

ORIGINAL ARTICLES

Herbal Supplement Use and Blood Lead Levels of United States Adults

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BACKGROUND: Some herbal supplements may contain lead.

OBJECTIVE: To examine whether use of specific herbal dietary supplements during the last 30 days is associated with blood lead levels in US men and women.

DESIGN: Cross-sectional analysis.

STUDY POPULATION: NHANES participants from 1999–2004, a representative sample of the civilian non-institutionalized US population.

MEASUREMENTS: Lead was measured in blood. Associations between lead and self-reported supplement use were estimated using multivariable regression weighted to account for NHANES sampling. Herbal supplements investigated were those previously reported to contain high heavy metal content: Ayurvedic or traditional Chinese medicine herbs, echinacea, ginkgo, ginseng, St. John's wort, and "other" herbs (specifically, kava, valerian, black cohosh, bee pollen, and nettle).

MAIN RESULTS: Among 6,712 women ≥ 20 years, those using herbal supplements had lead levels that were 10% higher than non-users (95% CI 3%–17%, $p=0.005$). Women using Ayurvedic or traditional Chinese medicine herbs, St. John's wort, and "other" herbs had lead levels 24% (95% CI 5%–45%, $p=0.01$), 23% (95% CI 4%–46%, $p=0.02$), and 21% (95% CI 2%–44%, $p=0.03$) higher, respectively, than non-users. No significant associations were observed between herb use and lead levels among men ($n=6,095$). Among reproductive-aged women (16–45 years), herbal supplement users had lead levels 20% higher than non-users (95% CI 5%–34%, $p=0.008$). In contrast, garlic and other dietary supplements were not associated with higher lead levels.

CONCLUSION: Use of specific herbal supplements is associated with higher blood lead levels among women. Our data suggest testing guidelines for herbal supplements and regulations limiting lead in supplements are needed.

KEY WORDS: herbs; Phytotherapy; Lead/analysis; Dietary supplements; medicine; Ayurvedic.

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BACKGROUND

Since the 1970s the removal of lead from gasoline, food cans, and paint products has dramatically decreased lead exposure in the US.¹ Nevertheless, reducing lead exposure remains a public health priority given accumulating research demonstrating associations between low levels of lead exposure and health risks, including increased hypertension, kidney disease, peripheral arterial disease, cardiovascular disease, cancer, and death from all causes,^{2–7} with significant associations for myocardial infarction and stroke mortality evident at blood lead levels >2 mcg/dl.⁴ Among adults, the potential implications of low-level lead exposure are most relevant to women of child-bearing age, as lead is especially harmful to developing nervous systems of fetuses and children⁸ and passes through the placenta and breast milk.⁹ Blood lead levels mainly estimate recent exposures, but also reflect past exposures, as lead accumulates in bones and is mobilized into circulation during periods of increased bone turnover (particularly in women during periods of pregnancy, lactation, and menopause).¹⁰ Calcium deficiency increases lead absorption and lead retention,^{11–14} and is a risk factor for increased maternal lead transfer.^{15–16}

The risk of lead exposure from dietary supplements has been recognized for several years.¹⁷ Lead in calcium supplements has been most publicized, especially supplements derived from natural sources, such as bone meal and dolomite.¹⁸ However, by 1996, reductions in environmental lead and processing improvements resulted in substantial declines in lead content in natural calcium supplements.¹⁹ Despite awareness that supplements could pose an avoidable lead exposure risk, they are subject to limited governmental regulation in the US, and the Dietary Supplement and Health Education Act (DSHEA) of 1994 does not require supplements be approved by the FDA as safe and efficacious prior to marketing.²⁰ Of concern, recent studies have identified heavy metal contaminants in several commercially available herbal

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supplements, with lead the most common to be present in potentially harmful concentrations.²¹⁻²⁴ In 2001, 50% of 38 Asian herbal remedies purchased in the US and >80% of 16 purchased in Southeast Asia and China were identified to have excess lead.²³ In 2003 and 2005, one in five Ayurvedic herbal supplements purchased in Boston²⁴ or over the Internet²⁵ had excess heavy metal content. Third-party evaluations of several other herbal supplements sold throughout the US have also revealed the presence of high lead content.²⁶

