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Food Insecurity, CKD, and Subsequent ESRD in US Adults

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Abstract

Background—Poor access to food among low income adults has been recognized as a risk factor for CKD, but there is no data on the impact of food insecurity on progression to ESRD. We hypothesized that food insecurity would be independently associated with risk of ESRD among persons with and without CKD.

Study Design—Longitudinal cohort study

Setting & Participants—2,320 adults (≥20 years) with CKD and 10,448 adults with 'No-CKD' enrolled in NHANES III (1988–1994) with household income ≤400% of the federal poverty level linked to Medicare ESRD Registry for a median follow-up period of 12 years.

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Disclosures
The authors have nothing to disclose.

Predictor—Food insecurity, defined as an affirmative response to the food insecurity screening question.

Outcome—Development of treated ESRD.

Measurements—Demographics, income, diabetes, hypertension, eGFR, and albuminuria. DAL was estimated from the 24-hr dietary recall. We used a Fine-Gray competing risk model to estimate the relative hazard [RH] for ESRD associated with food insecurity after adjusting for covariates.

Results—4.5% adults with CKD were food insecure. Food insecure individuals were more likely to be younger, have diabetes (29.9%) and hypertension (73.9%), or have albuminuria (90.4%) as compared to their counterparts (V $p<0.05$). Median DAL in the food secure vs. food insecure group was 51.2 mEq/day vs 55.6 mEq/day, respectively ($p=0.05$). Food insecure adults were more likely to develop ESRD (RH [95% CI]: 1.38 [1.08–3.10]) compared to food secure adults after adjustment for demographics, income, diabetes, hypertension, eGFR and albuminuria. In the No-CKD group, 5.7% were food insecure. Here, we did not find a significant association between food insecurity and ESRD (0.77 [0.40–1.49]).

Limitations—use of a single 24-hr diet recall, lack of laboratory follow-up data, and measure of changes in food insecurity over time; follow-up of the cohort ended 10 years ago.

Conclusion—Among individuals with CKD, food insecurity was independently associated with a higher likelihood of developing ESRD. Innovative approaches to address food insecurity should be tested for their impact on CKD outcomes.

Introduction

As per the Unites States Department of Agriculture[1], food security is defined as one's perceived ability to access nutritious and healthy food with essential nutrients, fruits and vegetables, and with less saturated fats, sugar, and salt[1] for an active and healthy life. In 2013, an estimated 14.3% of American households were categorized as food insecure as they did not have the proper availability or means to access food and often experienced hunger or inadequate nutrient intake.[2] Households with limited resources to buy enough food often try to stretch their food budgets by purchasing cheap, energy-dense, nutrient-poor foods that are filling. Thus, they consume fewer servings of fruits, vegetables, and dairy products; and consume higher amounts of refined grains, added sugars, and saturated and trans fats.[3] A lack of access to fresh, healthy foods can contribute to poor diet composition and higher levels of diet-related diseases. Such unhealthy dietary patterns are associated with some leading causes of chronic disease and death, including chronic kidney disease (CKD)[4], coronary heart disease[5], diabetes[6], hypertension[7], and obesity[8]. Unhealthy diets are also characterized by higher dietary acid load (DAL), which often corresponds to lower consumption of fruits and vegetables. DAL is associated with risk of CKD progression.[9] Compared to higher income, lower income individuals are more likely to be both food insecure and have higher DAL.[3,9]

Prior studies have shown an association of food insecurity with chronic diseases.[3,10] In particular, food insecurity has been shown to be associated with prevalent CKD.[11] We conducted a cross-sectional analysis of lower-income participants of NHANES 2003–2008 and the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study. We found that food insecurity may contribute to disparities in kidney disease, especially among persons with diabetes or hypertension. Despite an association being noted between food insecurity and prevalent CKD, little is known about the association of food insecurity and progression of CKD to end-stage renal disease (ESRD). Understanding these relationships is important given that nutritional self-care is an essential approach to management of CKD and its complications.[12] Further, emerging data suggest that certain healthy dietary patterns may slow kidney function decline.[13–15] In this study, we examined data from a nationally representative sample of U.S. adults to determine whether food insecurity is independently associated with progression to ESRD among individuals with and without CKD.

