Hyperuricemia and Gout in Taiwan: Results from the Nutritional and Health Survey in Taiwan (1993-96)

HSING-YI CHANG, WEN-HARN PAN, WEN-TING YEH, and KEH-SUNG TSAI

ABSTRACT. ***Objective.*** To evaluate the prevalence of hyperuricemia in Taiwan.

Methods. A multi-stage stratified sampling scheme was used in Nutrition and Health Survey, which was conducted in Taiwan between 1993 and 96. Complete biochemical and questionnaire data for 2754 males and 2953 females aged 4 years and older were included in the analysis. The colorimetric enzymatic method was used to measure plasma uric acid in fasting blood samples. Information on self-reported, physician-diagnosed gout was also obtained.

Results. The uric acid values of males were found to reach a peak between the ages of 13 and 18 and decrease slightly after 18. The uric acid values of females were stable before the age of 18, decreasing slightly between 19 and 44 years, and increasing in the mid to older age groups (≥ 45 years). Twenty-six percent of adult males (≥ 19 years) and 22% of older males (≥ 45 years) either had hyperuricemia (serum uric acid > 458.0 μM or 7.7 mg/dl) or were taking medication for it. Seventeen percent of adult females and 23% of older females either had hyperuricemia (serum uric acid > 392.57 μM or 6.6 mg/dl) or were taking medication for it. Both adult males and females in mountainous areas, who were primarily aboriginal, had the highest prevalence of hyperuricemia (> 50%) among the 7 survey areas. Mean body mass index (BMI), alcohol consumption, and prevalence of gout were among the highest in mountainous people compared to all included in the study. Multivariate analysis showed that mountainous area, age and BMI are important factors associated with hyperuricemia in males, whereas mountainous area, Class II townships, and BMI are the factors associated with hyperuricemia in females.

Conclusions. We found a high prevalence of hyperuricemia in Han Chinese in Taiwan despite a lack both of obesity and high alcohol consumption. Mountainous people (mainly aborigines) in Taiwan have an even higher prevalence of hyperuricemia, which cannot be completely explained by obesity and alcohol consumption. Genetic components and other environmental factors may have contributed to this pattern of hyperuricemia. (J Rheumatol 2001;28:1640–6)

Key Indexing Terms:
URIC ACID HYPERURICEMIA GOUT TAIWAN
ABORIGINES NATIONAL SURVEY

Recent epidemiological data reveal that both gout and hyperuricemia have been increasing in the United States, Europe, and New Zealand, being very prevalent in people of middle to old age[1-5]. Gout was uncommon between 1950 and 1970 in Taiwan[6-8], but its prevalence has increased in recent years[9-11]. These phenomena imply that hyperuricemia and gout may be closely related to changes in environmental factors. The data collected in the past were limited to single locations and did not represent the overall prevalence of hyperuricemia in Taiwan. We present an overall status of hyperuricemia in Taiwan using comprehensive national survey data.

MATERIALS AND METHODS

Study participants. The data for this paper came from the Nutrition and Health Survey in Taiwan that was done between 1993 and 96 (NAHSIT, 1993-1996). Taiwan is an island off the southeast coast of China with an area of 35,563 km^2 (13,869 square miles). NAHSIT was an island-wide survey focused on the nutrition and health status of people in Taiwan. The survey divided 359 townships in Taiwan into 7 groups according to the unique dietary patterns of the residents, urbanization index, and the geographical characteristics of the selected areas (Figure 1). These 7 groups were Hakka people areas, mountainous areas, the east coast area, the Peng-Hu islands, metropolitan cities, provincial cities, urbanization Class I townships, and urbanization Class II townships.

