The impact of the COVID-19 pandemic on kidney stone management in a single-payer system

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ABSTRACT

Introduction: We examined the effects of the COVID-19 pandemic on the incidence of kidney stone acute care visits and interventions.

Methods: We conducted a retrospective population-based cohort study using linked administrative healthcare data in the province of Ontario, Canada. We included all patients who, between March 1, 2018, and September 30, 2021, presented to an emergency department (ED) or were admitted to hospital with renal colic (RC), as well as patients who underwent stenting, nephrostomy tube (NT) insertion, shockwave lithotripsy (SWL), ureteroscopy (URS), or percutaneous nephrolithotomy (PCNL). Using univariate and multivariable analyses, outcomes of interest were compared before and after the onset of COVID-19.

KEY MESSAGES

- Rates of renal colic (RC) presentations to EDs, as well as rates of interventions for RC were similar before and during COVID-19.
- After the onset of the pandemic, patients who presented to EDs with RC were more likely to be women, sicker, and more marginalized.
- The duration from temporizing to definitive intervention for RC increased with the onset of the pandemic, which may have been driven by an observed decrease in shockwave lithotripsy use and lack of OR resources.

Results: Our cohort included 149 006 unique patients; there were 74 994 pre- vs. 94 067 peri-COVID RC episodes (p=0.74). Peri-pandemic patients were more likely to be sicker, women, and from marginalized communities. Mean time from temporizing to definitive intervention increased in the first three months of the pandemic (17.9 vs. 32 days), but no statistically significant effect on the overall proportion of patients undergoing definitive intervention was observed. The onset of COVID-19 was associated with a 29.5% reduction in SWL and a 7.9% and 5.4% increase in URS and NT use, respectively. Hospital admissions for RC increased by 10.9%, while ICU admissions decreased by 25% during the pandemic.
Conclusions: RC incidence and intervention rates were similar before and during the pandemic; however, patient demographics and morbidity differed. Understanding these trends can inform protocols for streamlining care in response to analogous strains on publicly funded healthcare systems.

INTRODUCTION

The COVID-19 pandemic placed unprecedented pressures on modern healthcare systems, particularly those with a limited ability to increase throughput. Measures implemented to control the spread of the virus resulted in the deferral and cancellation of most non-urgent outpatient surgeries. The *COVIDSurg Collaborative* estimated that 28,404,603 surgeries across 190 countries were cancelled or postponed in the first 3 months of the pandemic.[1] Concurrently, the estimated backlog of cases in Ontario reached 148,364 surgeries.[2] During the pandemic, pronounced decreases in surgical emergencies have been widely reported.[3,4,5] Delays in healthcare access secondary to government policy, patient anxiety, and treatment postponement may have contributed to higher morbidity.

Limitations on resource allocation particularly impacted the field of urology, where the majority of cases are managed electively. Despite limited data and experience in adjusting to similar public health crises of this magnitude, several expert-informed protocols for priority setting have been proposed in the field of urology.[6,7] Empirical evidence regarding the impact of COVID-19 on urologic care, particularly pertaining to urolithiasis, remains inadequate.[8]

Kidney stone disease is a costly and increasingly pervasive disease that impacts upwards of 10 to 12% of the population in industrialized countries at an annual economic cost of $5 billion.[9,10,11] Therapeutic management is highly variable depending on both stone-related and patient-specific factors. Given the high prevalence and intricacies of urolithiasis treatment, it is of paramount importance for urologists to examine the impact of the COVID-19 pandemic on practice patterns in stone disease for guiding quality patient care in the context of future public health crises and in response to analogous strains on healthcare systems, especially ones with a single-payer structure.\

The objective of our study was to assess the impact of the COVID-19 pandemic on the incidence and management of acute kidney stone disease in Ontario, Canada. To accomplish this we compared the incidence of emergency department (ED) visits and hospital admissions due to renal colic (RC), as well as the rate of interventions for kidney stones, such as ureteric stenting, nephrostomy tube (NT) placement, shock wave lithotripsy (SWL), ureteroscopy (URS), and percutaneous nephrolithotomy (PCNL), in Ontario between the 24 months preceding (pre-COVID) versus 12 months following the onset of the COVID-19 pandemic (peri-COVID).

METHODS

Study design

We conducted a retrospective population-based cohort study using the province of Ontario's administrative healthcare data that were linked to encoded identifiers of particular medical episodes/interventions. Several administrative databases were used to elucidate our cohorts, baseline characteristics, covariate information, and outcome data, including the Ontario Health Insurance Plan (OHIP), the Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD), the Same Day Surgery (SDS) database, the National Ambulatory Care Reporting System (NACRS), and the Registered Persons Database (RPDB). During the study period, approximately 16 million people with universal access to hospital care and physician service lived in Ontario. The annual rate of emigration from the province was approximately 0.5%;[12] therefore, loss to follow-up is minimal.

