The Rising Incidence of Gout and the Increasing Burden of Comorbidities: A Population-based Study over 20 Years

Mohanad M. Elfishawi, Nour Zleik, Zoran Kvrgic, Clement J. Michet Jr., Cynthia S. Crowson, Eric L. Matteson, and Tim Bongartz

ABSTRACT. ***Objective.*** To examine the incidence of gout over the last 20 years and to evaluate possible changes in associated comorbid conditions.

Methods. The medical records were reviewed of all adults with a diagnosis of incident gout in Olmsted County, Minnesota, USA, during 2 time periods (January 1, 1989–December 31, 1992, and January 1, 2009–December 31, 2010). Incident cases had to fulfill at least 1 of 3 criteria: the American Rheumatism Association 1977 preliminary criteria for gout, the Rome criteria, or the New York criteria.

Results. A total of 158 patients with new-onset gout were identified during 1989–1992 and 271 patients during 2009–2010, yielding age- and sex-adjusted incidence rates of 66.6/100,000 (95% CI 55.9–77.4) in 1989–1992 and 136.7/100,000 (95% CI 120.4–153.1) in 2009–2010. The incidence rate ratio was 2.62 (95% CI 1.80–3.83). At the time of their first gout flare, patients diagnosed with gout in 2009–2010 had higher prevalence of comorbid conditions compared with 1989–1992, including hypertension (69% vs 54%), diabetes mellitus (25% vs 6%), renal disease (28% vs 11%), hyperlipidemia (61% vs 21%), and morbid obesity (body mass index ≥ 35 kg/m^2; 29% vs 10%).

Conclusion. The incidence of gout has more than doubled over the recent 20 years. This increase together with the more frequent occurrence of comorbid conditions and cardiovascular risk factors represents a significant public health challenge. (First Release December 15 2017; J Rheumatol 2018;45:574–9; doi:10.3899/jrheum.170806)

Key Indexing Terms:
GOUT INCIDENCE EPIDEMIOLOGY COMORBIDITY

From Department of Rheumatology, Kasr Alainy Hospital, Cairo University, Cairo, Egypt; Division of Rheumatology, Mayo Clinic College of Medicine; Division of Biomedical Statistics and Informatics, Department of Health Sciences Research, Mayo Clinic College of Medicine; Division of Epidemiology, Department of Health Sciences Research, Mayo Clinic College of Medicine, Rochester, Minnesota; Department of Internal Medicine, Icahn School of Medicine at Mount Sinai, Queens Hospital Center, New York, New York; Division of Rheumatology, Augusta University, Atlanta, Georgia; Department of Emergency Medicine, Vanderbilt University, Nashville, Tennessee, USA.

This work was made possible using the resources of the Rochester Epidemiology Project, which is supported by the US National Institute on Aging of the National Institutes of Health (NIH) under award number R01AG034676 and Clinical and Translational Science Awards grant number UL1 TR000135 from the National Center for Advancing Translational Sciences, a component of the NIH.

M.M. Elfishawi, MD, Internal Medicine Resident, Icahn School of Medicine at Mount Sinai; N. Zleik, MD, Internal Medicine Resident, Division of Rheumatology, Augusta University; Z. Kvrgic, CCRP, Study coordinator, Mayo Clinic; C.J. Michet Jr., MD, Consultant, Mayo Clinic; C.S. Crowson, MS, Associate Professor, Mayo Clinic; E.L. Matteson, MD, MPH, Consultant, Mayo Clinic; T. Bongartz, MD, MS, Vanderbilt University.

Address correspondence to Dr. T. Bongartz, Department of Emergency Medicine, Vanderbilt University, 1313 21st Ave. S., 703 Oxford House, Nashville, Tennessee 37232-4700, USA. E-mail: Tim.Bongartz@Vanderbilt.edu. Or Dr. C. Crowson, Mayo Clinic, 200 First St. SW, Rochester, Minnesota 55905, USA. E-mail: crowson@mayo.edu

Accepted for publication October 18, 2017.