People in Taiwan are predominantly descendants of the so-called Han people, an inclusive name for various ethnic groups that have lived in the central plains of China since 2000 BC. The Hakkas are counted as Han but are different from other people by their dialogue, their dietary pattern (consumption of more preserved vegetables and high lard usage in cooking), and their strong tendency to intermarry. The Hakka areas are located primarily in the northwest of Taiwan. Hakka residents migrated to

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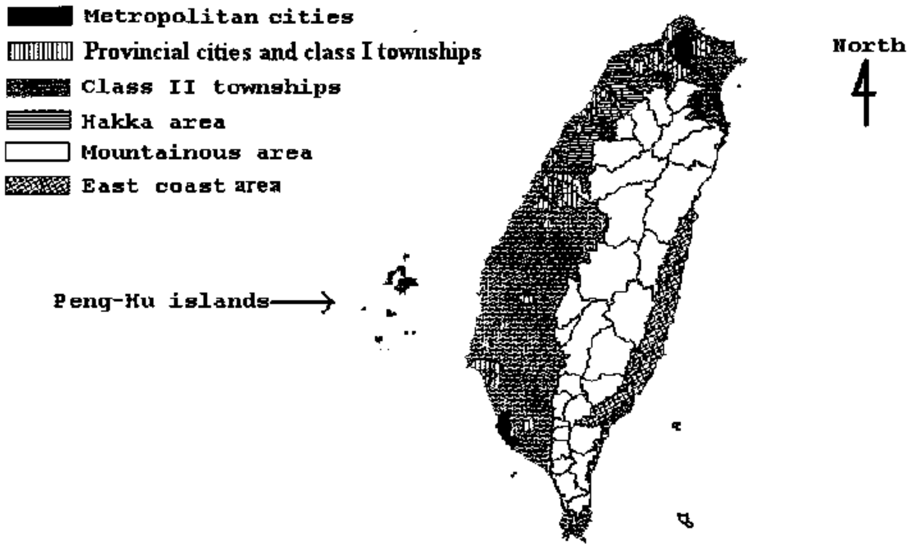

Figure 1. Map of Taiwan and locations of 7 strata of the Nutritional and Health Survey in Taiwan (1993-96).

Taiwan several hundred years ago from a few counties in the western part of China's southern Guangdong province. The other distinct group of people in Taiwan is the aborigines who are genetically related to the Malayo-Polynesians. Most of them live in the mountainous areas that occupy three-fifths of Taiwan and their population density is low. There are 9 major tribes of aboriginal people in Taiwan, and the mountainous group was chosen to gain more knowledge of their dietary patterns and health status. The east coast area is isolated from the affluent western part of the island that is influenced by the large number of aborigines living there. The Peng-Hu islands are the major offshore islands under Taiwan's jurisdiction. The rest of the groups were classified by their degree of urbanization.

Data collection. After the strata were defined, 3 townships (or districts) were selected from each with selection probability proportional to population size (PPS). Three villages (or Li's, the smallest administrative level) were selected from the 21 townships (or districts). A pseudo-Latin square design was used to balance the effects of season and year. One of every 3 villages was surveyed in a different season during the 3 survey years, the seasons being determined as February to May, June to September, October to January. A designated number of individuals (8 or 16 depending on the available age groups) were recruited door to door from 2 randomly selected geographical clusters within each village for each of the 14 age-sex groups (age groups: 4–6, 7–12,13–15, 16–18, 19–44, 45–64, and > 65, both men and women). The survey team consisted of 5 interviewers who stayed in a village for 3 weeks to interview the selected individuals. A physical examination team consisting of 8 well trained medical examiners and 2 public health nurses performed the physical examinations on the third and fourth weekend. Details about the design and the operational techniques of the survey have been described elsewhere[12]. Altogether, 9961 individuals were interviewed, which represented a response rate of 74%. Among the interviewed, 6464 (64.9%) completed the physical examination and 5843 (58.7%) of them had adequate fasting blood samples.

Our study incorporated questionnaires (sex, age, location and alcohol consumption), medical history, physical examinations and results of blood samples. Individuals were instructed to fast for at least 8 hours before the blood was drawn. The blood samples were centrifuged immediately. Serum samples were then frozen on dry ice, and delivered to the Academia Sinica and frozen at –70°C on the same day. The frozen serum samples were analyzed in the clinical laboratory of the National Taiwan University Medical College within one month. Plasma uric acid was analyzed by the colorimetric enzymatic method (Hitachi 747, Japan). The coefficient of variation was 1.9% for uric acid measurement, deriving from 5% duplicated blood samples.