We conducted this study according to a protocol that was approved by UHN's Research Ethics Board. Reporting of this study follows guidelines set for observational studies using routinely collected health data.[13]

Study population

We included all patients who presented to an ED or were admitted to hospital with acute RC, or who underwent definitive or temporizing intervention for kidney stones in Ontario, between March 1, 2018 and September 30, 2021. Presentations to an ED due to RC was identified through the NACRS database using International Classification of Diseases-10 (ICD-10) codes (Supplementary Table 1). Hospital admissions due to RC (most responsible diagnosis) were identified through the CIHI-DAD also using ICD 10 codes. Definite interventions for kidney stones were defined as SWL, URS, and PCNL. These were determined using Canadian Classification of Intervention (CCI) codes in the CIHI-DAD and SDS database (Supplementary Table 1). Temporizing interventions, defined as stenting and NT placement, were also determined using CCI in the CIHI-DAD and SDS database.

Only episodes associated with patients who were ≥18 years old on the date of the episode were included. Since the unit of analysis was episode, a single patient could have experienced multiple episodes. To account for this in our data and analysis, we considered all episodes in the 6 months following the 'index date' as part of the same episode. We defined the 'index date' as the date at least 6 months after the most recent episode in the 6-month lookback period prior to study commencement (for patients' first episode in the study period), or as the date of the first episode occurring at least 6 months after the 'index date' of the previous episode (for patients with multiple episodes). Patients could not have a record of an episode in the 6 months before their first episode in the study period – these first episodes were excluded from analysis.

Exposure and outcomes

The primary exposure was time period (as a proxy of COVID-19). For all outcome measures, we compared the 2 years prior to COVID-19 onset (March 1, 2018 – March 31, 2020) to the 18 months following COVID-19 onset (April 1, 2020 – September 30, 2021), with sub-classifications into 3-month blocks to control for known seasonal variations in acute kidney stone presentations and to enable more detailed comparisons. Our primary outcome measures were presentation to an ED due to RC, hospital admission due to RC, SWL, URS, PCNL, stenting, and NT placement. Our secondary outcomes included ICU admission and hospital length of stay for admitted patients.

In addition, the Charlson Comorbidity Index (CCI),[14] which assesses mortality risk associated with comorbidities, as well as the Ontario Marginalization Index (ON-Marg), which assesses socio-economic status,[15] were used alongside age, sex, residence (large urban, small urban, rural), and income level to account for potential confounding as a result of changes in the base population over time.

Statistical analysis

Age, number of ED visits per RC episode, and hospital length of stay were reported as means and standard deviations, and/or as medians and interquartile ranges. All other variables were reported as counts and proportions. Characteristics by time period were compared using standardized differences, and p-values. Multivariable interrupted time series models with Newey-West standard errors were used to model the impact of COVID-19 on outcomes, adjusting for age, residence, income level, CCI, and seasonality. Quasi-Poisson regression models being utilized for counts/proportion outcomes, and linear regression models were used for continuous outcomes. All hypothesis tests were two-sided, and p-values less than 0.05 were considered significant. Statistical analyses were conducted using R version 4.0.0 (R statistical software).[16]

RESULTS

A total of 149,006 patients with a total of 169,061 RC episodes were included in the study. Supplementary Table 2 shows demographics of the entire cohort of patients. The mean age was 53.6 (SD=16.4) years and 39.3% of patients were female. Most patients (80.9%) had a CCI score of 0. The vast majority of patients (89.1%) experienced only 1 acute RC episode during the entire study period. Table 1 shows demographic data stratified by pre- and peri-COVID time periods. There was no statistically significant difference in age between pre- and peri- COVID strata; however, the proportion of episodes experienced by female patients was greater in the peri-COVID stratum (39.8%) than in the pre-COVID stratum (39.3%) (p=0.04). Moreover, the peri-COVID stratum was comprised of more comorbid patients (p<0.001).

Nearly 70.0% of all patients resided in a large urban area, with only 8.2% residing in a rural setting. Income quintiles along with quintiles of each of the four ON-Marg dimensions are also shown in Supplementary Table 3. No significant differences were observed between pre- and peri-COVID strata for place of residence, income quintile, instability quintile, and ethnic diversity quintile; however, greater proportions of episodes were associated with higher deprivation and dependency quintiles in the peri-COVID stratum (differences in proportions between strata were significant at p=0.003 and p=0.010, respectively).

When considering all types of interventions in the full cohort, the greatest proportion of episodes (60.6%) was associated with non-intervention; 35.5% were associated with 1 intervention, 3.4% were associated with 2 interventions, and 0.8% were associated with ≥3 interventions. Similar trends were found when stratifying by time period. In the pre-COVID stratum, 62.2% of episodes were associated with non-intervention; 33.8% were associated with 1 intervention, 3.3% were associated with 2 interventions, and approximately 0.7% was associated with ≥3 interventions. In the peri-COVID stratum, 59.4% of episodes were associated with non-intervention; 36.3% were associated with 1 intervention, 3.5% were associated with 2 interventions, and approximately 0.8% was associated with ≥3 interventions.

