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# The factors of perceived disease knowledge and self-care behavior in type 2 diabetic patients with chronic kidney disease

## A cross-sectional study

Shu-Li Wang, MS[a], Tiffany Wan-Hua Shien, BS[b], Tzu-Hui Chen, MS[a], Pei-Ni Hsiao, MEd[a], Shih-Ming Hsiao, MS[a], Lan-Fang Kung, BSN[a], Shang-Jyh Hwang, MD[c,d], Yi-Wen Chiu, MD[c,e], Yi-Chun Tsai, MD, PhD[c,e,f,g,*], Jer-Ming Chang, MD, PhD[c,e]

**Abstract**

Chronic kidney diseases (CKD) is an important public health issue worldwide, and diabetes mellitus is the main cause of CKD. Having sufficient disease knowledge and good self-care behavior both help to prevent the progression of diabetes mellitus and CKD. This cross-sectional study enrolled 181 type 2 diabetic patients with CKD from July 2017 to October 2017. Perceived Kidney Knowledge survey and structured questionnaires of self-care behavior were used to measure perceived disease knowledge and CKD Self-Care (CKDSC) scales respectively with the determinants analyzed by linear regression. Meanwhile, socio-demographic information, kidney function and laboratory data were collected. Of 181 enrolled patients, the mean age was 66.8 ± 9.7 years, 59.1% were male and the mean estimated glomerular filtration rate was 33.1 ± 23.1 mL/min/1.73 $m^2$. The mean scores of CKDSC and perceived disease knowledge were 63.2 and 22.4, respectively. High scores of disease knowledge were significantly correlated with low glycated hemoglobin ($P$ = .03) and high scores of overall self-care behavior ($P$ = .03) and aspects of self-care behavior, including diet ($P$ = .003), exercise ($P$ = .02), and home blood pressure monitoring ($P$ = .04). The relationship between young age and high scores of disease knowledge was found ($P$ = .001); however, old age was significantly associated with high scores of overall self-care behavior ($P$ < .001) while additionally, married patients had high scores of regular medication behavior ($P$ = .03). Our findings identified the significant factors correlated with disease knowledge and self-care behavior in type 2 diabetic patients with CKD. Healthcare givers should establish personalized health education plans to improve perceived disease knowledge and self-care behavior.

**Abbreviations:** CKD = chronic kidney diseases, CKDSC = CKD Self-Care, DM = diabetes mellitus, KMUH = Kaohsiung Medical University Hospital, PIKS = perceived kidney knowledge survey, SPSS = statistical package for the social sciences.

**Keywords:** chronic kidney disease, health education, perceived disease knowledge, self-care, type 2 diabetes mellitus

## 1. Introduction

The population of chronic kidney diseases (CKD) is globally increasing, and has become a significant public health issue worldwide with a global prevalence estimated to be 9.1% in 2017 contributing to 1.2 million deaths.[1] Diabetes mellitus (DM) is the main cause resulting in CKD and further progression to end stage renal disease.[2] The prevalence of type 2 DM has increased by 62% during the past 10 years globally and is predicted to reach 700 million among those aged 20 to 79 years (10.9%) in 2045.[3] Patients with type 2 DM have higher morbidities and mortalities with burgeoning medical costs,[3]

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*[a] Department of Nursing, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan, [b] University of California, Berkeley, California, USA, [c] Department of Nephrology, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung M University, Kaohsiung, Taiwan, [d] Doctoral Degree Program in Toxicology, College of Pharmacy, Kaohsiung Medical University, Kaohsiung, Taiwan, [e] School of Medicine, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan, [f] Division of General Medicine, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan, [g] Liquid Biopsy and Cohort Research Center, Kaohsiung Medical University, Kaohsiung, Taiwan.*

**Correspondence: Yi-Chun Tsai, Department of General Medicine, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, 100 TzYou 1st Road, Kaohsiung 807, Taiwan (e-mail: lidam65@yahoo.com.tw).*



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bringing much pressure and distress to individuals, families, and society. To control type 2 DM well and avoid progression to CKD is an important issue for staff in clinical care.

Apart from medication of blood sugar, adequate management of blood pressure, and life style, such as dietary and exercise habits, and quitting smoking, are all helpful towards decreasing or delaying kidney disease progression in type 2 diabetic patients.[4,5] Thus, multidisciplinary health care, which includes providing disease knowledge, medicine and lifestyle modification, is necessary for treatment strategy of type 2 DM.[6] The patient disease knowledge plays a principal role in treatment efficiency.[7] A previous study determined that one third of patients had limited knowledge concerning kidney diseases and did not understand and further determine their treatment options.[7] Insufficient or incorrect disease knowledge may cause unsuccessful collaboration between patients and physicians in establishing health lifestyle patterns and good compliance with pharmaceutical therapy.[8] Previous studies have indicated that poor disease knowledge contributes to poor blood sugar control, further resulting in rapid decline in kidney function, and consequent adverse clinical outcomes in type 2 diabetic patients.[9,10]

Self-care behavior plays a pivotal role in the management of CKD.[9,10] Good disease knowledge is essential to enhance a patient ability to perform self-care.[11,12] The better the understanding of disease knowledge, the better the ability to proceed with self-care and management, which reduces the negative influences of disease on the patients' mental and physical status. Inadequate self-care behavior not only induces poor disease progression but impedes shared decision-making for therapeutic strategies as well.[13] Hence, it is absolutely necessary and urgent to empower patients to practice lifelong self-care behavior.

