National Institute of Diabetes and Digestive and Kidney Diseases

Urologic Diseases in America

2024

Urologic Diseases in America

ANNUAL DATA REPORT

Urinary Stone Disease

April 26, 2024

SPONSORED BY

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)

National Institutes of Health (NIH)

[This Page Intentionally Left Blank]

Acknowledgements

This year's *Urologic Diseases in America: Annual Data Report* was prepared in collaboration between Acumen, LLC and the contract sponsor, National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) of the National Institutes of Health (NIH). The NIDDK team composed of core members Kevin C. Abbott and Ziya Kirkali; as well as Kevin Friel, Melanie Hardy, Max Kimpson, and Ivonne Schulman.

Additional clinical urology contributions were coordinated by Acumen, LLC, led by Chad Ellimoottil (University of Michigan) and John P. Lavelle (Stanford University; Veterans Affairs Palo Alto, CA). The Acumen LLC team consisted of core members Kyle Buika, Po-Lun Chou, Myrna Cozen, Can Feng, John C. Hornberger, Sushant Joshi, Xiaofei Lai, Suraj Pant, and Lei Sandy Ye, with additional contributions from Yvonne Aubourg, Anqi Bu, Jiayue Chen, Tessa Davis, Natalia Derevnin, Johnathan Dinh, Paul Fanelli, Derek Fenson, Thomas Genova, Naomi Golin, Hanna Hassan, Zhiyuan Jiang, Gauri Kore, Sammy Murrell, Callie Richard, Rachel Rong, Nora Shepherd, Victoria Ta, Yiren Alan Wang, Chandler Xu, Jinjin Yu, Mandy Zhou, and many others.

Note

This document is one of the seven that collectively comprise the 2024 *Urologic Diseases in America: Annual Data Report (ADR)*. This document reports and discusses findings on Urinary Stone Disease (USD). Other topics in the 2024 ADR are Introduction and Methods; Benign Prostatic Hyperplasia and Associated Lower Urinary Tract Symptoms (BPH/LUTS); Urinary Incontinence (UI); Urologic Chronic Pelvic Pain Syndrome (UCPPS); Fournier's Gangrene (FG); and Healthcare Expenditures of Urologic Diseases. These analyses are available as separate documents on the UDA website. Additional details on the methodology and data sources are provided in Appendices A and B, respectively, in the Introduction and Methods document.

Suggested citation

Urologic Diseases in America. 2024 UDA Data Report: Epidemiology of non-malignant urologic disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2024.

[This Page Intentionally Left Blank]

Urinary Stone Disease

Main Takeaways

- The claims-based prevalence of urinary stone disease (USD) among persons aged 18-64 was 1-2% annually from 2012 to 2021, while for those aged 65 and older, it was 3-5%.
- USD often co-occurred with obesity, hypertension, diabetes, and urinary tract infections.
- Computed tomography (CT) scan remains the predominant imaging modality used to identify patients with USD. In 2020, 70% of patients underwent a CT scan within 15 months surrounding their diagnosis.
- Between 2012 and 2021, the percentage of patients with USD who filled an opioid prescription within the year decreased from 71% to 56% among patients aged 18-64 years and from 56% to 40% among those aged 65 years and older.
- From 2012-2021, there was a decline in the percentage of patients with USD who underwent extracorporeal shock wave lithotripsy (ESWL), from 9% to 6% among those aged 18-64 and 5% to 3% among those aged 65 and older.

1 Overview

Urinary stone disease (USD), also known as kidney stones or nephrolithiasis, is a condition in which stones form in the kidneys and/or bladder, leading to a range of symptoms such as pain and hematuria. Risk factors for USD include a family history of the condition, certain medical conditions, and diet. USD can significantly impact patients' quality of life by causing physical pain, depression, and anxiety.[1] This section summarizes the basic evaluation and management of USD. Section 2 shows results on prevalence, incidence, comorbidities, and diagnostic testing; prescription drugs filled and procedure use; and resource use, based on contemporary data on the different age cohorts (see 2024 Methods document for details on databases and related methods). Section 3 discusses our results relative to the literature.

For the surgical and medical management of USD, the American Urological Association (AUA) guidelines outline various diagnostic tests that should be considered for the initial evaluation, preoperative planning, and follow-up of patients with USD.[2] In the initial evaluation of patients with USD, clinicians may obtain laboratory tests such as serum electrolytes, calcium, creatinine, and uric acid, which may indicate underlying medical conditions associated with USD. A urinalysis should also be obtained to evaluate urine pH and indicators of infection. For preoperative planning, a non-

contrast computerized tomography (CT) scan is typically obtained to determine the appropriate type of surgery. For follow-up of patients, clinicians may periodically obtain imaging studies such as plain abdominal imaging, renal ultrasonography, 24 hour urine collection for metabolic analysis, or CT to assess for stone growth or new stone formation. Furthermore, functional imaging studies of the kidneys (e.g., diethylenetriaminepentaacetic acid [DTPA] or mercaptoacetyltriglycine [MAG3] nuclear medicine tests) may be considered if clinically significant loss of renal function is suspected.[3]

Prescription drugs play a crucial role in the treatment of USD. Persons with an acute stone episode may use nonsteroidal anti-inflammatory drugs, opioids and alpha-blockers to control pain and help with stone passage. To prevent stones, all patients are encouraged to monitor their fluid intake and adjust their diet. In addition to these preventative measures, some patients use pharmacological therapies such as thiazide diuretics, potassium citrate, allopurinol, cystine-binding thiol drugs, or acetohydroxamic acid, depending on their risk factors and the composition of their stones.

Surgery may be considered for patients who are experiencing symptoms or for some who are asymptomatic. Treatment options for kidney stones include extracorporeal shock wave lithotripsy (ESWL), ureteroscopy, and percutaneous nephrolithotomy (PCNL), with the best option depending on the size and location of the stone. Procedures and pharmacological classes considered for USD analysis are shown in Table 1 below.

