Understanding the relationship between health insurance and kidney stones: an examination of NHANES data

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BACHOUR K, REZAEE ME, SWANTON AR, PAIS JR VM. Understanding the relationship between health insurance and kidney stones: an examination of NHANES data. *Can J Urol* 2020;27(3):10238-10243.

Introduction: *To investigate the relationship between socioeconomic factors, specifically insurance status, and kidney stones using a nationally representative cohort.*

Materials and methods: *A retrospective secondary data analysis of National Health and Nutrition Examination Survey (NHANES) data from 2007 to 2014 was performed. Using univariate statistics and multiple logistic regressions, we examined the relationship between socioeconomic factors and kidney stone history.*

Results: *The weighted national prevalence of nephrolithiasis between ages 20 and 64 was 7.7% of a population of over 95.3 million. Fifty-three percent of the total population was female. The mean age was 42 years and the mean body mass index (BMI) was 28.7. The prevalence of nephrolithiasis was higher among individuals who had state-assisted insurance compared to those with private insurance (10.3% versus 7.3%, p = 0.005). On univariate regression analysis, having a college education was protective against stones compared to having less than a high-school degree (OR 0.62, 95% CI 0.43-0.84; p = 0.009). Income was also significantly associated with kidney stone prevalence. After adjusting for race, BMI, gender, water intake, income, and education level through multivariable analysis, having private insurance was associated with lower odds of developing nephrolithiasis compared to having state-assisted insurance (OR 0.62, 95% CI 0.44-0.89; p = 0.01).*

Conclusions: *Individuals with state-assisted insurance were found to have significantly increased odds of a kidney stone compared to those with private insurance. Urologists, primary care, and policy makers should recognize this disparity exists and target opportunities to elucidate mechanisms and provide intervention for this high-risk group.*

Key Words: nephrolithiasis, socioeconomic status, insurance, epidemiology, survey data

Introduction

The prevalence of kidney stones in the United States (U.S.) is approximately 8.8%, with more men (11%) experiencing stones compared to women (8%).[1] Symptomatic stones can cause significant patient morbidity, including hematuria, urinary tract infections, hydronephrosis, flank pain/renal colic, and even life-threatening sepsis. The burden of stone disease to the U.S. healthcare system is immense, accounting for over 2 billion dollars in healthcare costs per year.[2]

Accepted for publication January 2020

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Kidney stone formation is associated with lifestyle factors including limited water intake, consumption of diets rich in salt and animal protein, living in warmer climates, as well as multiple chronic conditions such as obesity.[2-4] Many lifestyle choices are influenced by socioeconomic factors, such as income and insurance. Socioeconomic status (SES) is a predictor of poorer health outcomes overall.[5,6] With respect to stone disease specifically, prior research has demonstrated a significant relationship between lower SES and increased risk of developing kidney stones in select populations. For example, compared to patients with private insurance, patients with state-assisted insurance have been shown to have increased urine pH, sodium, and calcium phosphate, as well as a higher likelihood of calcium phosphate stone formation.[7] Similar results have been observed among patients with lower educational obtainment and poverty status.[8]

Limited research evaluating the relationship between SES and kidney stones has been conducted at the national level. Such research would provide clinicians and public health professionals with a better understanding of which patients are at high-risk for stone disease. Therefore, the purpose of this study was to evaluate the relationship between SES, including income, education and insurance, and kidney stones using a large nationally-representative cohort of patients.

Materials and methods

Study population

The National Health and Nutrition Examination Survey (NHANES) is a federal program governed by the Centers for Disease Control and Prevention (CDC) that utilizes a series of interviews, physical exams, and laboratory studies to assess the health and nutritional status of the U.S. population.[9] The program collects information on diet habits, demographics, socioeconomics, physical examination findings and other health parameters for national research and health policy purposes. We conducted a retrospective secondary analysis of NHANES data from 2007-2014, years that the program collected information on kidney stone history. We limited our analysis to adult respondents aged 20 to < 65 years. The survey is approved by the National Center for Health Statistics (NCHS) ethics review board. Given that NHANES data is publicly available, institutional review board approval was not pursued for this project. However, this research as conducted in accordance with the Declaration of Helsinki.[10]