The following 2 definitions of hyperuricemia were used: (1) serum uric acid ≥ 458.0 μM (7.7 mg/dl) for males and ≥ 392.6 μM (6.6 mg/dl) for females[15], and (2) serum uric acid ≥ 416.4 μM (7.0 mg/dl) for males and ≥ 356.9 μM (6.0 mg/dl) for females. Other definitions were used wherever appropriate for comparison purposes. The prevalence of gout was calculated by counting those who report having had gout diagnosed by a physician and who were not cured at the time of interview.

Three categories of alcohol consumption were used: heavy drinkers, moderate drinkers and non-drinkers. Those who were beyond the 90th percentile (1126.8 g/ month for males and 13.2 g/month for females) of alcohol consumption were considered heavy drinkers. Those between 0 and 90th percentile were considered moderate drinkers.

Statistical analysis. All data were weighted to represent the population in Taiwan[12]. The population size of each age/sex group in each stratum was obtained from the national household registry system. The sampling weights were calculated by dividing the population by its corresponding sample in each stratum. Each sampled individual was weighted by sampling weights to represent the people of his or her own age/sex group in the stratum. Not all of those who filled out questionnaires had a physical examination, so 2 sets of weights were derived, one for questionnaire responses and one for physical examinations. Only the weights for the physical examinations were used. All analyses were carried out using the statistical software SAS[13] version 6.12. SUDAAN[14] version 7.5 was used to account for the sampling scheme.

RESULTS

Table 1 compares demographic variables of those who provided blood samples with those who did not. The distribution of education and occupation categories in both groups was very similar. However, due to the large sample size, there were statistically significant differences shown by chi-square tests. There was no statistical significant difference between responders and non-responders with regards to prevalence of gout. Nor did these 2 groups of people differ in their percent calorie consumption from protein, fat, and carbohydrate.

The average uric acid level (Table 2) was calculated from all blood samples excluding 47 samples of individuals taking drugs to lower serum uric acid (0.9% of males and

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Table 1. Comparison of the demographics of those who provided blood samples and those who did not.

Variable	Blood Drawn N	(%)	No Blood Drawn N	(%)	Chi-square (p)
Total N	5843	(58.7)	4118	(41.3)	
Education					18.8 (0.002)
None	858	(11.2)	784	(12.8)	
Elementary school	2558	(33.8)	1518	(30.3)	
Junior high school	1154	(19.4)	806	(20.9)	
Senior high school	956	(24.3)	743	(24.2)	
College	296	(10.7)	248	(11.0)	
> College	10	(0.7)	11	(0.5)	
Occupation					72.9 (0.001)
Farming, fishing, hunting, mining, etc.	732	(9.3)	510	(10.0)	
Industrial	671	(16.8)	299	(18.9)	
Business	343	(12.5)	269	(11.7)	
Government employers	209	(5.1)	116	(3.2)	
Other service types of work	159	(4.1)	130	(4.6)	
Students	2731	(28.8)	1826	(28.5)	
Housewives	440	(12.2)	255	(8.9)	
Retired	93	(1.4)	55	(1.5)	
Unemployed	608	(9.9)	498	(12.8)	
Gout					2.4 (0.142)
Yes	115	(1.6)	63	(0.9)	
Nutrient intakes (%)	Mean	(se)	Mean	(se)	t (p)
Calories from protein	16.1	(0.04)	15.9	(0.4)	0.38 (0.71)
Calories from fat	29.5	(0.7)	30.0	(0.3)	–0.64 (0.53)
Calories from carbohydrates	53.9	(0.8)	53.3	(0.6)	0.50 (0.62)

Percentages were adjusted by sampling weights. Chi-square tests and Student's t tests were used for determination of statistical significance. se: standard error.

Table 2. Serum uric acid and prevalence of hyperuricemia in Taiwan by sex and age groups. All values are weighted to reflect their representation in the population.