A greater proportion of RC episodes were associated with stenting than nephrostomy in both the pre-COVID stratum (8.0% vs. 7.0%, respectively) and the peri-COVID stratum (8.4% vs. 7.1%, respectively). Among definite interventions, a greater proportion of episodes were managed with URS than both SWL and PCNL in the pre-COVID stratum (22.5% vs. 3.6% vs. 1.3%, respectively), as well as in the peri-COVID stratum (23.2% vs. 5.4% vs. 1.8%, respectively). Mean time from temporizing to definitive intervention increased in the first 3 months of the pandemic (17.9 vs. 32 days), but no statistically significant effect on the overall proportion of patients undergoing definitive intervention was observed.

Results of multivariable regression analyses evaluating the impact of COVID-19 on RC incidence and intervention are shown in Table 2. COVID-19 had no significant impact on either RC incidence or the proportion of patients undergoing any intervention for RC**,** although the latter did increase by 0.2% over the entire study period (95% CI 0.996–0.999, p=0.002). While COVID-19 onset did result in a 5.4% increase in NT insertions (95% CI 1.001–1.110, p=0.045) (Figure 1A), there was no significant change in NT insertion rates between pre- and peri-COVID strata. For definitive interventions, COVID-19 onset resulted in a 29.5% reduction in SWL (95% CI 0.518–0.96, p=0.026) (Figure 1B) and a 7.9% increase in URS (95% CI 1.003–1.162, p=0.042) (Fig. 1C). Finally, in spite of a 1.5% decrease in PCNL over the entire study period (95% CI 0.974–0.995, p=0.004), no significant associations were found between COVID-19 and PCNL.

Table 3 shows results of regression analyses evaluating the impact of COVID-19 on ED visits, as well as on hospital and ICU admissions.

The mean number of ED visits per RC episode increased by 0.072 visits at COVID-19 onset (95% CI 0.038–0.106, p<0.001), but decreased during the peri-COVID-19 period at a rate of 0.007 visits per month (95% CI -0.009–[-0.004], p<0.001) (Figure 2). After adjusting for cohort characteristics, there remained an increase of 0.039 visits at COVID-19 onset (95% CI 0.011–0.067, p=0.012), as well as a decrease during the peri-COVID period at a rate of 0.004 visits per month (95% CI -0.006–[-0.002], p=0.002).

On multivariable analysis, COVID-19 onset resulted in a 10.9% increase in the proportion of patients hospitalized due to RC (95% CI 1.044–1.177, p<0.001) (Figure 3A). While there was a 25% decrease in the proportion of patients admitted to ICU due to RC at COVID-19 onset (95% CI 0.581–0.968, p=0.027) (Figure 3B), there was no significant change in the trend of ICU admissions during the peri-COVID period. Stratification by intervention vs. non-intervention was not possible due to the small number of ICU admissions.

DISCUSSION

Our study assessed the practice patterns of acute kidney stone management in a single-payer system in both pre- and peri- COVID periods. To our knowledge, our study encompasses the largest cohort to date investigating management of stone disease during the pandemic.

During the onset of the pandemic, people were advised to minimize in-person contact in order to mitigate the risk of transmission. Moreover, many hospitals in Ontario were overwhelmed with COVID-19 patients. Consequently, ED visits for conditions other than COVID-19 were expected to decline, resulting in delays in care and disease progression. A review by Sivakumar et al. found 10 studies that noted decreased rates in the number of patients presenting with urolithiasis, ranging from 21 to 70% of pre-pandemic levels.[8] A number of studies reported elevated creatinine and a higher proportion of septic stones during the pandemic.[17,18]

We did not see a change in RC incidence related to the onset of COVID-19 in our study. However, we found that RC patients presenting to ED in the peri-COVID period were more likely to be women, from marginalized communities, and sicker. While women are more likely than men to experience certain barriers to health care, studies also demonstrate women are more frequent users of primary care, perhaps owing to a lower treatment-seeking threshold and higher survival rates after hospitalization (albeit with disabling conditions).[19,20] The combination of these factors along with potentially greater barriers to accessing primary care during the pandemic may account for the sex-difference in RC patients observed in our study. Moreover, it is understandable that proportionally, sicker patients and those with less resources to cope at home were more likely to present to hospital for care. Commensurately, despite the avoidance of hospital admissions whenever possible, we found a 10.9% increase in the proportion of patients hospitalized due to RC after COVID onset. We also found a 5.4% increase in the NT insertion rate after the onset of COVID. This temporizing intervention may have been increasingly utilized due to a lack of access to OR time for stent insertion and definitive interventions such as URS or SWL. As patients attempted to avoid visiting hospitals, however, those that eventually presented to ED may have presented with worse disease burden (i.e., more significant obstruction or infections requiring urgent NT drainage). Having said that, we saw a 25% decrease in the proportion of RC patients admitted to the ICU after COVID-19 onset. This may be explained by the fact that ICU beds were completely overrun with intubated COVID patients.