Table 1. Procedures and pharmacological classes considered for USD analysis

Procedures	Pharmacological Classes
• Cystolithalopaxy • Extracorporeal shock wave lithotripsy (ESWL) • Laparoscopic stone surgery • Nephrostomy tube • Open stone surgery • Percutaneous nephrolithotomy (PCNL) • Ureteral stent placement • Ureteroscopy	• Alkalinizing agents • Allopurinol • Alpha blocker • Acetohydroxamic acid • Calcium channel blocker • Cholestyramine • Opioid • Opioid / Antimuscarinic • Thiazide • Cystine-binding thiols drugs

2 Results

➔ Study population

Table 2 shows the total number of patients with USD as well as the total population in each cohort in 2021 (note the cohorts in Medicare Advantage [MA] and Medicaid are only discussed for results on prevalence and comorbidities).

Table 2. Total number of patients with USD, 2021

Population	Commercial Insurance Age 18-64		Medicare FFS Age 65+		Medicaid Age 18+		MA Age 65+	
Gender	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Total	2,865,943	2,776,873	10,779,115	13,694,802	14,640,922	21,590,273	9,268,173	12,286,189
Patients with USD	36,181	28,460	687,575	418,273	203,912	344,335	571,149	395,941

➔ Prevalence

The claims-based period prevalence of USD was approximately 1.0% from 2012 to 2021 among privately insured persons aged 18-64 and approximately 4% in persons aged 65 and older in Medicare FFS or in MA (Figure 1a). Prevalence of USD was approximately 1.7% from 2016 to 2021 for persons aged 18 and older in the Medicaid population (Figure 1a).

The prevalence of USD was higher in men compared to women among persons aged 65 and older in Medicare FFS (Figure 1b). For men aged 65 and older in Medicare FFS, prevalence of USD increased from 4.3% to 6.4% between 2012 and 2021 (Figure 1b). In contrast, prevalence among women in the same age group only increased from 2.1% to 3.1% over the same period. Prevalence rates and trends were similar for persons aged 65 and older in MA. The gender disparities were less pronounced among privately insured persons aged 18-64. In contrast to the other cohorts, the prevalence of USD among women aged 18 and older in the Medicaid population was comparable to that among men (1.6% and 1.4%, respectively, in 2021). The prevalence of USD was generally higher for older age brackets, with the exception of persons 80 years and older, who had a slightly lower prevalence of USD compared to the 75-79 age bracket. These patterns were broadly similar among those in MA.

Figure 1a. Claims-based prevalence of USD, by year and insurance type (2012-2021)

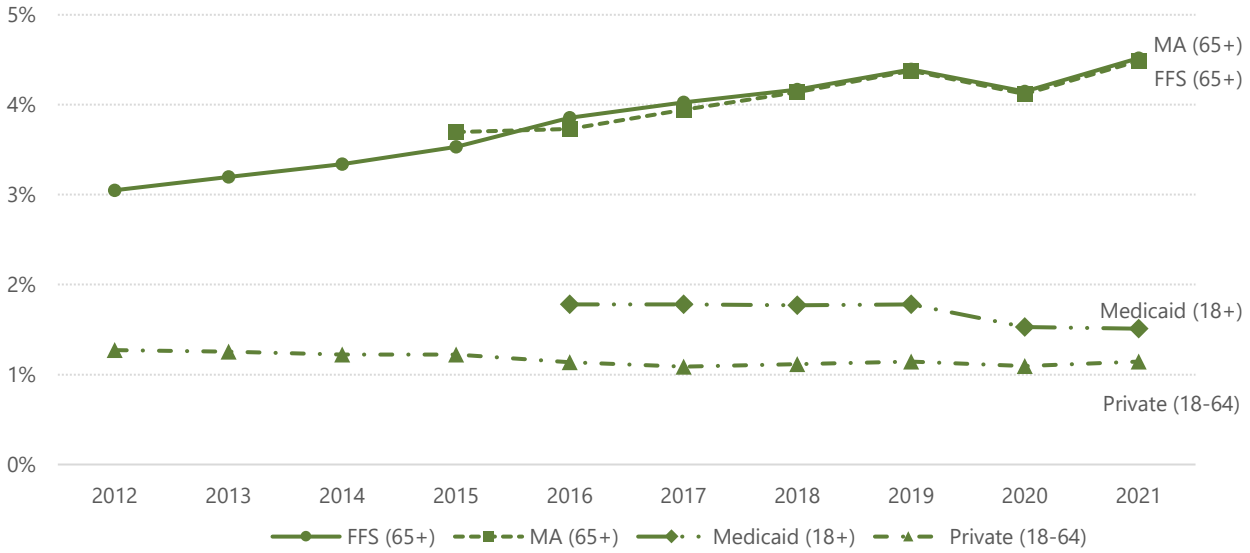
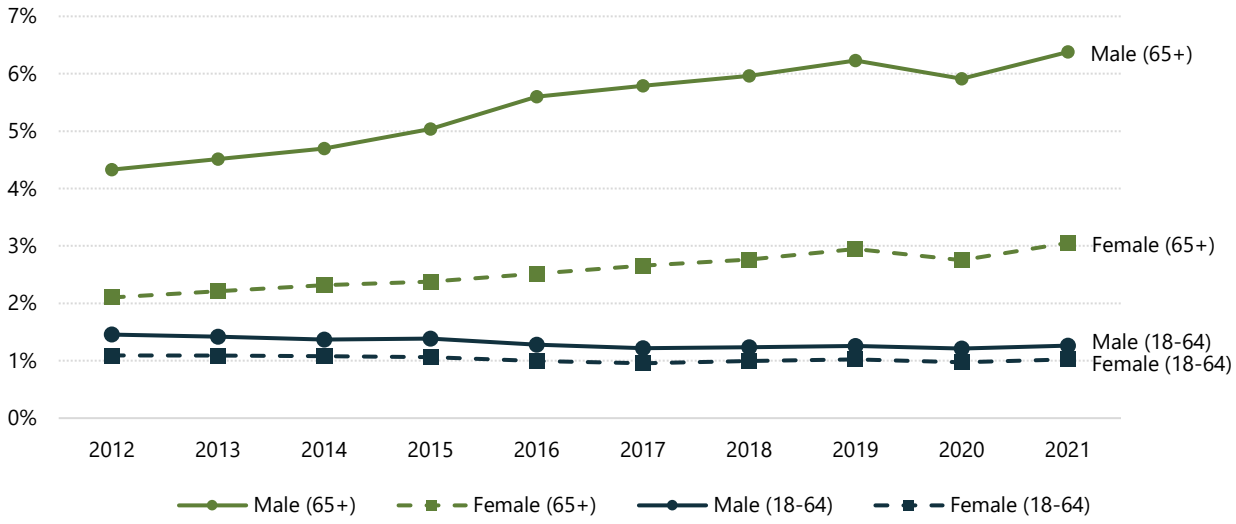


