Published in final edited form as:

Semin Arthritis Rheum. 2013 June ; 42(6): 551–561. doi:10.1016/j.semarthrit.2012.09.009.

Association of kidney disease with prevalent gout in the United States in 1988–1994 and 2007–2010[☆]

Stephen P. Juraschek^{a,b,c}, Lara C. Kovell^c, Edgar R. Miller III^{a,b,c}, and Allan C. Gelber^{a,b,c,*}

^aDepartment of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

^bWelch Center for Prevention, Epidemiology and Clinical Research, Baltimore, MD

^cJohns Hopkins University School of Medicine, Baltimore, MD

Abstract

Objective—To determine the prevalence of gout associated with progressive degrees of kidney disease in the US population.

Methods—We performed a cross-sectional analysis among non-institutionalized adults (age 20 and older) of the National Health and Nutrition Examination Surveys in 1988–1994 and 2007–2010. Gout status was ascertained by self-report of physician-diagnosed gout. Chronic kidney disease (CKD) was defined in stages based on estimated glomerular filtration rate (GFR) and single albuminuria measurements (albumin-to-creatinine ratio). Prevalence ratios comparing successive categories of GFR, albuminuria, and CKD as well as temporal trends over a 22-year interval were determined via Poisson regression.

Results—In the US, the crude prevalence of gout was 2–3% among participants without CKD, 4% among participants with CKD stage 1, 6–10% for stage 2, 11–13% for stage 3, and over 30% for stage 4. The adjusted prevalence ratio comparing the CKD stage 4 stratum to participants without CKD was 3.20 (95% CI: 1.96, 5.24) in 2007–2010 and remained significant even after adjustment for serum uric acid. Notably, there was a statistically significant, progressively greater adjusted prevalence ratio of gout associated with successively lower categories of GFR and higher categories of albuminuria.

Conclusions—Among US adults, there exists a strong dose–response association between impaired renal function and prevalent gout. Health providers should be aware of the elevated burden of gout among patients with CKD especially when evaluating new onset joint pain and swelling.

Keywords

Gout; Chronic kidney disease; Glomerular filtration rate; Albuminuria; NHANES

[☆]Supported in part by a NIH/NHLBI T32HL007024 Cardiovascular Epidemiology Training Grant, and the Donald B. and Dorothy Stabler Foundation.

© 2012 Elsevier Inc. All rights reserved.

*Corresponding author. Johns Hopkins University School of Medicine, 5200 Eastern Avenue, Mason F Lord Building, Center Tower, Suite 4100, Baltimore, MD 21224. agelber@jhmi.edu (A.C. Gelber).

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Introduction

The prevalence of gout is increasing with over eight million people affected in the United States [1]. While previous reports have cited increasing burden of metabolic syndrome or its components as a potential explanation for this population-wide increase [2,3], few have focused on the contribution of other comorbid conditions that are rising in the US [4] and related to gout risk.

The kidney is the primary means of uric acid disposal in the body, responsible for 70% of all uric acid elimination [5]. Reduced glomerular filtration rate (GFR) [6] and the presence of albuminuria [7] are associated with hyperuricemia [8,9], a well-established risk factor for gout [10]. The prevalence of chronic kidney disease (CKD) is also on the rise and currently affects over 13% of adults in the US [4]. However, the effect of this increase in CKD on the burden of gout in the US is unknown.

There have been few studies on the relationship between CKD and gout. Over the past 50 years, individual case reports have described gout among patients with renal impairment [11–15]. Other observational studies have described elevated relative risk for gout in men with CKD [16,17]. Cross-sectional studies have shown that a GFR less than 60 mL/min per 1.73 m² is associated with higher prevalence of gout [18]. However, the association of gout with microalbuminuria and stage of CKD has not been examined. In this study, we utilize a population representative of the gender and racial/ethnic demography of the US to: (1) quantify the prevalence of gout among US adults with varying degrees of kidney disease in relation to those with normal renal function; (2) determine whether the relationship between CKD and gout is independent of uric acid; and (3) study temporal trends in kidney disease and gout over the past 20 years. While CKD primarily contributes to gout via hyperuricemia, we propose that kidney disease could also directly contribute to a greater prevalence of gout.

Methods

Study Population

The NHANES surveys are large, cross-sectional studies conducted by the National Center for Health Statistics (NCHS) that utilize a complex, multistage sampling design. The present report focused on the interviews, physical examinations, and laboratory measurements of participants age 20 or older in NHANES III (conducted in 1988–1994) and in the continuous NHANES (2007–2010). Persons lacking a serum creatinine measurement, a urine albumin measurement, a urine creatinine measurement, or those who did not answer the query regarding gout status were excluded. The NCHS approved the protocols for the conduct and execution of the NHANES and obtained informed consent [19,20].

Prevalent Gout

The presence of gout was based on an affirmative response from NHANES participants to the questions, “Has a doctor or other health professional ever told you that you had gout?” (NHANES 2007–10) or “Has a doctor ever told you that you had gout?” (NHANES III). In other epidemiologic studies, the self-report of physician-diagnosed gout was shown to be a reliable and sensitive measure of gout [21]. We also conducted a sensitivity analysis in which cases of gout were restricted to those with both an affirmative self-report and either hyperuricemia or self-reported use of gout medications.

Estimated Glomerular Filtration Rate, Albuminuria, and Chronic Kidney Disease

Serum creatinine was measured using a kinetic Jaffe rate method. GFR was estimated with the Chronic Kidney Disease Epidemiology Collaboration equation [22], using standardized serum creatinine measurements [23], and was treated as a continuous variable or categorized in the following manner: 90 mL/min per 1.73 m², 60–89 mL/min per 1.73 m², 30–59 mL/min per 1.73 m², and <30 mL/min per 1.73 m². Albuminuria was quantified using the albumin–creatinine ratio (ACR), expressed in mg/g, where urine creatinine was measured using the modified kinetic rate Jaffe method and urine albumin was measured by a solid-phase fluorescent immunoassay. This ratio was treated as a log₁₀-transformed variable and also classified into three categories: normal (<30 mg/g), microalbuminuria (30–299 mg/g), and macroalbuminuria (≥300 mg/g). CKD was categorized as follows: stage 1, GFR ≥90 mL/min per 1.73 m² and ACR <30 mg/g; stage 2, GFR of 60–89 mL/min per 1.73 m² and ACR <30 mg/g; stage 3, GFR of 30–59 mL/min per 1.73 m²; stage 4, GFR of 15–29 mL/min per 1.73 m²; and stage 5, <15 mL/min per 1.73 m². These stages represent a modified version of the CKD stages established by the National Kidney Foundation Kidney Disease Outcomes Quality Initiative [24] in that only a single measure of albuminuria, rather than persistent albuminuria was used, due to lack of repeat measurements in NHANES 2007–2008. Although utilized in analytic models, stage 5 CKD was not presented as a distinct group due to small sample size.