The majority of RC episodes can be managed conservatively. Accordingly, we found that approximately 60% of all RC presentations to the ED were managed without intervention in both the pre- and peri- COVID strata. Of those that required intervention, however, we noticed a 23.4% increase in ED visits after the onset of COVID-19. This may be explained by limited access to outpatient follow-up care earlier in the pandemic, when most physicians and urologists had temporarily closed their practices and before virtual consultation services were implemented.

Our study also found a reduction in SWL interventions by nearly 30% during the outset of the pandemic coupled with a rise in URS of nearly 8%. Given that SWL is often performed on asymptomatic, non-obstructive stones, the three SWL centres in the province were closed. While URS is more invasive than SWL as it requires general anesthesia, it can be done on an outpatient basis as well. As such, many hospitals were permitting URS interventions to proceed. Without access to SWL, the necessity of performing more invasive procedures like URS to manage urolithiasis may have also contributed to the observed increase in hospitalizations as complications requiring hospital admission are known to be more common after URS than SWL.[21]

Several studies have also demonstrated a decline in SWL rates at the outset of the pandemic.[8,22] A cross-sectional American study observed a reduction in SWL of 22.7% during the first year of the pandemic followed by reductions in PCNL (19.3%) and URS (14.3%).[22] Nonetheless, increases in the use of SWL during the pandemic have been reported elsewhere.[23] SWL can in fact be performed on symptomatic or obstructing stones and is associated with lower complications, a lower risk of needing hospital admission and can be done without general anesthesia on an outpatient basis. Taken together, rather than closing SWL centres, it may be an invaluable option in future pandemics for limiting both aerosolization secondary to intubation and in-patient burden on healthcare systems.

Finally, we found a longer delay from temporizing to definitive intervention (i.e., mean 14.1 days) within the first 3 months of COVID onset. This was likely due to overall limited availability of resources for performing definitive interventions like SWL.

Strengths and limitations

Our study possesses several notable strengths. First, it includes a large cohort of patients identified through provincial administrative databases, with minimal loss to follow-up. Second, it offers insight into the response of a single-payer healthcare system to the COVID-19 pandemic in the context of a relatively common condition, urolithiasis.

However, the study also has limitations. First, we used ICU admission with RC as a surrogate marker for urosepsis secondary to an infected stone. This approach may have led to the under identification of relevant cases due to potential coding inaccuracies within the administrative databases. While such misclassification could introduce selection bias, we believe this is mitigated by the broad inclusion of a large and diverse patient population, enhancing generalizability.

Second, the absence of patient-level laboratory and imaging data limited our ability to assess disease severity, determine indications for intervention, and understand the rationale behind specific management decisions, including delays in definitive treatment.

Third, the impact of the pandemic varied across hospitals. While some were severely strained by COVID-19 admissions, others experienced a relatively lower burden. As a result, we could not evaluate hospital-specific trends in RC presentation or management.

Fourth, as an observational study, causality cannot be established. Fifth, although we adjusted for potential confounders such as demographics, socioeconomic status, and comorbidities, unmeasured factors—such as physician referral patterns, healthcare access, and diagnostic imaging availability—could not be fully accounted for.

Finally, although we aimed to assess mortality outcomes, the low incidence precluded meaningful analysis.

CONCLUSIONS

Our population-based retrospective cohort revealed similar rates of RC presentations to the ED and related interventions before and during the pandemic. After the onset of the COVID-19 pandemic, however, patients presenting to the ED were more likely to be women and from a marginalized community. Moreover, patients were more likely to be sicker as evidenced by higher CCI score and an 11% higher rate of admission. We also saw an increased duration from temporizing to definitive intervention with the onset of the pandemic, perhaps driven by a significant decrease in SWL and lack of OR resources. Hopefully, these findings can inform protocols for streamlining care in future health crises and in response to analogous strains on publicly funded healthcare systems.

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FIGURES AND TABLES

Figure 1A. Proportion of patients undergoing nephrostomy.