Given evidence that some herbs may contain high lead content, we sought to determine the effect of herbal supplement use on blood lead levels of adult US women and men. Using data from the National Health and Nutrition Examination Survey (NHANES), a representative sample of the civilian non-institutionalized US population, we investigated use of herbal supplements that had previously been found to contain high lead content. We defined high lead content to be >1.5 mcg/serving, based on the 1999 California criteria for acceptable lead levels of <1.5 mcg/serving of natural calcium supplement.²⁷ We stratified the analysis by sex, given different potential health concerns related to low-level lead exposure and because men and women typically use different types of herbs,²⁸ have different lead exposures,²⁹ and may metabolize lead differently.²⁹

METHODS

Study Population

From 1999–2004, 13,504 US adults ≥20 years participated in NHANES interviews, examinations, and had blood lead assessed. We excluded 697 with missing values in variables of interest, leaving 12,807 in the primary analysis. These analyses were approved by the Beth Israel Deaconess Medical Center Committee on Clinical Investigation.

Supplement Use

Supplement use was queried during household interviews. We examined any herbal supplements found to contain excess lead on prior studies or product testing available to the public, or that had been implicated in heavy metal poisonings.^{21,23-26,30-34} Specifically, the following were included: Ayurvedic and/or traditional Chinese medicine (TCM) herbs used as individual herbs (astragalus, dong quai, glycyrrhiza, green tea extract, guggul, medicago saliva, trigonella foenum-graecum, and turmeric) or as combination herb formulations (e.g., Sheng mai, a combination of 18 herbs and Ayurvedic Blood Sugar Formula, a combination of 12 herbs); ginkgo; ginseng (including Asian ginseng, American ginseng, and eleuthero, formerly called Siberian ginseng and frequently combined with other ginsengs); echinacea (with or without goldenseal); St. John's wort; and "other" herbal supplements, specifically, kava, valerian, black cohosh, bee pollen, and nettle. We dichotomized use or nonuse of any of these herbal supplements during the last month and examined exposure by specific supplement type. To adjust for possible effects of calcium on lead levels, we included use of calcium (yes/no) taken as a dietary supplement or antacid.

To assess potential confounding by unmeasured factors related to general use of supplements, we performed secondary analyses testing whether dietary supplement use overall was

associated with lead levels. We also explored associations between lead levels and use of garlic supplements (used by 2%), which have not been found to contain excess lead.^{26,34}

Blood Lead Levels

Lead was measured in whole blood at the CDC by graphite furnace atomic absorption spectrophotometry using a PerkinElmer Model SIMAA 6000 simultaneous multi-element atomic absorption spectrometer with Zeeman background correction. Results below the lower detection limit (<0.3 mcg/dl) were replaced with a value equal to the detection limit divided by $\sqrt{2}$.

Other Variables

Age, sex, race/ethnicity, education, country of birth, income, housing built before 1978 (when lead-based paint was banned from US housing), smoking, health status, activity level, and using home water treatment devices were based on self-report. Race/ethnicity was classified as non-Hispanic white, non-Hispanic black, Mexican American, or other. Participants were classified as never, former, or current smokers. Body mass index (BMI) was calculated as the measured weight in kilograms/the square of the measured height in meters. For kidney function, we corrected serum creatinine values in NHANES 1999–2000 (creatinine = $0.147 + 1.013 \times \text{NHANES 1999–2000 uncalibrated creatinine}$) to account for differences between NHANES 1999–2000 and the 2001–2002 and 2003–2004 surveys.³⁵ Glomerular filtration rate (eGFR) was estimated using the abbreviated Modification of Diet in Renal Disease Study formula based on creatinine, age, and race.³⁶ We defined kidney function as normal, mildly decreased, and low according to eGFR >90 ml/min, 60–90 ml/min, and <60 ml/min, respectively.³⁷ Folate was measured in serum using the Bio-Rad Laboratories "Quantaphase II Folate/vitamin B12" radioassay kit.

Statistical Analyses

Analyses were performed using SAS 9.1.3 (SAS Institute, Inc., Cary, NC) and SUDAAN 9.0 (Research Triangle Park, NC). Estimates were weighted to account for the unequal probabilities of selection resulting from the complex sample design, non-response, and planned over-sampling of selected populations.