Figure 1b. Claims-based prevalence of USD, by year and gender-age group (2012-2021)



Notes: In panel (a), for each age cohort, denominator denotes the total number of persons under each type of insurance. In panel (b), denominator denotes the total number of persons in each age-gender cohort among those in commercial insurance (age 18-64) or Medicare FFS (age 65+).

By race/ethnicity, the prevalence of USD was generally highest among Whites, with rates of 4.7% and 4.8% in 2021 for those aged 65 and older in Medicare FFS and MA, respectively; and 1.3% for privately insured persons aged 18 to 64. Among Whites aged 18 and older in the Medicaid population, prevalence was 2.0% in 2021. We also observed regional differences in prevalence of

USD. In 2021, prevalence of USD was the highest in the South for privately insured persons aged 18-64 (1.3%) and in the Northeast for persons aged 65 and older in Medicare FFS (5.1%) and MA (5.3%).

➔ Incidence

The average annual incidence of USD was approximately 170 per 10,000 persons (or 1.7%) from 2015 through 2021 among persons aged 65 and older. This translates to an average of approximately 390,000 newly identified cases of USD among the age 65 and older cohort. Similar to 2021 claims-based prevalence, we found that incidence among persons aged 65 and older was generally associated with age.

➔ Comorbidities

The different age-based cohorts shared several common comorbid conditions. For patients aged 18-64, common comorbidities in 2021 were hypertension (44%), obesity (32%), and diabetes (18%) (Figure 2a).[4] In those aged 65 and older, common comorbidities were hypertension (83%), diabetes (38%), and urinary tract infections (UTI, 36%) (Figure 2b). Among common comorbidities, their prevalence among patients with USD was substantially higher compared to all persons (including those without USD) in the same age group. Patterns were broadly similar among those in Medicaid and MA.

Figure 2a. Common comorbidities among patients with USD, age 18-64 (2021)