Despite clinical care provision of information such as disease control, dietary treatment, and daily management to patients, the actual efficiency of self-care still remains uncertain. Up to now, the real-world situations of disease knowledge and self-care behavior have not been well-explored in type 2 diabetic patients with CKD; thus, the aim of this study is to examine the determinants of the efficiency of disease knowledge and different domains of self-care behavior in type 2 diabetic patients with CKD.

## 2. Methods

### 2.1. Study participants

Between July 2017 to October 2017, this cross-sectional study was conducted, and enrolled a total of 181 type 2 diabetic patients with CKD not dependent on renal replacement therapy at Kaohsiung Medical University Hospital (KMUH), a tertiary hospital in southern Taiwan. All enrolled patients had received a multidisciplinary CKD program for more than 3 months, managed by a cross-disciplinary team, including clinical physicians, nursing staff members, nutritionists, and pharmacists to further enhance the efficacy of medical care. CKD was staged based on Kidney Disease Outcomes Quality Initiative definitions. The estimated glomerular filtration rate (eGFR) was calculated using the equation of the 4-variable Modification of Diet in Renal Disease Study. The stages of CKD were defined as follows: stage 1, eGFR > 90 mL/min/1.73 $m^2$; CKD stage 2, eGFR: 60 to 89 mL/min/1.73 $m^2$; CKD stage 3a, eGFR: 45 to 59 mL/min/1.73 $m^2$; CKD stage 3b, eGFR: 30 to 44 mL/min/1.73 $m^2$; CKD stage 4, eGFR: 15 to 29 mL/min/1.73 $m^2$; CKD stage 5, eGFR < 15 mL/min/1.73 $m^2$).[14,15] Diabetes was defined by history, use of anti-diabetic drugs, or blood glucose values according to the American Diabetes Association criteria. The structured questionnaires were used to measure perceived disease knowledge and self-care behavior in study participants. The participants filled out the questionnaires by themselves. Patients unable to complete the questionnaires by themselves or to care for themselves in daily life, having no available time to enroll this study, or who were receiving a CKD care program with duration <3 months were excluded. This study protocol was approved by the Institutional Review Board (IRB) of the Kaohsiung Medical University Hospital (IRB number: KMUH-IRB-20180086). All study participants have written informed consents, and all clinical investigations were conducted according to the principles expressed in the Declaration of Helsinki.

### 2.2. Clinical measurements

Information of socio-demographic characteristics and clinical data including age, gender, cigarette smoking (yes vs no), alcohol (yes vs no, medication including ant-hypertension agents, anti-diabetes agents or statins, marriage status (married vs single/divorced), education level (high school or above vs below high school), current occupation, financial support (independent vs dependent from someone), and co-morbidities were obtained by medical records and interviews with patients at enrollment. Patients were classified from their hypertensive as history, taking antihypertensive drugs, or measurement of home blood pressure ≥140/90 mm Hg, while heart disease was defined as history of myocardial infarction, ischemic heart disease or congestive heart failure. The time of CKD and time of CKD care were calculated by self-report and multidisciplinary CKD program enrollment respectively, while the incident number of health education was calculated between multidisciplinary CKD program enrollment and study interview. Body mass index was calculated as body weight divided by square body height. Participants were asked to fast for at least 12 hours before blood sample collection for the biochemistry study and protein in urine was measured using urine protein-creatinine ratio when receiving the interview to evaluate the self-care behavior and disease knowledge.

### 2.3. Perceived disease knowledge measurement

We obtained the information of perceived disease knowledge of CKD in study patients using the perceived kidney knowledge survey (PIKS) developed by Wright et al, with the patients completing the PIKS questionnaire by themselves at enrollment. The score rang (SR) of PIKS was 9 to 36. The PIKS included 9 questions (medications that help the kidney, medications that can hurt the kidney, foods to avoid if kidney function is low, blood pressure goal, treatment options if kidney function gets worse, symptoms of CKD, how kidney function is checked, functions of the kidney, why the patient was sent to a kidney doctor), to understand more about perceived kidney knowledge, make earlier presentations to the clinic and improve clinical communication in the CKD cohort.[16]

