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## Social Determinants of Kidney Stone Disease: The Impact of Race, Income and Access on Urolithiasis Treatment and Outcomes

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### Abstract

The medical and surgical management of kidney stones is one of the most common functions of the urologist. Management choices are often nuanced, involving the decision to embark on one surgical plan among several options. As the wider medical community critically evaluates the care we provide to an increasingly diverse population, it will be important to examine patient outcomes with a particular focus on ensuring equitable care. This review examines the influence of social parameters on the care of kidney stone patients. The dearth of literature in this area warrants rigorous studies on the relationship between race as well as socioeconomic status and the management of kidney stone disease.

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Socioeconomic status (SES) and race have been demonstrated to impact urologic conditions. The best-known example of this is with prostate cancer. Markers of low neighborhood SES correlate with advanced prostate cancer risk.<sup>1</sup> In multiple studies, non-white/black or underinsured populations present with more advanced prostate cancer, have higher recurrence, and/or have higher disease-specific mortality.<sup>2–4</sup> The impact of SES and race on urinary stone disease has, until recently, been less recognized.

The prevalence of urinary stone disease in the United States has been estimated to be 8.8%.<sup>5</sup> Interestingly, the prevalence of stone disease among Non-Hispanic whites (10.3%) was larger compared to Hispanics (6.4%) and blacks (4.3%).<sup>6</sup> Similarly, amongst a cohort of patients from twelve southeastern states, the age-adjusted incidence of kidney stones was found to be lower among blacks relative to whites.<sup>7</sup>

Despite lower disease burden amongst non-white individuals, we contend that these patients and those of lower SES, report worse quality of life, experience diagnostic and treatment delays, and may be more vulnerable to recurrence. In this review article, we will discuss the potential processes contributing to racial and socioeconomic disparities in kidney stone

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management. We will also investigate the multifactorial nature of these processes and how they may be mediated, in part, by systemic inequities.

## METHODS

A targeted review of the literature was performed using the following MeSH term combinations in the PubMed database: (1) ([urolithiasis] OR [nephrolithiasis] OR [urinary stone] OR [kidney stone]) AND socioeconomic; (2) ([urolithiasis] OR [nephrolithiasis] OR [urinary stone] or [kidney stone]) AND disparities. Next, the article title and abstracts were reviewed for further relevance. All articles that investigated the impact of any socioeconomic factor on any stone-related outcome were included. Next, we reviewed the references of each paper found by the search for further manuscript abstracts to review, applying the same inclusion criteria as above. This process was followed iteratively until no further articles could be included. Additional manuscripts were identified based on work previously performed by the authors, as well as associated work. No exclusion criteria was applied based on study time period. Studies that were not performed in American populations were excluded.

## EPIDEMIOLOGY

It remains unclear why differences in urinary stone disease prevalence exist between various racial and ethnic groups.<sup>8</sup> There have been efforts to determine a unifying theory for the decreased rates of lithogenesis in black patients as compared to white patients, with researchers often evaluating parameters based on 24 hour urine results.<sup>9</sup> These efforts have been largely unsuccessful. However, it is recognized that the number of stone patients across ethnic groups has been increasing in recent decades.<sup>6</sup> While urolithiasis is multi-factorial, there are several established heritable causes of kidney stone disease due to known genetic mutation, including cystinuria and primary hyperoxaluria.<sup>10</sup>

Twin studies have long demonstrated heritability of kidney stone disease.<sup>11,12</sup> A recent twin study using the Washington State Twin Registry, however, found that while nephrolithiasis is heritable in twins overall, it is significantly less heritable in female twins.<sup>13</sup> Furthermore, for female twins, there was a larger environmental impact on stone prevalence than for male twins.<sup>13</sup> The individual genetics of kidney stone disease will be most useful in the anticipated era of precision-medicine when individually targeted, whole genome sequencing is fully incorporated into clinical care.<sup>14</sup> However, to date, a limitation of most genome studies in kidney stone patients is that they have utilized databases with limited racial or ethnic diversity, thus restricting our ability to identify genomic factors affecting stone formation across ethnicities. More research is needed in order to clearly to define the associations between heritable stone disorders, socioeconomic factors, and subethnic groups.