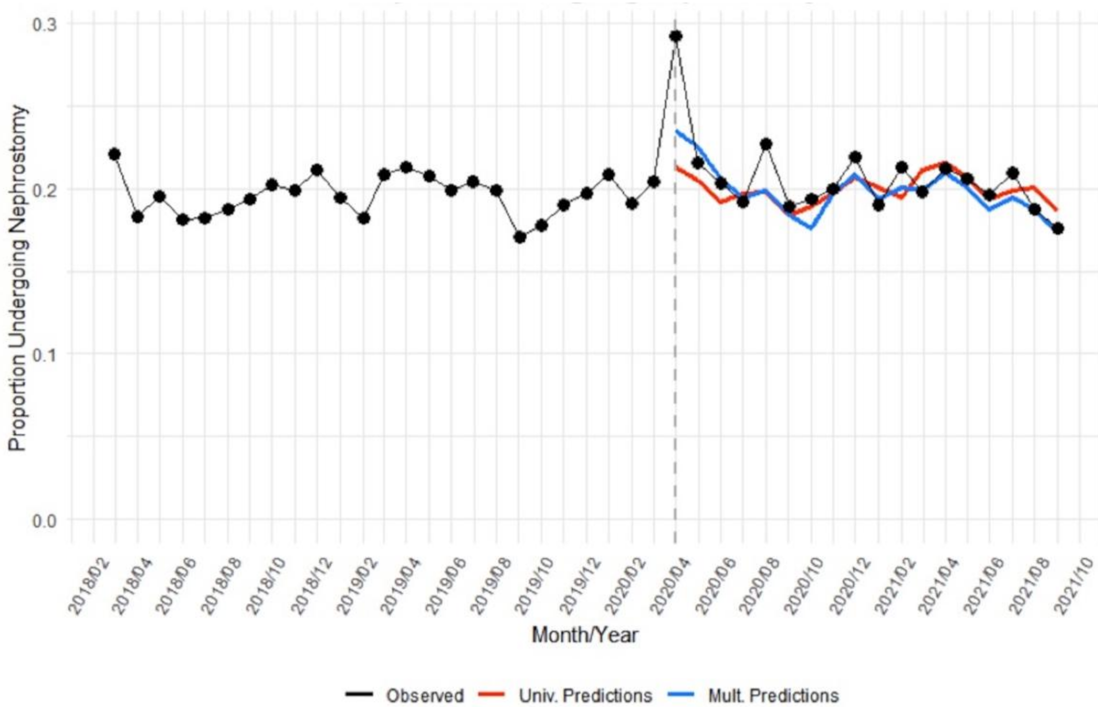

Figure 1B. Proportion of patients undergoing shock wave lithotripsy.

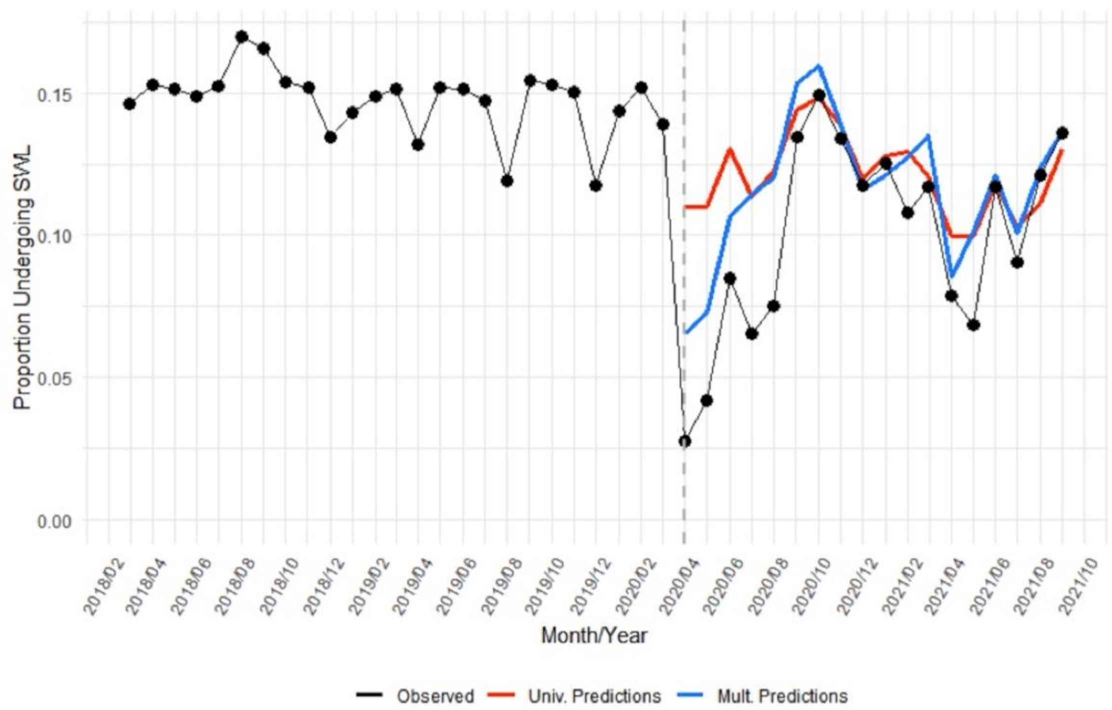

Figure 1C. Proportion of patients undergoing ureteroscopy.