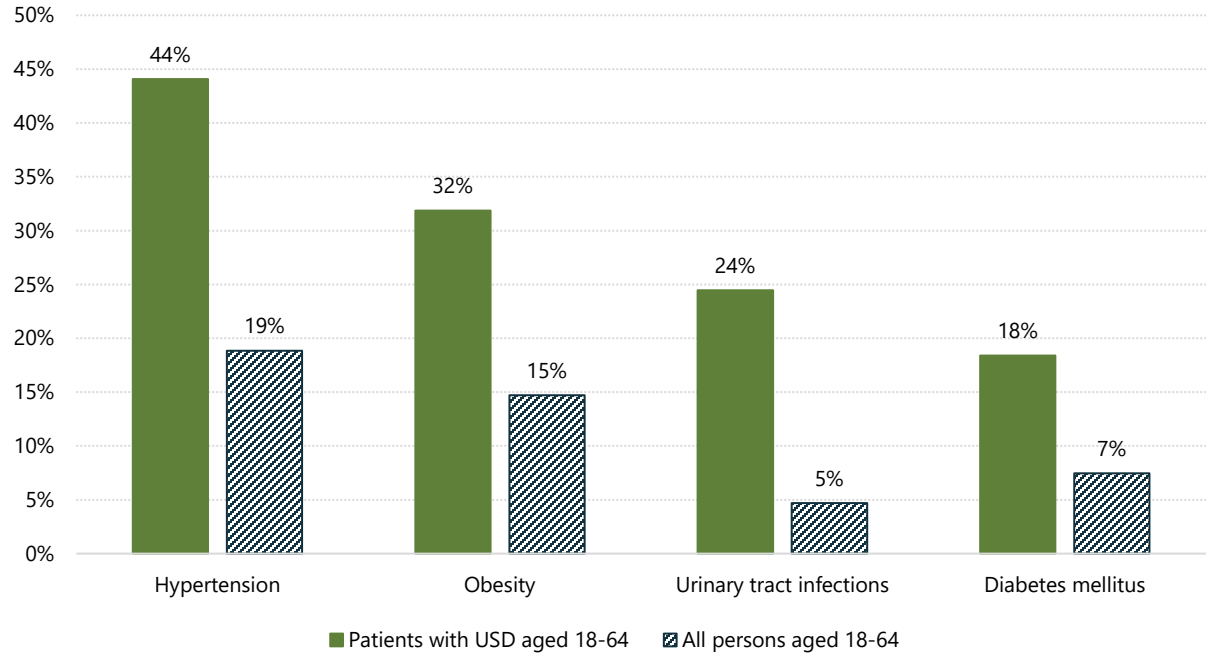
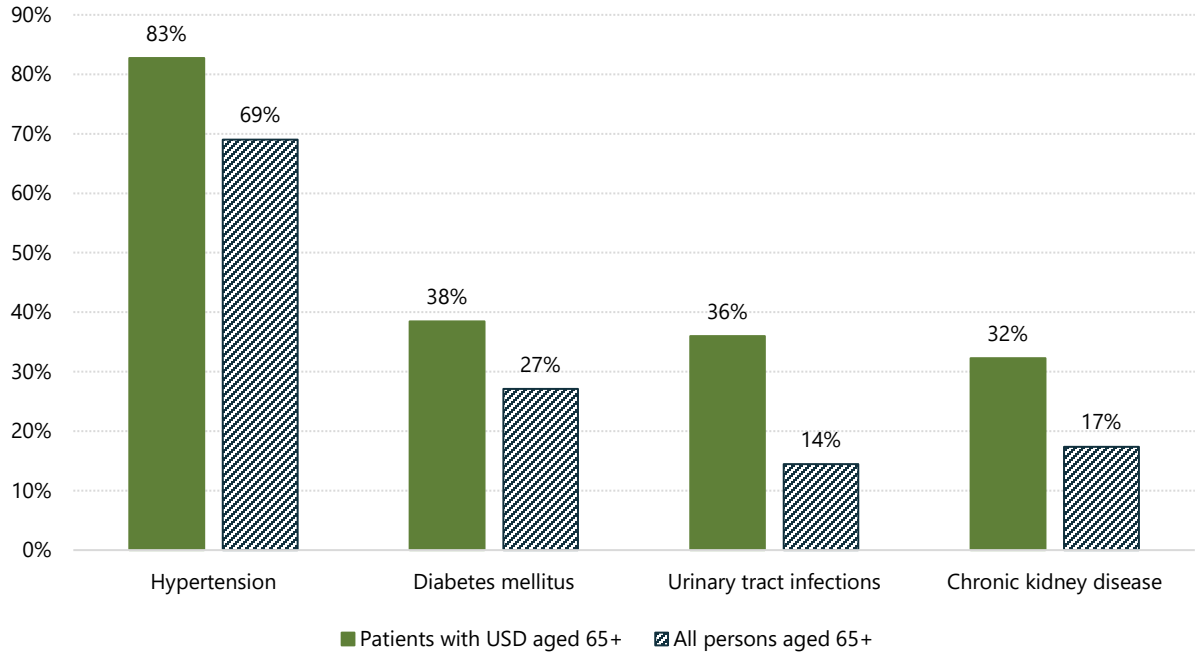


Figure 2b. Common comorbidities among patients with USD, age 65+ (2021)



Notes: Columns in solid denote percentage of patients with USD who were also identified with the comorbidity referenced. Columns in patterns denote the analogous metric for all persons (including those without USD) in each referenced age cohort. The age 18-64 cohort refers to those in commercial insurance, while the age 65+ cohort refers to those in Medicare FFS.

➔ Diagnostic tests

Nearly all patients with incident USD received some diagnostic test within 3 prior and 12 subsequent months to initial diagnosis. There was minimal change in the use of diagnostic testing from 2015 through 2020. Among those aged 65 and older, serum creatinine and urinalysis were the most frequently ordered laboratory tests (Figure 3a). 97% had a serum creatinine test and 84% had a urinalysis ordered within 3 prior and 12 subsequent months to initial diagnosis.[5]

For imaging, we found that in 2020 for those aged 65 and older, 70% of patients newly identified with USD underwent a CT scan and 40% had a renal ultrasound. Abdominal X-ray (25%), retrograde pyelogram (8%), and pelvic ultrasound (5%) were less common (Figure 3b). Abdominal magnetic resonance imaging (MRI), pelvic MRI, intravenous pyelogram (IVP), and antegrade pyelogram were used by less than 5% of patients in our cohort.

For patients with incident USD, 56% of patients had a subsequent imaging procedure within 5 years and 44% had at least one CT scan. 16% of patients had five or more imaging procedures in the 5-year follow up period. Among all imaging procedures, 59% were done within a year of incident diagnosis.

Figure 3a. Percent of patients aged 65+ with incident USD who had a laboratory diagnostic test within 3 prior and 12 subsequent months to initial diagnosis (2015-2020)