## DISPARITIES IN KIDNEY STONE TREATMENT AND OUTCOMES

### Emergency Room Management

While nephrolithiasis is less common in African Americans,<sup>6</sup> data suggest that these patients may receive worse analgesic care compared to white patients. Differences in pain

management along racial lines were noted in a cohort of just over 250,000 patients who presented to emergency rooms at approximately 700 national private and academic hospitals between 2003 and 2015.<sup>15</sup> African-Americans were less likely to receive ketorolac and African-American and Hispanic patients received lower quantities of morphine relative to white patients. These differences persisted despite adjusting for hospital and patient characteristics. While the authors did not specifically collect data on chronic kidney disease or acute kidney injury, the authors did exclude all patients with a diagnosis of renal insufficiency. Of note, payer type was not included in this analysis. Data on patient's pain level and pain medication prescribed at discharge were also not reported. It should be noted that a much smaller cohort composed of 2 emergency departments in the Bronx found no differences in analgesic administration by race or insurance type.<sup>16</sup>

Differences have also been demonstrated in the diagnostic work-up of patients presenting to the emergency department. A cohort of over 11,000,000 patient visits to the emergency department for urolithiasis between 2006 and 2015 was amassed using the Nationwide Emergency Department Sample, a national all-payer database for emergency department visits. In the adjusted analysis, patients living in the wealthiest average household income ZIP codes and those with private insurance were more likely to undergo diagnostic imaging, in this case CT imaging, during their emergency department visit.<sup>17</sup> Similarly, a cohort composed of over 1000 patients presenting with ureteral stones to 2 emergency departments found that patients from the lowest SES group were less likely to undergo any diagnostic imaging whatsoever in the form of KUB, ultrasound, or CT.<sup>16</sup> This study does not report if there were differences in type of imaging utilized by different SES groups though 89% of patients that were imaged were imaged with CT. Both studies cited above did not account for recent imaging nor a previous diagnosis of urinary stones, which limits the study findings. The utilization of imaging in the emergency department facilitates timely stone management. Thus, differences in the employment of diagnostic imaging may prevent or contribute to differences in timely stone management along lines of race and insurance. It should be noted that it is difficult to ascertain the specific impact of race and insurance on these or any stone-related outcome. Moreover, the interplay between race and insurance is complex and likely has some role in the findings the literature has elucidated.

### **Time to Surgical Intervention**

Data from California Office of Statewide Health Planning and Development between 2010 and 2012 found that privately insured individuals had more expedited surgical management for their stone disease than Medicaid and underinsured patients. On average, privately insured patients underwent surgery for their kidney stones approximately 3 weeks after their initial emergency department discharge while Medicaid and uninsured patients waited 8 and 10 weeks, respectively.<sup>18</sup> Similarly, white patients waited about 3 weeks while Hispanic and black patients waited 5 and 6 weeks, respectively. When the surgical approach was considered, time to treatment was shortest with ureteroscopy and shockwave lithotripsy at about 3–4 weeks while treatment with percutaneous nephrolithotomy resulted in a wait time of about 7 weeks. The authors included a multivariable analysis which among other factors included payer type, race/ethnicity, and stone procedure type. In this model, race, payer type, and surgery procedure were independently predictive of longer wait times. This difference in

wait time was not solely due to differences in procedure type as this was controlled for in the analysis. Together this suggests that race impacts time to definitive treatment and this effect is likely mediated by insurance type and stone complexity at presentation.