Sex	Age (years)	Uric Acid N	Uric Acid Mean (μM)	Uric Acid SE (μM)	Hyperuricemia Prevalence* N	%	(95% CI)	Hyperuricemia Prevalence** N	%	(95% CI)	Gout*** Prevalence N	%	(95% CI)
Male	4–6	244	315.7	6.5	17	3.0	(0.8, 5.1)	36	10.6	(7.1, 14.1)	0	0.0	—
	7–12	657	353.1	7.6	90	11.9	(8.4, 15.4)	157	23.0	(18.2, 27.8)	0	0.0	—
	13–18	505	436.4	4.1	192	37.3	(33.4, 41.2)	287	59.8	(53.5, 65.1)	1	0.02	—
	19–44	473	408.1	7.8	149	28.5	(23.2, 33.8)	243	44.1	(34.5, 53.7)	23	2.0	(0.5, 3.6)
	45–64	578	395.4	5.7	180	23.3	(17.4, 29.2)	264	39.4	(32.0, 46.8)	42	4.3	(1.1, 7.5)
	≥ 65	297	392.8	10.4	84	19.2	(11.8, 26.6)	127	36.8	(25.4, 48.2)	19	7.8	(2.4, 13.3)
	≥ 19	1348	403.2	3.9	413	26.1	(22.0, 30.2)	634	42.1	(36.6, 47.5)	84	3.3	(2.3, 4.3)
	≥ 45	875	394.6	4.8	264	21.9	(17.5, 26.3)	391	38.6	(33.8, 43.4)	61	5.5	(2.6, 8.3)
Female	4–6	247	325.1	4.5	47	16.1	(10.4, 21.8)	81	31.0	(19.6, 42.4)	0	0.0	—
	7–12	639	328.5	4.0	131	16.3	(11.0, 21.6)	226	31.4	(28.3, 34.5)	0	0.0	—
	13–18	566	324.2	5.3	117	16.8	(12.0, 21.6)	197	30.3	(27.0, 33.6)	0	0.0	—
	19–44	591	307.0	7.4	104	13.6	(8.7, 18.3)	162	23.5	(16.6, 30.4)	3	0.6	(0.0, 1.5)
	45–64	624	324.0	7.7	162	20.0	(14.4, 25.6)	225	30.6	(24.3, 36.5)	14	1.5	(0.4, 2.6)
	≥ 65	287	359.3	6.3	94	31.5	(27.4, 35.6)	127	44.1	(36.1, 52.1)	12	2.7	(0.0, 6.5)
	≥ 19	1498	316.5	6.5	360	17.0	(12.8, 21.2)	514	27.4	(21.7, 33.1)	29	1.1	(0.3, 1.8)
	≥ 45	908	334.4	5.3	256	23.5	(20.1, 26.9)	352	34.7	(30.1, 39.8)	26	1.9	(0.2, 3.5)

Those who took drugs to lower uric acid were not included in the calculations.
*Defined as uric acid ≥ 458.0 μM (7.7 mg/dl) for males and ≥ 392.6 μM (6.6 mg/dl) for females.
**Defined as uric acid ≥ 416.4 μM (7.0 mg/dl) for males and ≥ 356.9 μM (6.0 mg/dl) for females.
***Self-reported presence of gout at the time of interview, which was diagnosed by physicians. SE: standard error.

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0.7% of females), and 92 hemolyzed blood samples (1.5% of males and 1.7% of females). The mean value increased from preschool boys to boys aged between 6 and 12, and further increased for teenagers. The peak uric acid value for males occurred in teenagers (13–18 years), then decreased gradually after the age of 18. Females younger than 19 or older than 44 had higher mean values than those aged between 19 and 44. The mean uric acid values of males were higher than those of females in all age groups, except in the ages between 4 and 6 years.

Table 2 also shows the prevalence of hyperuricemia by sex and age groups. The highest prevalence of occurred between the ages of 13 and 18 for males using both definitions. The prevalence decreased as age increased. The lowest prevalence occurred between the ages of 19 and 44 for females. Females aged below 19 or older than 44 had relatively high prevalence rates. The highest prevalence in females occurred in the elderly women (≥ 65 years).