Gout is the most common inflammatory arthritis in the United States[1]. Several studies have demonstrated an increasing prevalence over recent decades[2,3,4,5]. The number of people living with disability due to gout has increased dramatically over the last 20 years[6].

Whether there has been an actual increase in the incidence of gout in recent years is unclear. Previous population-based studies using the Rochester Epidemiology Project (REP) have suggested that the incidence of gout nearly doubled between 1977–1978 and 1995–1996[4], but population-based data about gout incidence in the United States over the last 20 years are limited[7,8].

While the morbidity associated with gout itself is worrisome, patients with gout also have a higher likelihood of various comorbid conditions such as obesity, hyperlipidemia, renal disease, and hypertension (HTN)[9]. Possible changes in the prevalence of these comorbidities among individuals with gout would have a tremendous effect on the overall morbidity of patients with gouty arthritis.

The purpose of our present study was to examine trends in the incidence of gout in a US-based population, and to determine whether the prevalence of some comorbid condi-

tions having major effects on patient well-being and survivorship among affected patients has changed.

MATERIALS AND METHODS

Olmsted County, Minnesota, USA, is well suited for population-based studies through the resources of the REP[10]. The REP is a medical record linkage system that enumerates the population and provides ready access to the medical records from all healthcare providers in Olmsted County, Minnesota, USA, including the Mayo Clinic, the Olmsted Medical Center and its affiliated hospitals, local nursing homes, and the few private practitioners. The REP ensures the full identification of all the medical records, both inpatient and outpatient, for the population. The REP ensures virtually complete ascertainment of all clinically recognized cases of gout among the residents of Olmsted County, Minnesota. This study was approved by the institutional review boards of the Mayo Clinic (12-007239) and the Olmsted Medical Center (018-OMC-15).

Using the REP, adult (age ≥ 18 yrs) Olmsted County residents with the potential diagnosis of gout were retrieved using diagnostic codes (International Classification of Diseases, 9th ed: code 274.x) during 2 different time periods (January 1, 1989–December 31, 1992, and January 1, 2009–December 31, 2010). The medical records (inpatient and outpatient) of each potential case were then reviewed for ascertainment of gout diagnosis. Cases were identified as incident at the earliest date the case fulfilled at least 1 of 3 proposed gout criteria: the American Rheumatism Association (ARA) 1977 preliminary criteria for gout[11], the Rome criteria[12], or the New York criteria[13] (Table 1).

Demographic and clinical data were abstracted through medical record review. Smoking status (never, current, former) at the time of the incident gout diagnosis was collected. Body mass index (BMI) was calculated using the standing height and weight recorded in the medical record at the time of gout diagnosis. BMI was categorized based on the World Health Organization classification: normal (18.5–24.9 kg/m^2), overweight (pre-obese; 25–29.9 kg/m^2), class I obesity (30–34.9 kg/m^2), class II obesity (35–39.9 kg/m^2), class III obesity (≥ 40 kg/m^2)[14]. Cardiovascular (CV) and metabolic risk factors and comorbidities were abstracted from the records based on physician diagnoses and laboratory values (i.e., lipid profile) prior to or at the diagnosis of gout. Concomitant medication use for CV risk factors and comorbidities were recorded.

Statistical analysis. Descriptive statistics (means, percentages, etc.) were used to summarize data. Clinical characteristics were compared between the time periods using Wilcoxon rank sum tests and chi-square tests. P values < 0.05 were considered statistically significant. Age- and sex-specific incidence rates were calculated using the number of incident cases as the numerator and population estimates for adults (age ≥ 18 yrs) based on decennial census counts as the denominator, with linear interpolation used to estimate population size for intercensal years. Incidence rates were age- and sex-adjusted for the US 2010 white population. To compute 95% CI for incidence rates, it was assumed that the number of incident cases followed a Poisson distribution. Incidence rates were compared between the 2 time periods using Poisson regression methods. Analyses were performed using SAS version 9.4 (SAS Institute) and R 3.1.1 (R Foundation for Statistical Computing).