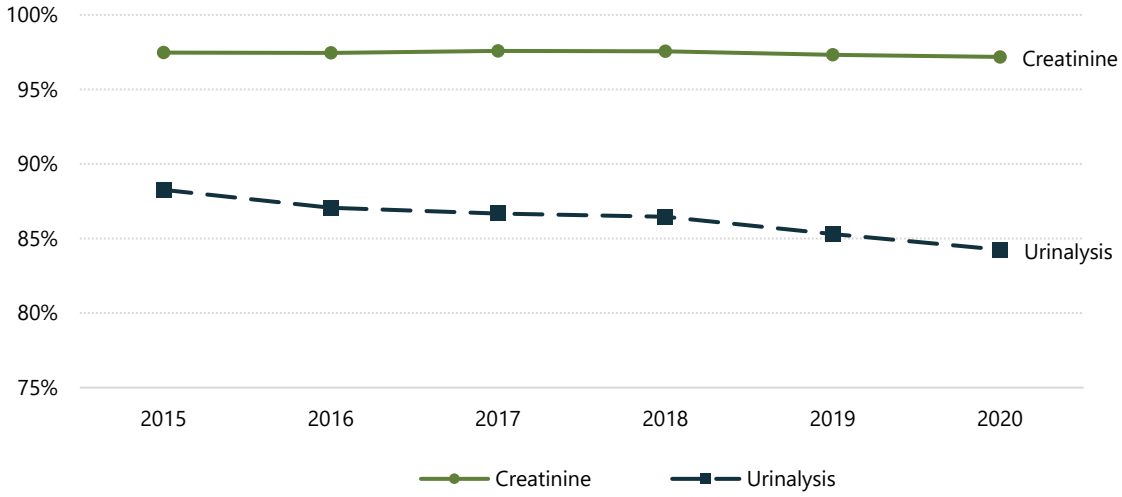
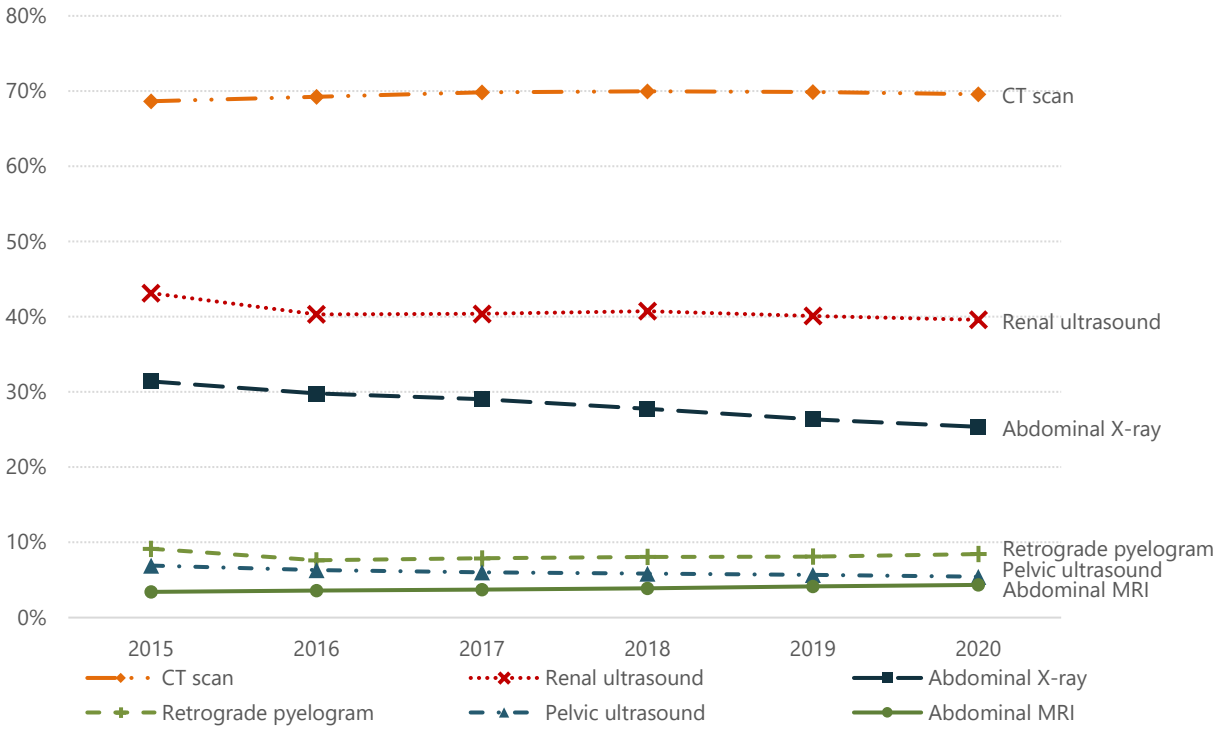


Figure 3b. Percent of patients aged 65+ with incident USD who had an imaging diagnostic test within 3 prior and 12 subsequent months to initial diagnosis (2015-2020)



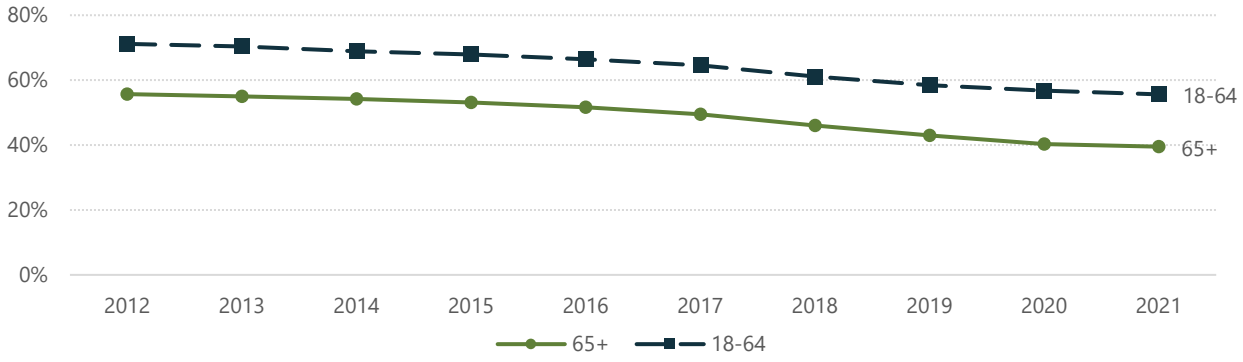
Notes: Numerator denotes number of patients with incident USD in each year who received each referenced diagnostic test within 3 prior and 12 subsequent months to initial diagnosis. Denominator denotes number of patients with incident USD in each year (Medicare FFS).

➔ Prescription drugs

We examined drugs used for stone prevention, such as thiazides, alkalinizing agents, and allopurinol. Our findings showed that thiazides were the most commonly filled preventive prescription. In 2012, 23% of patients aged 18-64 and 11% of patients aged 65 and older with USD filled a prescription for a thiazide. In contrast, other prescriptions used for stone prevention were much less frequently filled. For example, in 2021, only 5% of patients aged 65 and older with USD filled a prescription for alkalinizing agents, and this percentage was consistent with previous years. Similarly, only about 10% of patients aged 65 and older with USD filled a prescription for allopurinol. Drugs like cystine-binding thiol drugs were even less commonly filled, with less than 1% of patients with USD filling a prescription for them. It is worth noting our analysis was unable to determine whether these prescriptions were for stone prevention or other indications, such as hypertension in the case of thiazides.