### 2.4. Self-care behavior measurement

The structured questionnaire of self-care behavior was utilized and study patients completed the questionnaires at study enrollment. The CKD Self-Care (CKDSC) scale, as a 16-item questionnaire, consists of total scores (SR: 16–80) and 5 subscales including diet control (SR: 4–20), exercise (SR: 3–15), smoking (SR: 2–10), regular medication (SR: 5–25), and home blood pressure measurement (SR: 2–10). CKDSC scale is widely used as a reliable and available tool to assess self-care behavior in CKD patients.[13,17,18]

### 2.5. Statistical analysis

The baseline characteristics of the patients were stratified by eGFR. Continuous variables including age, clinical characteristics, questionnaires scales and laboratory date were expressed as mean ± standard deviation (SD) or median ($25^{th}$, $75^{th}$ percentile), as appropriate. Categorical variables including sex,

demographic data, comorbidities and types of medication were expressed as percentages. Continuous variables with skewed distribution were log-transformed to approximate normal distribution with significance of differences in continuous variables between groups tested using one-way analysis of variance or the Kruskal–Wallis H test, as appropriate. Differences in the distribution of categorical variables were tested using the chi-square test. Univariate and multivariate linear regression analyses were utilized to identify the factors related to self-care behavior and perceived disease knowledge. Multivariate models were adjusted for variables with $P$ value < .05 in univariable analysis. Statistical analyses were conducted using statistical package for the social sciences (SPSS) version 22.0 for Windows (SPSS Inc., Chicago, Illinois) with statistical significance being set at a 2-sided $P$ value < .05.

## 3. Results

### 3.1. Characteristics of entire cohort

The clinical characteristics among groups according to eGFR are shown in Table 1. The mean age of all participants was 66.8 ± 9.7 years, 59.1% were male, and 92.3%, 22.7%, and 62.4% had hypertension, heart disease, and hyperlipidemia respectively. Of 181 type 2 diabetic patients, 78.5% patients were married, 48.1% had graduated from senior high school or above, 27.6% were currently working, and 41.4% had financial self-support. Type 2 diabetic patients with eGFR ≥ 45 mL/min/1.73 $m^2$ were youngest and had the highest proportion of males, alcohol consumption, those currently working and with independent finances among the 4 groups. The mean scores of self-care behavior and disease knowledge of all type 2 diabetic