The prevalence of gout by sex and age groups is also presented in Table 2. Most of those who reported having gout were older than 19 years, except one boy aged between 13 and 18 years. The prevalence of gout increased with age in both males and females. More male adults (≥ 19 years) than females had gout. Similar patterns were found in other age groups, but the differences did not reach statistical significance.

Table 3 shows the average uric acid value and the prevalence of hyperuricemia in adults (≥ 19 years) by sex and geographical location. Information on mean body mass index (BMI), alcohol consumption, and prevalence of gout are also presented. People in the mountainous area had higher uric acid values than those in other areas. Mean uric acid of males in Class II townships and females in Hakka area were lower than that of people in other areas. The highest prevalence of hyperuricemia was found in the mountainous areas, where they also had the highest mean BMI and relatively high amounts of alcohol consumption. The lowest prevalence appeared in Class II townships for males and in metropolitan cities for females (Table 3). The high mean value of uric acid for males in mountainous areas was consistent with the high proportion being diagnosed with gout (Table 3). The mean BMI and alcohol consumption of the mountainous groups are also among the highest in all strata.

Table 4 presents the risks of hyperuricemia in relation to stratum effect before and after controlling for age, BMI, the degree of alcohol consumption and monthly variation for adults (≥ 19 years). The first definition of hyperuricemia was used in the model. The stratum for provincial Class II townships was used as reference for males, and Hakka area was the reference stratum for females. The results of univariate analysis indicate that males in mountainous areas had 5.82 times of higher risk than their provincial Class II counterparts in hyperuricemia. Women in mountainous area had 7.46 times of higher risk than Hakka women. Women in provincial Class II townships also had higher risk than Hakka women (OR = 2.08, $p < 0.05$). BMI were positively related to hyperuricemia in both men and women (OR =

Table 3. Uric acid and prevalence of hyperuricemia of adults (≥ 19 years) in Taiwan by sex and geographical locations.

Sex	Locations	Uric Acid (μM)			Gout*		Hyperuricemia				BMI (kg/m^2)		Alcohol (g/mo)	
		N	Mean	SE	N	Prevalence % (95% CI)	N	Prevalence** % (95% CI)	N	Prevalence*** % (95% CI)	Mean	SE	Mean	SE
Male	Hakka area	196	391.1	9.1	12	4.4 (1.5, 7.3)	51	25.0 (19..6, 30.4)	82	43.1 (38.4, 47.8)	23.0	0.1	355.3	77.8
	Mountainous area	206	497.4	13.1	33	15.3 (6.5, 24.1)	126	62.3 (56.1, 68.5)	159	82.0 (74.0, 90.1)	25.6	0.3	762.6	179.9
	East Coast area	204	409.1	13.6	7	2.1 (1.2, 3.0)	49	24.1 (13.2, 35.0)	73	36.9 (24.2, 49.6)	23.6	0.4	966.4	279.7
	Peng-Hu islands	174	411.1	6.5	8	3.8 (0.2, 7.4)	52	27.8 (21.6, 34.0)	85	51.1 (39.4, 62.6)	22.9	0.3	339.8	67.4
	Metropolitan cities	204	403.3	11.8	9	3.5 (1.8, 5.2)	52	27.2 (17.2, 37.2)	92	48.0 (39.6, 56.4)	23.0	0.3	227.8	31.5
	Provincial cities and Class I townships	177	410.9	6.3	9	3.2 (1.5, 4.9)	47	28.4 (19.4, 37.4)	77	43.3 (33.0, 55.6)	23.0	0.6	238.2	69.5
	Class II townships	187	391.8	5.6	6	2.9 (0.9, 4.7)	36	22.0 (20.3, 23.7)	66	36.3 (31.8, 40.8)	22.6	0.4	321.9	69.4
Female	Hakka area	217	303.0	6.5	4	1.4 (0.3, 2.5)	33	13.0 (9.1, 16.9)	48	20.2 (14.7, 25.7)	22.5	0.3	4.9	2.9
	Mountainous area	233	405.7	11.5	9	2.2 (1.4, 3.0)	128	52.6 (47.2, 58.0)	158	64.3 (58.8, 69.8)	26.3	0.5	573.1	234.5
	East Coast area	217	315.0	13.1	4	1.1 (0.2, 2.0)	43	17.3 (7.7, 26.9)	72	29.9 (16.0, 43.8)	23.6	0.4	129.1	87.6
	Peng-Hu islands	210	308.8	10.9	3	1.0 (0.2, 1.8)	39	16.9 (10.5, 23.3)	53	25.1 (17.8, 32.4)	23.4	0.4	13.0	7.6
	Metropolitan cities	201	308.4	6.6	2	0.5 (0.0, 1.0)	31	11.8 (6.1, 17.5)	52	20.7 (9.6, 32.1)	22.3	0.4	78.1	68.4
	Provincial cities and Class I townships	197	308.5	7.1	3	1.1 (0.0, 2.6)	32	13.7 (6.8, 20.6)	58	27.0 (16.2, 37.8)	23.0	0.2	8.5	1.8
	Class II townships	223	330.1	17.2	4	1.3 (0.0, 2.8)	54	23.6 (13.8, 33.4)	73	31.2 (23.2, 39.2)	22.9	0.3	56.1	44.0