Delays to upper urinary tract decompression have also been associated with SES. In a study of the Nationwide Inpatient Sample from 2010 to 2015, the largest all-payer inpatient American database,<sup>19</sup> investigators found that among patients with urinary tract infections and concomitant obstructive urinary stones, delayed decompression was associated with higher mortality (OR 1.29). Predictors of delayed decompression included decreasing severity of sepsis, age (OR 1.01), Elixhauser comorbidity score (1.03), nonwhite race (OR 1.34), weekend admission (OR 1.22), and living in areas with the lower median income (OR 1.25). Kirshenbaum et al assessed the impact of socioeconomic factors on rates of upfront ureteroscopy for stone removal.<sup>20</sup> The study investigated over 146,000 inpatient admissions for urinary stones using California (years 2007–2011) and Florida (years 2009–2014) state databases. They found that patients were less likely to undergo upfront stone removal if they were younger than 25 years of age, admitted on the weekend, had higher Charlson comorbidity scores, African-American or Hispanic, had Medicare, Medicaid or were uninsured, or had lower household incomes. Of note, upfront ureteroscopy was associated with a lower likelihood of a 30-day read-mission suggesting possible cost savings for the healthcare system overall.

The impact of delays in stone management was further explored by Brubaker et al.<sup>18</sup> A multivariable analysis which included race/ethnicity and payer type found that Medicare-insured, Medicaid-insured, uninsured patients, and black patients were more likely to visit the emergency department 3 or more times before definitive treatment. Another multivariable analysis found that Medicare-insured, Medicaid-insured, uninsured, and Hispanic patients were more likely to receive decompressive procedures rather than immediate definitive management. Ultimately patients who were black, Hispanic, on Medicare, on Medicaid, or without insurance experienced longer times to definitive treatment.

### Quality of Life

Differences in pain control and treatment delays may explain differences in quality of life reported along racial and socioeconomic lines. Pain is often the chief complaint among urolithiasis patients and its management serves as a quality-of-care metric. A cohort of over 2000 patients across eleven stone centers in the North American Stone Quality of Life Consortium were asked to complete the Wisconsin Quality of Life survey between 2014 and 2017. The Wisconsin Quality of Life survey assesses stone disease-specific quality of life. In the adjusted analysis, the authors found that lower incomes and nonwhite race were associated with worse stone disease-specific quality of life.<sup>21</sup> Non-Caucasian kidney stone formers have significantly lower-health related quality of life than their Caucasian counterparts.<sup>22</sup> This study also noted gender differences when analyzing how stone disease affected patients' perceived mental and physical health. They found that male gender was associated with a higher total health related quality of life score than female gender.<sup>22</sup> It will be important to investigate the intersection of race and gender in the overall care of kidney

stone patients. It should be noted that this study is limited by its cross-sectional nature. Longitudinal studies are needed.

### **Surgical Management**

Patients with low SES present with larger, more complex stones. A study analyzing a cohort of over 4000 patients presenting to a single referral center found that patients from severely distressed communities had a larger preoperative stone burden and were more likely to receive staged, percutaneous nephrolithotomies.<sup>23</sup> Patients from these communities were older, more often Latino, and had higher prevalence of diabetes and hypertension. In another cohort of 650 patients at a single public referral center, those presenting with a unilateral stone burden greater than 2cm had lower educational attainment, had fewer urologists per capita in their community, and resided in communities with a lower median household income.<sup>24</sup> A study from the same group found that treatment costs for referred urinary stones were higher if you were non-white, had less educational attainment, and lived in a community with fewer urologists per capita.<sup>25</sup> Potential mediators of the higher costs were probably larger, complex stones that required prolonged hospitalization, since these factors were associated with higher costs as well. Of note, the patients with larger stone burdens are from communities farthest from the referral center suggesting that the most severe stones in those communities are referred out, perhaps due to lack of available healthcare resources coupled with higher treatment costs. Together these findings suggest that complex urolithiasis appears to occur in communities that experience barriers to care access resulting in prolonged delays in treatment, often necessitating staged treatment with percutaneous approaches for these larger and more complex stones.