We also evaluated drugs that are used to manage acute stone episodes such as alpha blockers, calcium channel blockers, and opioids. Opioids were the most commonly filled USD-related drug for both patient cohorts. In 2021, 56% of USD patients aged 18-64 and 40% of those aged 65 and older filled a prescription for an opioid. Notably, between 2012 and 2021, the percentage of patients with USD who filled an opioid prescription within the year decreased from 71% to 56% among patients aged 18-64 years and from 56% to 40% among those aged 65 years and older (Figure 4). In 2021, 42% of patients aged 18-64 and 34% of patients aged 65 and older used alpha blockers. The same year, calcium channel blockers were filled by 3.4% of patients aged 18-64 and 1.6% of those aged 65 and older.

Figure 4. Percent of patients with USD who filled an opioid prescription during the calendar year, by age (2012-2021)



Notes: Denominator denotes number of patients with USD who were aged 65 and older and had full-time Part D enrollment in each year (Medicare FFS) or aged 18-64 (commercial insurance).

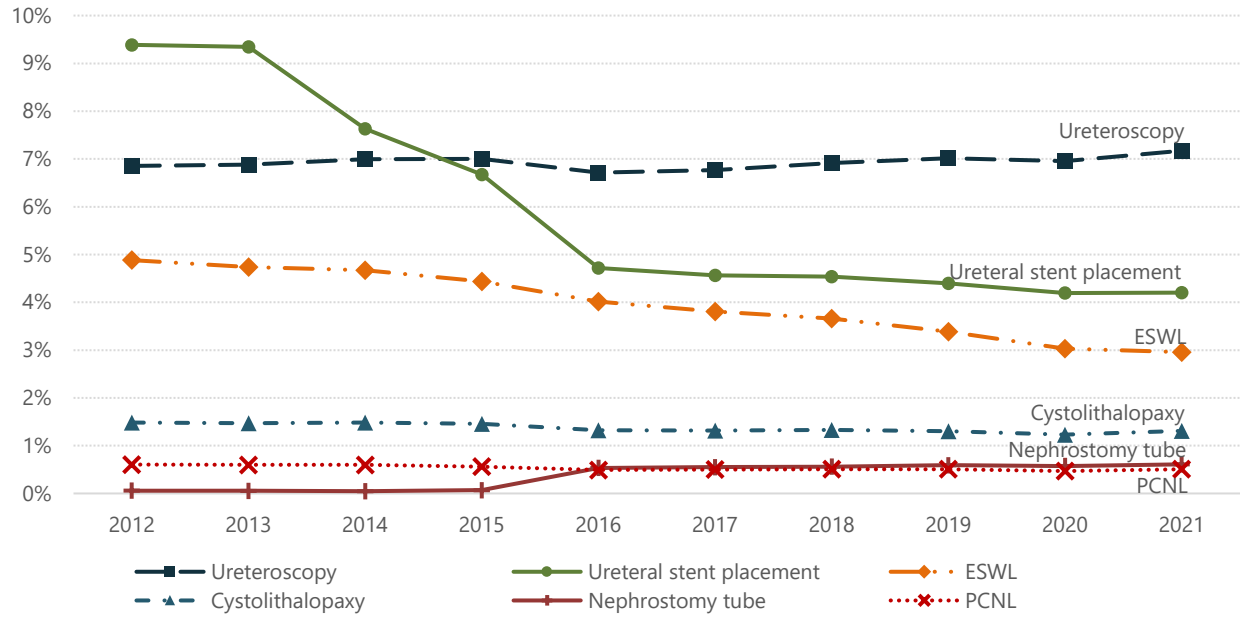
Among the 2015 incident cohort, 90% of patients aged 65 and older with USD filled any disease-related prescription within 5 years after initial diagnosis. The most common prescription filled

soonest after diagnosis was an opioid, accounting for 64% of patients' first filled prescription. The next most common ones were alpha blockers (21%) and thiazide (8%).

➔ Procedures

On average, between 2012 and 2021, 19% of patients aged 18 to 64 with USD underwent a procedure related to USD, while 11% of those aged 65 and older did the same. In both of our populations, ureteroscopy was the most common procedure performed for USD. In patients aged 18-64, 13% underwent at least one ureteroscopy and in patients aged 65 years and older, 7% underwent a ureteroscopy. Both the younger (13% to 6%) and older (9% to 4%) patient cohorts experienced a sharp decline in ureteral stent placement rates between 2013 and 2016. However, this decline may be an artificial result of the 2014 bundling of the ureteral stent procedure code with the ureteroscopy procedure code, rather than a reflection of a change in ureteral stenting behavior.[6] Extracorporeal shock wave lithotripsy (ESWL) exhibited a decline as well, from 9% to 6% among those aged 18-64 and 5% to 3% among those aged 65 and older (Figure 5).

Figure 5. Percent of patients aged 65+ with USD who underwent each USD-related procedure, by procedure type (2012-2021)



Notes: This figure shows the percent of patients aged 65 and older with USD who underwent each referenced procedure during 2012-2021 (Medicare FFS).

Among the incident cohort aged 65 and older, 21% of patients with incident USD underwent any disease-related procedure within 5 years after initial diagnosis in 2015. 35% of the first procedures during this period were ureteral stent placement, while ureteroscopy and ESWL accounted for 26% and 24%, respectively. The average time to first procedure within 5 years after initial diagnosis in 2015 was 10 months.