Those who took drugs to lower uric acid were not included in the calculations.
*Self-reported presence of gout at the time of interview, which was diagnosed by physicians.
**Defined as ≥ 458.0 μM (7.7 mg/dl) for males and ≥ 392.6 μM (6.6 mg/dl) for females.
***Defined as ≥ 416.4 μM (7.0 mg/dl) for males and ≥ 356.9 μM (6.0 mg/dl) for females. SE: standard error

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Table 4. Sex-specific risk of hyperuricemia for adults in relation to location effects, controlling for age, BMI, and alcohol consumption.

Sex	Location	Odds Ratio[1]	Odds Ratio[2]	95% (CI)**
Male	Hakka area	1.18	1.54	(0.82, 2.89)
	Mountainous area	5.82	6.78*	(3.72, 12.34)
	East Coast area	1.13	1.22	(0.70, 2.13)
	Peng-Hu islands	1.37	2.11*	(1.16, 3.82)
	Metropolitan cities	1.33	1.62	(0.93, 2.81)
	Provincial Class I townships	1.40	1.58*	(1.01, 2.48)
	Provincial Class II townships (reference)	1	1	
	Age, yrs	0.98*	0.98*	(0.96, 0.99)
	Age × age		1.00	(1.00, 1.00)
	BMI	1.14*	1.18*	(1.10, 1.28)
	Alcohol consumption: Heavy	1.10	0.92	(0.47, 1.80)
	Moderate	1.05	0.95	(0.62, 1.46)
	Non-drinker (reference)	1	1	
Female	Hakka area (reference)	1	1	
	Mountainous area	7.46*	4.66*	(1.94, 11.19)
	East Coast area	1.40	1.25	(0.49, 3.21)
	Peng-Hu islands	1.37	1.59	(0.66, 3.86)
	Metropolitan cities	0.90	0.97	(0.28, 3.35)
	Provincial Class I townships	1.05	0.94	(0.40, 2.21)
	Provincial Class II townships	2.08*	1.51	(0.64, 3.56)
	Age, yrs	1.02*	0.91	(0.83, 1.01)
	Age × age		1.00*	(1.00, 1.00)
	BMI	1.20*	1.22*	(1.14, 1.32)
	Alcohol consumption: Heavy	1.20	1.23	(0.55, 2.75)
	Moderate	1.26	1.27	(0.44, 3.65)
	Non-drinker (reference)	1	1	

[1] Results of univariate analysis.

[2] Results of multivariate analysis. Monthly variations were adjusted.

*p < 0.05.