Methods

Study Population and Baseline Data

To test the relation between food insecurity and CKD progression, we used data from the National Health and Nutrition Examination Survey (NHANES) III, a national probability sample of US non-institutionalized civilians conducted between 1988 and 1994 by the Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics (NCHS). We included participants ≥20 years of age with (i) complete data on dietary intake obtained from single 24-hr recall questionnaire (n=34,955), (ii) CKD that was defined as an estimated glomerular filtration rate (eGFR) 15–59 mL/min/1.73m^2 or urinary albumin-to-creatinine ratio (ACR)≥30 mg/g (n=4,234), (iii) an annual household income ≤400% of the federal poverty limit (FPL) [in order to exclude higher-income persons unlikely to experience food insecurity (as in previous studies[3,16])] (n=2,794), (iv) total caloric intake/day between 800–4200 kcal/day for men and between 600–3500 kcal/day for women[17] (n=2,349), and (v) who were not pregnant (n=2,320). For the Non-CKD group, we included participants with an eGFR≥60 mL/min/1.73m^2 and ACR≤200 mg/gm with all other inclusion criteria remaining the same (n=10,448).

A consent form was signed by the participants in the survey and the participants consented to storing specimens of their blood for future research.

Socio-Demographic and Clinical Measurements

Medical history and demographic data were collected through an in-person survey followed by a medical examination and laboratory testing as specified in NHANES documentation.[18]

Socio-demographic factors were assessed during the interview. Racial/ethnic categories were self-reported by participants and assigned as: non-Hispanic white (NHW), non-Hispanic black (NHB), Mexican American, and others (Asian, Native American, other Hispanic and those of unknown race/ethnicity). Self-reported information on education and income was obtained during the interview portions of the surveys. We excluded participants if income was missing. Income was assessed using the poverty income ratio (PIR), which is the ratio of household income to household poverty level.[18]

Diabetes was defined by self-report or measured hemoglobin A_{1c} (A_{1c})≥6.5%.[19] Hypertension was defined by either self-report, a measured average systolic blood pressure (BP) of ≥140 mm Hg, or measured average diastolic BP of ≥90 mm Hg or reported use of antihypertensive medications.[20] Body mass index (BMI) was calculated from the anthropometric data as weight (in kilograms)/height^2 (in meters). Nutrient intake data derived from NHANES single 24-hour dietary recall questionnaire was used to estimate DAL. Since we did not have the dietary chloride levels available in NHANES, we computed DAL using the simplified calculation model developed by Remer and Manz[21], as in our previous work.[9,22] This may possibly underestimate the predicted net acid excretion as the average dietary acid load of approximately 1 mEq/kg/day noted in average American diet is based on Lennon's estimation. Lennon *et al.*[23] estimate net endogenous acid by taking into account the unmeasured anion content of diet and stool (Na + K + Ca + Mg) − [Cl +1.8 P]).

Measurement and Classification of Albuminuria and Kidney Function

Serum and urine samples were collected in the mobile examination center (MEC). The procedures for measuring serum creatinine and urinary albumin and creatinine have been described.[22] eGFR was calculated using the CKD Epidemiology Collaboration[24] (CKD-EPI) equation to determine baseline CKD.

Food Insecurity

We defined food insecurity in NHANES III as an affirmative response to the question, 'In the last 12 months, did you or your household ever cut the size of your meals or skip meals because there wasn't enough money for food?'[25] This question was a proxy for the broader definition of food insecurity which includes a person's ability to access nutritious food.

Follow-Up Data

The primary outcome was the incidence of ESRD defined as entry into the Medicare ESRD Registry from the time of the survey through December 31, 2006. Death was ascertained through the National Death Index (NDI).[26] We used NHANES III data as to our knowledge this is the only national representative sample that is linked to Medicare ESRD Registry and NDI with a long follow-up and has measures on food insecurity.

Statistical Analyses

Baseline characteristics of study participants across the food secure and food insecure groups in both CKD and Non-CKD groups were compared using χ^2 tests for categorical and t-test for continuous variables; the Kruskal-Wallis test was used for the continuous variables if the normality assumption of the residuals was not met. In the CKD and Non-CKD groups, we investigated the association of food insecurity with the development of ESRD in subjects using the Fine-Gray competing risks method to account for potential bias due to the competing risk of death before ESRD.[27] Models were adjusted for demographics (age, gender, race/ethnicity), income, clinical risk factors (diabetes, hypertension), kidney function/damage markers (eGFR, albuminuria), and nutritional risk factors (total caloric intake/day, BMI, DAL). Both eGFR and albuminuria along with the nutritional risk factors were analyzed as continuous variables.

