Trends in kidney stone prevalence among U.S. adults: A concerning contemporary gender analysis from the NHANES database

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INTRODUCTION

The global prevalence of kidney stones is increasing, posing a substantial economic burden, estimated at $4.5 billion annually in the US in 2000.[1] Factors such as age, gender, race, environmental exposures, lifestyle choices, and dietary habits contribute to stone formation. Additionally, conditions like diabetes, obesity, and hypertension heighten the risk of kidney stones.[2,3]

The National Health and Nutrition Examination Survey (NHANES) provides comprehensive health data on the US population, including kidney stone prevalence and patient characteristics derived from interviews, lab tests, and physical exams. From NHANES II (1976-1980) to recent updates, stone prevalence rose from 3.8% to 8.8%, stabilizing in men but increasing in women.[4] This study aims to analyze temporal trends in kidney stone prevalence among US adults using NHANES data from 2007 to 2020.

METHODS

This cross-sectional observational study evaluated the lifetime prevalence of kidney stones using National Health and Nutrition Examination Survey (NHANES) data. NHANES is a health survey that provides nationally representative results for the civilian population of the United States. The study was approved by the Ethics Review Committee of the National Center for Health Statistics. We analyzed data from six NHANES cycles: 2007-2008, 2009-2010, 2011-2012, 2013-2014, 2015-2016, and 2017-2020, a 10.6-year period represented by

the midpoints of the first cycle and last cycle. The lifetime prevalence of kidney stones was determined based on responses to the question, "Have you ever had kidney stones?". We used survey statistical methods to estimate kidney stone prevalence overall and within subgroups defined by sex, age group, and race/ethnicity (Asian, Black, Mexican-American, White, Other Hispanic, or Other race / Multi-race). Nationally representative prevalence values were calculated and reported as percentages with standard errors (SE).

RESULTS

The analysis included 38,329 participants aged 20 and older. Population-weighted demographic data included a mean age of 37.4 years (SE 0.2) and 51.1% female (SE 0.2%). The racial distribution was 62.6% White (SE 1.5%), 12.1% Black (SE 0.8%), 10.3% Mexican-American (SE 0.8%), 8.4% Other / Multirace (SE 0.4%), and 6.6% other Hispanic (SE 0.5%). The weighted prevalence of kidney stones remained stable from 8.9% (SE 0.6%) in 2007-2008 to 9.9% (SE 0.6%) in 2017-2020 (p=0.23). However, kidney stone prevalence increased significantly in females during this period, from 6.5% (SE 0.5%) to 9.1% (SE 0.9%) (p=0.01) (Table 1). The prevalence of kidney stones remained stable during the study period in males, across age groups, and among racial/ethnic groups (Figure 1).

DISCUSSION

The weighted prevalence of kidney stones among US adults remained relatively stable from 8.9% in 2007-2008 to 9.9% in 2017-2020, with an upward trend observed specifically in women, increasing from 6.5% to 9.1% over the same period. Historically, stone disease prevalence was higher in males than females, but this gap has narrowed in recent decades, especially among younger women. A similar trend of this narrowing gender gap was also noted in a study of the Canadian population. The study identified a proportionally greater rise in surgical treatment rates for kidney stones among women compared to men in the same time period.[5]

The rising trend of kidney stones among women is concerning, complex and multifactorial. One possible explanation is the rising rates of obesity. In the last 2 decades, the prevalence of obesity in US adults increased from 30.5% to 42.4%.[6] Notably, the prevalence of severe obesity was higher among women. Obesity has been tied to an increase in the concentrations of uric acid and calcium in the urine, contributing to stone formation.[7] An evaluation of NHANES data from 2011 to 2018 also demonstrated that a higher total fat percentage is associated with a higher prevalence of stone disease.[8] Moreover, obese women might also be at a higher risk of forming stones compared with obese men. A previous study determined that the relative risk of incident stones in obese men is 1.27 versus that in normal weight men, whereas in obese women the risk was up to 2.09 times higher than in normal weight women.[9]