For patients with incident USD, 20% had a surgery within 56 months of the incident diagnosis. Among them, 32% had a retreatment within 4 months (or 120 days). Ureteroscopy was the most common retreatment procedure (54% of the total retreatments). The average time to retreatment (or second surgery) was 19 days.

➔ Service utilization

On average, patients aged 65 and older with an incident diagnosis of USD between 2015 and 2020 had 2.3 Evaluation and Management (E&M) visits within 12 months. During the same period, 2.6% of the same group had an inpatient hospitalization, 2.0% had an observation stay, and 14% had an emergency department visit with a primary diagnosis of USD within 12 months after initial diagnosis.

For patients with incident USD, 17% had a subsequent ED visit within a year of incident diagnosis. Furthermore, 20% had a subsequent ED visit within 5 years of USD diagnosis and the median time to these visits from incident diagnosis was 1 month. 6% of the incident patients had 4 or more ED visits within 5 years. For patients with incident USD, 19% and 26% had an ED and PCP visit, respectively, within 3 years of incident diagnosis. Among them, 61% and 37%, respectively, had a visit to a urologist in the following two years after the first ED and PCP visit.

3 Discussion

USD remains a prevalent disease, particularly among those aged 65 and older. USD often co-occurred with obesity, hypertension, diabetes, and urinary tract infections. There was a notable decline in the percentage of patients with USD filling prescriptions for opioids from 2012 to 2021. Additionally, for the same years, there was a decline in the percentage of patients undergoing ESWL.

The claims-based prevalence of USD among persons aged 18-64 was estimated at 1-2% from 2012 to 2021, while for those aged 65 and older, it was 3-5%. While these prevalence rates are comparable to those cited in the 2018 ADR, the prevalence of USD tends to be lower in studies that rely on claims for diagnosis. For example, according to self-reported data from the 2017-2018 cycle of the National Health and Nutrition Examination Survey (NHANES), an estimated 1 in 10 persons had USD.[7] Several reasons contribute to this discrepancy. Survey questions in NHANES assess lifetime prevalence of stones, whereas claims-based studies have a more limited time frame. Additionally, claims-based prevalence rates are based on patients seeking care, and some patients may pass kidney stones without seeking medical attention. Likewise, some stones may be asymptomatic and discovered incidentally on imaging, and patients may not seek care for them.

The relatively high prevalence of USD found in the South is consistent with prior studies. First identified in a 1989 study, the Southeast United States was termed the "stone belt" for its heightened USD prevalence, which some researchers indicated may in part be due to the region's relatively warm and wet climate that poses additional thermoregulatory burdens.[8] However, it appears that the Northeast has since surpassed the South in prevalence of USD among persons aged 65 and older.

This finding requires further investigation to understand factors that influence geographic variation in USD.

USD often co-occurred with obesity, hypertension, diabetes, and urinary tract infections, a finding that is consistent with previous studies that showed a strong association between USD and obesity, hypertension, and diabetes.[9] A number of factors resulting from these diseases have been linked to kidney stone formation, including alterations in urine composition, insulin resistance, metabolic derangements, and dietary factors.

The percentage of patients with USD filling prescriptions for opioids declined from 2012 to 2021. This finding is consistent with the growing literature on the efforts to reduce opioid consumption.[10] For patients with USD, the prescriptions filled for alpha-blockers increased by 8-10 percentage points between 2012-2021 (age 65+: 26% to 34% and age 18-64: 32% to 42%). This increasing use of alpha-blockers could suggest an increase in medical expulsive therapy between 2012-2021 for patients with USD.

The most common imaging test used during the first year of USD diagnosis was CT scan. Approximately two out of three patients had a CT scan performed either for diagnosis or within 15 months surrounding it. Use of CT for diagnosing USD has grown in recent decades due to its increased sensitivity to detect stones. Some researchers have indicated that the rise in USD prevalence may in part be explained by more common utilization of CT.[11] Repeat imaging was frequently utilized in the evaluation of stones. Our results showed that more than 44% of patients had repeat imaging within 3 months, rising to more than 50% within 5 years. The frequent use of imaging is consistent with findings in the literature.[12] CT scans were the most frequently utilized imaging procedures, even though existing literature indicates that ultrasonography subjects patients to a lower amount of radiation compared to CT scans, without significant differences in adverse events or missed diagnoses.[13]

The two most common laboratory tests performed within the first year of a urinary stone disease diagnosis are serum creatinine (97%) and urinalysis (84%). Given the standard of care, urinalysis rates would be expected to approach 100%. The possible undercounting of urinalysis in claims may result from the test not being billed to insurance, particularly in cases of point-of-care testing. Further research is essential to determine whether this lower-than-expected rate is attributable to undercounting or a quality of care issue.

Our results showed that 17% of incident patients had an ED visit within a year of incident diagnosis. Our results also showed that around 10% of the incident patients had more than one ED visit within a year. This is broadly consistent with past findings.[14]

The percentage of patients undergoing ESWL saw a notable decrease, from 9% to 6% among the younger population and 5% to 3% among those aged 65 and older. This finding is consistent with the literature. For example, one study using IBM Marketscan data showed that between 2007 and

2014, there was a declining trend in the use of ESWL and a growing use of ureteroscopy. Our analysis of contemporary data indicated that the declining trend in the use of ESWL continued through 2021, while the use of ureteroscopy remained relatively stable. This trend could be attributed in part to the literature supporting the use of ureteroscopy for higher stone-free rates, especially for ureteral stones.[15]

About a third of patients received retreatment within 120 days of the first surgery. Retreatment for kidney stones in the short term has been used as an indicator for the degree of clinical effectiveness.[16] However, our finding on retreatment does not distinguish between a failed initial treatment or staged treatment, which may have different implications. This is a worthwhile area for future research.