Lead levels were skewed and were log transformed to improve normality. We performed sex-stratified linear regression to evaluate independent relations of herbal supplement use with the logarithmic blood lead levels. For these analyses we fit separate models for men and women using the same variables in each model. Based on a priori assumptions, we included the potential confounders: age, race/ethnicity, education, country of birth, income, home built before 1978, smoking status, activity level, general health status, BMI, renal function (eGFR), calcium supplement use, and water treatment device use. Race/ethnicity, education, income, and country of birth were included in all models to control as thoroughly as possible for socioeconomic status. Because some did not report incomes or know when their home was constructed, we created missing categories for income [n=889 (6.4%)] and year home was built [n=2,778 (15.8%)]. Given

particular concerns about prenatal lead exposure, we created additional models to assess herbal supplement use and blood levels among women of reproductive age (ages 16–45). The percent differences in lead levels were estimated as $[(\beta) - 1] \times 100\%$, where β is the estimated regression coefficient.

To assess modifying effects of herbal supplement use by sex on blood lead levels, we fit a model including both men and women in a single regression and used an interaction term [sex*(supplement)] to assess for statistical interaction. We fit separate regression models to examine interactions between supplement use and other factors (age, race/ethnicity, BMI, and renal function) on blood lead levels, incorporating interaction terms [(factor)*(supplement)] into the original models for men and women. In post hoc analyses, we also examined whether blood folate or iron levels influenced the results. The level of statistical significance for all results was considered $p < 0.05$.

RESULTS

Use of the specific herbal supplements was more common among those with greater education and income and participants who were non-Hispanic white, born in the US, 40–59 years, never/former smokers, more active, using a home-water-treatment device, and taking calcium supplements (Table 1). Blood lead levels >10 mcg/dl were rare (0.6% of the total sample).

Table 2 shows overall 4.3% of the population (representing 7.5 million adults) used at least one of the specific herbal supplements included during the last month. Although overall prevalence of any specific herbal supplement use was similar in women and men, the types of supplements used differed substantially by sex. Among herbal supplement users, 28% of women and 31% of men had used >2 of the specific herbal supplements included in this study during the last month.

Table 3 shows geometric means of blood lead levels by participant characteristics. The highest lead levels were found among men, older subjects, current/former smokers, individuals born in Mexico, and those with lower education, lower or missing income, poorer kidney function, and poorer health.

Figure 1 shows the estimated difference in blood lead level and 95% CIs associated with use of any specific herbal supplement included and with the types of herbal supplements used among women and men. Lead levels among women reporting any use of these herbal supplements were 10% (95% CI 4%–18%) higher compared to women non-users ($p=0.005$). Statistically significant associations with higher lead levels were observed for use of St. John's wort, TCM/Ayurvedic herbs, and "other" herbal supplements. Although similar patterns of association were seen among men, no statistically significant associations were observed, effects were less, and formal tests of interaction indicated a statistically significant difference in the estimated effect of herbal supplement use on lead levels in men compared to women (interaction term p -value=0.045).

Figure 2 shows regression model results for reproductive-aged women (16–45 years). Among this group, women who used any of these herbal supplements had lead levels 20% (95% CI 5%–34%, $p=0.008$) higher than women who did not.

We observed inverse relationships between calcium supplement use and lead levels. Among women, 31% used calcium supplements, and users had lead levels 7% lower than non-users (95% CI -10% – -3% , $p=0.0005$); among men, 18% used

Table 1. Characteristics of Participants According to Use or Non-Use of the Specific Herbal Supplements^a Evaluated in this Study. Adults ≥ 20 Years, NHANES 1999–2004