1.14 and 1.20, respectively). Age was a protective factor in males (OR = 0.98, $p < 0.05$), but a risk factor in females (OR = 1.02, $p < 0.05$). Age had mild nonlinear effects on hyperuricemia in females. Monthly variations of uric acid levels were observed in this study (data not shown), corresponding to several Chinese holidays. Since investigating the reasons for this variation is beyond the scope of this study, the monthly effects were adjusted in regression analyses. After adjusting for age, BMI, alcohol consumption and monthly variation, the stratum effects remained significant. BMI was also an important factor associated with hyperuricemia adjusting for other factors.

DISCUSSION

We present mean values of uric acid and prevalence of hyperuricemia in the general population of Taiwan. The mean values of uric acid of Taiwanese people aged 45 years and older were 394.6 ± 4.8 μM and 334.4 ± 5.3 μM for males and females respectively. Those mean values were higher than those reported in urban and rural areas of Beijing, China[17]. The mean uric acid of people aged 40–58 years in 1987–1988 in urban areas of Beijing were 342.0 μM and 277.8 μM for males and females, respectively[17], and the mean values in rural areas were 332.0 μM and 266.5 μM for males and females, respectively. The differences between Taiwan and Beijing and between rural and urban Beijing could be attributed to the various degrees of modernization.

The prevalence estimated from this island-wide survey is similar to estimates from several other regional studies in recent years. Table 5 compares the prevalence of hyperuricemia in previous studies in Taiwan. If the conventional criteria were used for hyperuricemia, i.e., males with serum uric acid ≥ 458.0 μM (7.7 mg/dl) or females with serum uric acid ≥ 392.6 μM (6.6 mg/dl) [15], 26.1% of adult males (≥ 19 years) and 17.0% of adult females presented hyperuricemia. That is similar to the prevalence in Kin-Hu, Kinmen[18], an island under Taiwan's jurisdiction but geographically very close to China. The overall prevalence reported in our study was higher than that of Pu-Li[10], which is a provincial Class II rural township. The prevalence in metropolitan cities in our study was slightly lower than that of another study carried out in Taipei City[9], the capital of Taiwan. As a whole, the lower the degree of urbanization, the lower the prevalence, except in the mountainous areas.

Darmawan, *et al*[16] summarized the prevalence of hyperuricemia in different adult male populations that included

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Table 5. Comparison of prevalence of hyperuricemia in different studies in Taiwan.

Study	Time of Study	Areas	Age Group (sex)	% Prevalence[1] (95% CI)
NAHSIT	1993–96	Taiwan	≥ 20 (Males)	25.1 (21.4, 29.3)
			(Females)	17.0 (13.0, 21.0)
		Adjusted to 1976 world population	≥ 20 (Both)	21.6 (18.7, 23.9)
		Adjusted to 1976 European population	≥ 20 (Both)	21.5 (16.2, 37.4)
		Adjusted to 1970 US population	≥ 20 (Both)	26.8 (16.2, 37.4)
NAHSIT	1993–96	Metropolitan cities	≥ 20 (Males)	26.8 (16.2, 37.4)
			(Females)	12.1 (6.6, 17.5)
NAHSIT	1993–96	Mountainous area	≥ 20 (Males)	61.5 (56.2, 66.7)
			(Females)	51.4 (45.1, 57.7)
Chen[9]	1993–94	Taipei city	≥ 20 (Males)	29.3
			(Females)	16.0
Chou[10]	1987–88	Pu-Li	≥ 30 (Males)	20.3
			(Females)	14.6
Lin[18]	1991–92	Kin-Hu, Kinmen	≥ 30 (Males)	25.8[2]
			(Females)	15.0[2]

[1] ≥ 458.0 μlM (7.7 mg/dl) for males; ≥ 392.6 μM (6.6 mg/dl) for females.
[2] ≥ 416.4 μM (7.0 mg/dl) for males; ≥ 356.9 μlM (6.0 mg/dl) for females.

Table 6. Prevalence of hyperuricemia in adults of different countries.