**Table 1**

**The clinical characteristics of study patients stratified by renal function.**

| | Entire Cohort N = 181 | eGFR ≥ 45 mL/min/1.73 $m^2$ N = 43 | eGFR 30~44 mL/min/1.73 $m^2$ N = 38 | eGFR 15~29 mL/min/1.73$^2$ N = 53 | eGFR < 15 mL/min/1.73 $m^2$ N = 47 | *P* value |
|---|---|---|---|---|---|---|
| Demographics | | | | | | |
| Age (yr) | 66.8 ± 9.7 | 63.6 ± 10.9 | 69.4 ± 10.9 | 69.0 ± 8.1 | 65.1 ± 8.0 | .008 |
| Sex (male, %) | 59.1 | 79.1 | 57.9 | 45.3 | 57.4 | .01 |
| Smoking (yes, %) | 26.0 | 25.6 | 21.1 | 24.5 | 31.9 | .70 |
| Alcohol consumption (yes, %) | 7.2 | 18.6 | 5.3 | 3.8 | 2.1 | .01 |
| Marital status (yes, %) | 78.5 | 81.4 | 78.9 | 77.4 | 76.6 | .95 |
| Currently working (yes, %) | 27.6 | 41.9 | 21.1 | 13.2 | 36.2 | .006 |
| Independent economy source (yes, %) | 58.6 | 81.4 | 44.7 | 50.9 | 57.4 | .004 |
| Education (high school or above, %) | 48.1 | 62.8 | 36.8 | 49.1 | 42.6 | .10 |
| Comorbidities | | | | | | |
| Hypertension (yes, %) | 92.3 | 90.7 | 86.8 | 98.1 | 91.5 | .23 |
| Heart disease (yes, %) | 22.7 | 18.6 | 23.7 | 17.0 | 31.9 | .29 |
| Gout (yes, %) | 25.4 | 23.3 | 21.1 | 34.0 | 21.3 | .40 |
| Hyperlipidemia (yes, %) | 62.4 | 67.4 | 63.2 | 66.0 | 53.2 | .48 |
| Clinical characteristics | | | | | | |
| Body mass index (kg/$m^2$) | 25.8 ± 4.5 | 25.9 ± 3.6 | 27.2 ± 4.7 | 24.6 ± 3.6 | 26.0 ± 5.5 | .05 |
| Health education times | 12.8 ± 9.5 | 14.1 ± 9.1 | 13.3 ± 8.7 | 12.4 ± 9.0 | 11.3 ± 11.1 | .56 |
| CKD duration (yr) | 8.3 ± 7.1 | 9.5 ± 7.8 | 7.3 ± 5.8 | 8.6 ± 7.9 | 7.7 ± 6.2 | .47 |
| CKD care duration (yr) | 4.1 ± 3.6 | 5.7 ± 4.2 | 3.8 ± 2.8 | 3.7 ± 3.1 | 3.4 ± 3.5 | .005 |
| Medications | | | | | | |
| ACEI/ARB usage (%) | 29.3 | 46.5 | 28.9 | 22.6 | 21.3 | .03 |
| β-blocker (%) | 41.4 | 44.7 | 42.1 | 45.3 | 32.6 | .58 |
| Calcium channel blocker (%) | 41.4 | 21.3 | 47.4 | 41.5 | 58.1 | .004 |
| Sulfonylurea (%) | 11.0 | 14.9 | 23.7 | 3.8 | 4.7 | .009 |
| DPP-4 inhibitor (%) | 59.7 | 51.1 | 65.8 | 73.6 | 46.5 | .02 |
| Thiazolidinedione (%) | 3.3 | 4.3 | 2.6 | 3.8 | 2.3 | .95 |
| Insulin (%) | 25.4 | 17.0 | 15.8 | 34.0 | 32.6 | .08 |
| Metformin (%) | 20.4 | 46.8 | 31.6 | 0 | 0 | <.001 |
| Statin (%) | 48.6 | 46.8 | 50.0 | 50.9 | 46.5 | .96 |
| Questionnaires | | | | | | |
| Self-care total score | 63.2 ± 10.1 | 63.4 ± 10.4 | 63.0 ± 10.2 | 63.7 ± 9.3 | 62.7 ± 10.9 | .96 |
| Diet | 14.3 ± 3.6 | 14.1 ± 3.8 | 13.8 ± 3.8 | 14.4 ± 3.2 | 15.0 ± 3.6 | .47 |
| Exercise | 9.9 ± 4.4 | 9.9 ± 4.6 | 9.9 ± 4.6 | 9.6 ± 4.6 | 12.3 ± 3.8 | .89 |
| Home blood pressure monitoring | 6.7 ± 2.6 | 6.8 ± 2.6 | 6.3 ± 2.6 | 6.9.±2.6 | 6.7 ± 2.7 | .67 |
| Smoking | 8.9 ± 2.4 | 9.0 ± 2.4 | 9.0 ± 2.3 | 9.0 ± .22 | 8.6 ± 2.7 | .85 |
| Regular medication | 23.3 ± 2.8 | 22.6 ± 2.4 | 24.0 ± 2.6 | 23.6 ± 2.6 | 22.2 ± 3.4 | .01 |
| Perceived disease knowledge total score | 22.4 ± 5.8 | 22.3 ± 6.0 | 20.5 ± 4.7 | 20.8 ± 6.4 | 21.8 ± 5.8 | .45 |
| Laboratory parameters | | | | | | <.001 |
| Blood urea nitrogen (mg/dL) | 30.5 (21.1, 45.8) | 18.1 (15.2, 21.3) | 24.1 (18.9, 28.5) | 36.6 (30.0, 42.9) | 62.8 (47.9, 80.4) | <.001 |
| eGFR (mL/min/1.73 $m^2$) | 33.1 ± 23.1 | 65.8 ± 19.4 | 38.7 ± 4.7 | 23.4 ± 5.0 | 9.8 ± 3.8 | <.001 |
| Glycated hemoglobin (%) | 6.6 (6.1, 7.2) | 6.2 (5.9, 6.8) | 6.6 (6.2, 7.3) | 6.6 (6.3, 7.7) | 6.6 (5.8, 7.3) | .05 |
| Hemoglobin (g/dL) | 11.9 ± 2.1 | 13.8 ± 2.0 | 12.6 ± 1.8 | 11.4 ± 1.5 | 10.2 ± 1.3 | <.001 |
| Albumin (g/dL) | 4.2 ± 0.4 | 4.4 ± 0.2 | 4.2 ± 0.4 | 4.2 ± 0.3 | 4.1 ± 0.3 | .005 |
| Uric acid (mg/dL) | 6.6 ± 1.6 | 6.7 ± 1.5 | 6.5 ± 1.7 | 6.5 ± 1.6 | 6.6 ± 1.4 | .13 |
| Cholesterol (mg/dL) | 169 ± 38 | 164 ± 30 | 165 ± 34 | 173 ± 38 | 170 ± 45 | .64 |
| Triglyceride (mg/dL) | 123 (85, 193) | 100 (76, 181) | 127 (101, 184) | 125 (86, 204) | 133 (90, 199) | .23 |
| Urine protein/creatinine ratio | 0.7 (0.2, 2.1) | 0.1 (0.1, 0.4) | 0.6 (0.1, 1.6) | 0.7 (0.3, 1.7) | 2.2 (1.6, 4.1) | <.001 |

Data are expressed as number (percentage) for categorical variables and mean ± SD or median (25$^{th}$, 75$^{th}$ percentile) for continuous variables, as appropriate.