	Users (N=455) %	Non-users (N=12,352) %	P-value
Age, years			
20–39	28	40	<0.001
40–59	46	38	
≥ 60	26	22	
Male	49	48	0.89
Education			<0.001
< High school	12	21	
High school graduate	20	26	
> High school	68	53	
Race/ethnicity			<0.001
Non-Hispanic white	84	72	
Non-Hispanic black	6	10	
Mexican American	4	8	
Other	5	11	
Smoking			0.01
Never	48	50	
Former	33	25	
Current	18	25	
Country of birth			<0.001
US	95	85	
Mexico	2	5	
Other	3	10	
Income			<0.001
$< \$20,000$	15	24	
$\$20,000$ to $< \$45,000$	30	28	
$\geq \$45,000$	48	42	
Refused or unknown	7	6	
Year home built			<0.001
1978 or later	38	35	
Before 1978	55	50	
Unknown	8	15	
Health status			0.48
Excellent/very good	57	53	
Good	27	30	
Fair/poor	16	17	
Physical activity			<0.001
Sedentary	24	37	
Moderate	34	29	
Vigorous	42	34	
Estimated GFR ^b			0.02
< 60 ml/min	5	5	
60–90 ml/min	50	43	
> 90 ml/min	45	52	
Home water treatment	40	29	<0.001
Use of calcium supplement	39	24	
Blood lead level			0.49
< 2 mcg/dl	62	64	
2 to < 10 mcg/dl	37	36	
> 10 mcg/dl	0.8	0.6	

^aAyurvedic herbs, bee pollen, black cohosh, echinacea, ginkgo, ginseng, kava, nettle, Saint John's wort, traditional Chinese medicine herbs, and/or valerian

^bTo convert values from conventional units to SI units, multiply by the conversion factor: $0.0483 \mu\text{mol/L}$. GFR, glomerular filtration rate

calcium supplements and had lead levels 3% lower than non-users (95% CI -7% – 1% , $p=0.10$).

Further adjustment for folate and iron levels did not materially alter the results in men or women. There were no statistically significant differences in the association with herbal supplements on lead levels across strata of age, race/ethnicity, renal function, or BMI.

When we examined use of other supplements, we found overall use of any dietary supplement was inversely associated

Table 2. Prevalence (%) Use of Specific Herbal Supplements and Any Dietary Supplements During the Last Month Among Adult Participants ≥ 20 Years of Age. NHANES 1999–2004

Supplement	Total %	Female %	Male %
Any specific herbal supplement	4.3	4.2	4.3
Ginkgo	1.8	1.6	2.0
Echinacea	1.1	1.1	1.0
Ginseng ^a	0.9	0.6	1.3
Saint John's wort	0.6	0.6	0.6
Traditional Chinese medicine and/or Ayurvedic herbs	0.5	0.6	0.3
"Other herbs" ^b	0.6	0.8	0.4
Any dietary supplement ^c	54	60	47

^aAsian ginseng, American ginseng and/or eleuthero (formerly called Siberian ginseng)

^bKava, valerian, black cohosh, bee pollen and/or nettle

^cVitamins, minerals, herbs, and non-vitamin/non-mineral supplements

with lead levels for women and men; however, the associations became non-significant when calcium was excluded. We found no significant association between lead levels and garlic supplement use.

DISCUSSION

To our knowledge, this study is the first showing associations between herbal supplement use and blood lead levels in US women. After controlling for multiple factors, lead levels of women users of specific herbal supplements were 10% higher than women nonusers. When we examined herbal supplement use among reproductive age women, the relationship with lead levels was even stronger, with lead levels 20% higher overall, up to 40% higher among users of select herbal supplements compared to non-users. These findings were not observed for other dietary supplements and were restricted to types of herbal supplements that have been implicated in heavy metal contamination.

Consistent with recent reports among US adults,³⁸ mean blood lead levels were generally low for women (1.3 mcg/dl) and men (2.0 mcg/dl). Diet is the main lead exposure for most US adults and is estimated to be ~10 mcg/day.³⁹ Consuming one supplement containing 1.5 mcg of lead represents 15% of this amount. The contribution would be greater for supplements containing more lead and when using multiple supplements (reported by 30%). Because adults absorb about 10% of ingested lead,⁴⁰ among women, regular use of a supplement containing 1.5 mcg of lead/serving would be expected to increase lead levels by ~11%, which approximates the mean difference found in our study.