RESULTS

A total of 429 patients with incident gout were identified: 158 in 1989–1992 and 271 in the 2009–2010 time period. While the age and sex distribution of individuals diagnosed with gout remained similar when comparing both time periods (Table 2), the proportion of nonwhites increased from 6% to 10%. BMI in the 2009–2010 cohort was significantly higher than that of the 1989–1992 cohort (median 30.9 vs 28.3, respectively; p < 0.001). This increase in BMI was observed in both men and women. Moreover, the number of individuals with class II and III obesity tripled between the earlier and the later cohort (29% vs 10% with BMI ≥ 35 kg/m^2 in 2009–2010 vs 1989–1992, respectively; p < 0.001).

In addition, there were notably higher rates of CV risk factors and comorbidities in the 2009–2010 cohort, including hyperlipidemia, diabetes mellitus (DM), HTN, and renal

Table 1. Criteria used for gout diagnosis: 1977 ARA preliminary criteria, Rome criteria, and New York criteria.

The 1977 ARA Preliminary Criteria[11]	Rome Criteria[12]	New York Criteria[13]
Presence of characteristic urate crystals in the joint fluid*	Any 2 of the following:	Urate crystals in joint fluid or tissue or tophus *
Presence of a tophus proven to contain urate crystals by chemical means or polarized light microscopy*	1. Presence of urate crystals in synovial fluid or tissues	Any 2 of the following:
Presence of 6 of the following clinical, laboratory, and radiographic phenomena:	2. Painful joint swelling, abrupt onset, clearing in 1–2 weeks initially	1. Response to colchicine — major reduction in inflammation within 48 h
1. Unilateral attack involving first metatarsophalangeal joint	3. Serum uric acid > 7 mg/dl in males or > 6 mg/dl in females	2. Abrupt onset and remission in 1–2 weeks initially
2. Development of maximal inflammation within 1 day	4. Presence of tophi	3. 2 attacks of painful limb joint swelling
3. Attack of monoarticular arthritis		4. First MTP attack
4. More than 1 attack of acute arthritis		5. Presence of a tophus
5. Pain or swelling in first MTP joint		
6. Observation of joint redness		
7. Unilateral attack involving tarsal joint		
8. Suspected tophus		
9. Hyperuricemia		
10. Asymmetric swelling within a joint on radiograph		
11. Subcortical cysts without erosions on radiograph		
12. Negative culture of joint fluid for microorganisms during attack of joint inflammation		

*This criterion is sufficient for diagnosis of gout. ARA: American Rheumatism Association; MTP: metatarsophalangeal.

Table 2. Patient characteristics, major associated comorbidities, and medication use among Olmsted County, Minnesota, USA residents with incident gout in 1989–1992 compared with 2009–2010. Values are n (%) unless otherwise specified.