Demographic Characteristics, Chronic Kidney Disease-Related Medical Conditions, and Gout Risk Factors

The age, gender, and race/ethnicity of all participants were recorded as part of the NHANES protocol. Age was treated as a continuous variable. Race/ethnicity was recorded in four categories as non-Hispanic white, non-Hispanic black, Mexican American, and Other. In 2007–2010, the new NHANES “Hispanic” category was combined with the “Other” category in this report to maintain consistency between survey periods. BMI was calculated using weight and standing height measurements and treated as a continuous variable. Hypertension was defined by a systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg or use of antihypertensive medications [25]. Diabetes was defined by self-report. Low levels of high density lipoprotein cholesterol (HDLc) was defined as <40 mg/dL for men and <50 mg/dL for women; high total cholesterol was defined as ≥240 mg/dL [26]. In standard fashion, serum uric acid was treated as a continuous variable. Hyperuricemia was defined as a serum uric acid measurement >6.0 mg/dL (360 μmol/L) in women and >7.0 mg/dL (420 μmol/L) in men [27]. Alcohol consumption was categorized as never, former, current non-excessive, or current excessive [28]. Gout medications included allopurinol, probenecid, colchicine, sulfapyrazone, and alloxanthine. Diuretic medications included loop diuretics, potassium-sparing diuretics, thiazide diuretics, carbonic anhydrase inhibitors, or miscellaneous diuretics. Use of gout or diuretic medications were treated as dichotomous variables.

Statistical Analyses

All analyses were performed in concordance with the NHANES complex sampling design employing, the sample weights, primary sampling units, and strata that accompanied each survey [19,20]. Standard errors for all estimates were calculated using the Taylor series (linearization) method recommended by the National Center for Health Statistics [19,20]. Analyses were performed in Stata 11.1 (StataCorp LP, College Station, TX).

Weighted prevalence estimates, or means and their associated standard errors, were calculated for demographic characteristics, CKD-related medical disorders, use of gout and diuretic medications, and alcohol consumption for NHANES III and NHANES 2007–2010. Furthermore, we calculated the prevalence of gout according to the categories of GFR,

albuminuria, and CKD, in both survey periods. Poisson regression was used to estimate prevalence ratios, which compared the various GFR, albuminuria, and CKD categories to the reference range, i.e. participants without CKD or with normal renal function. The continuous associations between prevalent gout and GFR (per 10 mL/min per 1.73 m²) or log₁₀-transformed albuminuria were determined via Poisson regression as well. Poisson models were nested as follows: unadjusted; adjusted for age, gender, and race/ethnicity; adjusted for the preceding demographic characteristics plus CKD-related medical disorders, namely, hypertension, BMI, low HDLc, high total cholesterol, self-reported diabetes, diuretic use, and alcohol use; and finally further adjusted for serum uric acid concentration.

In both survey periods, the proportion of NHANES participants with gout and hyperuricemia were plotted using linear splines with knots at each category cut point in order to visualize the continuous association between renal function or kidney disease and prevalent hyperuricemia and gout. Linear splines are models that permit depiction of different relationships between two variables, by allowing the slope of the observed association to vary at different points along the range of x-axis values (e.g. gout prevalence in relation to various levels of GFR or albuminuria). Furthermore, we compared the distribution of GFR and albuminuria by gout status using kernel density plots. The median values of the distributions were compared with weighted quantile regression. GFR and albuminuria distributions were also compared via unweighted, two-sample Kolmogorov–Smirnov equality-of-distributions tests.

Temporal trends in the prevalence of gout, CKD, and the prevalence of gout among participants with CKD were evaluated by comparing prevalence estimates in 2007–2010 with the 1988–1994 survey period, using Poisson regression models. The prevalence ratios generated in these models were adjusted for age, sex, race/ethnicity as well as gout risk factors.

Results

There were 15,132 adults, age 20 and older, examined at the mobile examination center in NHANES 1988–1994 and 10,814 in NHANES 2007–2010 among whom serum creatinine, urine albumin, and urine creatinine were measured (Table 1). Regardless of survey period, mean values of age, albuminuria, serum uric acid, and the proportion with hypertension, self-reported diabetes, and hyperuricemia were greater as estimated GFR declined. In contrast, the proportion of men was smaller with lower levels of GFR in both survey periods. With regards to medication use, in both survey periods a larger proportion of participants reported taking either diuretic or gout medications at successively lower estimated GFR categories. Of gout medication users, 83% reported a physician diagnosis of gout in NHANES III and 88% in NHANES 2007–2010. BMI, race, and low HDLc did not demonstrate consistent trends across survey periods. Alcohol consumption seemed inconsistent by estimated GFR category, but in general the number of former drinkers was greater among those with successively lower estimated levels of GFR while the number of current excessive drinkers was lower with a lower estimated GFR. There were an unweighted total of 421 participants with gout in NHANES III and 499 in NHANES 2007–2010. This represented an overall prevalence of 2.7% or 4.4 million US adults in 1988–1994 and 3.7% or 7.5 million adults in 2007–2010.

Spline models depict the continuous relationship between estimated GFR and albuminuria (Fig. 1A–D). In both survey periods, a greater estimated GFR was associated with a lower proportion of hyperuricemia and gout, while a lower GFR was associated with a proportion of hyperuricemia as high as 75% and gout as high as 30%. Similarly, with higher

albuminuria values, both the proportion of hyperuricemia and gout rose to 35–40% and 10–18% respectively.

A comparison of the probability densities of GFR and albuminuria are depicted in Figure 2A–D. In both survey periods, the probability distribution for GFR was shifted leftward among participants with gout versus participants without gout. In both survey periods these distributions were found to be significantly different by Kolmogorov–Smirnov equality-of-distributions test ($P < 0.001$). Similarly the median GFR for participants with gout was 76–82 mL/min per 1.73 m², while the median GFR for participants without gout was 97–102 mL/min per 1.73 m² ($P < 0.001$ in both survey periods). Likewise, the median ACR for participants with gout was approximately 10 mg/g versus 6 mg/g among those without gout ($P < 0.001$ in both survey periods).

