Influence of Socioeconomic Factors on Stone Burden at Presentation to Tertiary Referral Center: Data From the Registry for Stones of the Kidney and Ureter

David B. Bayne, Manint Usawachintachit, Manuel Armas-Phan, David T. Tzou, Scott Wiener, Timothy T. Brown, Marshall Stoller, and Thomas L. Chi

OBJECTIVE To determine social factors associated with advanced stone disease (defined as unilateral stone burden >2 cm) at time of presentation to a regional stone referral center. Little is known about social determinants of urolithiasis. We hypothesize that socioeconomic factors impact kidney stone severity at intake to referral centers.

METHODS A retrospective review of the prospectively collected data from the Registry for Stones of the Kidney and Ureter from 2015 to 2018 was conducted to evaluate patient characteristics predictive of having a large (>2 cm) unilateral kidney stone. Data on patient age, gender, body mass index, diabetes, race, language, education level, infection, distance, income, referring regional urologist density, American Society of Anesthesiologists score, and stone analysis were evaluated.

RESULTS Complete imaging and patient variable data was present in 650 of 1142 patients including 197 patients with unilateral stone burden >2 cm. On multivariate analysis, obesity, lower education level, increased distance from the referral center, and symptoms of infection predicted for unilateral stone burden greater than 2 cm. Among 191 patients with stone analysis data present, stone type, income, and urologist density predicted for unilateral stone burden greater than 2 cm.

CONCLUSION In addition to known biological risk factors, patients with lower education levels and from regions of lower mean income were found to be more likely to present to our tertiary care center with stone burden greater than 2 cm. More research is needed to elucidate the social and societal determinants of advanced stone disease and the impact this has on population costs for stone treatment. UROLOGY 131: 57−63, 2019. Published by Elsevier Inc.

Large, untreated kidney stones are a known risk factor for renal failure, infection, and death.[1] Kidney stone disease has increased in prevalence over the past several decades and is now estimated to be as high as 8.4%.[2,3] This is associated with up to 4.5 billion dollars in health care costs.[4-6] Multiple factors have been implicated in the etiology of kidney stone disease including diet,[7] elevated body mass index (BMI),[8] infection,[9,10] and elements of the metabolic syndrome.[11] Ambient temperature also may be associated with propensity to form kidney stones.[12,13]

Funding Support: *This study was supported by NIH funding:* NIH P20-DK-100863; *This funding played no role in the study design, collection, analysis, interpretation, writing and decision to submit the manuscript.*

From the University of California San Francisco, Urology, San Francisco, CA; the King Chulalongkorn Memorial Hospital, Bangkok, Thailand; the University of Arizona College of Medicine, Tucson, AZ; and the University of California, Berkeley, School of Public Health, Berkeley, CA

Address correspondence to: David Bayne, MD, MPH, University of California San Francisco, Urology, 400 Parnassus Ave, 6th floor Urology Clinics A638, San Francisco, CA 94143. E-mail: david.bayne@ucsf.edu

Submitted: February 27, 2019, accepted (with revisions): May 16, 2019

Although a connection between urinary tract infections and larger staghorn configured stones has been described,[9,10] there is limited information as to what additional factors contribute to presentation with advanced stone burden. This is an important consideration given that patients who present with large stone burden require more invasive surgical intervention and/or multiple procedures for stone removal, often at tertiary care referral centers. Typically a cut off of 2 cm stone burden dictates whether shockwave lithotripsy or ureteroscopy vs percutaneous nephrolithotomy (PCNL) is the recommended intervention based on urological guidelines.[14] An understanding of patient factors associated with large stone burden among the tertiary referral population provides insight into which patients present with stone disease that may be more expeditiously treated at tertiary referral centers. It also provides insight into the characteristics that predict for preferential referral to tertiary care by primary care physicians and urologists practicing in a community setting.

Published by Elsevier Inc. https://doi.org/10.1016/j.urology.2019.05.009
0090-4295

We hypothesize that in addition to known biological and environmental factors, societal and economic factors impact kidney stone size at presentation to surgical referral centers. Our objective was to determine patient characteristics associated with large stone burden at time of presentation to tertiary care. It is our hope that this will better elucidate which patients are at high risk for large stones due to societal and environmental circumstances, and in doing so uncover a target population that may benefit dramatically from improved diagnostic efforts and surgical expediency in the treatment of stone disease.