Outcomes

Our primary outcome of interest was history of a kidney stone. Respondents with a history of a kidney stone were identified by a "yes" response to the interview question, "Have you ever had a kidney stone?". Several variables were used as proxies for SES to evaluate their relationship with kidney stones, including insurance type, education level, and income level. Additional covariates included age, gender, race (white, black, Hispanic, and other), and body mass index (BMI). BMI between 30 and < 35 was defined at Obese Class 1, between 35 and < 40 as Obese Class 2, and > 40 as Obese Class 3. In regard to insurance type, the state-assisted group was comprised of patients with Medicaid and state-sponsored plans, while the private group had privately sponsored health plans. Medicare patients were excluded from the study as our primary goal was to investigate how socioeconomic factors, specifically insurance, may be associated with kidney stones. We excluded Medicare patients because these individuals became eligible for this insurance due to their age.

Statistical analysis

Sample weights and strata were applied from the NCHS to ensure that the results would accurately represent the U.S. population. Only individuals with complete information on kidney stone history were included in the analysis. Descriptive statistics, including Chi-square analysis and univariate logistic regression, were used to examine the crude relationship between SES factors and history of kidney stones. Multivariable logistic regression was used to assess the relationship between SES variables and history of kidney stones while controlling for confounders. Results with a p value < 0.05 were considered to be statistically significant. Statistical analyses were performed using Stata 13 (StataCorp, College Station, TX, USA).

Results

Baseline characteristics

The study cohort consisted of 8,259 respondents who were either on state-assisted insurance or private insurance weighted to represent the U.S. population of 95,253,653 individuals. Baseline characteristics were examined by kidney stone history status, see Table 1. There was no difference in prevalence of kidney stones among both genders. Individuals with kidney stones were older ($p < 0.001$) and were more likely to be obese ($p = 0.003$). Kidney stones were also more prevalent in whites than in blacks, Hispanics, Asians, and other races ($p < 0.001$) - 81% of individuals with a history of a kidney stone were white. Educational level was significantly different between the two groups. Individuals with a history of a kidney stone were less likely to have completed a college graduate degree or above (38.7 versus 36.8; $p = 0.02$). Similarly, there were significant differences among income levels. Individuals with a history of a kidney stone were less likely to have an income over $100,000 (32.4 versus 25.8; $p = 0.03$). Water intake was significantly different between the two groups ($p = 0.03$). We found that individuals with state-assisted insurance were more likely to have a history of kidney stone (16.0 versus 11.6; $p = 0.005$).

Multivariate logistic regression

After adjustment for age, race, gender, BMI class, income, education, and water intake, see Table 2, individuals with private insurance had 37% decreased odds of having a kidney stone compared to those with state-

TABLE 1. **Baseline characteristics of study cohort**

Variable	Kidney stones		p value
	No, n = 7,668	Yes, n = 591	
Gender (%)			0.22
Male	46.4	49.7	
Female	53.6	50.3	
Chronic medical conditions (%)			< 0.001
No	70.5	55.6	
Yes	29.5	44.4	
Body mass index %			0.003
Normal	30.1	19.8	
Overweight	33.0	33.1	
Obese class 1	19.1	25.4	
Obese class 2	8.4	10.4	
Obese class 3	9.4	11.3	
Race %			< 0.001
White	71.4	81.1	
Black	11.5	5.9	
Hispanic	9.8	8.2	
Other	7.3	4.8	
Age %			< 0.001
20-34	31.5	17.3	
35-49	36.1	38.2	
50-64	32.4	44.5	
Education %			0.02
Less than high school diploma	11.3	14.3	
High school diploma	20.0	23.5	
Some college	31.9	33.6	
College graduate or above	36.8	28.7	
Income %			0.03
0-24,999 $	13.3	14.4	
25,000-99,999 $	54.3	59.7	
Over 100,000 $	32.4	25.8	
Water %			0.03
Less than 1 cup	21.4	26.1	
Between 1 cups-3 cups	17.4	20.5	
Between 3 cups-8 cups	33.3	29.6	
More than 8 cups	27.9	23.7	
Insurance type %			0.005
State-assisted	11.6	16.0	
Private	88.4	84.0	