Our findings are similar to epidemiological studies in Taiwan,^{22–41} showing elevated blood lead levels in those who use TCM herbs compared to nonusers and a study in China showing increased lead in breast milk of mothers using Chinese medicine herbs compared with non-users.⁴² In contrast to prior studies, we observed no statistically significant associations in men. This should be interpreted with caution, as among men, use of some supplements was very low, and we observed wide confidence intervals around many effect estimates. Although we controlled for several factors, we lacked data on occupation; thus, some degree of unadjusted con-

founding is probable, particularly in men who are most apt to be employed in occupations with high lead exposure. Alternatively, differences in the impact of lead exposure could be explained by women having greater susceptibility. For example, compared to men and older women, young women appear to retain lead more avidly²⁹ and have periods of increased nutrient demands (e.g., pregnancy and lactation). Increased lead absorption has been associated with lower iron stores and may occur before frank deficiency.⁴³ Although we did not see an association between lead and circulating iron (measured by serum iron), inclusion of ferritin (a better measure of iron stores) in future studies would be useful to explore if higher iron requirements of childbearing women might explain observed differences between women of childbearing age and older women or men. Finally, growing literature suggests that genetic polymorphisms that may modify lead kinetics^{44,45} play a greater role in women compared to men.⁴⁶

We adjusted for calcium supplement use both because some calcium products may contain excess lead⁴⁷ and prior studies suggest an inverse correlation between calcium and lead levels.^{16,48–50} Our findings support clinical trial evidence demonstrating a protective effect of calcium supplements on lead levels in lactating women⁴⁹ and suggests the effect is not limited to this group alone. It is hypothesized that this effect is likely due to suppression of lead absorption in the gut and suppression of bone turnover.¹⁵

We considered whether higher lead levels might be associated with herbs not included in our study or with less well-defined factors related to using any dietary supplement. We did not observe higher lead levels among garlic supplement users or among dietary supplement users in general, lending support to the specificity of the association between specific herbal supplement use and blood lead levels.

Lead is readily taken up from soil by plants.^{51,52} Soil and air pollution influences herb lead content.⁵³ It is possible that excess lead found in some herbs may, in part, be due to herbs grown in less-regulated countries, such as China and India, which are major exporters of raw plant products for the supplement industry.⁵⁴ Alternatively, uncontaminated herbs could acquire lead during manufacturing due to contaminated water, equipment, pipes, or storage.¹⁹ Saper et al. found US-manufactured Ayurvedic supplements contained a median lead content of 7.5 mcg/g compared to 11.0 mcg/g for Indian-manufactured supplements,²⁵ demonstrating that choosing only US-manufactured supplements may decrease, but not assure a lead-free supplement, suggesting the problem is likely due to multiple factors.

The study does not allow determination of causality, many variables were self-reported, and the use of some herbal supplements was low, which consequently limited our power to detect associations among specific herbal supplements, particularly among men who infrequently used some herbs showing the strongest associations among women. Differences in use of "Ayurvedic/TCM" and "Other" herbs could be because of higher use among women for menstrual and menopausal symptoms.⁵⁵

Unfortunately, we lacked information on frequency and total duration of supplement use. This information and additional information on occupational and non-occupational lead exposures, such as urban living, home renovations, and hobbies, would be of interest for future studies. In this study, we restricted our examination of herbal supplements to those that

Table 3. Blood Lead Levels by Participant Characteristics. Adults ≥20 Years, NHANES 1999–2004

