between marital status and mortality in the female patients. In the subgroup of participants with high school graduate or less educational level and more than college educational level, marriage had a protective effect against death (HR = 1.46, 95% CI: 1.20–1.77 and HR = 1.62, 95% CI: 1.01–2.60, respectively). However, there was no significant effect of marital status on death in other group of different education. Meanwhile, the middle-income and high-income group also

Table 3. The association of marriage status and depression in the whole cohort and according to gender, eGFR, education level, and income

	Depression cases/ N (%)	Married	Unmarried ^a		Unmarried ^b		Unmarried ^c	
			OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
All	423/3,865 (10.9)	Ref	1.55 (1.26–1.90)	<0.001	1.21 (0.98–1.51)	0.081	1.26 (1.01–1.57)	0.045
<i>Gender</i>								
Men	159/1,856 (8.6)	Ref	1.69 (1.21–2.34)	0.002	1.39 (0.98–1.95)	0.061	1.45 (1.02–2.06)	0.037
Women	264/2,009 (13.1)	Ref	1.26 (0.97–1.65)	0.085	1.13 (0.85–1.50)	0.389	1.21 (0.91–1.63)	0.197
<i>Category of education level</i>								
High school graduate or less	284/2,204 (12.9)	Ref	1.35 (1.05–1.73)	0.020	1.26 (0.97–1.64)	0.083	1.20 (0.91–1.57)	0.204
College	113/1,008 (11.2)	Ref	1.20 (0.81–1.77)	0.364	1.01 (0.67–1.52)	0.983	1.05 (0.67–1.63)	0.844
More than college	26/653 (4.0)	Ref	7.07 (2.79–17.86)	<0.001	5.95 (2.29–15.5)	<0.001	12.4 (3.75–41.02)	<0.001
<i>Category of income</i>								
Low	237/1,388 (17.1)	Ref	1.15 (0.86–1.53)	0.344	1.2 (0.88–1.62)	0.249	1.28 (0.93–1.75)	0.130
Middle	68/641 (10.6)	Ref	1.43 (0.86–2.36)	0.168	1.17 (0.69–1.99)	0.569	1.28 (0.73–2.23)	0.393
High	118/1,836 (6.4)	Ref	1.51 (1.04–2.20)	0.032	1.3 (0.88–1.92)	0.184	1.28 (0.86–1.91)	0.226
<i>Category of eGFR</i>								
eGFR ≥60 mL/min/1.73 m ²	239/1,893 (12.6)	Ref	1.57 (1.19–2.06)	<0.001	1.24 (0.93–1.66)	0.149	1.33 (0.98–1.79)	0.064
eGFR <60 mL/min/1.73 m ²	184/1,972 (9.3)	Ref	1.53 (1.13–2.08)	0.006	1.28 (0.92–1.79)	0.149	1.27 (0.90–1.79)	0.169

Ref, reference; eGFR, estimated glomerular filtration rate; HDL-c, high-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride. Participants with depression score ≥10 were defined as having depression. ^a Nonadjusted. ^b Adjusted for age, sex, race/ethnicity, citizen living, education level, and category of income. ^c Additionally adjusted for hypertension, diabetes, physical activity, alcohol consumption, smoking status, BMI, eGFR, HDL-c, TC, TG, and uric acid.

Table 4. The association of marriage status and mortality in the whole cohort and according to gender, eGFR, education level, and income