Metabolic syndrome, which is closely linked to hypertension and diabetes, has been associated with increased risk of kidney stones.[10] Insulin resistance in diabetes is associated with increased intestinal absorption and renal excretion of calcium. Furthermore, diabetic stone formers excrete more oxalate than non-diabetic patients, all of which increases the risk of calcium oxalate stones.[11] Metabolic syndrome also induces a series of inflammatory

responses that precipitate calcification through the expression of monocyte chemoattractant protein 1, osteopontin and macrophage infiltration.[12] These inflammatory cascades cause an increase in reactive oxygen species (ROS) that is linked to calcification not only in the kidneys but also in the vascular endothelium which is theorized to cause hypertension.[13] The rising diagnosis of cardiovascular disease among younger women suggests shared physiological mechanisms that may also explain the increasing prevalence of kidney stones in this demographic. [14]

Our data shows that kidney stone prevalence has remained largely stable for men and women older than 60. The increasing trend of stones in women was largely contributed by those under the age of 60. Another possible hypothesis is the broader societal shift towards greater gender equality in the workforce. According to the U.S. Bureau of Labor Statistics, women's labor force participation has increased over the decades, with women playing increasingly significant roles across various sectors and industries in the United States. Women were also more likely to pursue higher levels of education, surpassing men in the number of bachelor's and doctoral degrees.[15] The increase in an educated female workforce, facilitated by better work-related health insurance coverage, could mean greater awareness as well as access to healthcare services. Consequently, this could lead to more frequent check-ups, potentially leading to a rise in detection of asymptomatic kidney stones.[16]

This study's strengths lie in its large, representative sample of the US adult population, allowing for broad generalizability. The extended data analysis period offers a comprehensive view of kidney stone prevalence. Leveraging NHANES data enabled a thorough exploration of medical history, lifestyle, socioeconomic factors, and biochemistry measures related to stones. Machine learning techniques identified key variables linked to stone prevalence and incidence among statistically significant factors. However, limitations include the cross-sectional design, hindering causal relationship establishment. Additionally, NHANES data's reliance on self-reports introduces potential recall bias. Lastly, important factors like dietary habits, body composition, environmental exposures, and also stone-specific information like stone composition and 24-hour urinary metabolites were not fully captured.

CONCLUSIONS

the overall lifetime prevalence of kidney stones among American adults has remained relatively stable over the past decade. However, there is a notable upward trend in kidney stones among females that demands further investigation. Possible contributing factors include diet, obesity, metabolic syndrome, as well as changes in working status, attitude, and access to healthcare.

Conflicts of interest: *Dr. Miller reports consultancy with Boston Scientific. Dr. Bhattacharyya reports employment with Boston Scientific. Dr. Tailly reports consultancy with Boston Scientific. Dr. Bhojani reports consultancy with Boston Scientific. Dr. Chew reports consultancy with Boston Scientific.*

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FIGURES AND TABLES

Figure 1. Trends in kidney stone prevalence in US adults: a) among all participants; b) by age group; c) by sex; and d) by race/ethnicity. Plotted values are percentage (standard error).