METHODS

A retrospective review of patient intake data from the Registry for Stones of the Kidney and Ureter (ReSKU) from 2015 to 2018 was conducted to evaluate patient characteristics predictive of large unilateral kidney stone burden at time of diagnostic stone imaging. This prospectively collected registry records patient metrics on an ongoing basis and is integrated into the electronic medical record system.[15] The ReSKU study has been approved by the Committee on Human Research (Protocol 14-14533). Our primary outcome was total unilateral stone burden greater than 2 cm in diameter as measured by commuted tomography, X-ray, and/or ultrasound. Data on patient age, gender, race, education level, BMI, infection symptoms, American Society of Anesthesiologists (ASA) score, stone analysis, mean income based on tax return data by zip code, travel distance to referral center, primary spoken language, and history of previous stone surgery were included in our analysis. Obesity was defined as a BMI greater than 30. Patients who reported recurrent symptoms of fever, pyelonephritis, and/or urinary tract infection prior to or at any point since the diagnosis of their kidney stone per intake history were classified as having symptoms of infection associated with their stone episode. Further details on patient education data, race, income data, stone burden data, urologist density, distance traveled, imaging modalities, and outcome determinants are available in our Supplementary Materials section.

Statistical Analysis

Univariate analysis was performed using Fisher's exact test. Multivariate analysis was performed using logistic regression and robust standard errors were used to construct 95% confidence intervals. In our multivariate analysis, Type 1 and Type 2 diabetes were combined as one variable to obtain adequate sample sizes. This is medically appropriate given both types of diabetes are implicated in metabolic syndrome.[16] Multivariate analysis was also performed for the subgroup of patients with data available for stone analysis type and ASA score. In our multivariate analysis, adjustments were made for patient age, gender, race, education level, BMI, infection symptoms, ASA score, stone analysis, mean income based on tax return data by zip code, travel distance to referral center, primary spoken language, and history of previous stone surgery. Further details on our multivariate model are included in the Supplementary Materials section. Statistical analysis was performed using R version 3.5.0 and Stata 15.1.

RESULTS

Imaging data were present in 792 of 1142 total registry patients. Complete data was available on 650 patients. Of these patients, 197 presented with unilateral stone burden greater than 2 cm. Our mean patient age was 53.9 with a range of 3-97. Only 4 patients were less than 18. In total, 49.8% of our patients were female. Mean BMI was 28.4 with a range of 14.6-60.7. Furthermore, 36.3% of our patients were non-White (3.5% Black, 10% Latino or Hispanic, 4.9% Chinese, 3.1% Non-Chinese East Asian, and 4.3% Southeast Asian or South Asian, 6.6% other, 3.9% American Indian/Alaskan Native, Native Hawaiian/ Pacific Islander, or Middle Eastern/Arab American) and 26.7% of our patients had a high school education or less. Additionally, 12.3% of patients did not speak English as a primary language. Mean distance from patient zip code to the referral center was 50.8 miles with a range of 0-508 (Table 1).

Overall, 8.5% of patients had asymptomatic kidney stones, and there was no statistically significant difference in asymptomatic stone frequency comparing patients with unilateral stone burden greater than 2 cm and stones less than or equal to 2 cm (8.2% vs 9.2% respectively, $P = 0.649$). Frequency of type 2 diabetes was 11.5% among patients with unilateral stone burden less than or equal to 2 cm and 20.8% among patients with unilateral stone burden greater than 2 cm ($P = 0.002$). Women ($P = 0.005$), obese patients ($P < .001$), patients with lower education levels ($P < .001$), lower income based on zip code ($P < .001$), those with primary language other than English ($P = 0.004$), patients living greater distances from the referral center ($P < .001$), patients living in counties with lower urologist density ($P < .001$), patients with symptoms of infection ($P < .001$), and those with prior surgery for kidney stones ($P = 0.001$) were more likely to present with a unilateral stone burden greater than 2 cm on univariate analysis (Table 2, Fig. 1A).

On multivariate analysis, obesity ($P = 0.003$; OR 1.81, 1.216-2.692), lower education level ($P = 0.005$; OR 1.905, 1.213-2.992), increased distance from the referral center ($P = 0.001$; OR 2.735, 1.535-4.873), and associated symptoms of infection ($P = 0.001$; OR 1.913, 1.188-3.079) predicted for unilateral stone burden greater than 2 cm (Table 3, Fig. 1B).