	Death cases/ N (%)	Married	Unmarried ^a		Unmarried ^b		Unmarried ^c	
			HR (95% CI)	p value	HR (95% CI)	p value	HR (95% CI)	p value
All	802/3,865 (20.8)	Ref	1.46 (1.27–1.68)	<0.001	1.36 (1.17–1.58)	<0.001	1.36 (1.17–1.58)	<0.001
<i>Gender</i>								
Men	450/1,856 (24.1)	Ref	1.66 (1.37–2.00)	<0.001	1.63 (1.34–1.98)	<0.001	1.64 (1.35–2.00)	<0.001
Women	352/2,009 (17.5)	Ref	1.64 (1.32–2.05)	<0.001	1.05 (0.83–1.32)	0.715	1.03 (0.81–1.31)	0.798
<i>Category of education level</i>								
High school graduate or less	521/2,204 (23.6)	Ref	1.56 (1.31–1.85)	<0.001	1.41 (1.17–1.70)	<0.001	1.46 (1.20–1.77)	<0.001
College	189/1,008 (18.8)	Ref	1.02 (0.77–1.36)	0.882	1.12 (0.81–1.55)	0.488	1.14 (0.82–1.60)	0.431
More than college	92/654 (14.1)	Ref	1.65 (1.09–2.49)	0.018	1.69 (1.07–2.67)	0.025	1.62 (1.01–2.60)	0.044
<i>Category of income</i>								
Low	295/1,388 (21.3)	Ref	1.49 (1.17–1.89)	0.001	1.27 (0.98–1.65)	0.073	1.22 (0.94–1.60)	0.141
Middle	165/641 (25.7)	Ref	1.23 (0.90–1.66)	0.191	1.41 (1.01–1.95)	0.043	1.47 (1.04–2.08)	0.029
High	342/1,836 (18.6)	Ref	1.47 (1.19–1.82)	<0.001	1.43 (1.13–1.80)	0.003	1.44 (1.14–1.82)	0.003
<i>Category of eGFR</i>								
eGFR ≥60 mL/min/1.73 m ²	255/1,893 (13.5)	Ref	1.48 (1.16–1.90)	0.002	1.34 (1.02–1.76)	0.035	1.47 (1.11–1.94)	0.007
eGFR <60 mL/min/1.73 m ²	547/1,972 (27.7)	Ref	1.44 (1.22–1.70)	<0.001	1.38 (1.15–1.66)	0.001	1.30 (1.08–1.57)	0.006

Ref, reference; eGFR, estimated glomerular filtration rate; HDL-c, high-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride. ^a Nonadjusted. ^b Adjusted for age, sex, race/ethnicity, citizen living, education level, and category of income. ^c Additionally adjusted for hypertension, diabetes, physical activity, alcohol consumption, smoking status, BMI, eGFR, HDL-c, TC, TG, uric acid, and whether depression.

Fig. 2. Survival curve for patients with CKD depending on marital status.

had a significant association between all-cause mortality and marital status, unmarried ones showed a higher risk to death than married ones (HR = 1.47, 95% CI: 1.04–2.08; HR = 1.44, 95% CI: 1.14–1.82), while the low-income group did not show this result. Both subgroups grouped by eGFR showed a significant association between all-cause mortality and marital status.

Discussion

Our study showed that there was an association between marital status and depression among patients with CKD. Unmarried ones were more likely to have depression than married ones in CKD patients, especially in men, patients with more than college education level. Besides, unmarried ones showed a higher risk of all-cause mortality among CKD patients and some subgroups, including males, patients with high school graduates or less educational level, and higher income group, for example.

This study showed that CKD patients had worse situation of depression than non-CKD patients, which was consistent with previous study [11]. CKD not only triggers major challenges in regard to health but also causes enormous economic losses [24]. Lots of factors lead to this result, including biological factors, psychological factors, and sociodemographic factors [25]. Additionally, recurrent symptoms, life-long treatment, diet, and fluid re-

striction of CKD increase the risk of depression among CKD patients [26].

Married ones had lower depression scores and were less likely to have depression than unmarried ones among patients with CKD, which implied that the situation of depression in married ones was better than unmarried ones in this study. The positive role of marriage in the quality of life had been reported in other study [27]. That is, married ones had a higher quality of life than with unmarried ones because of the social support [28], including family income, which might protect people from depression. Furthermore, the mental support from partners or families helps patients release or share the pain and the depression caused by the disease, which partly explained that married ones had healthier mental health [29]. Therefore, these advantages may improve the self-rated quality of life and further help CKD patients to deal with the situation of depression [30].

The influence of marriage on depression was different in different CKD patients [31]. Our study indicated that male CKD patients benefit more from marriage than female patients to avoid having depression, which was consistent with findings in other studies about general people [32]. Females have larger and stronger social support networks than men [33], and men often told that their wives were their chief source of social support, which may partly explain why single, widowed, and divorced males are more likely to have depression than married ones [34]. But the mecha-

nism of sex difference in marital status affection among CKD patients is not clear now [35], which needs further studies. Our study also showed that unmarried ones had a higher risk to have depression than married ones among CKD patients with more than college education level. A previous study showed that highly educated people paid more attention to mental health than other people [36], thus these participants with CKD were more likely to look for more social support to overcome the negative thoughts during the period of illness [37]. As marriage plays an important role of social support mentioned before [28], this may partly explain this result.