Characteristics	1989–1992, n = 158	2009–2010, n = 271	p
Age at diagnosis, yrs, mean (SD)	59.3 (17.9)	60.0 (17.0)	0.68
Male sex	116 (73)	196 (72)	0.81
Race and ethnicity			
White	149 (94)	244 (90)	0.17
African American	1 (1)	2 (1)	
Somali	0 (0)	2 (1)	
Asian	5 (3)	12 (4)	
Native Hawaiian/Pacific Islander	1 (1)	0 (0)	
Other	0 (0)	9 (3)	
Unknown	2 (1)	2 (1)	
Smoking			
Never	64 (42)	131 (48)	0.068
Current	17 (11)	26 (10)	
Former	72 (47)	106 (39)	
Unknown	0 (0)	8 (3)	
Major associated comorbidities			
BMI, kg/m^2, median (IQR)	28.3 (24.9–32.0)	30.9 (27.4–35.8)	< 0.001
Obesity (BMI ≥ 30 kg/m^2)	56 (37)	150 (56)	< 0.001
Hypertension	86 (54)	188 (69)	0.002
Heart failure	10 (6)	27 (10)	0.20
Diabetes mellitus	9 (6)	68 (25)	< 0.001
Renal disease	18 (11)	77 (28)	< 0.001
Coronary artery disease	36 (23)	53 (20)	0.43
Stroke	7 (4)	20 (7)	0.24
Hyperlipidemia	33 (21)	164 (61)	< 0.001
Total cholesterol*, mg/dl, median (IQR)	214 (188–244)	179 (152–207)	< 0.001
Low-density lipoprotein cholesterol*, mg/dl, median (IQR)	136 (66–267)	96 (74–126)	< 0.001
High-density lipoprotein cholesterol*, mg/dl, median (IQR)	39 (33–48)	43 (35–52)	0.014
Triglycerides*, mg/dl, median (IQR)	174 (107–246)	142 (103–212)	0.075
Serum uric acid level**, mg/dl, mean (SD)	8.0 (1.8)	8.2 (2.0)	0.65
Number tested	107	179	
Medication use			
Diuretic use	68 (43)	130 (48)	0.32
Aspirin	36 (23)	107 (39)	< 0.001
Statin	7 (4)	111 (41)	< 0.001

*Available lipid values for 1989–1992 and 2009–2010, respectively: total cholesterol n = 126 and n = 215; low-density and high-density lipoprotein cholesterol n = 79 and n = 215; triglycerides n = 116 and n = 216. **At incidence date to 2 weeks postincidence date; n = 107 for 1989–1992 and n = 179 for 2009–2010. BMI: body mass index; IQR: interquartile range.

disease (Table 2). The use of aspirin increased from 23% to 39% between the 1989–1992 and 2009–2010 cohorts ($p < 0.01$), and the use of statins increased from 4% to 41% between these 2 periods. Of note, the serum levels of total and low-density lipoprotein cholesterol were significantly lower in the 2009–2010 cohort than the 1989–1992 cohort, while high-density lipoprotein levels were higher in the more recent cohort.

Using the combined criteria set, the age- and sex-adjusted incidence rate of gout among adults (age ≥ 18 yrs) in the 1989–1992 time period was 66.6/100,000 (95% CI 55.9–77.4) compared with 136.7/100,000 (95% CI 120.4–153.1) in the 2009–2010 time period. This constitutes a more than 2-fold increase of incident gout within 20 years (rate ratio 2.62, 95% CI 1.80–3.83; $p < 0.001$). This increase affected both sexes to a similar extent (Figure 1) and involved all age groups (Table 3).

The significant increase in the incidence of gout was also apparent when applying each of the criteria separately. Using the 1977 ARA preliminary criteria identified 118 incident cases in 1989–1992 and 183 incident cases in 2009–2010; the age- and sex-adjusted incidence rate rose from 49.5 (95% CI 40.2–58.7) in the 1989–1992 cohort to 92.7 (95% CI 79.2–106.2) in the 2009–2010 cohort (rate ratio 2.64, 95%