In both 1988–1994 and 2007–2010, when examined in strata of GFR, successively lower categories of kidney function were associated with a greater prevalence of gout, from about 1–2% among participants with an estimated GFR ≥ 90 mL/min per 1.73 m² versus to 30% in participants with an estimated GFR < 30 mL/min per 1.73 m² (Table 2). This corresponds to an unadjusted prevalence ratio of 18.7 (95% CI: 12.3, 28.5). However, after adjusting for demographic characteristics, CKD-related medical disorders, and serum uric acid, the prevalence ratio remained significant with participants in the lowest estimated GFR category having about 3 times the prevalence of gout compared to those with a normal estimated GFR. In like manner, an inverse association was seen in models of continuous estimated GFR and prevalent gout with every 10 mL/min per 1.73 m² higher estimated GFR being associated with a 10% lower prevalence of gout (NHANES 2007–2010 PR: 0.83; 95% CI: 0.77, 0.89).

A similar pattern was observed for albuminuria. In both survey periods, there was a graduated association between albuminuria and prevalent gout in which each higher category of albuminuria was associated with a successively greater prevalence of gout. Furthermore, even after adjusting for all covariates, macro-albuminuria was associated with about 2 times the prevalence of gout compared to participants with a normal albuminuria (Table 2).

As expected, the combination of albuminuria and GFR in stages of CKD mirrored the results observed for GFR and albuminuria. As such, successive stages of CKD demonstrated a progressively greater prevalence of gout as well as progressively greater prevalence ratios (Table 3). While adjustment for demographic characteristics and covariates associated with CKD and gout attenuated the associations between CKD and prevalent gout, stages 3 and 4 were still significantly associated with 2–4 times the prevalence of gout compared to participants with no CKD in both survey periods.

Temporal trends with regard to gout, CKD, and gout among persons with CKD are shown in Supplemental Table 1. In the US, the demographic-adjusted prevalence of gout in 2007–2010 was 1.3 times the prevalence of gout in 1988–1994 (95% CI: 1.1, 1.6); however, this was no longer significant after adjusting for gout risk factors ($P = 0.17$). Similarly, there was no increase in the prevalence of CKD over time after adjusting for demographic characteristics ($P = 0.22$). Furthermore, the prevalence of gout in persons with CKD was not significantly higher in 2007–2010 compared to 1988–1994 after accounting for gout risk factors.

Sensitivity analyses using a more specific definition of gout that included hyperuricemia or gout medication did not fundamentally alter our principal findings (Supplemental Tables 2 & 3). In both survey periods, we observe a graded increase in the prevalence of gout among

persons with lower kidney function or higher albuminuria, even after adjusting for demographic characteristics and CKD-related medical disorders.

Discussion

This study represents one of the first attempts to describe the burden of gout among US adults with varying degrees of kidney function and disease. Overall, we found that about 30% of individuals with stage 4 CKD reported a physician diagnosis of gout, which unadjusted represents a 10 times greater prevalence compared with participants without CKD. This association remained significant even after adjusting for serum uric acid. Moreover, consecutive categorical decline in kidney function was associated with a progressively greater prevalence of gout. While the prevalence of gout seems to be increasing over time, population-wide changes in gout risk factors seem to explain this trend.

There is growing evidence that a decline in kidney function may precede hyperuricemia and ultimately contribute to the development of gout. The kidney is responsible for 70% of urate elimination [5,29,30]. Uric acid is freely filtered by the kidney and undergoes reabsorption and secretion in the proximal tubule [31]. Several clinical studies have linked both reduced renal filtration [11,13] and impaired tubular secretion with gout [11,32]. Furthermore, prospective studies have shown that reduced GFR is predictive of incident hyperuricemia [6]. Together these studies may explain the elevated burden of gout among participants with CKD.

There is also evidence that the relationship between hyperuricemia and CKD is bidirectional [33]. Several rat models have shown that hyperuricemia contributes to kidney injury [34,35]. Furthermore, gouty nephropathy is a well-described consequence of hyperuricemia-induced crystal formation in the inter-stitium of the kidney medulla [36]. While several observational studies have not found uric acid to be a risk factor for CKD [37,38], others have found an association between hyperuricemia and kidney disease progression as well as incident ESRD [39–42]. Similarly, several trials of urate-lowering gout medications have reported improvement in kidney function [43–46] while others have reported no effect [47]. Additional studies examining the longitudinal relationship between CKD and incident gout are necessary to elucidate the temporal relationship between CKD and gout.

In our study, we found an association between gout and CKD even after adjustment for serum uric acid concentrations. This is consistent with several clinical studies that demonstrated a lower urinary urate excretion rate in gout patients regardless of serum urate concentrations [32,48]. However, whether this independent association is mediated by inflammation or a cumulative effect of excess uric acid exposure has yet to be determined.

Our study is unique in showing a graded relationship between albuminuria and gout. This relationship was attenuated with adjustment for serum uric acid, suggesting that uric acid may be a mediator or confounder of this association. However, many of the models remained significant even after adjusting for uric acid. This likely reflects the cumulative effect of chronic hyperuricemia on the kidney. Several animal models [49] as well as clinical studies [40,41] have shown that chronic hyperuricemia is associated with the progression of kidney injury. Thus, while current elevations in uric acid are reflective of previous elevations, albuminuria may also capture the chronicity of one's previous exposure to hyperuricemia.

The findings in this report are clinically relevant, showing that hyperuricemia and gout were highly prevalent in patients with CKD. Health practitioners treating CKD patients with new onset joint pain or swelling should be vigilant for undiagnosed gout. Moreover, practitioners

treating patients with gout should be wary of CKD as an underlying factor contributing to both hyperuricemia and gout risk since many urate-lowering medications require renal dosing or have associated nephrotoxicity [50,51].