ACEI/ARB = angiotensin converting enzyme inhibitors/angiotensin II receptor blockers, DPP4 = dipeptidyl peptidase-4, eGFR = estimated glomerular filtration rate.

patients were 63.2 and 22.4, respectively. There were no significant differences of total scores of self-care behavior and disease knowledge among patients with different eGFR. Among 5 domains of self-care behavior, significant difference of regular medication was found within type 2 diabetic patients with different eGFR ($P = .01$), while the other 4 domains of self-care behavior were not different among groups. Type 2 diabetic patients with eGFR < 15 mL/min/1.73 $m^2$ had lower proportion of angiotensin converting enzyme inhibitor/angiotensin II receptor blocker, sulfonylurea, or metformin usage, hemoglobin and serum albumin levels, and had higher blood urea nitrogen and urine protein-creatinine ratio levels compared to those with other groups.

### 3.2. Determinants of perceived disease knowledge in type 2 diabetic patients with CKD

Disease knowledge score was positively correlated with self-care behavior, the female gender, education level, currently working, duration of health education, and duration of CKD, but negatively correlated with age, receiving financial support from others, and glycated hemoglobin level in univariate linear regression analysis (Table 2). After adjusting the significant variables in univariate analysis, the results showed that high disease knowledge scores were significantly associated with high self-care behavior scores ($P = .02$), young age ($P < .001$), education level of high school ($P = .02$) or above, and low glycated hemoglobin ($P = .03$).

### 3.3. Determinants of self-care behavior in type 2 diabetic patients with CKD

Linear regression analysis was used to investigate the determinants of total self-care behavior (Table 3). In univariate analysis, self-care behavior scores were positively correlated with age, duration of health education, hypertension history, serum albumin level, and disease knowledge scores, but negatively correlated with currently working, receiving financial support from others, and glycated hemoglobin level in type 2 diabetic patients with CKD. We submitted these variables to multivariate linear analysis, which revealed that high self-care scores were significantly associated with high disease knowledge scores ($P = .03$), old age ($P < .001$), being financially independent ($P = .03$), and having low glycated hemoglobin level ($P = .005$).

We further examined the determinants of 5 domains of self-care behavior, including diet, exercise, home blood pressure monitoring, smoking and regular medication in type 2 diabetic patients with CKD. Univariate linear analysis was utilized to investigate the correlators of 5 domains of self-care behavior (Supplemental Table 1, http://links.lww.com/MD/K256). Furthermore, multivariate linear analysis was employed, which revealed that older age was positively correlated with the scores of diet ($P = .03$), exercise ($P = .001$), home blood pressure monitoring ($P = .04$), and regular medication ($P = .002$) (Table 4). In addition, high disease knowledge scores were associated with high scores of diet ($P = .003$), exercise ($P = .02$) and home blood pressure monitoring ($P = .04$). Glycated hemoglobin was significantly and negatively correlated with the scores of diet ($P = .001$) and home blood pressure monitoring ($P = .03$). Married patients had higher scores of regular medication than did non-married patients ($P = .03$).

## 4. Discussion

This study explored the correlators of disease knowledge and self-care behavior in type 2 diabetic patients with CKD. Patients with high disease knowledge scores had better glucose control and greater overall self-care behavior and other aspects of self-care behavior, including diet, exercise and home blood pressure monitoring. Young age or high education level was significantly correlated with greater disease knowledge; conversely, older patients had better self-care behaviors. Compared with