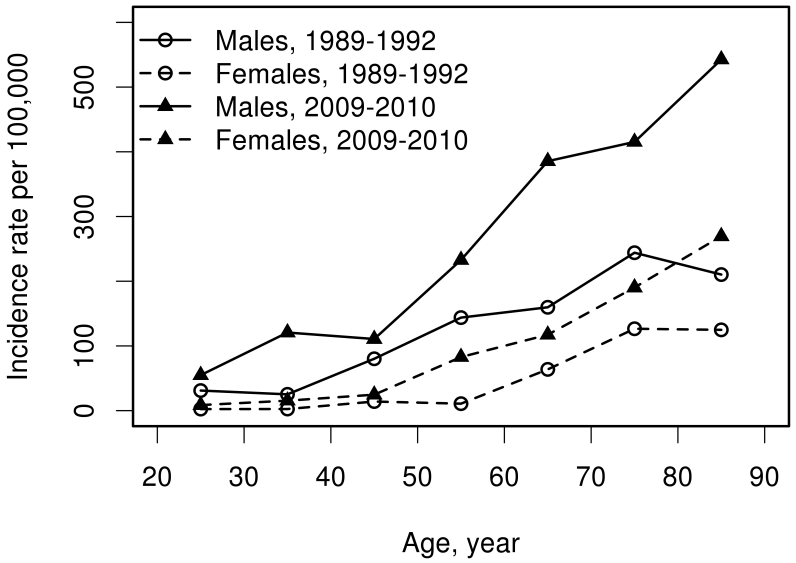

Figure 1. Incidence of gout among adult (age ≥ 18 yrs) Olmsted County, Minnesota, USA residents in 1989–1992 and 2009–2010, based on the earliest date of fulfillment of the 1977 American Rheumatism Association, Rome, or New York criteria, according to age and sex.

Table 3. Incidence of gout among adult (age ≥ 18 years) Olmsted County, Minnesota residents in 1989–1992 and 2009–2010 based on the earliest date of 1977 American Rheumatism Association, Rome, or New York criteria, according to age and sex.

Time Period	Age Group, Yrs	Female		Male		Total	
		n	Rate*	n	Rate*	n	Rate*
1989–1992	18–29	1	2.4	12	31.0	13	16.2
	30–39	1	2.5	10	25.2	11	13.8
	40–49	4	14.1	22	80.1	26	46.5
	50–59	2	10.8	27	143.8	29	77.6
	60–69	9	63.7	20	159.7	29	108.9
	70–79	14	126.5	18	244.0	32	173.5
	80+	11	124.8	7	210.3	18	148.3
Overall** (95% CI)		42	31.3 (21.7–41.0)	116	104.9 (84.7–125.1)	158	66.6 (55.9–77.4)
2009–2010	18–29	2	8.6	11	54.9	13	31.0
	30–39	3	15.4	24	120.7	27	68.6
	40–49	5	24.7	22	110.7	27	67.3
	50–59	17	82.8	45	232.8	62	155.5
	60–69	15	117.3	44	385.5	59	243.8
	70–79	15	190.3	28	415.2	43	294.0
	80+	18	269.5	21	542.6	39	369.7
Overall** (95% CI)		75	70.6 (54.5–86.6)	196	210.2 (180.3–240.2)	271	136.7 (120.4–153.1)

*Rates are reported per 100,000 population. **Overall sex-specific rates are age-adjusted and total rates are age- and sex-adjusted to the US white 2010 population.

CI 1.69–4.13). When the New York criteria were used, 91 incident cases in 1989–1992 and 217 incident cases in 2009–2010 were identified and the age- and sex-adjusted incidence rate increased from 39.0 (95% CI 30.7–47.2) in the 1989–1992 cohort to 110.0 (95% CI 95.2–124.7) in the 2009–2010 cohort (rate ratio 3.41, 95% CI 2.13–5.44). Finally, applying the Rome criteria (119 incident cases in 1989–1992 and 240 incident cases in 2009–2010) resulted in an age- and sex-adjusted incidence rate of 50.4 (95% CI 41.0–59.7) in the 1989–1992 cohort and 121.3 (95% CI 105.9–136.8) in the 2009–2010 cohort (rate ratio 2.94; 95% CI 1.95–4.43).

The serum uric acid level at the time of the first attack was not significantly different between the cohorts (median 8.0 in the 1989–1992 vs 8.2 in the 2009–2010 cohort; p = 0.65; Table 2). Similarly, the use of diuretics at the time of incident gout did not differ significantly (43% in the 1989–1992 vs 48% in the 2009–2010 cohort; p = 0.32).