Stone analysis data were available in 191 patients. There were 125 patients with calcium oxalate predominant stones. 19 patients had calcium phosphate stones, 18 patients had carbon apatite stones, 17 patients had uric acid stones, 7 patients had struvite stones, 2 patients had cystine stones, and 3 had stones categorized as other. Within this subgroup of patients with available stone analysis data, 52% of stone formers with unilateral stone burden greater than 2 cm had calcium oxalate stones while 76% of stone formers with stone burden less than or equal to 2 cm had calcium oxalate stones ($P = <.001$). Struvite was predominant in 2% patients with stone burden less than or equal to 2 cm vs 6% of patients with stones greater than 2 cm ($P = .245$). For uric acid predominant stones, frequencies were 8% vs 11% in small vs large stone burden cases ($P = .610$). For calcium phosphate, frequencies were 7% vs 14% ($P = .094$), and for carbon apatite frequencies were 6% vs 14% ($P = .079$) in small vs large stone burden cases, respectively.

ASA data were also available in this subset of 191 patients given these were patients who underwent surgery and therefore were evaluated preoperatively by an anesthesiologist. Frequency of ASA score of 3 or higher was 18% among patients with stone burden less than or equal to 2 cm and 27% among patients with stone burden greater than 2 cm ($P = .160$).

In the subgroup of patients where stone analysis and ASA data were available, multivariate analysis showed that when considering all other variables in our model, only noncalcium

Table 1. Patient characteristics comparing patients with and without total stone burden >2 cm at diagnosis

	Stone ≤ 2 cm (Total = 453)	Stone > 2 cm (Total = 197)
Mean ± standard deviation (range)		
Age	53.7 ± 15.8 (3-97)	54.4 ± 16.6 (16-91)
BMI	27.5 ± 6.6 (14.9-58.9)	30.4 ± 8.2 (14.6-60.7)
Distance	37.9 ± 68.2 (0-508)	80.6 ± 72.3 (0-384.8)
Urologist density per 100,000 (range)	4.97 ± 2.17 (0-6.96)	3.12 ± 1.96 (0-6.96)
Stone size (in cm)	0.86 ± 0.47 (0.10-2.00)	3.85 ± 2.37 (2.00-15.00)

BMI, body mass index.

Table 2. Univariate analysis of patient characteristics comparing patients with and without total stone burden >2 cm at diagnosis

	Stone ≤ 2 cm Percent of Total (n = 453)	Stone > 2 cm Percent of Total (n = 197)	*P* Value
Variable			
Age >65	24.7%	27.4%	.494
Female gender	46.1%	58.4%	.005
BMI >30	25.4%	44.7%	<.001
Type 1 diabetes	2.2%	5.1%	.080
Type 2 diabetes	11.5%	20.8%	.002
Diabetes	11.7%	21.3%	.002
Hyperlipidemia	22.1%	16.8%	.139
Hypertension	26.5%	26.9%	.923
Non-White race	34.2%	41.1%	.110
High school education level or less	20.1%	41.6%	<.001
Some college	34.9%	23.4%	.004
Completed college	27.6%	12.7%	<.001
Graduate school	17.4%	22.3%	.157
English as second language	9.7%	18.3%	.004
Symptoms of infection	12.8%	29.4%	<.001
Asymptomatic	8.2%	9.2%	.649
<25th percentile distance from referral center	35.8%	9.1%	<.001
>75th percentile distance from referral center	15.0%	49.2%	<.001
>75th percentile zip code weighted income	31.6%	12.2%	<.001
<25th percentile zip code weighted income	18.1%	40.1%	<.001
>75th percentile urologist density per 100,000	49.4%	14.7%	<.001
<25th percentile urologist density per 100,000	11.9%	41.1%	<.001
History of prior kidney stone surgery	25.6%	38.6%	.001

oxalate stones (*P* = .008; odds ratio [OR] 2.672, 1.295-5.512), low income (*P* = .044; OR 2.375, 1.025-5.502), and low urologist density (*P* = 0.003; OR 4.877, 1.741-13.662) were significantly associated with stone burden >2 cm. Variables of age (*P* = .472), gender (*P* = .485), BMI >30 (*P* = .349), diabetes (*P* = .056), education (*P* = .205), infectious symptoms (*P* = .557), distance (*P* = .588), ASA score (*P* = .462), and a history of prior stone surgery (*P* = .435) were not found to be statistically associated with stone burden among this subgroup.