This study has some important limitations. First, the NHANES are cross-sectional studies. As a result, the causal direction of associations between kidney function and gout cannot be determined. Second, gout was ascertained by self-report of a physician diagnosis without the aspiration of synovial fluid (arthrocentesis) for the identification of urate crystals. The NHANES protocol does not collect information as to the frequency of gout flares nor whether the activity of the respondent's gout course is acute versus chronic. Whereas a crystal-proven diagnosis via arthrocentesis is the gold standard diagnostic approach in clinical practice [52], the self-report approach is a pragmatic option with demonstrated reliability in other epidemiologic studies [21]. Further, self-report could overinflate the prevalence of gout in the US as several studies show low validation rates with self-reported gout [53,54]. It should be noted that pseudogout is also associated with CKD [55] and in the absence of confirmatory arthrocentesis could be misclassified as gout. However, in sensitivity analyses using a more specific definition of gout, we observed the same relationship between CKD stages and gout. Third, NHANES had few individuals in the low range of estimated GFR. This group is underrepresented in our study since anuric individuals, who did not provide an albumin specimen, were excluded from our dataset. Finally, CKD stages 1 and 2 were defined using a single measurement of albuminuria rather than persistent albuminuria. This may result in some misclassification of individuals as having CKD stage 1 or 2 who likely do not have CKD, which might introduce a conservative bias.

Conclusion

Successive stages of CKD are strongly associated in a dose-response fashion with a greater prevalence of gout. While uric acid concentration is an important factor in this relationship, CKD is independently associated with prevalent gout. Health practitioners should be attentive to undiagnosed gout in patients with CKD. Future studies should prospectively examine the relationship between CKD and gout to determine whether CKD increases the risk of gout.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Zhu Y, Pandya BJ, Choi HK. Prevalence of gout and hyperuricemia in the US general population: The National Health and Nutrition Examination Survey 2007–2008. *Arthritis Rheum.* 2011; 63(10): 3136–41. [PubMed: 21800283]
2. Juraschek, SP.; Miller, ER., 3rd; Gelber, AC. Body mass index, obesity, and prevalent gout in the United States in 1988–1994 and 2007–2010: Body Mass Index. *Obesity Gout Arthritis Care Res* [Internet]. 2012 Jul 6. [cited 2012 Jul 18]; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/22778033>
3. Choi HK, Ford ES, Li C, Curhan G. Prevalence of the metabolic syndrome in patients with gout: The Third National Health and Nutrition Examination Survey. *Arthritis Rheum.* 2007; 57(1):109–15. [PubMed: 17266099]
4. Coresh J, Selvin E, Stevens LA, Manzi J, Kusek JW, Eggers P, et al. Prevalence of chronic kidney disease in the United States. *J Am Med Assoc.* 2007; 298(17):2038–47.
5. Lipkowitz MS. Regulation of uric acid excretion by the kidney. *Curr Rheumatol Rep.* 2012; 14(2): 179–88. [PubMed: 22359229]

6. Ryu S, Chang Y, Zhang Y, Kim S-G, Cho J, Son HJ, et al. A cohort study of hyperuricemia in middle-aged South Korean men 2012;175(2):133–43. *Am J Epidemiol.* 2012; 175(2):133–43. [PubMed: 22156041]
7. Toto RD, Greene T, Hebert LA, Hiremath L, Lea JP, Lewis JB, et al. Relationship between body mass index and proteinuria in hypertensive nephrosclerosis: results from the African American Study of Kidney Disease and Hypertension (AASK) cohort. *Am J Kidney Dis.* 2010; 56(5):896–906. [PubMed: 20801567]
8. Chen N, Wang W, Huang Y, Shen P, Pei D, Yu H, et al. Community-based study on CKD subjects and the associated risk factors. *Nephrol Dial Transplant.* 2009; 24(7):2117–23. [PubMed: 19193736]
9. Sorensen LB. Role of the intestinal tract in the elimination of uric acid. *Arthritis Rheum.* 1965; 8(5):694–706. [PubMed: 5859543]
10. Campion EW, Glynn RJ, DeLabry LO. Asymptomatic hyperuricemia. Risks and consequences in the Normative Aging Study. *Am J Med.* 1987; 82(3):421–6. [PubMed: 3826098]
11. Sorensen LB. The pathogenesis of gout. *Arch Intern Med.* 1962; 109:379–90. [PubMed: 13915270]
12. Talbott JH, Terplan KL. The kidney in gout. *Medicine (Baltimore).* 1960; 39:405–67. [PubMed: 13775026]
13. Vecchio PC, Emmerson BT. Gout due to renal disease. *Br J Rheumatol.* 1992; 31(1):63–5. [PubMed: 1730109]
14. Sheane BJ, Cunnane G. Tophaceous gout and chronic kidney disease. *J Clin Rheumatol.* 2007; 13(5):293. [PubMed: 17921803]
15. Medeiros MMC., Silva, GB., Jr; Daher, EF. Tophus gout and chronic kidney disease in a young female patient: Report of familial juvenile hyperuricemic nephropathy in three generations of the same family. *Rheumatol Int [Internet].* 2011 Sep 10. [cited 2012 Mar 24]; Available from: <http://www.ncbi.nlm.nih.gov/pubmed/21909621>
16. Gibson T, Highton J, Potter C, Simmonds HA. Renal impairment and gout. *Ann Rheum Dis.* 1980; 39(5):417–23. [PubMed: 7436572]
17. Choi HK, Atkinson K, Karlson EW, Curhan G. Obesity, weight change, hypertension, diuretic use, and risk of gout in men: the health professionals follow-up study. *Arch Intern Med.* 2005; 165(7):742–8. [PubMed: 15824292]
18. Zhu Y, Pandya BJ, Choi HK. Comorbidities of Gout and Hyperuricemia in the US General Population: NHANES 2007–2008. *Am J Med.* 2012; 125(7):679–87. e1. [PubMed: 22626509]
19. Centers for Disease Control. NHANES - NHANES III – Reports and Reference Manuals [Internet]. 1988. [cited 2011 Nov 22]. Available from: <http://www.cdc.gov/nchs/nhanes/nh3rrm.htm>
20. Centers for Disease Control. NHANES – NHANES 1999–2010 – Manuals, Brochures, and Consent Documents [Internet]. 1999. [cited 2011 Nov 22]. Available from: <http://www.cdc.gov/nchs/nhanes/>
21. McAdams MA, Maynard JW, Baer AN, Kottgen A, Clipp S, Coresh J, et al. Reliability and sensitivity of the self-report of physician-diagnosed gout in the campaign against cancer and heart disease and the atherosclerosis risk in the community cohorts. *J Rheumatol.* 2011; 38(1):135–41. [PubMed: 21123328]
22. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med.* 2009; 150(9):604–12. [PubMed: 19414839]
23. Selvin E, Manzi J, Stevens LA, Van Lente F, Lacher DA, Levey AS, et al. Calibration of serum creatinine in the National Health and Nutrition Examination Surveys (NHANES) 1988–1994, 1999–2004. *Am J Kidney Dis.* 2007; 50(6):918–26. [PubMed: 18037092]
24. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis.* 2002; 39(2 Suppl 1):S1–266. [PubMed: 11904577]
25. Egan BM, Zhao Y, Axon RN. US trends in prevalence, awareness, treatment, and control of hypertension, 1988–2008. *J Am Med Assoc.* 2010; 303(20):2043–50.