**Table 2**

**The determinant of perceived disease knowledge in study subjects.**

| | Perceived disease knowledge | | | |
|---|---|---|---|---|
| | Univariate | | Multivariate | |
| | β (95%CI) | *P* value | β (95%CI) | *P* value |
| Age (yr) | −0.17 (−0.25, −0.08) | <.001 | −0.20 (−0.29, −0.10) | <.001 |
| Sex (male, %) | −2.10 (−3.81, −0.38) | .02 | −1.17 (−2.89, 0.55) | .18 |
| Smoking (yes, %) | 1.08 (−0.87, 3.03) | .27 | -- | -- |
| Alcohol consumption (yes, %) | −0.46 (−3.78, 2.86) | .78 | -- | -- |
| Marital status (yes, %) | 0.31 (−1.77, 2.40) | .76 | -- | -- |
| Currently working (yes, %) | 2.09 (0.20, 3.98) | .03 | −0.50 (−2.81, 1.80) | .66 |
| Independent finances (no, %) | −2.58 (−4.27, −0.88) | .003 | 0.48 (−1.59, 2.54) | .65 |
| Education (high school or above, %) | 3.54 (1.90, 5.17) | <.001 | 2.13 (0.42, 3.83) | .02 |
| Hypertension (yes, %) | 1.77 (−1.43, 4.96) | .27 | -- | -- |
| Heart disease (yes, %) | 0.43 (−1.61, 2.47) | .67 | -- | -- |
| Body mass index (kg/$m^2$) | 0.14 (−0.05, 0.33) | .15 | -- | -- |
| Health education times | 0.10 (0.01, 0.18) | .03 | 0.05 (−0.05, 0.13) | .32 |
| CKD duration (yr) | 0.15 (0.03, 0.27) | .01 | 0.11 (−0.02, 0.23) | .08 |
| Blood urea nitrogen (mg/dL) | 0.01 (−0.02, 0.05) | .48 | -- | -- |
| eGFR (mL/min/1.73 $m^2$) | −0.00 (−0.04, 0.04) | .96 | -- | -- |
| Log-formed glycated hemoglobin | −1.00 (−1.74, −0.26) | .009 | −0.83 (−1.57, −0.10) | .03 |
| Hemoglobin (g/dL) | 0.26 (−0.15, 0.66) | .20 | -- | -- |
| Albumin (g/dL) | 1.83 (−0.58, 4.24) | .13 | -- | -- |
| Uric acid (mg/dL) | −0.21 (−0.70, 0.28) | .40 | -- | -- |
| Cholesterol (mg/dL) | −0.01 (−0.03, 0.01) | .34 | -- | -- |
| Log-formed triglyceride | −3.07 (−6.47, 0.33) | .07 | -- | -- |
| Log-formed urine protein/creatinine ratio | −0.67 (−1.76, 1.02) | .60 | -- | -- |
| Self-care behavior | 0.11 (0.02, 0.18) | .01 | 0.10 (0.02, 0.19) | .02 |

CKD = chronic kidney disease, eGFR = estimated glomerular filtration rate.

**Table 3**

**The determinant of self-care behavior total score in study subjects.**

| | Self-care behavior score | | | |
|---|---|---|---|---|
| | Univariate | | Multivariate | |
| | β (95%CI) | *P* value | β (95%CI) | *P* value |
| Age (yr) | 0.29 (0.14, 0.43) | <.001 | 0.32 (0.15, 0.48) | <.001 |
| Sex (male, %) | −1.32 (−4.33, 1.70) | .39 | 0.48 (−2.45, 3.39) | .74 |
| Smoking (yes, %) | −0.95 (−4.33, 2.44) | .58 | -- | -- |
| Alcohol consumption (yes, %) | −4.12 (−9.85, 1.60) | .15 | -- | -- |
| Marital status (yes, %) | 3.08 (−0.51, 6.66) | .09 | -- | -- |
| Currently working (yes, %) | −3.33 (−6.62, −0.04) | .04 | −3.22 (−7.08, 0.65) | .10 |
| Independent finances (no,%) | −3.98 (−6.94, −1.02) | .009 | −3.86 (−7.34, −0.38) | .03 |
| Education (high school or above, %) | 3.47 (0.54, 6.40) | .02 | 2.16 (−0.78, 5.09) | .15 |
| Hypertension (yes, %) | 5.72 (0.22–11.22) | .04 | 3.51 (−1.50, 8.52) | .16 |
| Heart disease (yes, %) | 0.01 (−3.54, 3.56) | .99 | -- | -- |
| Body mass index (kg/m$^2$) | −0.32 (−0.65, 0.01) | .06 | -- | -- |
| Health education times | 0.11 (−0.05, 0.26) | .17 | -- | -- |
| Nutrition education times | 0.31 (−0.03, 0.66) | .07 | | |
| CKD duration (yr) | −0.01 (−0.22, 0.20) | .96 | -- | -- |
| Blood urea nitrogen (mg/dL) | 0.01 (−0.05, 0.07) | .77 | -- | -- |
| eGFR (mL/min/1.73 m$^2$) | −0.04 (−0.08, 0.00) | .07 | -- | -- |
| Log-formed glycated hemoglobin | −2.67 (−3.93, −1.42) | <.001 | −1.84 (−3.10, −0.57) | .005 |
| Hemoglobin (g/dL) | −0.42 (−1.12, 0.28) | .24 | -- | -- |
| Albumin (g/dL) | 4.2 (0.10, 8.44) | .04 | 2.49 (−1.37, 6.35) | .20 |
| Uric acid (mg/dL) | −0.15 (−1.01, 0.70) | .73 | -- | -- |
| Cholesterol (mg/dL) | −0.03 (−0.07, 0.01) | .11 | -- | -- |
| Log-formed triglyceride | −5.06 (−10.96, 0.83) | .09 | -- | -- |
| Log-formed urine protein/creatinine ratio | −1.89 (−4.29, 0.50) | .12 | -- | -- |
| Disease knowledge | 0.32 (0.07, 0.56) | .01 | 0.28 (0.03, 0.53) | .03 |

CKD = chronic kidney disease, eGFR = estimated glomerular filtration rate.