DISCUSSION

Here we demonstrate that socioeconomic factors influence stone burden at our center even after adjusting for patient biology, prior exposure to urological surgery, referral distance, and referring regional urologist density. Our primary analysis demonstrates that at our stone referral center, low education level is associated with increased stone burden at presentation, independent of patient age, gender, BMI, race, language, infection, distance from referral center, income level, urologist density, and prior history of urological surgery. Our subanalysis demonstrates that patients from low income areas presenting to our stone center were more likely to have stone burden greater than 2 cm independent of age, gender, BMI, diabetes, race, education level, infection, distance from referral center, urologist density, stone type on stone analysis, prior history of urological surgery, and ASA score. Although previous studies have shown the effect of socioeconomic status on dietary habits[17] and other lifestyle factors in stone formers,[18] no prior studies have shown a link between socioeconomic status and degree of stone burden.

Patient Biology

Stone occurrence is less frequent in women relative to men, but women are more likely to present with both infection-based struvite stones and calcium phosphate stones.[19,20,21] Struvite stones are more inclined to produce large staghorn-configured stones,[22] and women have been shown to produce heavier stones relative to men based on

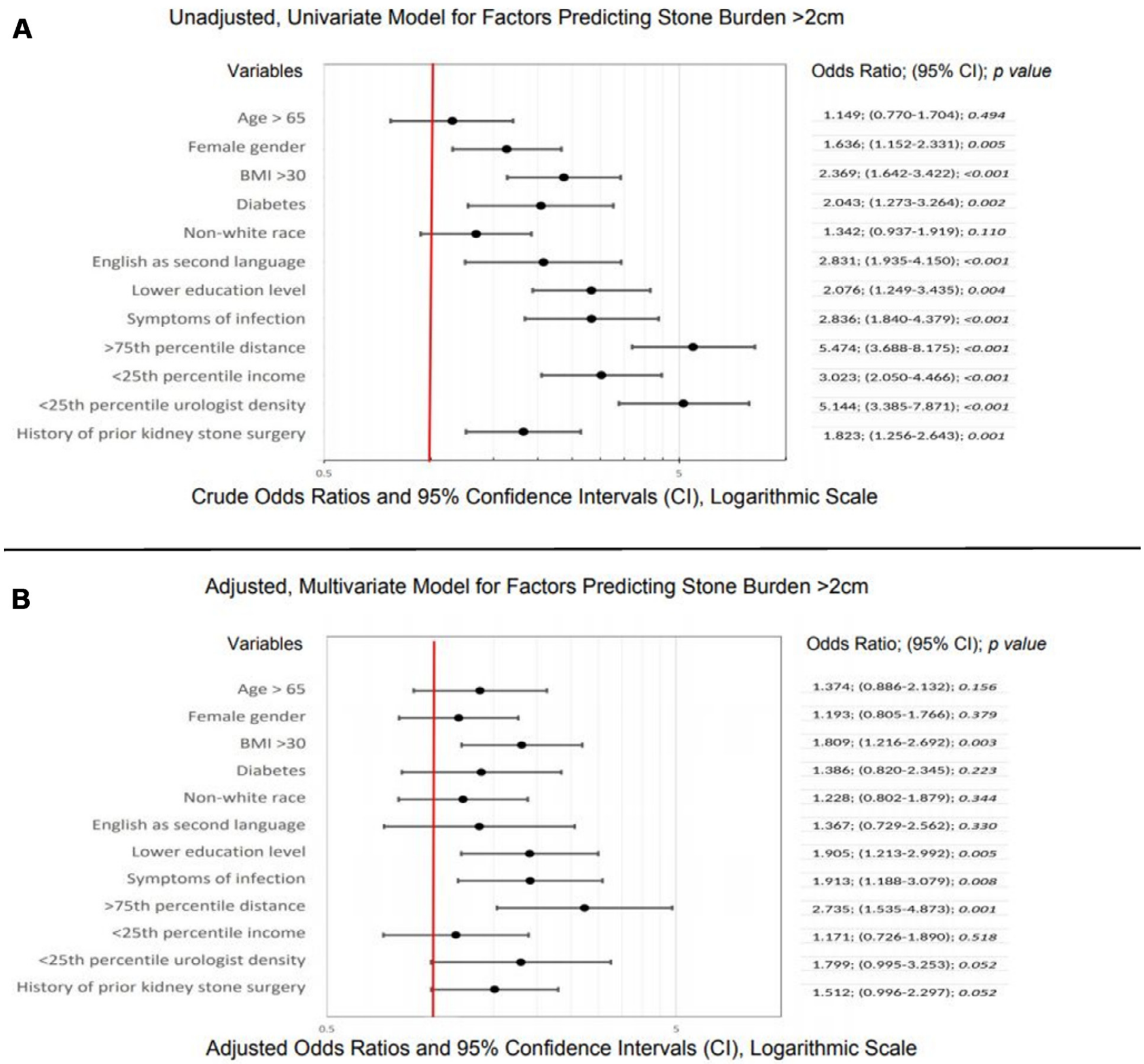

Figure 1. Variables associated with a stone burden >2 cm. (**A**) Forest plot of crude odds ratios for univariate model. (**B**) Forest plot of adjusted odds ratios from multiple regression analysis. For both models, dots represent the odds ratio and whiskers represent the 95% confidence interval. CI = confidence interval. (Color version available online.)

Table 3. Multivariate analysis of characteristics associated with stone burden >2 cm

Variable	Odds Ratio	95% CI		*P* Value
Age >65	1.374	0.886	2.132	.156
Female gender	1.193	0.805	1.766	.379
BMI >30	1.809	1.216	2.692	.003
Diabetes	1.386	0.820	2.345	.223
Non-White race	1.228	0.802	1.879	.344
English as second language	1.367	0.729	2.562	.330
Lower education level	1.905	1.213	2.992	.005
Symptoms of infection	1.913	1.188	3.079	.008
>75th percentile distance	2.735	1.535	4.873	.001
<25th percentile income	1.171	0.726	1.890	.518
<25th percentile urologist density	1.799	0.995	3.253	.052
History of prior kidney stone surgery	1.512	0.996	2.297	.052