In the CKD group, we ran additional analyses for mortality as the primary endpoint and ESRD as competing risk to determine if food insecurity was also a risk factor for mortality.

Sensitivity Analyses

We carried out five sets of sensitivity analyses to test the robustness of our findings. First, we performed stratified analyses among participants with incomes<200% FPL (based on the PIR) to study the association between food insecurity and ESRD in low-income individuals (n=1,557). Second, we performed another analysis in the general population comprising of both CKD and Non-CKD adults in NHANES III, who were ≥20 years and had dietary intake data, with incomes<400% FPL, to explore the association of food insecurity with risk of ESRD (n=11,726). Third, we examined the association of food insecurity and incidence of ESRD in the CKD group using the propensity score method for covariate adjustment.[28] The propensity scores were used in two ways and two sets of results were generated. First, the propensity score as a continuous variable was entered into the final multivariable competing risk model. Second, the quintiles of the propensity score were entered into the final model. Fourth, we used the isotope dilution mass spectrometry (IDMS)-traceable 4-variable Modification of Diet in Renal Disease (MDRD) Study equation [29] to estimate GFR in our definition of CKD and then examined the association of food insecurity with ESRD in the CKD and Non-CKD groups. Fifth, we examined the association of food insecurity and development of ESRD in NHANES 2001–2004 (n=1,253) as this is a more recent cohort and provides information on food insecurity based on an 18-item household questionnaire. The scored responses from the questionnaire were grouped into four categories: full (0 affirmative responses), marginal (1–2), low (3–5), and very low (6–10) food security. We defined food security as the combined full and marginal categories and defined the food insecure participants as those who were in the low or very low categories. In NHANES 2001–2004, because the number of events was small due to the shorter duration of follow-up, we used propensity score method for covariate adjustment.[28]

Analyses included the NHANES survey sample weights to account for the complex sample design following the analytical guidelines for NHANES data as proposed by CDC.[29] For variance estimates, we used Fay’s balanced repeated replication procedure, an approach for estimation of standard errors for multistage samples that consist of many sampling units.[30] Results were considered significant if $p < 0.05$. All analyses were performed using SAS 9.2 (SAS Institute, Inc. Cary, NC).

Institutional Review Board Approval

This study was approved by the University of California, San Francisco, Institutional Review Board (Committee on Human Research application #10-04162).

Results

In our study population of NHANES III participants with CKD (n= 2,320), 4.5% had food insecurity. Baseline characteristics are presented in Table 1. Food insecure participants compared to food secure participants were younger in age, had lower incomes, less likely to be NHB (28.8% vs 32.8%), and more likely to have diabetes (29.9% vs 25.0%), hypertension (73.9% vs 67.3%), and albuminuria (90.4% vs 77.1%), p<0.05. DAL was greater for the food insecure participants but the results were of borderline statistical significance (p=0.05).

Among the Non-CKD participants (n=10,448), 5.7% were food insecure. In this population, food insecure participants compared to food secure participants were younger in age, less likely to be NHB (27.7% vs 28.8%), had lower educational attainment (67.0% vs 41.9%), and less likely to have hypertension (31.5% vs 35.8%), p<0.05.

On examining the incident ESRD events by eGFR groups and ACR groups, we found 115, 125, and 346 events to be associated with eGFR groups <45, 45–60, and >=60, respectively while a total of 227, 125, and 234 events associated with ACR groups <30, 30–300, and >300, respectively.

CKD Group

During a median of 12.4 years (interquartile range 6.6 – 14.9 years), 120 (5.2%) NHANES III participants with CKD developed ESRD. Figure 1, Panel A illustrates cumulative incidence by food security status. This was significantly different (P<0.001 by log-rank test). In crude analyses, those reporting food insecurity were 2.8 times more likely to progress to ESRD than the food secure group. Multivariable adjustment for age, gender, and race/ethnicity did not much alter the risk of ESRD (Relative Hazard [RH]= 2.64; 95% CI: 1.52–5.68). On adjustment for income, the results were further attenuated (2.15 [1.25–4.90]). The risk of ESRD was substantially attenuated with adjustment for the clinical risk factors of diabetes and hypertension (1.77 [1.19–4.20]) and then on subsequent adjustment for eGFR and albuminuria (1.39 [1.09–3.77]). The RH was not materially different when adjusted for total caloric intake/day and BMI (1.38 [1.08–3.10]). When the model was further adjusted for DAL, the RH was further attenuated and was of borderline significance (1.22 [0.99–2.11]).