DISCUSSION

Our population-based study demonstrates a marked increase in the incidence of gout among residents of Olmsted County, Minnesota, over the last 20 years. The rate of newly diagnosed cases of gout more than doubled within the observed time period for both men and women and across all age groups. Importantly, these results supplement numerous studies that have demonstrated an increase in the prevalence of gout, not only in the United States but in various geographic settings[1–5,15–20].

Why are the incidence and prevalence rates of gout increasing at such a remarkable rate? Our study was not designed to investigate the underlying cause for this increase, but other authors have suggested changes in risk factors of gout as the main contributing factor[9,16]. Risk factors of gout that have been increasing in the US population over recent years include obesity, age, DM, chronic renal disease, and aspirin use[21,22,23,24,25,26,27,28]. Moreover, as the population advances in age, serum uric acid level was found to increase as well[29]. Interestingly, despite the significant increases in diagnosis of HTN, there were no differences in the use of thiazide diuretics noted between time periods. Thus, increased thiazide diuretic use is unlikely to be responsible for the increasing incidence of gout in this population, despite previous reports linking them to gout occurrence[30].

There has been a marked increase in the prevalence of CV comorbidities among patients with gout. In our study, diseases including obesity, HTN, DM, chronic renal disease, and hyperlipidemia have become significantly more common in patients diagnosed with gout in the more recent years of 2009–2010 compared with those diagnosed with gout 20 years ago. The change in the prevalence of obesity in patients with gout is particularly noteworthy. Severe, class II, and class III obesity have tripled in this cohort over the past 20 years.

The high prevalence of comorbidities among patients with gout has been demonstrated in several previously published cohorts[21,22,28,31]. For example, in the 2007–2008 US National Health and Nutrition Examination Survey cohort, Zhu, *et al* found a prevalence of 74% HTN, 71% chronic renal disease, 53% obesity, 26% DM, and 11% heart failure among patients with gout[22]. Except for chronic renal disease, which was less common in our study, these numbers are comparable to the findings in the 2009–2010 cohort reported in our current study.

Our study has a number of strengths. The population-based approach and availability of the complete medical records for all patients offer the advantage of a comprehensive assessment of all patients diagnosed with gout in a defined geographic area, thereby minimizing the risk of referral bias. The use of a systematic approach to case identification using multiple criteria sets in both time periods is another strength of the study.

Inherent limitations of the study relate to its retrospective design. The assessment and documentation of criteria used to diagnose gout may have changed over time. For example, arthrocentesis with crystal analysis was more commonly performed in more recent years. This may reflect a change in practice patterns. Use of all 3 proposed criteria sets for gout mitigates against imprecision of case ascertainment[11,12,13], lowering the dependence on single criteria that may have been assessed or documented differently over time. In addition, a subanalysis was performed using each criteria set independently, with each showing a significant increase in the incidence of gout over time. Since the completion of our study, new gout classification criteria have been published[32]. These criteria incorporate new imaging modalities including musculoskeletal ultrasound and dual-beam computed tomography. Because these imaging methods were not used during the 1989–1992 time period, but were widely available during the 2009–2010 period, the 2015 American College of Rheumatology/European League Against Rheumatism classification criteria were not applied to our current study, to reduce imbalance in diagnostic assessment resulting in ascertainment bias.

The classification of comorbidities was based on physician diagnosis as reflected in the medical record, therefore the possibility of changing documentation patterns over time could affect ascertainment. However, this would not apply to diagnoses of obesity, because classification was based on BMI, and weight and height have been documented for every patient in both cohorts. Finally, the population of Olmsted County is mainly white and the socioeconomic characteristics largely resemble those of the US white population in general[33]. Caution has to be exercised when generalizing these findings to populations with a different demographic composition, especially in other populations with higher prevalence of African Americans; higher incidence rates have been previously reported in the latter population compared to white populations[34,35,36].