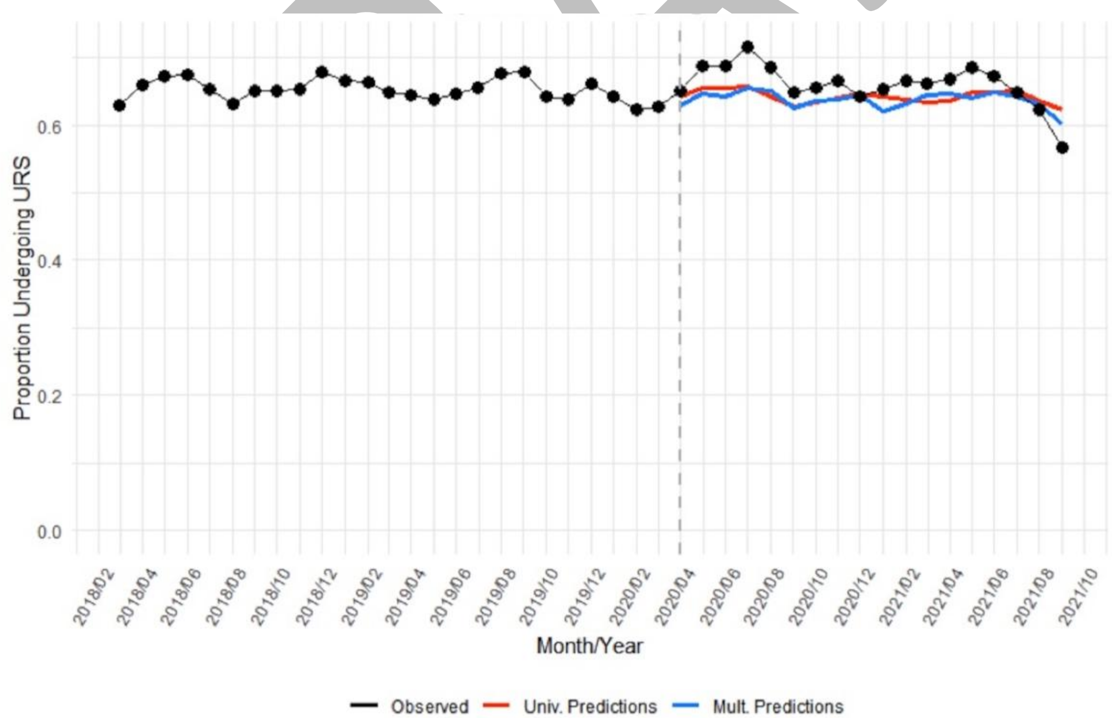

Figure 2. Mean number of ED visits.

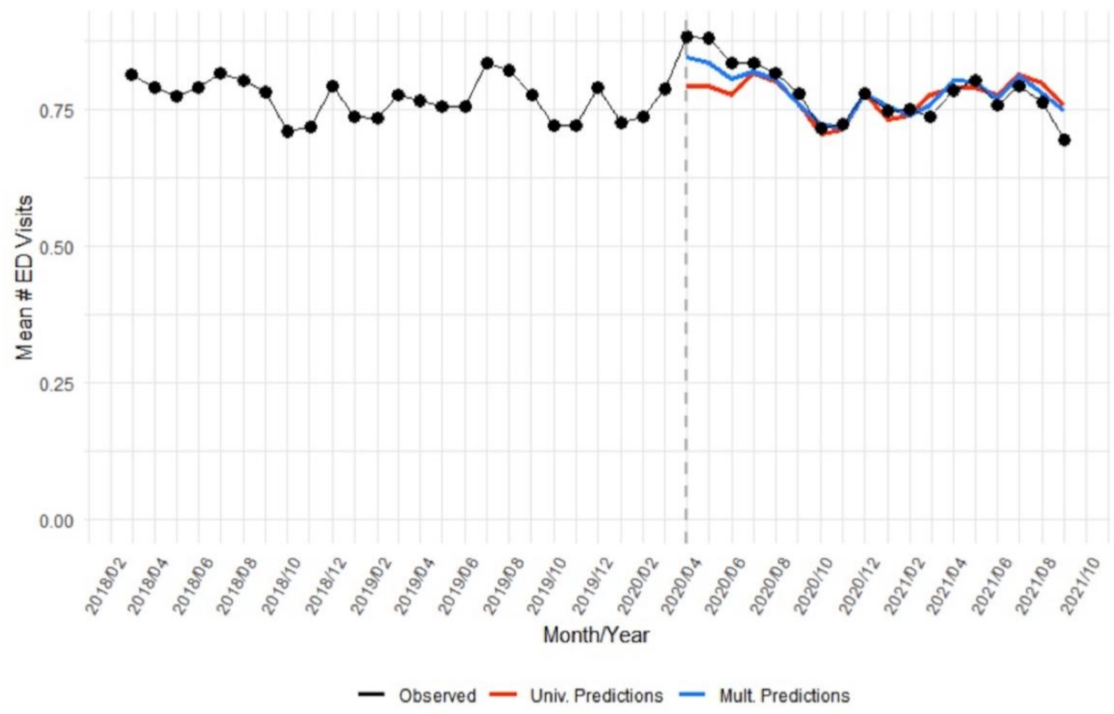

Figure 3A. Proportion of hospitalized patients.