Non-CKD Group

In a median period of 14.4 years (interquartile range 12.8–16.2 years), 226 (2.2%) of NHANES III participants developed ESRD. Figure 1, Panel B illustrates the cumulative incidence by food security status in the Non-CKD group. A multivariable model adjusted for demographics, PIR, clinical factors, kidney markers, and nutritional factors revealed that food insecurity was not associated with risk of ESRD (0.77 [0.40–1.49]).

Sensitivity Analyses

CKD population below 200% FPL—When we examined participants with CKD and incomes below 200% of the FPL, we found our results to be similar to our primary analysis. A total 8.8% of this sample was food insecure. The unadjusted hazard of ESRD for food insecure participants was three times greater than the food secure participants (2.97 [1.68–5.18]). After multivariable adjustment for demographics, income, clinical risk factors, kidney markers, and nutritional risk factors, the risk was attenuated (1.38 [1.07–1.98]). On further adjustment for DAL, the increased risk for ESRD among food insecure individuals

was reduced to 25% (1.25 [0.995–1.81]), and was of borderline significance (p-value=0.055).

General population—On exploring the association between food insecurity and ESRD in the general population (n=11,726) whose income was below 400% FPL, 7.2% of participants were noted to be food insecure. Fully, 586 (4.9%) participants developed ESRD in the general population. We did not find any significant association between food insecurity and risk of ESRD (1.10 [0.64–1.99]).

Propensity Score Method in NHANES III—Among food insecure participants, after adjusting the competing risk model using propensity scores for risk factors to be food insecure, the RH for ESRD was 1.26 [0.98–2.04] for propensity score as a linear covariate. That is, with increasing propensity, the risk for ESRD also increased. The RH for ESRD for propensity score as quintiles was 1.27 [1.00–2.02].

eGFR<60 and ACR>300—When we examined the association of food insecurity with incident ESRD in participants with eGFR<60 and ACR>300, we found 221 of 230 participants to be food insecure. There were 97 (42.2%) ESRD events observed. In the multivariable model, the RH for incident ESRD for participants who were food insecure was 2.29 (0.91–5.92) when compared to those who were food secure.

Food Insecurity and Mortality—In competing risk analyses, the results were no longer significant if death was included as the endpoint in lieu of being treated as a competing risk. The RH for death was 1.07 (0.62–1.86) comparing food insecure to food secure participants with CKD.

MDRD Equation—Using the isotope dilution mass spectrometry (IDMS)-traceable 4-variable Modification of Diet in Renal Disease (MDRD) Study equation for calibrated creatinine[29] to determine baseline CKD, 6.1% of 2,369 NHANES III participants with CKD were food insecure while 7.2% were food insecure in the Non-CKD group. We noted 136 (5.7%) ESRD events in the CKD participants and 214 (2.1%) ESRD events in the Non-CKD participants. The relative hazard associated with ESRD in the unadjusted model for CKD participants was 2.81 (1.62–5.84) while for the Non-CKD participants it was 0.50 (0.25–0.98). In the multivariable model when adjusted for demographics, income, and clinical risk factors, the relative hazard in the CKD group was 1.79 (1.20–4.20) and in the No-CKD group it was 0.77 (0.40–1.47). The fully adjusted model showed a relative hazard of 1.21 (0.99–2.10) in the CKD group and of 0.76 (0.39–1.47) in the No-CKD group, which were similar compared to that estimated using the CKD-EPI equation.

NHANES 2001–2004—Baseline characteristics of the participants are presented in Supplementary Table 1 (ST1). We found 7.9% of the 1,253 participants with CKD to be food insecure in this cohort. There were 32 (2.6%) ESRD events observed. Among food insecure participants, after adjusting the model using propensity scores for risk factors to be food insecure, the RH for ESRD was 1.07 [0.99–1.31] for propensity score as a linear covariate. The RH for ESRD for propensity score as quintiles was 1.09 [1.00–1.30] (ST 2).

In the Non-CKD group, we found 10.2% of the 4,883 participants to be food insecure. There were 16 (0.3%) ESRD events observed. The RH for incident ESRD adjusted for propensity scores for risk factors to be food insecure was not significant (ST 2).