Our data demonstrate a significant increase in the incidence of gout over the last 20 years. Gout is the most common inflammatory arthritis in the United States and affects more than 3% of the population[1]. This rise in incidence is combined with an alarming increase in comorbidities such as HTN, hyperlipidemia, DM, renal disease, and a tripling of grades II and III obesity among patients with gout. The importance of these comorbidities cannot be overemphasized; previous studies have demonstrated their significant contribution to the excess mortality and morbidity in patients with gout[37].

These findings emphasize the importance of acknowledging gout as a "sentinel" disease that rarely occurs in isolation, but points to a likely aggregation of various CV risk factors and comorbidities. Thus, in most patients, management of the initial gout flare will represent only a minor component of treatment. A comprehensive, multispecialty approach is needed to reduce the morbidity and mortality of gout and its associated health conditions in these patients.

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;63:3136-41.
2. Portis AJ, Laliberte M, Tatman P, Moua M, Culhane-Pera K, Maalouf NM, et al. High prevalence of gouty arthritis among the Hmong population in Minnesota. Arthritis Care Res 2010; 62:1386-91.
3. Lawrence RC, Felson DT, Helmick CG, Arnold LM, Choi H, Deyo RA, et al; National Arthritis Data Workgroup. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. Arthritis Rheum 2008;58:26-35.
4. Arromdee E, Michet CJ, Crowson CS, O'Fallon WM, Gabriel SE. Epidemiology of gout: is the incidence rising? J Rheumatol 2002;29:2403-6.
5. Wallace KL, Riedel AA, Joseph-Ridge N, Wortmann R. Increasing prevalence of gout and hyperuricemia over 10 years among older adults in a managed care population. J Rheumatol 2004;31:1582-7.
6. Smith E, Hoy D, Cross M, Merriman TR, Vos T, Buchbinder R, et al. The global burden of gout: estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis 2014;73:1470-6.
7. Maynard JW, McAdams DeMarco MA, Baer AN, Köttgen A, Folsom AR, Coresh J, et al. Incident gout in women and association with obesity in the Atherosclerosis Risk in Communities (ARIC) Study. Am J Med 2012;125:717.e9-717.e17.
8. Bhole V, de Vera M, Rahman MM, Krishnan E, Choi H. Epidemiology of gout in women: fifty-two-year followup of a prospective cohort. Arthritis Rheum 2010;62:1069-76.
9. Singh JA, Reddy SG, Kundukulam J. Risk factors for gout and prevention: a systematic review of the literature. Curr Opin Rheumatol 2011;23:192-202.
10. St Sauver JL, Grossardt BR, Yawn BP, Melton LJ 3rd, Rocca WA. Use of a medical records linkage system to enumerate a dynamic population over time: the Rochester epidemiology project. Am J Epidemiol 2011;173:1059-68.
11. 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;20:895-900.
12. Kellgren JH, Jeffrey MR, Ball J. The epidemiology of chronic rheumatism. I. Oxford: Blackwell Scientific Publications; 1963: 295-7.
13. Decker JL. Report from the subcommittee on diagnostic criteria for gout. In: Population studies of the rheumatic diseases. New York: Proceedings of the Third International Symposium; 1966:457-8.
14. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2000;894:9.
15. Roddy E, Doherty M. Epidemiology of gout. Arthritis Res Ther 2010;12:223.
16. Kuo CF, Grainge MJ, Zhang W, Doherty M. Global epidemiology of gout: prevalence, incidence and risk factors. Nat Rev Rheumatol 2015;11:649-62.