their higher propensity to form calcium phosphate stones.[21] In our data set, large stone burden was more common in women on univariate analysis, but this did not carry over to multivariate analysis where other (potentially more potent) contributing variables, such as infection, were considered. In contrast, Infectious symptoms did associate with larger stone burden on both multivariate and univariate analysis.

Our smaller subgroup analysis incorporated stone type and ASA score, but this group was limited in size to only 191 operative patients. Gender and symptoms of infection were not associated with stone burden when adjusting for stone type in the multivariate model for this smaller subgroup. This suggests that properties intrinsic to the stone itself predominate over mere associates of stone type (such as gender and infection) when predicting for stone size.

Having a larger BMI also predicts for increased stone occurrence as demonstrated in previously published literature.[8,23] Metabolic syndrome traits such as diabetes mellitus, hypertension, and hyperlipidemia also have known correlation with kidney stone frequency.[11,24] In our analysis, obesity (BMI >30) was higher in large stone formers on both univariate and multivariate analysis. Diabetes was higher in patients with larger stone burden, but not in a statistically significant fashion on multivariate analysis. Other traits of metabolic syndrome such as hypertension and hyperlipidemia were not higher in large stone formers.

Referral Distance and Urologist Density

Multivariate analysis did reveal that living further from the stone referral center was associated with higher frequency of unilateral stone burden greater than 2 cm. This suggests that in addition to the biological characteristics of obesity and infection, factors impacting regional access to surgical care may be strong predictors of large stone disease. These patients coming from greater distances may only have access to local, smaller-practice urologists more likely to refer out larger (and therefore more complex) stone disease to high-volume specialists.

Urologists are disproportionately distributed in urban areas and greater than 60% of counties in the United States do not have urologists.[25] Improvements in clinical outcomes for urological diseases among patients living in regions with increased urologist density have been documented for urological cancers.[26] Consistent with this, in our dataset, patients coming from zip codes with lower urologist density were more likely to present with advanced stone disease on univariate analysis. In our subgroup, multivariate analysis showed that coming from a county with low urologist density is predictive of presentation to the urologist referral center with unilateral stone burden greater than 2 cm.