26. National Heart Lung and Blood Institute. Third report of the National Cholesterol Education Program (NCEP) Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) [Internet]. 2002 Sep. Report No.: NIH Publication No. 02-5215. Available from: <http://www.nhlbi.nih.gov/guidelines/cholesterol/atp3full.pdf>
27. Feig DI, Kang D-H, Johnson RJ. Uric acid and cardiovascular risk. *N Engl J Med*. 2008; 359(17): 1811–21. [PubMed: 18946066]
28. Tsai J, Ford ES, Li C, Zhao G. Past and current alcohol consumption patterns and elevations in serum hepatic enzymes among US adults. *Addict Behav*. 2012; 37(1):78–84. [PubMed: 21975024]
29. Maesaka JK, Fishbane S. Regulation of renal urate excretion: A critical review. *Am J Kidney Dis*. 1998; 32(6):917–33. [PubMed: 9856507]
30. Marangella M. Uric acid elimination in the urine. Pathophysiological implications. *Contrib Nephrol*. 2005; 147:132–48. [PubMed: 15604613]
31. Rieselbach RE. Renal handling of uric acid. *Adv Exp Med Biol*. 1977; 76B:1–22. [PubMed: 324249]
32. García Puig J, Mateos Antón F, López Jiménez M, Conthe Gutiérrez P. Renal handling of uric acid in gout: impaired tubular transport of urate not dependent on serum urate levels. *Metab Clin Exp*. 1986; 35(12):1147–53. [PubMed: 3784914]
33. Kang D-H, Chen W. Uric acid and chronic kidney disease: new understanding of an old problem. *Semin Nephrol*. 2011; 31(5):447–52. [PubMed: 22000652]
34. Mazzali M, Hughes J, Kim YG, Jefferson JA, Kang DH, Gordon KL, et al. Elevated uric acid increases blood pressure in the rat by a novel crystal-independent mechanism. *Hypertension*. 2001; 38(5):1101–6. [PubMed: 11711505]
35. Nakagawa T, Mazzali M, Kang D-H, Kanellis J, Watanabe S, Sanchez-Lozada LG, et al. Hyperuricemia causes glomerular hypertrophy in the rat. *Am J Nephrol*. 2003; 23(1):2–7. [PubMed: 12373074]
36. Gonick HC, Rubini ME, Gleason IO, Sommers SC. The Renal Lesion in Gout. *Ann Intern Med*. 1965; 62:667–74. [PubMed: 14274831]
37. Sturm G, Kollerits B, Neyer U, Ritz E, Kronenberg F. Uric acid as a risk factor for progression of non-diabetic chronic kidney disease? The Mild to Moderate Kidney Disease (MMKD) Study. *Exp Gerontol*. 2008; 43(4):347–52. [PubMed: 18294794]
38. Hunsicker LG, Adler S, Caggiula A, England BK, Greene T, Kusek JW, et al. Predictors of the progression of renal disease in the Modification of Diet in Renal Disease Study. *Kidney Int*. 1997; 51(6):1908–19. [PubMed: 9186882]
39. Iseki K, Ikemiya Y, Inoue T, Iseki C, Kinjo K, Takishita S. Significance of hyperuricemia as a risk factor for developing ESRD in a screened cohort. *Am J Kidney Dis*. 2004; 44(4):642–50. [PubMed: 15384015]
40. Ohno I, Hosoya T, Gomi H, Ichida K, Okabe H, Hikita M. Serum uric acid and renal prognosis in patients with IgA nephropathy. *Nephron*. 2001; 87(4):333–9. [PubMed: 11287777]
41. Syrjänen J, Mustonen J, Pasternack A. Hypertriglyceridaemia and hyperuricaemia are risk factors for progression of IgA nephropathy. *Nephrol Dial Transplant*. 2000; 15(1):34–42. [PubMed: 10607765]
42. Tomita M, Mizuno S, Yamanaka H, Hosoda Y, Sakuma K, Matuoka Y, et al. Does hyperuricemia affect mortality? A prospective cohort study of Japanese male workers. *J Epidemiol*. 2000; 10(6): 403–9. [PubMed: 11210110]
43. Siu Y-P, Leung K-T, Tong MK-H, Kwan T-H. Use of allopurinol in slowing the progression of renal disease through its ability to lower serum uric acid level. *Am J Kidney Dis*. 2006; 47(1):51–9. [PubMed: 16377385]
44. Goicoechea M, de Vinuesa SG, Verdalles U, Ruiz-Caro C, Ampuero J, Rincón A, et al. Effect of allopurinol in chronic kidney disease progression and cardiovascular risk. *Clin J Am Soc Nephrol*. 2010; 5(8):1388–93. [PubMed: 20538833]
45. Momeni A, Shahidi S, Seirafian S, Taheri S, Kheiri S. Effect of allopurinol in decreasing proteinuria in type 2 diabetic patients. *Iran J Kidney Dis*. 2010; 4(2):128–32. [PubMed: 20404423]
46. Gibson T, Rodgers V, Potter C, Simmonds HA. Allopurinol treatment and its effect on renal function in gout: A controlled study. *Ann Rheum Dis*. 1982; 41(1):59–65. [PubMed: 7039523]