assisted insurance (OR 0.62, 95% CI 0.44-0.89; p = 0.01). Female gender did not impact the odds of having a history of kidney stones (OR 0.88, 95% CI 0.68-1.12; p = 0.29). Compared to normal BMI, individuals who were Obese Class 1 (OR 1.59, 95% CI 1.11-2.29; p = 0.013) and Class 3 (OR 1.75, 95% CI 1.21-2.53; p = 0.004) had significantly increased odds of having a history of kidney stones. Similarly, compared to those in the age group from 20 to 34, those between 35 and 49 (OR 1.91, 95% CI 1.42-2.57; p < 0.001) and those between 50 and 64 (OR 2.20, 95% CI 1.62-2.99; p < 0.001) had significantly increased odds of history of a kidney stone. Compared

TABLE 2. **Multivariable regression model for nephrolithiasis**

Variable	Crude odds ratio	95% confidence interval	Adjusted odds ratio	95% confidence interval
Gender				
Male	Ref	-	Ref	-
Female	0.88	0.71-1.08	0.88	0.68-1.12
Body mass index				
Normal	Ref	-	Ref	-
Overweight	1.52	1.05-2.21	1.30	0.92-1.84
Obese class 1	2.02	1.37-2.96	1.59	1.11-2.29
Obese class 2	1.88	1.23-2.86	1.45	0.96-2.19
Obese class 3	1.83	1.27-2.63	1.75	1.21-2.43
Race				
Hispanic	Ref	-	Ref	-
Black	0.60	0.43-0.84	0.54	0.38-0.78
White	1.35	1.05-1.76	1.47	1.12-1.93
Other	0.79	0.47-1.30	1.01	0.57-1.80
Age				
20-34	Ref	-	Ref	-
35-49	1.92	1.44-2.56	1.91	1.42-2.57
50-64	2.49	1.84-3.63	2.20	1.62-3.00
Education				
Less than high school diploma	Ref	-	Ref	-
High school diploma	0.94	0.71-1.24	0.92	0.65-1.30
Some college	0.84	0.63-1.11	0.94	0.66-1.36
College graduate or above	0.62	0.43-0.88	0.71	0.47-1.07
Income				
0-24,999 $	Ref	-	Ref	-
25,000-99,999 $	1.01	0.79-1.29	1.13	0.87-1.48
Over 100,000 $	0.73	0.53-1.01	0.84	0.60-1.17
Water				
Less than 1 cup	Ref	-	Ref	-
Between 1-3 cups	0.97	0.70-1.35	1.12	0.79-1.59
Between 3-8 cups	0.73	0.53-1.01	0.84	0.60-1.17
More than 8 cups	0.70	0.50-0.96	0.82	0.57-1.18
Insurance type				
State-assisted	Ref	-	Ref	-

to Hispanics, individuals that were white had 47% increased odds of a kidney stone (OR 1.47 95% CI 1.12-1.93; p = 0.006) while individuals that were black had decreased odds by 46% (OR 0.54, 95% CI 0.38-0.78; p = 0.002). Education and income did not impact the odds of having a kidney stone on multivariate adjustment.

Discussion

Lower socioeconomic status has been well established as a risk factor for the development of chronic disease and poorer health outcomes. Studies have shown that lower SES increases risk of cardiovascular disease, metabolic syndrome, cerebral vascular disease and other chronic conditions.[11-13] Our study examined the association between SES factors and self-reported history of kidney stones. We found that individuals with private insurance had significantly decreased odds of reporting a history of kidney stones compared to individuals with state-insurance. We also found that income and education status were associated with kidney stones, but these findings were not significant in multivariable models.