Socioeconomic Factors

Education level, markers of low income, and additional social factors predict for advanced presentation of oncologic diseases such as prostate cancer,[27,28] but have not been demonstrated in stone disease. Education level may explain a lower level of health care literacy that manifests as a reduced response to stone symptomatology and a less heightened understanding of the importance of seeking urgent medical attention. Previous studies have shown that greater than 50% of stone risk can be attributed to health modifiable risk factors.[18] Education level may associate with elements of health care literacy that correspond to these lifestyle factors.[17] It is also important to consider barriers that patients with lower income and lower education levels may face in accessing care, such as reduced trust in healthcare providers, limits in health insurance coverage, or increased work demands.[29] In addition, because of limited resources, urologists in areas of lower socioeconomic status may be less equipped to perform percutaneous procedures for large stones and as a result may be more inclined to refer out patients with large stone burden.

Education level and income both influenced stone size in our models independent of patient biology, referral distance traveled, and referring regional urologist density. Lower education level was strongly predictive of unilateral stone burden greater than 2 cm on multivariate analysis in our main patient population. Additional variables associated with lower socioeconomic status such as non-English primary language or race were not significant on multivariate analysis. This lack of significance on multivariate analysis was consistent even when race was broken down into more specific subgroups (see Supplementary Information). This may, in part, be explained by the association of potentially overshadowing factors of obesity and diabetes with racial and language associates of lower socioeconomic status.[30] The variables of obesity and diabetes may be the true drivers of increased stone burden in non-English speaking patients and in patients of non-White race. However, even when considering stone type, income level was associated with stone burden greater than 2 cm in our subgroup on multivariate analysis. There was no association found between stone burden and age, ASA score, diabetes, or obesity in this subgroup.

Limitations

This study is limited by lack of patients' insurance information. Higher education and higher income are likely a proxy for having more robust health insurance. In addition, patient insurance plans dictate reimbursement rates and carry mandated referral networks that likely affect urologist referral practices. Consequently, these factors may confound our findings. However, all patients referred to our center must have confirmation of some form of health insurance prior to referral. Another limitation is that patient income is based on mean income by zip code tax return data rather than patients' actual income. This results in random measurement error that can bias estimated parameters toward zero. This study analyzes data from a single tertiary referral center. Many patients in this study have come to our center after referral from their local urologist or primary care physician and do not reflect the general population of patients in the community upon initial presentation with stone disease. Nevertheless through a robust analysis that accounts for multiple variables associated with patient biology, social demographics, and the characteristics of their referring regions, this study highlights that markers of low socioeconomic status correlate independently with advanced stone disease among patients seen and treated at our stone center referral center.

Implications

Patients with advanced stone disease in the form of large stone burden require complex interventions which ultimately result in increased health care costs. In addition, stone size up to 2 cm correlates with worsening renal function.[31] Therefore, treating patients prior to their stones reaching 2 cm size may have dramatic effects on reducing health care costs associated with chronic kidney disease as well as patient morbidity from more invasive surgical procedures. It is not clear why patients of lower socioeconomic status seen at our stone referral center are disproportionately more likely to have large stones. This could be due to the possibility that these patients are less readily treated by local urologists in their regional communities. This may also be explained by delayed diagnosis of stone disease in these patients due to barriers in access to initial medical care for factors explained above. It would be inefficient to screen asymptomatic patients for nephrolithiasis, but it is possible that patients of lower socioeconomic status with symptomatic chronic stone disease (hematuria, recurrent urinary tract infections, flank pain, renal failure, etc) are at higher risk for delays in diagnosis and treatment of their kidney stones. This study may reveal a target population of patients at risk for delayed diagnosis and delayed treatment of stone disease that could benefit from improved awareness among health care providers. Our results also provide a foundation to advocate for the improvement of urologists' ability to treat large stones with expediency and efficiency, particularly for those urologists practicing in communities of lower socioeconomic status. Ultimately, more resources should be allocated to investigating the interaction of social factors and advanced stone disease.