47. Noman A, Ang DSC, Ogston S, Lang CC, Struthers AD. Effect of high-dose allopurinol on exercise in patients with chronic stable angina: a randomised, placebo controlled crossover trial. *Lancet*. 2010; 375(9732):2161–7. [PubMed: 20542554]
48. Simkin PA. Urate excretion in normal and gouty men. *Adv Exp Med Biol*. 1977; 76B:41–5. [PubMed: 855762]
49. Kang D-H, Nakagawa T, Feng L, Watanabe S, Han L, Mazzali M, et al. A role for uric acid in the progression of renal disease. *J Am Soc Nephrol*. 2002; 13(12):2888–97. [PubMed: 12444207]
50. Dykeman-Sharpe J. Treatment of acute gouty arthritis in patients with chronic kidney disease. *CANNT J*. 2004; 14(1):48–50. [PubMed: 15544173]
51. El-Zawawy H, Mandell BF. Managing gout: How is it different in patients with chronic kidney disease? *Cleve Clin J Med*. 2010; 77(12):919–28. [PubMed: 21147946]
52. Wallace SL, Robinson H, Masi AT, Decker JL, McCarty DJ, Yü TF. Preliminary criteria for the classification of the acute arthritis of primary gout. *Arthritis Rheum*. 1977; 20(3):895–900. [PubMed: 856219]
53. O'Sullivan JB. Gout in a New England town. A prevalence study in Sudbury, Massachusetts. *Ann Rheum Dis*. 1972; 31(3):166–9. [PubMed: 5032448]
54. Choi HK, Atkinson K, Karlson EW, Willett W, Curhan G. Purine-rich foods, dairy and protein intake, and the risk of gout in men. *N Engl J Med*. 2004; 350(11):1093–103. [PubMed: 15014182]
55. Sarraf P, Kay J, Reginato AM. Non-crystalline and crystalline rheumatic disorders in chronic kidney disease. *Curr Rheumatol Rep*. 2008; 10(3):235–48. [PubMed: 18638433]

Appendix A. Supplementary materials

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.semarthrit.2012.09.009>.

Fig. 1.

Linear spline graph of the proportion of the US population with gout (solid line) or hyperuricemia (dashed line) in (A) NHANES III or (C) NHANES 2007–2010 according to the glomerular filtration rate (mL/min per 1.73 m²) with knots located at 30, 60, and 90 mL/min per 1.73 m². Also, shown are linear splines according to albuminuria (mg/g) in (B) NHANES III or (D) NHANES 2007–2010 with knot located at 30 and 300 mg/g. Hyperuricemia is defined by a serum uric acid measurement >6.0 mg/dL in women and >7.0 mg/dL.

Fig. 2.

Kernel density plot depicting the distribution of glomerular filtration rate (mL/min per 1.73 m²) by the presence (solid line) or absence (dashed line) of gout in (A) NHANES III or (C) NHANES 2007–2010. Similarly, the distribution of albuminuria (mg/g) by gout status in (B) NHANES III or (D) NHANES 2007–2010.

Table 1

Weighted Means and Prevalence Estimates by Estimated Glomerular Filtration Rate Category for NHANES III and NHANES 2007–2010.

Weighted Mean or % (SE) by Estimated GFR Category (mL/min per 1.73 m ²)		Overall (N = 15,132)	90 (N = 10,143)	60–89 (N = 3,958)	30–59 (N = 964)	<30 (N = 67)
NH88–94, No. = 247,729,796^a						
Age, year		44.62 (0.46)	37.48 (0.23)	58.93 (0.63)	72.48 (0.74)	73.53 (1.62)
Male, %		47.89 (0.47)	48.39 (0.66)	47.82 (1.08)	40.72 (2.93)	42.44 (9.50)
Race/ethnicity ^b						
Non-Hispanic white, %		76.77 (1.27)	72.87 (1.51)	85.70 (1.24)	86.44 (2.06)	76.38 (6.41)
Non-Hispanic black, %		10.37 (0.60)	11.87 (0.70)	6.69 (0.48)	7.82 (0.89)	15.80 (4.18)
Mexican American, %		5.10 (0.42)	6.52 (0.56)	1.94 (0.14)	1.21 (0.23)	1.89 (0.52)
Other, %		7.76 (0.84)	8.75 (0.98)	5.67 (0.95)	4.53 (1.86)	5.94 (5.65)
Body mass index, kg/m ²		26.56 (0.11)	26.21 (0.13)	27.38 (0.14)	27.39 (0.24)	25.94 (0.95)
Estimated GFR mL/min per 1.73 m ²		99.15 (0.51)	110.13 (0.28)	78.54 (0.21)	50.33 (0.29)	23.49 (0.81)
Albuminuria (ACR), mg/g		25.73 (1.55)	14.70 (0.90)	32.26 (3.94)	118.29 (13.14)	741.90 (198.80)
Low HDL cholesterol, %		36.64 (1.10)	35.67 (1.24)	37.42 (1.15)	46.46 (2.58)	52.85 (10.78)
Elevated total cholesterol, %		19.51 (0.64)	15.32 (0.62)	27.31 (1.21)	39.55 (2.96)	34.47 (8.92)
Hypertension, %		23.91 (0.85)	13.78 (0.64)	42.09 (1.54)	74.57 (1.66)	79.62 (8.74)
Self-reported diabetes, %		3.58 (0.23)	2.15 (0.25)	5.85 (0.45)	11.69 (1.08)	25.19 (7.11)
Serum uric acid, mg/dL		5.32 (0.02)	5.12 (0.03)	5.62 (0.04)	6.54 (0.09)	7.88 (0.31)
Hyperuricemia, % ^c		15.67 (0.50)	11.17 (0.58)	21.94 (0.76)	46.34 (2.10)	79.06 (6.42)
Diuretic medications, %		6.49 (0.34)	2.79 (0.25)	10.74 (0.73)	36.64 (2.25)	67.26 (8.19)
Gout medications, % ^d		0.93 (0.11)	0.29 (0.07)	1.75 (0.31)	5.62 (1.32)	11.05 (4.80)
Allopurinol use, %		0.71 (0.11)	0.25 (0.07)	1.25 (0.26)	4.40 (0.99)	10.50 (4.76)
Alcohol status						
Never, %		12.99 (0.76)	11.55 (0.65)	15.02 (1.15)	23.72 (2.70)	14.26 (4.29)
Former, %		32.26 (1.03)	28.70 (1.09)	38.61 (1.27)	48.77 (2.39)	72.89 (7.30)
Non-excessive current, %		24.71 (0.96)	23.52 (0.88)	28.35 (1.58)	23.00 (3.04)	9.98 (6.05)
Excessive current, %		30.05 (1.21)	36.23 (1.31)	18.02 (1.10)	4.50 (0.87)	2.86 (2.55)
Overall (N = 10,814)			90 (N = 6,450)	60–89 (N = 3,418)	30–59 (N = 847)	<30 (N = 99)