This study showed marital status had a great effect on the mortality of CKD patients as well. As a partner can share the emotional burden and provide appropriate social support [38], it was not surprise to find this result. Meanwhile, a partner can also help you realize the disease earlier [39], which is important to decrease the mortality rate of a disease. The protective effect of marriage in all-cause mortality among male patients with CKD was found in this study, which was compatible with previous researches among the common population [40]. There are several potential reasons for this phenomenon. First, males may get more mental support from marriage than females [41]. Second, some bad life habits, such as smoking and drinking, can be strongly impacted by marriage [42]. Since males tend to have more bad habits than females have [43], males may benefit more than females from the lifestyle change caused by marriage. Our study also found that among patients with school graduate or less educational level and more than college educational level, there was a significant beneficial influence of marriage in all-cause mortality. Since patients with lower educational level may have less knowledge of CKD and lower compliance to doctors [44], they may get more reminders than others from partner to have a regular doctors' office visiting [45]. Hence, this may partly explain what we found in this study. The patients with more than college educational level benefit from marriage have mentioned before, which may also prevent patients from death as well. Similarly, marriage may confer a protective effect regarding all-cause mortality in CKD patients with middle and high income. First of all, high income often relates to high pressure, the support from partner or family is much more important to them than other groups [46]. Second, this subgroup had better economic support to receive good medical services than other subgroups, thus the phys-

ical condition of patients may play a critical role in the mortality of this group of CKD patients [47]. Previous studies showed that marriage influences the function of the body physiologically, partially through modulating the level of endocrinal hormones which may influence the mortality of CKD [48].

There are several limitations to this study. First, marital status is a time-varying covariate, but we only have cross-sectional data and the length of time for participants with a certain marital status could not be getting from the data. Second, the quality of marriage was not presented in that survey, and it may have some influence between marital status and outcomes of this study. Third, we only had data about the self-reported measures of depression, which may have less specificity compared with doctor-diagnosed depression [49]. Last, many covariates were available only at baseline. Therefore, we do not know whether these time-varying covariates have an impact on the mortality of CKD or not. Though these limitations, this study has a large and nationally representative sample, a high follow-up rate, and detailed data of each participant. Meanwhile, we adjusted lots of covariates in this study to explore the independent influence of marital status on depression and mortality of CKD patients.

Conclusion

On the basis of our findings, marital status has great influence on depression and mortality of CKD patients. Further, studies are still needed to explore the mechanism of how marital status effect CKD patients' mental health and mortality. These researches may help improve mental health and reduce the mortality of CKD patients.

Statement of Ethics

The NHANES is a periodic survey conducted by the NCHS of the CDC. NCHS performed the data accumulation with approval from the NCHS Ethics Review Board (protocol #2005-06; protocol #2011-17), and all participants provided written informed consent.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

This work was financially supported by the International (regional) cooperation and exchange projects (NSFC-DFG, Grant No. 81761138041); National Natural Science Foundation of China (Grants 81570667, 81470948, 81670633); Major Research Plan of the National Natural Science Foundation of China (Grant No. 91742204); the National Key R&D Program of China (Grant No. 2018YFC1314003-1, 2015BAI12B07), and National key research and development program (Grants 2016YFC0906103).

Author Contributions

Z.W. and Y.C. had full access to all of the data in the study and takes responsibility for the accuracy of the data analysis. S.G., G.X., and Z.W. developed study concept and design. Z.W., N.Z., R.L., Y.C., and K.G. performed the statistical analyses and drafted the manuscript. G.X. and S.G. obtained the funding and supervised the study. Requests for reprints should be addressed to Shu-Wang Ge, PhD, Department of Nephrology, Tongji Hospital, Tongji Medical College, and Huazhong University of Science and Technology, No. 1095 Jiefang Road, Wuhan 430030, China. E-Mail: geshuwang@tjh.tjmu.edu.cn.

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