Study	Time of Study	Location (or Race)	Age	Sex	% Prevalence[1] (95% CI)
NAHSIT	1993–96	Taiwan	≥ 15	Males	43.7 (39.2, 48.2)
				Females	27.4 (22.4, 32.4)
		Adjusted to 1976 world population	> 15	Both	22.6 (19.7, 25.5)
		Adjusted to 1976 European population	≥ 15	Both	22.1 (19.4, 26.3)
		Adjusted to 1970 US population	≥ 15	Both	22.5 (19.8, 25.2)
	1992	Java[16]	≥ 15	Males	24.3
				Females	11.7
	1992	New Zealand[5] (Maoris)	≥ 15	Males	27.1
				Females	26.6
		New Zealand[5] (Caucasians)	≥ 15	Males	9.4
				Females	10.5
NAHSIT	1993–96	Mountainous area	≥ 20	Males	90.5 (85.9, 95.1)
NAHSIT	1993–96	Taiwan	≥ 20	Males	70.2 (66.7, 73.7)
	1965–80[16]	Indonesia, Malaysia, Mariana islands (Malayo-Polynesian)	Adult	Males	40–60[2]
		Hawaii, Alaska, Philippines (Malayo-Asians)			40–45[2]
		North America, New Zealand, Finland, Netherlands (Caucasians)			5–40[2]
		Japan, Canada (Asians)			9–30[2]
		Arizona, Montana, Canada (Native Americans)			5–20[2]
		Jamaica, Nigeria (Blacks)			8–13[2]

[1] Definition for hyperuricemia was ≥ 416.4 μl (7.0 mg/dl) for males; ≥ 356.5 μl (6.0 mg/dl) for females aged 15 years or older. The cutoff point for uric acid ≥ 356.9 (6.0 mg/dl) was used for comparisons of adult males or males aged 20 years or above.
[2] Range of prevalence, not confidence interval.

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Native Americans, Blacks from Jamaica and Africa, Asians from Canada, Taiwan, Malaysia and Japan, Caucasians and Malayo-Polynesians. They found that the prevalence was low in Blacks from different areas and for Native Americans, medium in Asians and Caucasians, and high in Malayo-Polynesians, suggesting that hyperuricemia might be related to ethnicity. However, the prevalence in the same ethnic group in different continents differed from each other greatly. Thus, the interaction between ethnicity and environment is important. The results from NAHSIT showed that using 356.9 μM (6.0 mg/dl) as the cutoff point, the prevalence in Taiwan (70.2%) far surpassed that for Malayo-Polynesians (Table 6). The prevalence in aborigines in Taiwan (90.5%) was even higher (Table 6). The higher prevalence in mountainous areas than in other areas in Taiwan was confirmed by another study of Chang[11]. The hypothesis of a strong correlation between alcohol consumption and hyperuricemia was not shown by our data. Indeed, the high level of alcohol consumption but low prevalence in the East Coast (Table 3) could confound the overall relationship.

Chang[11] found that the BMI was associated with hyperuricemia in aboriginal children. This study found that mean uric acid value, prevalence of hyperuricemia, average BMI, and alcohol consumption were higher in aborigines than in people in other parts of Taiwan. Controlling for alcohol consumption and BMI could not negate the high prevalence of hyperuricemia in the mountainous strata (Table 4), indicating a possible genetic difference between Han people and Taiwan aborigines.

We found a high prevalence of hyperuricemia in Han Chinese in Taiwan despite a lack of both high alcohol consumption and obesity (geographical mean of BMI ranging from 22.3 to 23.6). In contrast, aborigines from the mountainous regions in Taiwan have an even higher prevalence of hyperuricemia, which may be due to a combination of obesity and genetic predisposition. Uric acid is a metabolite of uracil, which is abundant in certain foods. Chou[10] also found that hyperuricemia was associated with the consumption of offal meats, such as heart, kidney and liver sweetbreads, in Pu-Li. Further investigation on the relationships between hyperuricemia and obesity, race, diet, and alcohol is essential in order to develop preventative strategies for hyperuricemia, and therefore gout.

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