The contemporary management of urinary stones has evolved towards minimally invasive approaches; however, recent literature has found differences in adoption of surgical approaches to stone disease across socioeconomic strata. According to a study of the California Office of Statewide Health Planning and Development database between 2005 and 2016, the total cases of ureteroscopy relative to shockwave lithotripsy (SWL) has been increasing.<sup>26</sup> Two-thirds of patients state-wide were managed with ureteroscopy in 2016. When regions in California that predominantly use SWL were compared to those regions which predominantly use ureteroscopy, those regions which had adopted a ureteroscopy-majority practice were more likely to have a higher percentage of college-educated individuals in that community, a higher per-capita income, and a higher percentage of patients who were privately insured. Unfortunately, the dataset does not provide insight into how these differences are impacted by stone size, complexity, or location. Some studies have demonstrated improved outcomes of ureteroscopy compared to SWL with respect to stone free rates,<sup>27</sup> likely leading to the increase in its adoption in North America.<sup>28</sup> In another study, a cohort of 300,000 patients with ureteral stones were identified in the Medicare claims data for the years 2001, 2004, 2007, and 2010. In addition to also noting an increase in utilization of ureteroscopy over time, this study found that ureteroscopy utilization was higher among white patients while SWL was more often utilized for patients of minority ethnicities.<sup>29</sup> The reason for this is unclear, particularly since the study does not include surgeon-level data on treatment choices.

A recent manuscript evaluating the effect of socioeconomic parameters on management of urolithiasis patients in a North Carolina hospital system found that black patients were significantly more likely to undergo PCNL than white patients. They also showed that public insurance payers were more likely to undergo PCNL and less likely to undergo SWL than private insurance payers.<sup>30</sup> However, the database used for this study did not provide granular data on stone size or complexity.

It is not clear what is driving differences in rates of SWL along racial and socioeconomic lines. SWL is the least invasive treatment option and may therefore be the preferred treatment method for those patients with more self-advocacy for their treatment pathway (individuals with private insurance). However, it may also be overutilized inappropriately in patients who are less able to advocate for the best treatment approach to render themselves stone free (ethnic minorities). Particularly since SWL tends to be better reimbursed in the United States,<sup>31</sup> it may be important to evaluate physician motivations for the choice of 1 procedure vs the other in a given patient population. In addition, no literature to our knowledge investigates patient preference along socioeconomic or racial/ethnic lines and this may also be contributing to these findings.

### **Surgical Outcomes**

There are few additional studies in this area investigating surgical outcomes based on race, ethnicity or socioeconomic status. A nationally representative study investigating complications after percutaneous nephrolithotomy found that in-hospital death, blood transfusion, and infectious complications, occurred in higher proportions of publicly-insured patients (Medicare, Medicaid) compared to privately-insured patients.<sup>32</sup> These differences were not found in a sub-analysis of patients without comorbidities, suggesting that the differences in complications between various pay-groups are mediated, in part, by differences in comorbidities between the pay-groups. In another single-institution study investigating risk factors for forgotten ureteral stones, it was found that being male or uninsured was a risk factor for forgotten stents.<sup>33</sup>

### **FOLLOW-UP AND STONE PREVENTION**

A recent study showed that adherence to stone prevention recommendations is associated with having an education, having insurance coverage, and having a monthly income of >\$1000.<sup>34</sup> It should be noted that a limitation of that paper is that adherence was self-reported and the study was conducted with a non-validated questionnaire. Rates of adherence to 24-hour urine collection are higher in healthcare markets with wealthier and more educated patients in addition to markets with higher number of primary care physicians per capita.<sup>35</sup>

In one single referral center study, patients who underwent uncomplicated ureteroscopic stone treatment were less likely to follow-up if they were Medicaid insured.<sup>36</sup> It is possible that those being referred with Medicaid insurance are traveling farther distances for treatment which makes the subsequent follow-up visit more difficult to attend. Consequently, disparities in follow up and the utilization of secondary prevention measures such as 24-hour urine evaluation likely contribute to disparities in rates of stone recurrence.