Weighted Mean or % (SE) by Estimated GFR Category (mL/min per 1.73 m ²)					
	Overall (N = 15,132)	90 (N = 10,143)	60–89 (N = 3,958)	30–59 (N = 964)	<30 (N = 67)
NH07–10, No. = 299,539,907 ^a					
Age, year	46.90 (0.32)	39.40 (0.22)	56.67 (0.31)	71.19 (0.68)	71.17 (1.38)
Male, %	48.32 (0.42)	48.26 (0.62)	50.23 (0.77)	39.72 (1.99)	35.50 (4.63)
Race/ethnicity ^b					
Non-Hispanic white, %	69.42 (2.46)	62.26 (2.70)	80.94 (2.03)	82.72 (2.01)	70.61 (5.60)
Non-Hispanic black, %	10.46 (0.99)	12.21 (1.08)	7.22 (0.85)	9.12 (1.21)	14.88 (3.93)
Mexican American, %	8.54 (1.32)	11.51 (1.63)	3.85 (0.83)	2.91 (0.90)	4.30 (1.43)
Other, %	11.59 (1.28)	14.03 (1.48)	7.99 (1.10)	5.26 (1.11)	10.21 (3.32)
Body mass index, kg/m ²	28.62 (0.10)	28.53 (0.12)	28.64 (0.12)	29.36 (0.21)	29.45 (0.71)
Estimated GFR mL/min per 1.73 m ²	95.15 (0.55)	108.83 (0.30)	78.00 (0.18)	50.18 (0.37)	21.82 (0.81)
Albuminuria (ACR), mg/g	32.46 (2.99)	16.46 (1.14)	30.63 (3.42)	134.20 (35.96)	811.08 (180.96)
Low HDL cholesterol, %	32.94 (0.84)	34.58 (0.95)	28.92 (1.18)	35.91 (1.81)	48.26 (5.84)
Elevated total cholesterol, %	14.11 (0.56)	12.50 (0.59)	17.31 (1.05)	13.50 (1.57)	17.48 (4.27)
Hypertension, %	31.24 (0.81)	19.93 (0.63)	43.46 (1.05)	76.74 (2.18)	89.85 (3.39)
Self-reported diabetes, %	8.24 (0.44)	5.74 (0.41)	9.62 (0.78)	24.18 (1.97)	40.11 (4.82)
Serum uric acid, mg/dL	5.47 (0.02)	5.24 (0.02)	5.70 (0.04)	6.47 (0.07)	7.23 (0.20)
Hyperuricemia, % ^c	18.36 (0.56)	12.76 (0.62)	23.01 (0.75)	48.60 (2.25)	60.92 (4.93)
Diuretic medications, %	10.07 (0.48)	4.58 (0.39)	14.50 (0.79)	39.17 (1.85)	64.35 (5.03)
Gout medications, % ^d	1.32 (0.17)	0.40 (0.09)	1.88 (0.34)	6.51 (0.71)	17.20 (4.14)
Allopurinol use, %	1.15 (0.16)	0.37 (0.09)	1.51 (0.29)	5.82 (0.71)	17.20 (4.14)
Alcohol status					
Never, %	10.95 (0.57)	10.05 (0.57)	11.09 (1.02)	17.77 (1.59)	29.84 (5.89)
Former, %	22.71 (1.05)	19.84 (1.18)	24.62 (1.41)	40.76 (1.98)	37.93 (5.28)
Non-excessive current, %	36.18 (0.87)	33.14 (0.96)	42.48 (1.55)	33.97 (2.41)	28.23 (4.88)
Excessive current, %	30.17 (0.86)	36.97 (1.11)	21.81 (1.26)	7.50 (1.91)	4.00 (2.76)

Abbreviations: NH, NHANES.

^aWeighted number representing the total US population.

^bIn order to account for a change in NHANES race/ethnicity definitions in 2007–2010, we placed Hispanic in the “Other” to be consistent with NHANES 1988–1994.

^cHyperuricemia is defined as a serum uric acid >7 mg/dL in men and >6 mg/dL in women.

^dAllopurinol, probenecid, colchicine, sulfipyrazone, alloxanthine.

Table 2
Prevalence (SE) and Prevalence Ratios (95% CI) of Gout by Glomerular Filtration Rate or Albuminuria.