**Table 4**

**The determinant of 5 domains of self-care behavior in study subjects by multivariate linear analysis.**

| | Diet | Exercise | Home blood pressure monitoring | Smoking | Regular medication |
|---|---|---|---|---|---|
| | β (95%CI) | β (95%CI) | β (95%CI) | β (95%CI) | β (95%CI) |
| Age (yr) | 0.06 (0.01, 0.12)* | 0.12 (0.05, 0.18)** | 0.05 (0.01, 0.09)* | 0.03 (−0.01, 0.06) | 0.06 (0.02, 0.10)** |
| Sex (male, %) | −0.04 (−1.11, 1.04) | −0.97 (−2.30, 0.35) | −0.14 (−0.92, 0.63) | 0.26 (−0.46, 0.97) | −0.11 (−0.97, 0.74) |
| Smoking (yes, %) | -- | -- | -- | −2.25 (−3.04, −1.45)*** | -- |
| Alcohol consumption (yes, %) | -- | -- | −1.80 (−3.27, −0.33)* | −0.48 (−1.72, 0.77) | -- |
| Marital status (yes, %) | -- | -- | -- | -- | 1.12 (0.10, 2.15)* |
| Currently working (yes, %) | -- | -- | -- | −0.12 (−0.94, 0.71) | -- |
| Independent finances (no, %) | −0.69 (−1.82, 0.44) | −1.00 (−2.40, 0.40) | -- | -- | -- |
| Education (high school or above, %) | 0.67 (−0.39, 1.72) | -- | -- | -- | -- |
| Hypertension (yes, %) | 1.92 (0.11, 3.73)* | -- | -- | -- | -- |
| Heart disease (yes, %) | -- | -- | -- | -- | -- |
| Body mass index (kg/m$^2$) | −0.10 (−0.21, 0.01) | -- | -- | -- | -- |
| Health education times | -- | -- | -- | -- | -- |
| CKD duration (yr) | -- | -- | -- | -- | -- |
| Blood urea nitrogen (mg/dL) | -- | -- | -- | -- | −0.01 (−0.02, 0.02) |
| eGFR (mL/min/1.73 m$^2$) | −0.01 (−0.04, 0.02) | -- | -- | -- | -- |
| Log-formed glycated hemoglobin | −0.74 (−1.18, −0.29)** | −0.56 (−1.13, 0.00) | −0.35 (−0.68, −0.01)* | -- | -- |
| Hemoglobin (g/dL) | −0.30 (−0.60, 0.01) | -- | -- | -- | -- |
| Albumin (g/dL) | -- | -- | -- | -- | 1.21 (−0.02, 2.43) |
| Uric acid (mg/dL) | -- | -- | -- | -- | -- |
| Cholesterol (mg/dL) | -- | -- | -- | -- | -- |
| Log-formed triglyceride | -- | -- | -- | -- | -- |
| Log-formed urine protein/creatinine ratio | -- | -- | -- | -- | −0.72 (−1.53, 0.10) |
| Disease knowledge | 0.14 (0.05, 0.23)** | 0.14 (0.03, 0.25)* | 0.08 (0.01, 0.14)* | −0.04 (−0.10, 0.02) | -- |

CKD = chronic kidney disease, eGFR = estimated glomerular filtration rate.

*$P < .05$,

**$P < .01$,

***$P < .001$.

non-married patients, married patients had better regular medication behavior. These findings provide significant evidences for healthcare givers in order to better understand the factors affecting disease knowledge and self-care behavior in type 2 diabetic patients with CKD.

In type 2 diabetic patients with CKD, we found that age and education level were significantly correlated with high disease knowledge scores. Elderly patients had poor disease knowledge compared to younger patients. Aging-related changes such as altered physical, perceptual, reading, and mathematical abilities might create difficulties in conveying and teaching health knowledge for elderly patients.[19] Elderly patients might need regular assessments of physical function, psychological status and social supports. Therefore, according to their status, healthcare providers should modify the strategies of health education, such as making appointment with patients, allocating easily accessible resources to health education and increasing flexibility of time and place of health education in order, to fulfill educational needs and enhance satisfaction of elderly patients.[20]

Our novel findings illustrate the associated factors of 5 aspects of self-care behavior, including diet, exercise, home blood pressure, smoking and regular medication in type 2 diabetic patients with CKD. The positive correlation between knowledge of kidney disease and total self-care behavior was shown in these patients although there was no significant association of disease knowledge with smoking or regular medication behavior. Conversely, we found that older patients had better overall self-care behavior and other aspects of self-care behavior, including diet, exercise, home blood pressure monitoring and regular medication compared with younger patients, in spite of older patients having insufficient disease knowledge. Previous studies have reported that patients with low education level might be at high risk for poor clinical outcomes.[21,22] Older patients might have more awareness of poor physical function and multiple morbidities, which motivates them to perform better self-care.[23,24] As mentioned, high education level was positively correlated with disease knowledge but did not associate with overall self-care behavior, and although younger patients had high education level to gain more disease knowledge, evidence has indicated significant correlation between younger age and poor self-care behavior in chronic diseases, such as heart failure, type 2 DM and CKD.[25–27] The potential reason might be that younger patients lack the motivation to actually empower themselves toward self-care and adherence to medical suggestions. Beliefs, attitudes and expectations might affect younger patients' motivation; additionally, miscommunication between health care providers and patients might reduce the efficiency of health education. Increasing capacities and resources of health education through telehealth or mobile health might improve communications between clinical staffs and patients, further enhancing the motivation of performing self-care well.[28] Thus, healthcare providers might futurewise consider designing and providing personal health education plans according to various age groups.