Covariates ^b	n	Total (n=12,807) lead, mcg/dl ^a		Female (n=6,712) lead, mcg/dl ^a		Male (n=6,095) lead, mcg/dl ^a	
		Geometric mean	SE	Geometric mean	SE	Geometric mean	SE
Overall	12,807	1.61	0.02	1.31	0.02	2.00	0.03
Age, years							
20–39	4,620	1.26	0.02	0.98	0.03	1.63	0.03
40–59	3,828	1.76	0.03	1.42	0.03	2.19	0.04
≥60	4,359	2.15	0.03	1.86	0.04	2.59	0.04
Education							
< High school	4,080	2.02	0.03	1.62	0.04	2.56	0.04
High school graduate	3,044	1.67	0.03	1.35	0.03	2.10	0.05
> High school	5,683	1.45	0.02	1.20	0.02	1.79	0.03
Race/ethnicity							
Non-Hispanic white	6,488	1.58	0.02	1.29	0.02	1.96	0.03
Non-Hispanic black	2,347	1.76	0.04	1.49	0.05	2.20	0.07
Mexican American	2,942	1.75	0.05	1.33	0.04	2.24	0.06
Other	1,030	1.59	0.05	1.31	0.05	1.99	0.06
Smoking							
Never	6,577	1.36	0.02	1.18	0.03	1.67	0.03
Former	3,426	1.82	0.03	1.42	0.04	2.21	0.04
Current	2,804	2.00	0.04	1.60	0.04	2.39	0.05
Country of birth							
US	9,905	1.57	0.02	1.29	0.02	1.96	0.03
Mexico	1,702	2.10	0.06	1.59	0.05	2.62	0.07
Other	1,200	1.74	0.05	1.45	0.04	2.12	0.07
Income							
<\$20,000	3,997	1.76	0.04	1.49	0.04	2.24	0.05
\$20,000 to <\$45,000	3,808	1.64	0.03	1.30	0.03	2.09	0.04
≥\$45,000	4,175	1.48	0.02	1.18	0.02	1.82	0.02
Refused or unknown	827	1.88	0.05	1.56	0.05	2.33	0.11
Year home built							
1978 or later	3,685	1.46	0.03	1.19	0.03	1.83	0.04
Before 1978	6,344	1.69	0.03	1.38	0.03	2.09	0.04
Unknown	2,657	1.71	0.04	1.40	0.04	2.15	0.05
Health status							
Excellent/very good	5,871	1.52	0.03	1.23	0.03	1.89	0.03
Good	4,061	1.63	0.03	1.32	0.03	2.06	0.04
Fair/poor	2,867	1.89	0.04	1.58	0.04	2.35	0.05
Estimated GFR							
<60 ml/min	1,015	2.19	0.05	2.00	0.06	2.58	0.10
60–90 ml/min	4,935	1.72	0.03	1.42	0.03	2.09	0.03
>90 ml/min	6,857	1.47	0.03	1.16	0.03	1.89	0.03
Home water treatment							
Yes	3,182	1.50	0.03	1.22	0.03	1.85	0.04
No	9,625	1.66	0.02	1.35	0.03	2.07	0.03
Use of calcium supplement							
Yes	2,793	1.51	0.03	1.31	0.03	1.95	0.04
No	10,014	1.64	0.02	1.31	0.02	2.02	0.03

GFR, glomerular filtration rate. SE, standard error

^aTo convert values from conventional units to SI units, multiply by the conversion factor: 0.0483 μmol/l

^bAll covariates examined in relationship to lead level were statistically significant at a p-value <0.05, with the exception of calcium supplement use among men and women

had previously been reported to contain high levels of lead. However, not all supplements have been analyzed for lead content, and it is possible that some with excess lead are missing from our study. Some forms of herbs may have been missed as participants were queried about “dietary supplement” use and may not have reported herbs purchased as raw herb mixtures, whole herbs, or teas, which are not labeled as dietary supplements and may be regarded as traditional foods or medicine.

We lacked sufficient information to assess supplements according to source and lacked power to assess them according to different brands, which is of interest for future studies, as the quality of a supplement may vary according to herb

source and manufacturer. Finally, the NHANES is conducted only in English and Spanish and may not represent recent immigrants from other countries living in the US, who may be disproportionately affected both by higher lead levels⁵⁶ and by lead poisonings due to use of folk herbal remedies.⁵⁷

Our observations suggest that among women, including women of reproductive age, specific herbal supplement use is a significant contributor to circulating lead. At present, there are limited data supporting the clinical efficacy of herbal supplements included in this study.^{58–62} Unless health benefits can be clearly demonstrated by well-designed, well-executed studies, our findings suggest that the potential for harm from use of some herbal supplements may exceed the benefit. Unfortu-