Estimated Glomerular Filtration Rate (mL/min per 1.73 m ²)							
NHANES III	N ^a	Prevalence, % (SE)	Unadjusted (N= 15,132)	Model 1 (N= 15,132)	Model 2 (N= 14,396)	Model 3 (N= 14,396)	
90	10,143	1.37 (0.19)	Ref = 1	Ref = 1	Ref = 1	Ref = 1	
60–89	3,958	4.35 (0.41)	3.18 (2.28, 4.44)	1.51 (0.85, 2.68)	1.35 (0.75, 2.43)	1.18 (0.68, 2.03)	
30–59	964	11.32 (1.45)	8.28 (5.78, 11.86)	2.83 (1.39, 5.77)	2.10 (1.02, 4.33)	1.50 (0.79, 2.85)	
<30	67	32.07 (†)	23.46 (12.17, 45.21)	7.57 (3.26, 17.61)	4.92 (2.00, 12.07)	2.65 (1.14, 6.16)	
NHANES 2007–10	N ^a	Prevalence, % (SE)	Unadjusted (N= 10,814)	Model 1 (N= 10,814)	Model 2 (N= 9,711)	Model 3 (N= 9,708)	
90	6,450	1.59 (0.16)	Ref = 1	Ref = 1	Ref = 1	Ref = 1	
60–89	3,418	5.73 (0.46)	3.60 (2.81, 4.61)	1.81 (1.29, 2.53)	1.80 (1.28, 2.52)	1.53 (1.11, 2.11)	
30–59	847	12.93 (†)	8.13 (6.33, 10.45)	2.81 (1.90, 4.15)	2.36 (1.54, 3.62)	1.59 (1.00, 2.51)	
<30	99	29.81 (†)	18.74 (12.34, 28.46)	6.49 (3.88, 10.84)	5.11 (2.89, 9.07)	2.84 (1.48, 5.42)	
Continuous estimated GFR ^c							
	N ^a	Prevalence, % (SE)	Unadjusted	Model 1	Model 2	Model 3	
NHANES III	15,132	2.65 (0.20)	0.69 (0.66, 0.72)	0.79 (0.71, 0.87)	0.85 (0.76, 0.94)	0.91 (0.82, 1.01)	
NHANES 2007–10	10,814	3.72 (0.24)	0.70 (0.68, 0.72)	0.79 (0.74, 0.85)	0.83 (0.77, 0.89)	0.89 (0.82, 0.98)	
Albuminuria (ACR, mg/g)							
NHANES III	N ^a	Prevalence, % (SE)	Unadjusted (N= 15,132)	Model 1 (N= 15,132)	Model 2 (N= 14,396)	Model 3 (N= 14,396)	
<30	13,334	2.23 (0.20)	Ref = 1	Ref = 1	Ref = 1	Ref = 1	
30–299	1,471	6.16 (0.95)	2.76 (1.86, 4.09)	1.80 (1.21, 2.68)	1.49 (0.98, 2.27)	1.38 (0.93, 2.06)	
300	327	13.67 (2.82)	6.13 (4.06, 9.26)	3.16 (2.05, 4.87)	1.81 (1.04, 3.15)	1.66 (0.98, 2.82)	
NHANES 2007–10	N ^a	Prevalence, % (SE)	Unadjusted (N= 10,814)	Model 1 (N= 10,814)	Model 2 (N= 9,711)	Model 3 (N= 9,708)	
<30	9,503	3.13 (0.27)	Ref = 1	Ref = 1	Ref = 1	Ref = 1	
30–299	1,091	7.78 (0.72)	2.49 (1.89, 3.27)	1.44 (1.13, 1.83)	1.10 (0.84, 1.45)	1.08 (0.82, 1.42)	
300	220	21.03 (3.53)	6.72 (4.63, 9.77)	3.85 (2.62, 5.68)	2.94 (1.91, 4.53)	2.35 (1.47, 3.74)	
Continuous log ₁₀ ACR							
	N ^a	Prevalence, % (SE)	Unadjusted	Model 1	Model 2	Model 3	

Estimated Glomerular Filtration Rate (mL/min per 1.73 m ²)						
NHANES III	N ^a	Prevalence, % (SE)	Unadjusted (N= 15,132)	Model 1 (N= 15,132)	Model 2 (N= 14,396)	Model 3 (N= 14,396)
NHANES III	15,132	2.65 (0.20)	2.37 (1.96, 2.87)	1.79 (1.45, 2.21)	1.41 (1.11, 1.78)	1.36 (1.09, 1.69)
NHANES 2007–10	10,814	3.72 (0.24)	2.31 (1.97, 2.71)	1.71 (1.45, 2.01)	1.41 (1.15, 1.72)	1.34 (1.10, 1.62)

Abbreviations: GFR, glomerular filtration rate; ACR, albumin-to-creatinine ratio

Model 1: Adjusted for age, sex, race/ethnicity. Model 2: Model 1 + hypertension, body mass index, low high density lipoprotein cholesterol, elevated total cholesterol, diabetes, diuretic use, and alcohol use.
Model 3: Model 2 + serum uric acid.

^a N represents the unweighted number.
^b Unable to estimate variance due to small sample size.
^c Units of estimated glomerular filtration rate are per 10 mL/min per 1.73 m².

Table 3
Prevalence (SE) and Prevalence Ratios (95% CI) of Gout by Chronic Kidney Disease Stage.

NHANES III ^a	N ^b	Prevalence, % (SE)	Unadjusted (N= 15,132)	Model 1 (N= 15,132)	Model 2 (N= 14,396)	Model 3 (N= 14,396)
No CKD	12,674	1.92 (0.19)	Ref = 1	Ref = 1	Ref = 1	Ref = 1
Stage 1	799	4.11 (1.03)	2.14 (1.23, 3.72)	2.62 (1.50, 4.58)	1.82 (0.98, 3.38)	1.96 (1.08, 3.56)
Stage 2	628	6.80 (1.41)	3.54 (2.20, 5.69)	1.71 (1.02, 2.85)	1.37 (0.80, 2.33)	1.29 (0.78, 2.15)
Stage 3	964	11.32 (1.45)	5.89 (4.40, 7.89)	2.26 (1.56, 3.28)	1.77 (1.20, 2.59)	1.39 (0.98, 1.97)
Stage 4	52	34.49 (^c)	17.94 (9.25, 34.81)	6.29 (3.37, 11.74)	4.30 (2.34, 7.89)	2.46 (1.24, 4.90)
NHANES 2007–10 ^d	N ^b	Prevalence, % (SE)	Unadjusted (N= 10,814)	Model 1 (N= 10,814)	Model 2 (N= 9,711)	Model 3 (N= 9,708)
No CKD	8,885	2.69 (0.25)	Ref = 1	Ref = 1	Ref = 1	Ref = 1
Stage 1	536	4.02 (0.77)	1.50 (0.95, 2.37)	1.71 (1.15, 2.53)	1.08 (0.70, 1.68)	1.16 (0.75, 1.79)
Stage 2	447	10.28 (1.67)	3.83 (2.61, 5.62)	1.82 (1.21, 2.72)	1.40 (0.94, 2.10)	1.37 (0.94, 2.00)
Stage 3	847	12.93 (^c)	4.82 (3.72, 6.24)	1.90 (1.43, 2.52)	1.52 (1.14, 2.03)	1.14 (0.83, 1.56)
Stage 4	77	31.02 (^c)	11.55 (7.27, 18.36)	4.56 (2.90, 7.18)	3.20 (1.96, 5.24)	1.80 (1.05, 3.07)

Model 1: Adjusted for age, sex, race/ethnicity. Model 2: Model 1 + hypertension, body mass index, low high density lipoprotein cholesterol, elevated total cholesterol, diabetes, diuretic use, and alcohol use. Model 3: Model 2 + serum uric acid.

^aIn NHANES III, the unweighted number of gout cases in each CKD category were: 244, 23, 41, 102, and 9, respectively. There were 2 cases of gout with stage 5 CKD.

^bN represents the unweighted number.

^cUnable to estimate variance due to small sample size.

^dIn NHANES 2007–2010, the unweighted number of gout cases in each CKD category were: 264, 26, 51, 129, and 24, respectively. There were 5 cases of gout with stage 5 CKD.