Discussion

In this population-based cohort study of adults with CKD, food insecurity was associated with a higher likelihood of developing ESRD independent of demographics, income, clinical risk factors, and kidney markers. Nutritional factors including DAL explained some of the association between food insecurity and kidney failure. Food insecurity may be an, heretofore, unrecognized risk factor for progression to ESRD among adults with CKD. On the contrary, adults with no CKD showed no association between food insecurity and incident ESRD.

A number of studies have reported cross-sectional associations between food insecurity and chronic diseases[3,32,33], including one report on CKD.[11] To our knowledge, our analysis is the first report of an association between food insecurity and CKD progression to ESRD. Controlling for the potential confounders in the multivariable model attenuated the association between food insecurity and ESRD, suggesting that these confounders contributed to an increased risk of ESRD among food insecure adults with CKD. The large relative hazard of ESRD observed among food insecure adults could possibly be explained on the basis of several factors such as diabetes status, low income, and nutritional factors. We observed a two-fold risk of ESRD when the model was adjusted for the demographic factors, low income, diabetes and hypertension. These results are consistent with previous work showing food insecurity is associated with increased risk of type-2 diabetes and worse glycemic control[16], and food insecurity is most strongly associated with CKD among persons with either diabetes or hypertension.[11]

Food insecurity is closely linked to poverty. Among individuals living at <200% of the U.S. federal poverty line, it has been estimated that 45.7% are food insecure.[34] Several studies have highlighted a strong association between SES and the incidence of ESRD.[35–38] Garrity et al.[35] found in an analysis of 1,373,454 U.S. adult patients initiating dialysis during years 1995–2010, area-level poverty status (zip code-defined area with ≥20% of households living below the federal poverty line) to be associated with a 1.24-fold higher ESRD incidence, after accounting for the distribution of age, sex, and race/ethnicity within a zip code. Compounding the issues of poverty and food insecurity, many low income neighborhoods lack availability of healthful foods in nearby stores and markets. In the U.S., stores stocking healthier options are clustered in more affluent neighborhoods as compared to those which are less affluent.[39–41] This may have contributed to observed differences in DAL (a reflection of fruit and vegetable intake) between food insecure and food secure participants in our study.

In this study, we observed that total caloric intake/day, BMI, and DAL explained a portion of the risk of ESRD associated with food insecurity. When financial or geographic constraints become a barrier for poor communities to access healthy foods, they are likely to consume fewer fruits and vegetables[42] and instead to consume lower quality and high energy dense foods (e.g. processed) that are high in starches, added sugars, and added saturated fats.[43] Consumption of energy-dense foods that are high in acid precursors and limited intake of fruits and vegetables, and fiber may explain the increase in DAL.[44] Further, earlier studies have shown that diet composition resulting in an acid-producing diet increases the risk of progression to ESRD among CKD adults.[22,45] By adding total caloric intake, BMI, and DAL to explain the association of food insecurity with ESRD, the relative hazard was attenuated to 1.21 from 1.40, the risk after adjusting for demographics, income, clinical risk factors, and kidney markers. This implies that food insecurity might lead to ESRD through direct effects of diet quality on kidney health, which has important implications for clinical practice, research, and public health. These observations reflect the complexity of addressing and interpreting the relationship of diet quality as a possible causal mechanism for the disease burden of ESRD among those of lower SEP and with food insecurity.

Our study’s strengths include a large national sample of well-characterized participants from NHANES III and 12–18 years of follow-up. Thus, it represents one of the largest cohorts establishing that food insecurity is associated with poor outcomes. However, the limitations of our study deserve comment. First, we did not have laboratory follow-up data and measures of food insecurity over time. Thus, with measurements at a single time point, there is a possibility of misclassification if levels of CKD risk factors (e.g. diabetes, hypertension), or other factors (e.g. eGFR, ACR, food insecurity) change over time. The lack of longitudinal assessments further limits our ability to adequately examine mediation. Further, due to the lack of follow-up data on food insecurity, we cannot consider the baseline measure of food insecurity as an indication of chronic food insecurity. Second, food insecurity in NHANES was defined at a household level whereas ESRD was determined on an individual-level. However, evidence suggests that if food insecurity is present in a household, it affects almost all the adults in the household.[46] Third, the food sufficiency question that was used in NHANES III does not permit a distinction to be made between moderate and severe insecurity and it also does not allow the food security status of children and adults to be estimated separately. However, similar but not significant results from the 18-item questionnaire used in NHANES 2001–2004 suggests that the screening question minimizes respondent burden without substantially biasing the data. Fourth, this survey was conducted in the early 1990’s; subsequent changes in public assistance and food programs may limit the applicability of results to the current situation. However, this cohort was used because it is the most recent nationally representative sample that is linked to ESRD Registry with a long duration of follow-up and data on food insecurity. Our sensitivity analysis using NHANES 2001–2004 provides more recent information on eating patterns, although with much shorter follow-up. The similarity of results from the two NHANES cohorts supports the validity of results.