Future Directions

To better understand the population of patients with stone burden greater than or equal to 2 cm, it would be meaningful to investigate how these patients present at the initial interface with the medical system prior to referral to tertiary referral centers. Given that some of these patients do undergo surgery prior to referral (see Supplementary Materials section), for future studies it would be informative to know whether adherence to stone surgery guidelines prior to referral differs based on patient socioeconomic status. Furthermore, differences in follow-up care and quality of life scores along socioeconomic levels would be important to investigate in future studies. Consequently, it is crucial to continue to follow patients and accrue prospective numbers needed to answer these related and relevant questions in future studies.

CONCLUSION

Patients with lower education levels and patients from lower income areas were found to be more likely to present at our stone referral center with stone burden greater than 2 cm relative to other patients even after adjusting for known biological risk factors, referral distance, and referring regional urologist density. This study is the first of its kind to demonstrate significant association between lower socioeconomic status and increased stone burden. More research is needed to elucidate the social and societal determinants of large stone burden and the opportunities for cost saving and morbidity reduction through more prompt diagnosis and treatment of high-risk patients.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.urology.2019.05.009.

References

1. Deutsch PG, Subramonian K. Conservative management of staghorn calculi : a single-centre experience. *BJU Int*. 2016:444–450. https://doi.org/10.1111/bju.13393.
2. Stamatelou KK, Francis ME, Jones CA, Nyberg LM, Curhan GC. Time trends in reported prevalence of kidney stones in the United States: 1976-1994. *Kidney Int*. 2003;63(5):1817–1823. https://doi.org/10.1046/j.1523-1755.2003.00917.x.
3. Scales Jr CD, Smith AC, Hanley JM, Saigal CS. Urologic diseases in America project. Prevalence of kidney stones in the United States. *Eur J Urol*. 2012;62:160–165. https://doi.org/10.1016/j.pestbp.2011.02.012.Investigations.
4. Pearle MS, Calhoun EA, Curhan GC. Urologic diseases in America project: urolithiasis. *J Urol*. 2005;173:848–857. https://doi.org/10.1097/01.ju.0000152082.14384.d7.
5. Antonelli JA, Maalouf NM, Pearle MS, Lotan Y. Use of the national health and nutrition examination survey to calculate the impact of obesity and diabetes on cost and prevalence of urolithiasis in 2030. *Eur Urol*. 2014;66:724–729. https://doi.org/10.1016/j.eururo.2014.06.036.
6. Saigal CS, Joyce G, Timilsina AR. Urologic diseases in America project. Direct and indirect costs of nephrolithiasis in an employed population: opportunity for disease management? *Kidney Int*. 2005;68:1808–1814.
7. Turney BW, Appleby PN, Reynard JM, Noble JG, Key TJ, Allen NE. Diet and risk of kidney stones in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC). *Eur J Epidemiol*. 2014;29:363–369. https://doi.org/10.1007/s10654-014-9904-5.
8. Taylor EN, Stampfer MJ, Curhan GC. Obesity, weight gain, and the risk of kidney stones. *JAMA*. 2005;293:455–462.
9. Mariappan P, Smith G, Moussa SA, Tolley DA. One week of ciprofloxacin before percutaneous nephrolithotomy significantly reduces upper tract infection and urosepsis : a prospective controlled study. *BJU Int*. 2006;98:1075–1079. https://doi.org/10.1111/j.1464-410X.2006.06450.x.
10. Shigeta M, Hayashi M, Igawa M. A clinical study of upper urinary tract calculi treated with extracorporeal shockwave lithotripsy : association with bacteriuria before treatment. *Urol Int*. 1995;730:214–216.