[1] New, Francesca and Bhaskar K. Somani. 2016. "A Complete World Literature Review of Quality of Life (QOL) in Patients with Kidney Stone Disease (KSD)." *Current Urology Reports* 17 (12): 88. https://doi.org/10.1007/s11934-016-0647-6.

[2] Pearle, Margaret S., David S. Goldfarb, Dean G. Assimos, et al. 2014. "Medical Management of Kidney Stones: AUA Guideline." *Journal of Urology* 192 (2): 316–324. https://doi.org/10.1016/j.juro.2014.05.006.

[3] Assimos, Dean, Amy Krambeck, Nicole L. Miller, et al. 2016. "Surgical Management of Stones: American Urological Association/Endourological Society Guideline, Part I." *Journal of Urology* 196 (4): 1153–1160. https://doi.org/10.1016/j.juro.2016.05.090.

[4] In 2021, approximately 7% and 9% of the patients with USD in commercial insurance and Medicaid, respectively, also had chronic kidney disease.

[5] For comparative perspective, the percentage of patients with chronic kidney disease with evidence of serum creatinine test results among VA patients was around 65-75% during 2005-2018. See Centers for Disease Control and Prevention. "Chronic Kidney Disease (CKD) Surveillance System." https://nccd.cdc.gov/ckd/detail.aspx?Qnum=Q642.

[6] Prior to 2014, ureteroscopy and stent placement in the same setting could be billed separately. However, in 2014, Current Procedural Terminology (CPT) code 52356 was introduced, which bundles ureteroscopy with stent placement. Therefore, after 2014, we saw a drop in ureteral stent placement that are billed alone in claims.

[7] Abufaraj, Mohammad, Tianlin Xu, Chao Cao, et al. 2021. "Prevalence and Trends in Kidney Stone Among Adults in the USA: Analyses of National Health and Nutrition Examination Survey 2008-2018 Data." *European Urology Focus* 7 (6): 1468–1475. https://doi.org/10.1016/j.euf.2020.08.011.

[8] Dallas, Kai B., Simon Conti, Joseph C. Liao, Mario Sofer, Alan C. Pao, John T. Leppert, and Christopher S. Elliott. 2017 "Redefining the Stone Belt: Precipitation Is Associated with Increased Risk of Urinary Stone Disease." *Journal of Endourology* 31 (11): 1203–1210. https://doi.org/10.1089/end.2017.0456.

[9] Scales, Charles D. Jr., Alexandria C. Smith, Janet M. Hanley, and Christopher S Saigal. 2012. "Prevalence of Kidney Stones in the United States." *European Urology* 61 (1): 160–165. https://doi.org/10.1016/j.eururo.2012.03.052; Taylor, Eric N., Meir J. Stampfer, and Gary C. Curhan. 2005 "Diabetes Mellitus and the Risk of Nephrolithiasis." *Kidney International* 68 (3): 1230–1235. https://doi.org/10.1111/j.1523-1755.2005.00516.x; Taylor, Eric N., Meir J. Stampfer, and Gary C. Curhan. 2005. "Obesity, Weight Gain, and the Risk of Kidney Stones." *JAMA,* 293 (4): 455–462. https://doi.org/10.1001/jama.293.4.455.

[10] Krughoff, Kevin and Vernon M. Pais Jr. 2021. "Kidney Stones and the Opioid Epidemic: Recent Developments and Review of the Literature." *Current Opinion in Urology* 30 (2): 159–165. https://doi.org/10.1097/MOU.0000000000000705.

[11] Fwu, Chyng-Wen, Paul W. Eggers, Paul L. Kimmel, John W. Kusek, and Ziya Kirkali. 2013 "Emergency Department Visits, Use of Imaging, and Drugs for Urolithiasis Have Increased in the United States." *Kidney International* 83 (3): 479–486. https://doi.org/10.1038/ki.2012.419.

[12] See for example, Broder, Joshua, Josie Bowen, Jeffrey Lohr, Andrew Babcock, and Jungyeon Yoon. 2007. "Cumulative CT Exposures in Emergency Department Patients Evaluated for Suspected Renal Colic." *Journal of Emergency Medicine* 33 (2): 161–168. https://doi.org/10.1016/j.jemermed.2006.12.035. https://pubmed.ncbi.nlm.nih.gov/17692768/.

[13] Smith-Bindman, Rebecca, Chandra Aubin, John Bailitz, et al. 2014. "Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis." *New England Journal of Medicine* 371 (12): 1100–1110. https://doi.org/10.1056/NEJMoa1404446. https://www.nejm.org/doi/full/10.1056/nejmoa1404446.

[14] Fwu Chyng-Wen, Paul W. Eggers, Paul L. Kimmel, John W. Kusek, and Ziya Kirkali. 2013. "Emergency Department Visits, Use of Imaging, and Drugs for Urolithiasis Have Increased in the United States." *Kidney International* 83 (3): 479–486. https://doi.org/10.1038/ki.2012.419. https://pubmed.ncbi.nlm.nih.gov/23283137/.

[15] Aboumarzouk, Omar M., Slawomir G. Kata, Francis X. Keeley, Samuel McClinton, and Ghulam Nabi. 2012. "Extracorporeal Shock Wave Lithotripsy (ESWL) Versus Ureteroscopic Management for Ureteric Calculi." *Cochrane Database of Systematic Reviews* 16 (5): 2–24. https://doi.org/10.1002/14651858.CD006029.pub4.

[16] Bowen, Diana K., Lihai Song, Jen Faerber, John Kim, Charles D. Scales, Jr., and Gregory E. Tasian. 2020. "Re-treatment After Ureteroscopy and Shock Wave Lithotripsy: A Population Based Comparative Effectiveness Study." *The Journal of Urology* 203 (6): 1156–1162. https://doi.org/10.1097/JU.0000000000000712.