In summary, we have observed that food insecurity in lower income individuals with CKD is associated with an increased risk of ESRD and that this association is partially mediated by nutritional factors including higher levels of DAL. This finding may have important public health implications. Further studies might be considered to clarify whether the excess risk for ESRD apart from the traditional risk factors is confined to the nutritional factors that we measured or to other environmental factors. Better detection of food insecurity in a clinical setting and more systematic ways to measure food insecurity among individuals accessing the healthcare system for treatment of chronic diseases may be appropriate to evaluate how best to meet their needs and to improve their health outcomes. Dietary interventions to slow CKD progression that address the financial difficulty participants may have in implementing recommended dietary changes may be beneficial for low-income communities.

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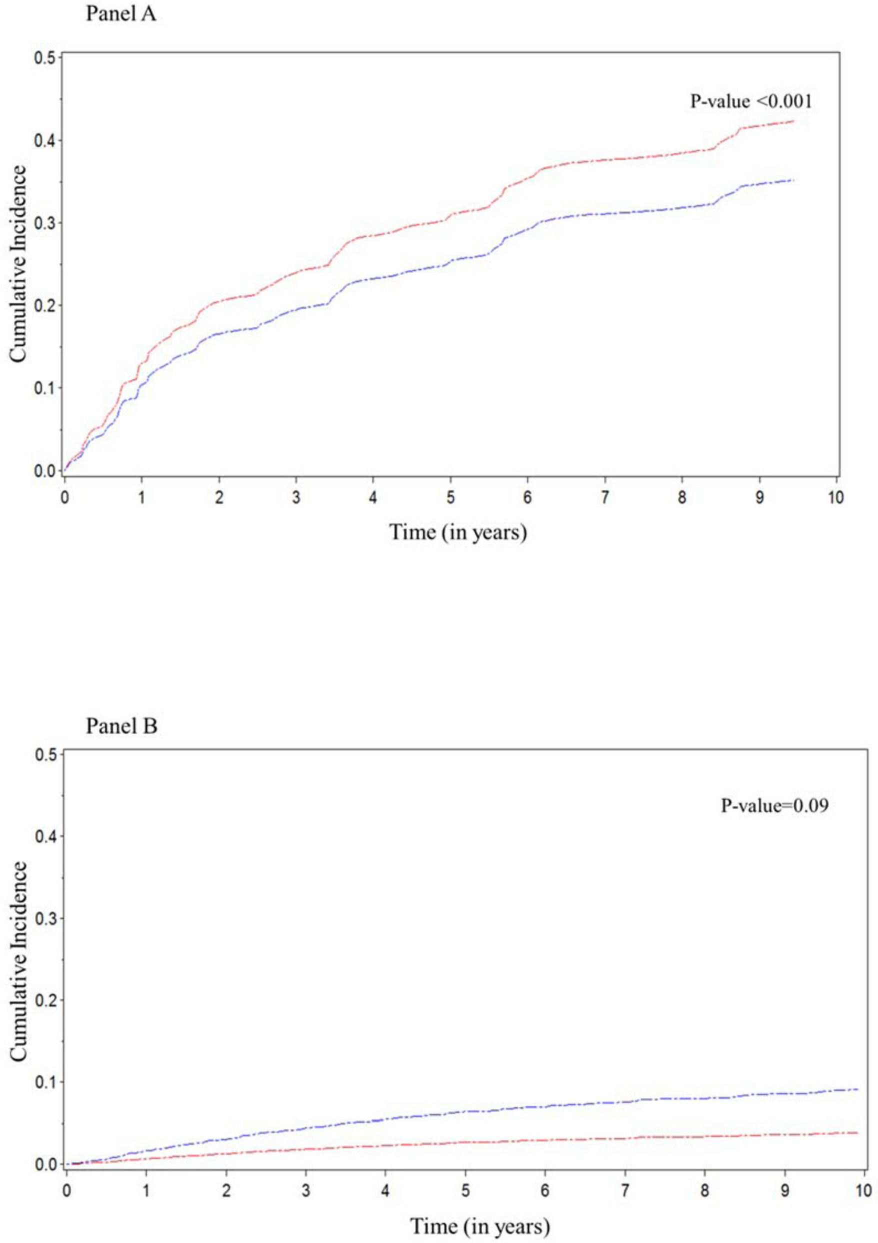

Figure 1.