However, a study investigating US Veterans Health Administration data revealed that black stone formers are less likely to undergo 24 hour urine testing compared to white stone formers, despite being managed within the same system, suggesting that there may be additional factors contributing to this disparity.<sup>37</sup>

It is important to acknowledge dietary factors when discussing differences in stone prevention. It is well established that food environment contributes to differences in obesity rates.<sup>38,39</sup> In the same fashion, food environment may also influence adherence to kidney stone prevention diets. These systemic factors have the potential to make socioeconomically disadvantaged individuals disproportionately vulnerable to kidney stone recurrence due to difficulty with dietary adherence.

## GLOBAL UROLOGY

When discussing disparities in the treatment and outcomes of kidney stone disease, the conversation would not be complete without addressing disparities in urological care in resource limited settings. Urolithiasis is one of the most common conditions treated by surveyed urologists in both high-income countries (HIC) and low- and middle-income countries (LMIC),<sup>40</sup> however, treatment approaches greatly differ. This survey also revealed that an 8 millimeter proximal ureteral stone would be treated with ureteroscopy by 61% of surveyed HIC urologists but only 37% of LMIC urologists.<sup>40</sup> Patients with kidney stones in LMICs may not be able to afford or have access to treatment, resulting in delayed presentations with obstructive renal failure, requiring nephrectomy.<sup>41</sup> LMIC urologists report being much less likely to be able to provide standard-of-care interventions for kidney stones as defined by American Urological Association guidelines.<sup>41</sup> LMICs continue to utilize open stone surgery despite guideline recommendations for minimally invasive approaches that have largely been adopted in HICs.<sup>41</sup> The expense of such equipment has been exorbitant for many surgeons in LMICs. While the prevalence of chronic kidney disease remains lower in African and Caribbean countries compared to higher income countries, age-standardized morbidity from chronic kidney disease is demonstrated to be higher in LMICs.<sup>42</sup> This may be due in part to the sequelae of open stone surgery.

Global partnerships can bridge the gap in kidney stone treatment seen between HICs and LMICs. Surgical mentorship, both in-person and virtual, allow for skill-sharing between countries and advanced training of surgeons in lower resource countries.<sup>43</sup> Well-planned partnerships benefit both physician parties, in addition to the patients who gain access to more advanced and less invasive treatment options.<sup>43</sup>

## LIMITATIONS

More rigorous research is needed to elucidate the relationships between race, SES, and kidney stones as well as disparities in kidney stone disease outcomes (Fig. 1). Many studies investigating disparities in kidney stone disease rely on claims data. Unfortunately, this data often lacks granular patient-level information such as stone size, complexity, and/or location. The decision to perform SWL, ureteroscopy, or PCNL is heavily influenced by stone size. However, procedure type is also influenced by urologist preferences, equipment, insurance,



and perceived “ease” of the procedure. These nuances cannot be teased out from billing data alone. Studies are lacking in specific rates of PCNL by race/ethnicity as well as rates of repeat surgical interventions in <5 years for patients with stone disease. Furthermore, many of these studies are retrospective in nature and therefore vulnerable to bias.

Additional limitations to our investigation include the inherent variation in interpretations of race and ethnicity. For many studies it is unclear if race and ethnicity are self-reported by the patients or assigned by the provider. Also, there is a legitimate concern that categorical racial distinctions leave certain patients or populations excluded.