We observed a significant inverse relationship between private insurance and a self-reported history of a kidney stone, which is consistent with what other studies have observed. Looking at types of stones, Herrick et al found that individuals with state insurance were more likely to develop calcium phosphate stones compared to those with private insurance.[7] Patients with state insurance have also been shown to have higher urinary pH, sodium and calcium phosphate levels; all of which can increase risk of stone formation.[7,14,15] The biochemical etiology of this relationship may be explained by both factors associated with lower insurance coverage as well as the implications of lower coverage.

Private health insurance is associated with improved healthcare access, quality and patient outcomes.[16] Many studies have shown that patients with Medicaid insurance experience consistently worse health outcomes compared to those with private insurance.[17,18] This disparity may be explained by the fact that individuals with Medicaid are more limited in accessing adequate healthcare compared to their privately insured counterparts. Private insurance, which is associated with expanded coverage, has been shown to boost access to preventive healthcare and decrease the incidence of and complications-associated with certain chronic conditions that may increase kidney stone risk.[19] Privately insured individuals are also more likely to be employed, physically active, healthy, and of higher economic status, which are characteristics considered to be protective of kidney formation. Therefore, factors associated with private insurance may help explain why we found that individuals with private insurance had significantly decreased odds of having a history of kidney stones compared to those with state-assisted insurance. Further investigation into the relationship between insurance and odds of kidney stones is warranted to not only understand the limitations of state-assisted insurance in preventing and mitigating risk factors associated with kidney stone formation, but to additionally assess the underlying socioeconomic determinants of health and disease for which insurance status may simply serve as surrogate.

While our univariate analysis revealed an inverse relationship between income and self-reported kidney stone history, our multivariable model did not. This may be explained by our adjustment for BMI as some studies have found a strong correlation between obesity and income levels.[20] Obesity has also been shown to be associated with stone disease, specifically with respect to central adiposity and high waist-to-hip ratios.[21] Other studies have also looked at BMI and reported a significant increase in relative risk of stone disease with higher BMIs, which is consistent with our findings.[22] A possible explanation to this link is that subjects with higher BMIs excrete higher amounts of urinary oxalate, uric acid, sodium, and phosphate and have a lower pH.[2] Furthermore, lower income status has previously been demonstrated to be associated with poorer health outcomes in multiple studies. However, we did not observe a significant relationship between income status and kidney stones in adjusted analyses. Therefore, income alone may be less important in understanding kidney stone risk.

We did not find a significant relationship between education level and a history of a kidney stone. Prior studies have found that patients with higher education levels are more likely to be involved in health planning and be at lower risk of kidney stone formation.[23] However, we found no relationship between education level and a history kidney stones. There are likely numerous etiologies behind this finding. For example, individuals with lower educational obtainment may obtain their private insurance through a spouse with higher educational obtainment. There are also many occupations that offer private insurance but do not require higher degrees for employment. Although education level is associated with better health literacy and overall health status and was associated with stone disease on univariate analysis, we did not observe a relationship between education and kidney stones on multivariate analysis.

Our study had limitations that must be considered when interpreting the results. As a retrospective study, it has inherent biases. While we attempted to account for any confounders with our multivariable model, factors such as urine composition were not available. Additionally, geographical location was not available to us, which is a known risk factor for stone formation (e.g. regional climate). Additionally, our data collection was primarily based on a self-reported questionnaire, which may be subject to both recall bias and selection bias. We also only looked at history of a kidney stone and not the composition of stones or number of stones, which might have also impacted our data. Finally, as a cross sectional study, temporality cannot be assessed. Although the association remains, it is conceivable that those with stone disease may for a myriad of reasons be less likely to receive private insurance and thus be recipients of state-assisted insurance. Nevertheless, our findings still hold significance as they represent a large national cohort of individuals.

Conclusion

Individuals with state-assisted insurance were found to have significantly increased odds of a kidney stone compared to those with private insurance. Although many factors may drive this association, our findings suggest that those with state assisted insurance may particularly benefit from preventive efforts. Future research is needed to understand why this disparity in kidney stone formation exists and how it can be prevented and mitigated. Urologists, primary care physicians, and policy makers should understand that this disparity exists and work to identify, educate, and intervene on patients at higher risk of stone formation. □

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