Cumulative incidence for risk of ESRD by food insecurity status in the CKD group (Panel A) and in the No-CKD group (Panel B). Red line- Food Insecure ; Blue line- Food Secure group

Table 1

Baseline Characteristics of U.S. Adults with CKD and No-CKD by Food Security Status in NHANES III 1988–1994

	CKD Group (n=2,320)				Non-CKD Group (n=10,448)			
Characteristic	**All**	**Food Secure**	**Food Insecure**	**P-value**	**All**	**Food Secure**	**Food Insecure**	**P-value**
Age, years (median, 25th–75th percentile)	68.0 (50.0–78.0)	69.0 (51.0–79.0)	52.0 (34.0–68.0)	0.01	41.0 (30.0–61.0)	41.0 (30.0–61.0)	35.0 (27.0–49.0)	0.02
20–50, %	23.5	22.5	43.6		63.2	62.4	76.2	
51–70	37.2	37.3	35.6		23.4	23.7	18.6	
>70	39.3	20.8	20.8		13.4	13.9	5.2	
Male,%	42.9	43.2	37.5	0.21	45.2	45.4	43.0	0.54
Race/Ethnic Groups, %				<0.0001				<0.0001
Other	3.1	3.0	4.8		4.4	4.5	3.1	
Mexican American	23.4	21.9	53.8		31.2	29.7	56.5	
Non-Hispanic Black	32.5	32.8	28.8		28.7	28.8	27.7	
Non-Hispanic White	41.0	42.4	12.5		35.6	37.0	12.7	
Poverty Income Ratio (mean, SD)	1.7 (0.9)	1.8 (0.9)	0.9 (0.5)	<0.0001	1.8 (1.0)	1.9 (1.0)	0.8 (0.5)	<0.0001
Education, %				0.02				<0.0001
<High School	56.8	56.0	72.2		43.3	41.9	67.0	
High School-Some College	37.0	37.5	26.7		48.5	49.6	31.0	
≥College	6.2	6.5	1.1		8.2	8.5	2.0	
Weight (in kg)								
Male	78.1 (68.5–89.9)	78.3 (68.5–89.7)	73.1 (65.8–92.3)	0.77	77.9 (68.6–88.6)	78.1 (68.8–88.8)	74.8 (65.6–85.3)	0.007
Female	68.8 (59.3–81.1)	68.5 (59.0–81.1)	70.0 (61.3–81.1)	0.42	67.5 (58.4–80.3)	67.5 (58.4–80.2)	68.8 (58.8–80.7)	0.95
Height (in cm)								
Male	171.6 (166.6–176.6)	171.6 (166.6–176.6)	169.1 (162.2–176.2)	0.09	172.9 (168.1–178.1)	173.0 (168.3–178.2)	170.2 (165.1–175.6)	<0.0001
Female	158.0 (153.3–163.2)	158.0 (153.4–163.2)	156.3 (151.3–162.2)	0.23	160.0 (155.6–165.0)	160.2 (155.7–165.0)	157.9 (153.3–164.0)	<0.0001
Body Mass Index								
Male	26.8 (23.8–30.2)	26.8 (23.9–30.1)	27.0 (22.9–32.8)	0.57	26.1 (23.3–29.3)	26.1 (23.4–29.2)	25.8 (22.8–29.4)	0.61
Female	27.7 (23.6–32.4)	27.6 (23.5–32.3)	28.9 (25.7–33.2)	0.14	26.5 (22.9–31.2)	26.4 (22.8–31.1)	27.5 (23.8–32.5)	0.05