We also found a potential impact of marriage status on regular medication behavior in type 2 diabetic patients with CKD, where married patients had better regular medication behavior. Previous studies have reported the correlation between being married and low distress related to DM.[29] Patients reporting loneliness had higher risks for poor glycemic control and DM complications such as diabetic foot infection.[30] The treatment efficacy is significantly affected by various factors, including the possibility of frequent treatment changes, complexity of treatment strategies, effectiveness during long-term treatment periods, or having difficulties of accessing and purchasing medicine.[31] Patients with spouses or families might overcome these challenges of treatment and enhance efficiency of treatment. Healthcare providers might establish a multi-perspective supporting system, containing health informational and emotional support for these patients without family support.[31]

Our multidisciplinary CKD program is managed by a cross-disciplinary team, including clinical physicians, nursing staff members, nutritionists, and pharmacists is to enhance the efficacy of medical care. The CKD program provides health education to improve disease knowledge and health literacy, further enhancing self-care behavior in daily life; however, behavior prepotency, exemplified by existing habits and social practices might cause behavior changes barriers, and changing their lifestyle or medical behavior is not easy for patients with chronic disease. Motivation, composed of future desires and past experiences to further form present behaviors, as well as self-regulation, both play important roles in performing self-care behavior well. Healthcare providers could enhance self-regulation by empowering patients with tactical and situational skills to improve lifestyle habits and strategies to resist temptation or back-sliding.[32] Furthermore, internalizing motivation to self-care leads to behaviors being performed with a sense of choice.[33] The cooperation and partnership between patients and healthcare providers is the principal step to promote self-care behavior. Patients are invited to participate in making medical decision with healthcare providers, who encourage patients to actively take care of themselves, and urge their family members to join in the care program.[34,35] Such strategies above could promote medication adherence and establish self-efficiency, further improving self-care behavior.

Some limitations must be mentioned in this study. Firstly, we used questionnaire to examine self-care behavior and disease knowledge, and recall bias may have affected the results. Patients unable to complete the questionnaires by themselves were excluded, thereby the results not being applied to all populations; nevertheless, we believe that this questionnaire is the convenient and reliable tool to measure self-care behavior and disease knowledge in type 2 diabetic patients with CKD, and healthcare providers could gain real-time status of patients in providing immediate and appropriate suggestions to meet the patients' needs. Secondly, we only enrolled patients in the outpatient department, and such derived results might not apply to the population of type 2 diabetic with CKD. Finally, this cross-sectional study examines the determinants of self-care behavior and disease knowledge in type 2 diabetic with CKD. Further prospective study is necessary to evaluate the impact of self-care behavior and disease knowledge on clinical outcomes in this population.

In conclusion, this study demonstrated the determinants of affecting disease knowledge and overall and subtypes of self-care behavior in type 2 diabetic patients with CKD. These findings may assist healthcare providers in designing health education plans dependent on personal needs in type 2 diabetic patients with CKD.

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## Author contributions

**Conceptualization:** Shu-Li Wang, Shang-Jyh Hwang, Yi-Wen Chiu, Yi-Chun Tsai, Jer-Ming Chang.
**Data curation:** Shu-Li Wang, Tzu-Hui Chen, Pei-Ni Hsiao, Shih-Ming Hsiao, Lan-Fang Kung.
**Formal analysis:** Yi-Chun Tsai.
**Funding acquisition:** Shu-Li Wang.
**Investigation:** Shu-Li Wang, Tzu-Hui Chen, Pei-Ni Hsiao, Shih-Ming Hsiao, Lan-Fang Kung.
**Methodology:** Shu-Li Wang, Yi-Chun Tsai.
**Project administration:** Shu-Li Wang.
**Resources:** Shu-Li Wang, Tzu-Hui Chen, Pei-Ni Hsiao, Shih-Ming Hsiao, Shang-Jyh Hwang, Yi-Wen Chiu, Yi-Chun Tsai, Jer-Ming Chang.

**Supervision:** Yi-Chun Tsai.
**Validation:** Yi-Chun Tsai.
**Visualization:** Yi-Chun Tsai.
**Writing – original draft:** Shu-Li Wang, Tiffany Wan-Hua Shien, Yi-Chun Tsai.
**Writing – review & editing:** Yi-Chun Tsai.

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