11. Wong Y, Cook P, Roderick P, Somani BK. Metabolic syndrome and kidney stone disease: a systemic review of literature. *J Endourol.* 2016;30:246–253. https://doi.org/10.1089/end.2015.0567.
12. Fakheri RJ, Goldfarb DS. Ambient temperature as a contributor to kidney stone formation : implications of global warming. *Kidney Int.* 2011;79:1178–1185. https://doi.org/10.1038/ki.2011.76.
13. Brikowski TH, Lotan Y, Pearle MS. Climate-related increase in the prevalence of urolithiasis in the United States. *Proc Natl Acad Sci USA.* 2008;105:9841–9846.
14. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American Urological Association/Endourological Society Guideline, Part I. *J Urol.* 2016;196:1153–1160.
15. Chang HC, Tzou DT, Hsi RS, Harper JD, Sorensen MD, Stoller ML. Rationale and design of the Registry for Stones of the Kidney and Ureter (ReSKU): a prospective observational registry to study the natural history of urolithiasis patients. *J Endourol.* 2016;30: 1332–1338. https://doi.org/10.1089/end.2016.0648.
16. Chillarón JJ, Le-roux JAF, Benaiges D, Pedro-botet J. Type 1 diabetes, metabolic syndrome and cardiovascular risk. *Metabolism.* 2014; 63:181–187. https://doi.org/10.1016/j.metabol.2013.10.002.
17. Saint Elie DT, Patel PV, Healy KA, et al. The impact of income and education on dietary habits in stone formers. *Urology.* 2010; 76:307–313.
18. Ferraro PM, Taylor EN, Gambaro G, Curhan GC. urolithiasis/endourology dietary and lifestyle risk factors associated with incident kidney stones in men and women. *J Urol.* 2017;198:858–863. https://doi.org/10.1016/j.juro.2017.03.124.
19. Lieske JC, Rule AD, Krambeck AE, et al. Stone composition as a function of age and sex. *Clin J Am Soc Nephrol.* 2014;9:2141–2146. https://doi.org/10.2215/CJN.05660614.
20. Daudon M, Dore J-C, Jungers P, Lacour B. Changes in stone composition according to age and gender of patients : a multivariate epidemiological approach. *Urol Res.* 2004;32:241–247. https://doi.org/10.1007/s00240-004-0421-y.
21. Gualt MH, Chafe L. Relationship of frequency, age, sex, stone weight and composition in 15,624 stones: comparison of results for 1980 to 1983 and 1995 to 1998. *J Urol.* 2000;164:302–307.
22. Viprakait DP, Sawyer MD, Herrell SD, Miller NL. Changing composition of staghorn calculi. *J Urol.* 2011;186:2285–2290. https://doi.org/10.1016/j.juro.2011.07.089.
23. Curhan G, Willett W, Rimm E, Speizer F, Stampfer M. Body size and risk of kidney stones. *J Am Soc Nephrol.* 1998;9:1645–1652.
24. West B, Luke A, Durazo Arvizu RA, Cao G, Shoham D, Kramer H. Metabolic syndrome and self-reported history of kidney stones: the National Health and Nutrition Examination Survey (NHANES III) 1988-1994. *Am J Kidney Dis.* 2008;51:741–747. https://doi.org/10.1053/j.ajkd.2007.12.030.
25. Odisho AY, Fradet V, Cooperberg MR, Ahmad AE, Carroll PR. Outcomes/epidemiology/socioeconomics geographic distribution of urologists throughout the United States using a county level approach. *J Urol.* 2009;181:760–766. https://doi.org/10.1016/j.juro.2008.10.034.
26. Odisho AY, Cooperberg MR, Fradet V, Ahmad AE, Carroll PR. Urologist density and county-level urologic cancer mortality. *J Clin Oncol.* 2010;28:2499–2504. https://doi.org/10.1200/JCO.2009.26.9597.
27. Porten SP, Richardson DA, Odisho AY, Mcaninch JW, Carroll PR, Cooperberg MR. Oncology : Prostate/testis/penis/urethra disproportionate presentation of high risk prostate cancer in a safety net health system. *J Urol.* 2010;184:1931–1936. https://doi.org/10.1016/j.juro.2010.06.116.
28. Derouen MC, Schupp CW, Yang J, et al. Impact of individual and neighborhood factors on socioeconomic disparities in localized and advanced prostate cancer risk. *Cancer Causes Control.* 2018;29: 951–966. https://doi.org/10.1007/s10552-018-1071.
29. Fiscella K, Franks P, Gold MR, Clancy CM. Inequality in quality: addressing socioeconomic, racial, and ethnic disparities in health care. *JAMA.* 2000;283:2579–2584.
30. Kurian AK, Cardarelli KM. Racial and ethnic differences in cardiovascular disease risk factors: a systematic review. *Ethn Dis.* 2007; 17:143–152.
31. Ahmadi F, Etemadi SM, Lessan-pezeshki M, et al. Clinical investigation contribution of stone size to chronic kidney disease in kidney stone formers. *Int J Urol.* 2015;22:104–108. https://doi.org/10.1111/iju.12606.