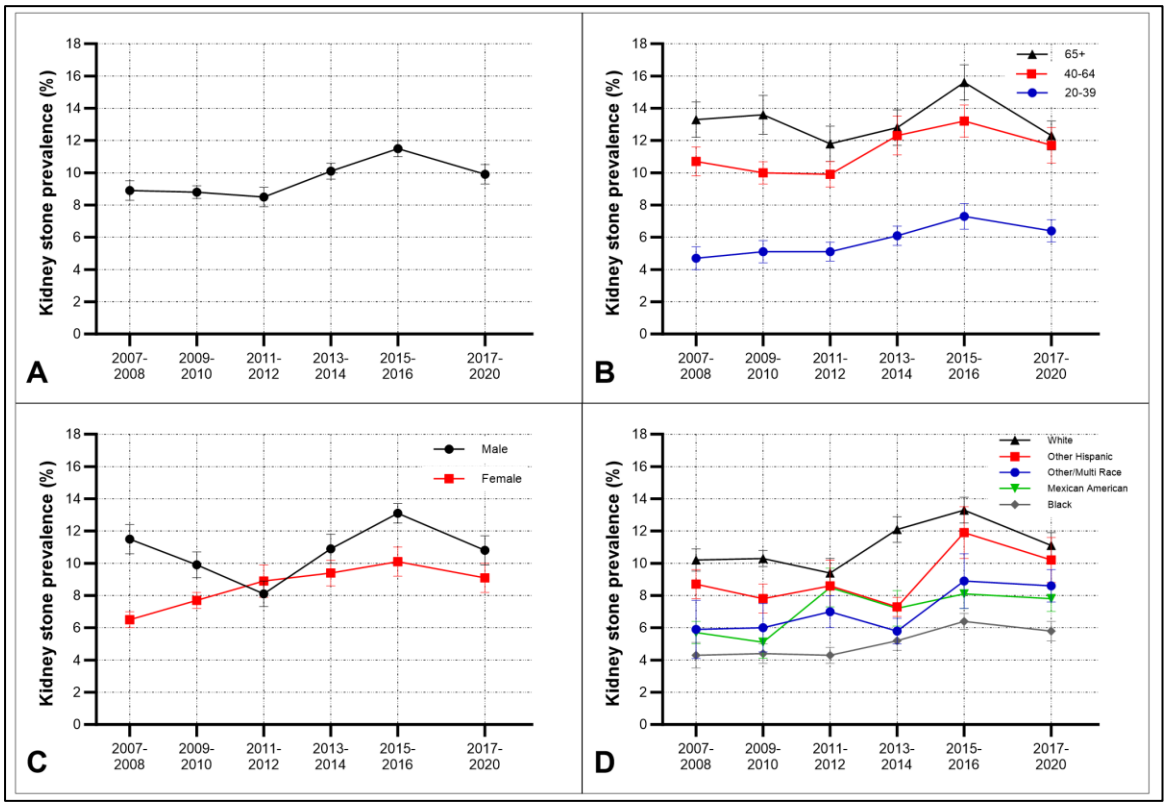

Table 1. Trends in kidney stone prevalence in U.S. adults, 2007–2020*							
Groups	**2007–2008**	**2009–2010**	**2011–2012**	**2013–2014**	**2015–2016**	**2017–2020**	**P**
All subjects	8.9 (0.6)	8.8 (0.4)	8.5 (0.6)	10.1 (0.5)	11.5 (0.5)	9.9 (0.6)	0.23
Sex							
Female	6.5 (0.5)	7.7 (0.5)	8.9 (1.0)	9.4 (0.8)	10.1 (0.9)	9.1 (0.9)	0.01
Male	11.5 (0.9)	9.9 (0.8)	8.1 (0.8)	10.9 (0.9)	13.1 (0.6)	10.8 (0.9)	0.59
Age							
20-39	4.7 (0.7)	5.1 (0.7)	5.1 (0.6)	6.1 (0.6)	7.3 (0.8)	6.4 (0.7)	0.12
40-64	10.7 (0.9)	10.0 (0.7)	9.9 (0.8)	12.3 (1.2)	13.2 (1.0)	11.7 (1.1)	0.48
65+	13.3 (1.1)	13.6 (1.2)	11.8 (1.1)	12.8 (1.1)	15.6 (1.1)	12.3 (0.9)	0.47
Race							
Mexican American	5.7 (0.7)	5.1 (1.0)	8.5 (1.2)	7.2 (1.1)	8.1 (0.9)	7.8 (0.8)	0.06

Other Hispanic	8.7 (0.9)	7.8 (0.9)	8.6 (1.6)	7.3 (0.6)	11.9 (1.6)	10.2 (1.4)	0.37
White	10.2 (0.7)	10.3 (0.5)	9.4 (0.9)	12.1 (0.8)	13.3 (0.8)	11.1 (0.8)	0.45
Black	4.3 (0.8)	4.4 (0.6)	4.3 (0.5)	5.2 (0.6)	6.4 (0.5)	5.8 (0.6)	0.14
Other / multi race	5.9 (1.8)	6.0 (1.5)	7.0 (1.0)	5.8 (0.8)	8.9 (1.7)	8.6 (1.0)	0.24

*Values are percent (standard error).