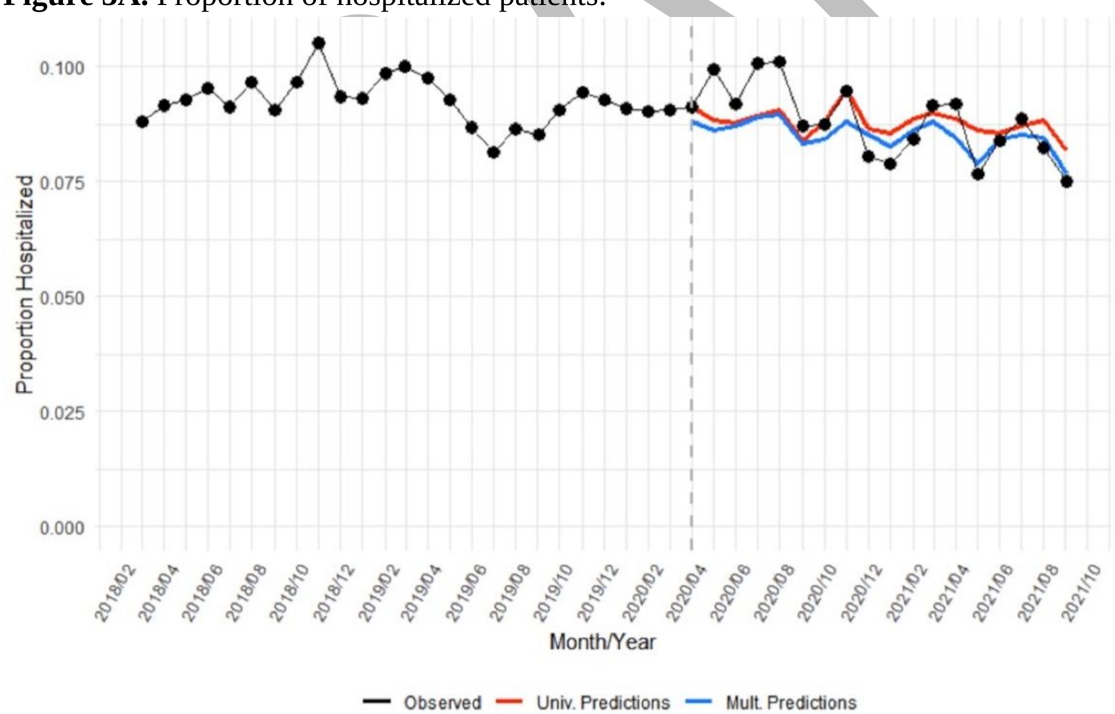

Figure 3B. Proportion of patients with ICU admission.