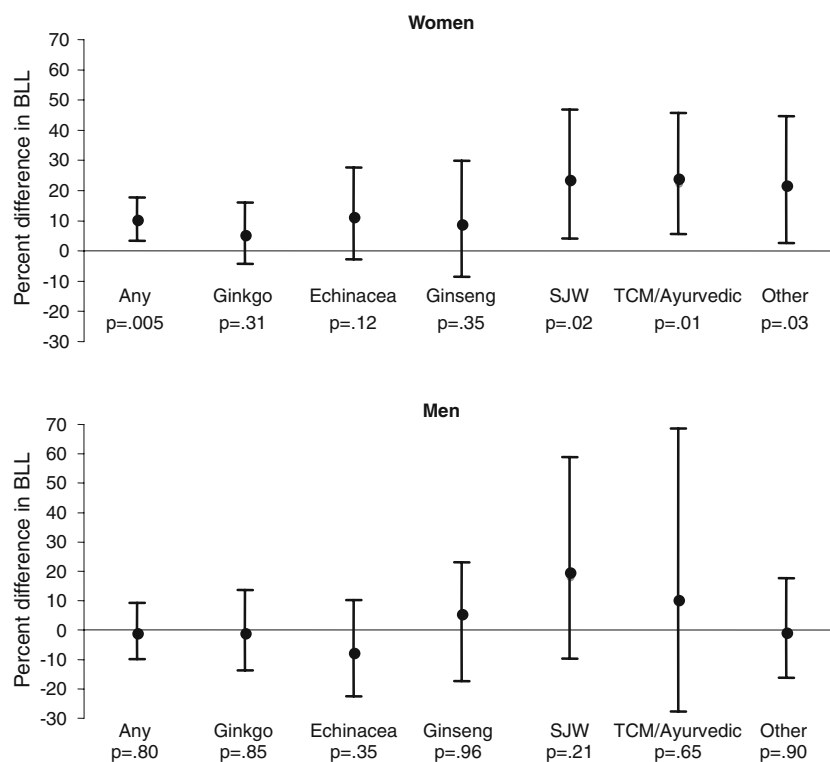


Figure 1. Adjusted estimated difference and 95% CI in blood lead levels (BLL) among women and men ≥ 20 years by use of specific herbal supplements, ginkgo, echinacea, ginseng (Asian, American, or eleuthero), St. John's wort (SJW), traditional Chinese medicine herbs (TCM) or Ayurvedic herbs, or "other" (kava, valerian, black cohosh, bee pollen, and nettle). Adjusted for age, race/ethnicity, educational levels, country of birth, income, year home was built, smoking status, BMI, renal function (estimated GFR), calcium supplement use, and use of a water treatment device.

nately, US consumers are often misinformed about the regulation, safety, and effectiveness of dietary supplements.⁶³ Moreover, 37% of physicians surveyed across the US were unaware that supplements do not require FDA pre-market approval for safety and efficacy,⁶⁴ indicating increased training and CME on this topic are needed. It is hoped that the FDA's current good manufacturing practices (CGMPs), which by

2010 require all manufacturers to evaluate supplement identity, purity, strength, and composition, will lead to safer supplements. However, CGMPs are based primarily on industry self-regulation and do not address premarket proof of safety or efficacy. Furthermore, without increased resources, the FDA is unlikely to have the capacity to widely inspect or enforce these rules.

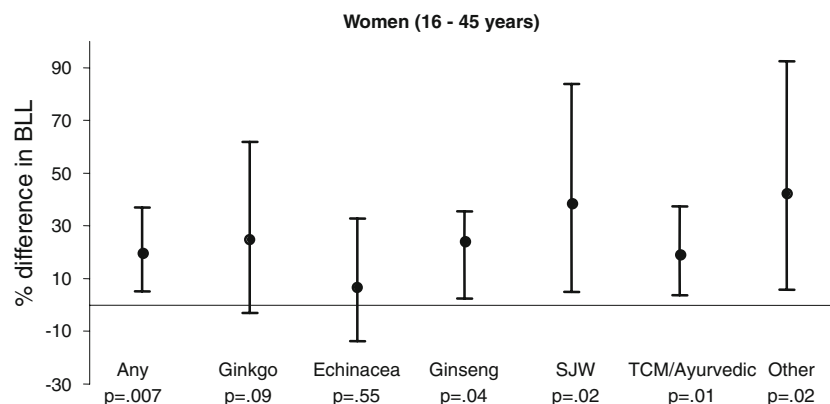


Figure 2. Adjusted estimated difference and 95% CI in blood lead levels (BLL) among women of child-bearing age by use of specific herbal supplements, ginkgo, echinacea, ginseng (Asian, American, or eleuthero), St. John's wort (SJW), traditional Chinese medicine herbs (TCM) and/or Ayurvedic herbs, or "other" (kava, valerian, black cohosh, bee pollen, and nettle). Adjusted for age, race/ethnicity, educational levels, country of birth, income, year home built, smoking status, BMI, renal function (estimated GFR), calcium supplement use, and use of a water-treatment device.

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