17. Li R, Sun J, Ren LM, Wang HY, Liu WH, Zhang XW, et al. Epidemiology of eight common rheumatic diseases in China: a large-scale cross-sectional survey in Beijing. Rheumatology 2012;51:721-9.
18. Kuo CF, Grainge MJ, See LC, Yu KH, Luo SF, Zhang W, et al. Epidemiology and management of gout in Taiwan: a nationwide population study. Arthritis Res Ther 2015;17:13.
19. Klemp P, Stansfield SA, Castle B, Robertson MC. Gout is on the increase in New Zealand. Ann Rheum Dis 1997;56:22-6.
20. Annemans L, Spaepen E, Gaskin M, Bonnemaire M, Malier V, Gilbert T, et al. Gout in the UK and Germany: prevalence, comorbidities and management in general practice 2000-2005. Ann Rheum Dis 2008;67:960-6.
21. Juraschek SP, Miller ER 3rd, Gelber AC. Body mass index, obesity, and prevalent gout in the United States in 1988-1994 and 2007-2010. Arthritis Care Res 2013;65:127-32.
22. Zhu Y, Pandya BJ, Choi HK. Comorbidities of gout and hyperuricemia in the US general population: NHANES 2007-2008. Am J Med 2012;125:679-87.e1.
23. 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;165:742-8.
24. 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;57:109-15.
25. Caspi D, Lubart E, Graff E, Habot B, Yaron M, Segal R. The effect of mini-dose aspirin on renal function and uric acid handling in elderly patients. Arthritis Rheum 2000;43:103-8.
26. Ajani UA, Ford ES, Greenland KJ, Giles WH, Mokdad AH. Aspirin use among U.S. adults: Behavioral Risk Factor Surveillance System. Am J Prev Med 2006;30:74-7.
27. Gu Q, Burt VL, Dillon CF, Yoon S. Trends in antihypertensive medication use and blood pressure control among United States adults with hypertension. Circulation 2012;126:2105-14.
28. Kuo CF, Grainge MJ, Mallen C, Zhang W, Doherty M. Comorbidities in patients with gout prior to and following diagnosis: case-control study. Ann Rheum Dis 2016;75:210-7.
29. Kuzuya M, Ando F, Iguchi A, Shimokata H. Effect of aging on serum uric acid levels: longitudinal changes in a large Japanese population group. J Gerontol A Biol Sci Med Sci 2002;57:M660-4.
30. McAdams DeMarco MA, Maynard JW, Baer AN, Gelber AC, Young JH, Alonso A, et al. Diuretic use, increased serum urate levels, and risk of incident gout in a population-based study of adults with hypertension: The Atherosclerosis Risk in Communities cohort study. Arthritis Rheum 2012;64:121-9.
31. Richette P, Clerson P, Périssin L, Flipo RM, Bardin T. Revisiting comorbidities in gout: a cluster analysis. Ann Rheum Dis 2015;74:142-7.
32. Neogi T, Jansen TL, Dalbeth N, Fransen J, Schumacher HR, Berendsen D, et al. 2015 gout classification criteria: an American College of Rheumatology/European League Against Rheumatism collaborative initiative. Ann Rheum Dis 2015;74:1789-98.
33. St Sauver JL, Grossardt BR, Leibson CL, Yawn BP, Melton LJ 3rd, Rocca WA. Generalizability of epidemiological findings and public health decisions: an illustration from the Rochester Epidemiology Project. Mayo Clin Proc 2012;87:151-60.
34. Singh JA. Racial and gender disparities among patients with gout. Curr Rheumatol Rep 2013;15:307.
35. Maynard JW, McAdams-DeMarco MA, Law A, Kao L, Gelber AC, Coresh J, et al. Racial differences in gout incidence in a population-based cohort: Atherosclerosis Risk in Communities study. Am J Epidemiol 2014;179:576-83.
36. Hochberg MC, Thomas J, Thomas DJ, Mead L, Levine DM, Klag MJ. Racial differences in the incidence of gout. The role of hypertension. Arthritis Rheum 1995;38:628-32.
37. Krishnan E, Svendsen K, Neaton JD, Grandits G, Kuller LH; MRFIT Research Group. Long-term cardiovascular mortality among middle-aged men with gout. Arch Intern Med 2008;168:1104-10.