There is a need for further research that compares stone-related outcomes on the basis of race and ethnicity. Currently, much of the literature on this topic relies on insurance claims databases. These databases often are de-identified and with that lose the ability to ascertain the impact of socioeconomic factors, race, and other important factors including stone-related (size, location, symptoms), patient preference, and physician preference, and procedural cost. Studies which include all these factors will allow a more accurate assessment of the role of each and how they are associated with one another. Specifically, more studies are needed to determine how the aforementioned factors drive disparities in surgical management, urolithiasis recurrence, and procedural complications.

## CONCLUSIONS

Differences do exist in kidney stone management and outcomes along distinctions of race and SES. Future research must investigate the influence of social determinants of disease in kidney stone formers. Understanding the impact of systemic inequities on kidney stone disease will require a multidimensional research approach (Fig. 1) to determine how race, SES, and other social factors such as healthcare access and community resources interact to influence kidney stone treatment and outcomes.

## Financial Disclosure:

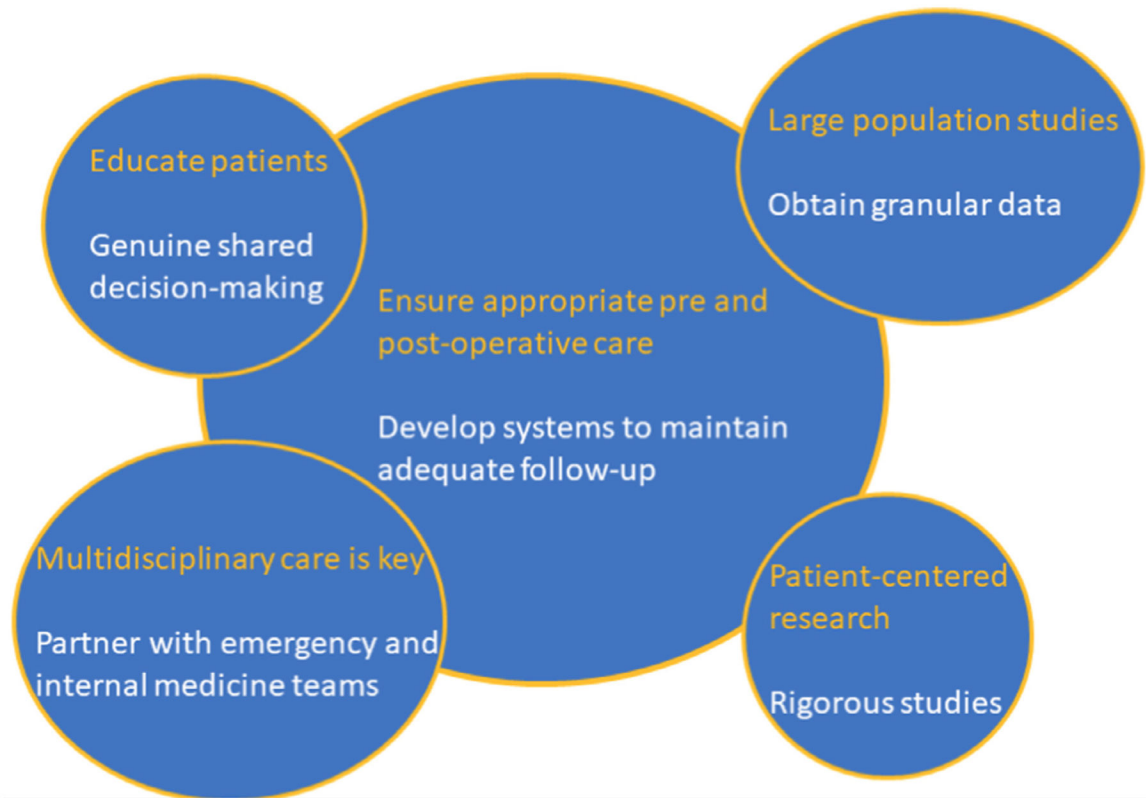
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**Figure 1.**

A paradigm for management of diverse nephrolithiasis patients. Appropriate care of kidney stone patients must incorporate a commitment to equitable management and to undertaking multidimensional research.