Characteristic	CKD Group (n=2,320)				Non-CKD Group (n=10,448)			
	All	**Food Secure**	**Food Insecure**	**P-value**	**All**	**Food Secure**	**Food Insecure**	**P-value**
Diabetes (yes), %	29.7	25.0	29.9	0.001	7.2	7.2	7.4	0.49
Hypertension (yes), %	73.6	67.3	73.9	0.03	35.6	35.8	31.5	0.02
eGFR (median, 25th–75th percentile) *	73.2(48.0–121.9)	73.9 (50.2–117.7)	71.5 (47.1–122.5)	0.04	123.7 (99.4–151.6)	122.8 (98.4–150.5)	136.2 (110.2–165.5)	<0.0001
Albuminuria (>30 mg/gm), %	77.7	77.1	90.4	0.008	8.3	8.2	9.4	0.41
Total Calories (Kcal/day) (median, 25th–75th percentile)								
Male	1786 (1355–2351)	1790 (1361–2353)	1637 (1308–2274)	0.38	2272 (1706–2935)	2274 (1712.5–2935)	2256 (1635–2898)	0.29
Female	1401 (1063–1837)	1405 (1072–1837)	1327 (952–1866)	0.40	1640 (1245–2119)	1640 (1244–2115)	1644 (1263–2159)	0.44
Dietary Acid Load (mEq/day) (median, 25th–75th percentile)								
Male	52.8 (47.6–59.9)	52.8 (47.6–59.9)	53.5 (45.3–59.4)	0.41	57.4 (51.1–64.3)	57.5 (51.2–64.4)	56.6 (49.5–63.0)	0.33
Female	45.0 (39.7–50.5)	44.9 (39.5–50.5)	45.2 (39.9–50.6)	0.91	47.0 (42.0–52.8)	47.0 (42.0–52.7)	46.9 (41.8–52.9)	0.36

Poverty Income Ratio = a ratio of family income to poverty threshold; Hypertension defined as self-reported, avg BP>140/90 and use of medications;

[*] 22 participants were missing data for eGFR estimation in NHANES III.

Table 2

Relative Hazard for risk of ESRD for food insecurity in NHANES III participants with CKD

Model Adjusted for	**n**	**# ESRD Events**	**Food Secure**	**RH (95% CI)**	***P-Value***
Unadjusted	2320	120	1.0 (Reference)	2.75 (1.60–5.90)	0.01
+ Demographics	2320	120	1.0 (Reference)	2.64 (1.52–5.68)	0.03
+ Income	2320	120	1.0 (Reference)	2.15 (1.25–4.90)	0.04
+ Clinical Factors	2320	120	1.0 (Reference)	1.77 (1.19–4.20)	0.01
+ Kidney Markers	2156	101	1.0 (Reference)	1.39 (1.09–3.77)	0.03
+ Nutritional Factors	2156	101	1.0 (Reference)	1.22 (0.99–2.11)	0.06

Demographic factors (age, gender, race); Clinical factors (DM, HTN); Kidney function/damage status (eGFR, albuminuria); Nutritional factors (total caloric intake/day, BMI, DAL).

NHANES=National Health and Nutrition Examination Survey, RH= relative hazard, CI=confidence interval, DM=diabetes, HTN=hypertension, eGFR=estimated glomerular filtration rate, BMI= body mass index, DAL= dietary acid load

Table 3

Relative Hazard for risk of ESRD for food insecurity in NHANES III participants with No-CKD

Model Adjusted for	**n**	**# ESRD Events**	**Food Secure**	**RH (95% CI)**	***P-Value***
Unadjusted	10448	226	1.0 (Reference)	0.55 (0.32–1.02)	0.06
+ Demographics	10448	226	1.0 (Reference)	0.60 (0.35–1.07)	0.06
+ Income	10448	226	1.0 (Reference)	0.75 (0.40–1.39)	0.11
+ Clinical Factors	10448	226	1.0 (Reference)	0.79 (0.41–1.47)	0.15
+ Kidney Markers	10254	220	1.0 (Reference)	0.75 (0.38–1.40)	0.10
+ Nutritional Factors	10254	220	1.0 (Reference)	0.77 (0.40–1.49)	0.18

Demographic factors (age, gender, race); Clinical factors (DM, HTN); Kidney function/damage status (eGFR, albuminuria); Nutritional factors (total caloric intake/day, BMI, DAL).

NHANES=National Health and Nutrition Examination Survey, RH= relative hazard, CI=confidence interval, DM=diabetes, HTN=hypertension, eGFR=estimated glomerular filtration rate, BMI= body mass index, DAL= dietary acid load