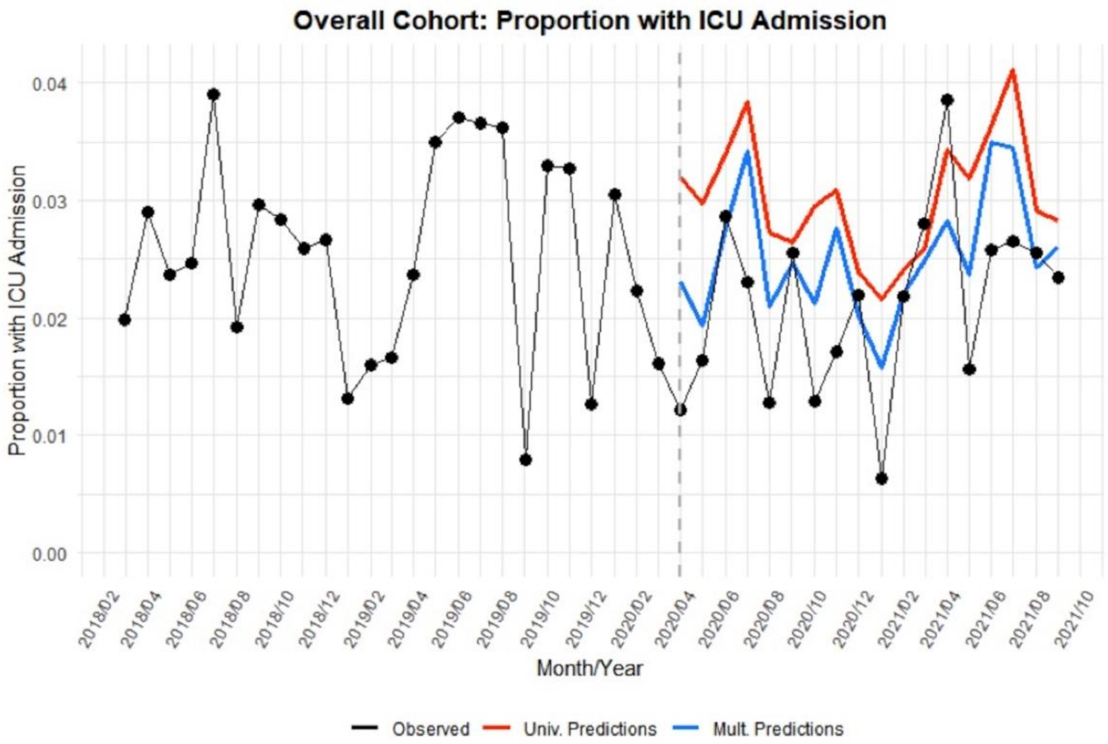

Table 1. Characteristics of 149,006 unique patients reported at the renal colic EPISODE-LEVEL and stratified by time period (i.e., pre-COVID vs. peri-COVID)					
Characteristic	**Full cohort (N=169 061)**	**Pre-COVID (n=74 994)**	**Peri-COVID (n=94 067)**	**Standardized difference**	**p**
Age					0.278
Mean ± SD	53.78±16.41	53.73±16.53	53.82±16.30	0.01	
Median (IQR)	55 (42–66)	55 (41–66)	55 (42–66)	0	
Sex					0.038*
Female	66 935 (39.6%)	29 485 (39.3%)	37 450 (39.8%)	0.01	
Male	102 126 (60.4%)	45 509 (60.7%)	56 617 (60.2%)	0.01	
CCI					<0.001**
0	134 745 (79.7%)	60 200 (80.3%)	74 545 (79.2%)	0.03	
1–2	24 674 (14.6%)	10 618 (14.2%)	14 056 (14.9%)	0.02	
3–4	5254 (3.1%)	2301 (3.1%)	2953 (3.1%)	0	
≥5	4388 (2.6%)	1875 (2.5%)	2513 (2.7%)	0.01	

*Significant difference between pre- and peri- COVID periods at $p<0.05$. **Significant difference at $p<0.001$.
CCI: Charlson comorbidity index; IQR: interquartile range; SD: standard deviation.

Table 2. Impact of COVID on renal colic incidence and intervention				
Variable	**Time parameter**	**Multivariable**		
		IRR or estimate	**CI**	**p**

RC incidence	Over time	1.001	0.999, 1.003	0.42
	Onset	0.993	0.941, 1.047	0.78
	Peri-COVID	0.999	0.993, 1.005	0.74
Proportion undergoing intervention	Over time	0.998	0.996, 0.999	0.002*
	Onset	1.009	0.954, 1.068	0.75
	Peri-COVID	1.001	0.996, 1.006	0.68
Stent	Over time	0.999	0.994, 1.003	0.53
	Onset	1.026	0.934, 1.127	0.60
	Peri-COVID	1.001	0.994, 1.008	0.81
Nephrostomy	Over time	0.999	0.996, 1.002	0.45
	Onset	1.054	1.001, 1.11	0.045*
	Peri-COVID	0.998	0.993, 1.003	0.49
SWL	Over time	0.990	0.979, 1	0.061
	Onset	0.705	0.518, 0.96	0.026*
	Peri-COVID	1.020	0.998, 1.043	0.078
URS	Over time	0.999	0.996, 1.003	0.66
	Onset	1.079	1.003, 1.162	0.042*
	Peri-COVID	0.996	0.979, 1.013	0.62
PCNL	Over time	0.985	0.974, 0.995	0.004*
	Onset	1.167	0.886, 1.536	0.27
	Peri-COVID	0.996	0.978, 1.015	0.69

Over time = variable trend over entire study period (pre- and peri- COVID periods). Onset = level change in variable trend at COVID onset. Peri-COVID = change in variable trend from pre-COVID period to peri-COVID period. *Significant association between time parameter and variable at $p<0.05$. **Significant association at $p<0.001$. CI: confidence interval; IRR: incidence rate ratio; PCNL: percutaneous nephrolithotomy; RC: renal colic; SWL: shockwave lithotripsy; URS: ureteroscopy.

Table 3. Impact of COVID on emergency department (ED) visits, hospital admission, and ICU admission, wherein renal colic was the most responsible diagnosis

Variable	**Time parameter**	**Multivariable**		
		IRR or estimate	**CI**	**p**
Mean ED visits/colic				
Overall	Over time	0.000	-0.001, 0.001	0.98
	Onset	0.039	0.011, 0.067	0.012*
	Peri-COVID	-0.004	-0.006, -0.002	0.002*
Intervention cohort	Over time	-0.003	-0.003, -0.002	<0.001**
	Onset	0.048	0.030, 0.066	<0.001**
	Peri-COVID	-0.001	-0.003, 0.002	0.63
	Over time	0.001	-0.001, 0.002	0.42

Non-intervention cohort	Onset	0.034	-0.008, 0.076	0.12
	Peri-COVID	-0.005	-0.010, -0.001	0.024*
Proportion with ED visit				
Overall	Over time	1.000	0.999, 1.001	0.58
	Onset	1.020	0.991, 1.050	0.17
	Peri-COVID	0.999	0.996, 1.001	0.32
Intervention cohort	Over time	0.990	0.987, 0.993	<0.001**
	Onset	1.234	1.161, 1.311	<0.001**
	Peri-COVID	0.998	0.991, 1.005	0.59
Non-intervention cohort	Over time	1.000	1.000, 1.001	0.07
	Onset	1.006	0.997, 1.014	0.18
	Peri-COVID	0.999	0.998, 1.000	0.005*
Proportion hospitalized				
Overall	Over time	0.997	0.993, 1.001	0.12
	Onset	1.109	1.044, 1.177	<0.001**
	Peri-COVID	0.993	0.983, 1.003	0.19
Intervention cohort	Over time	0.997	0.988, 1.005	0.42
	Onset	1.178	0.941, 1.475	0.15
	Peri-COVID	0.991	0.979, 1.002	0.112
Non-intervention cohort	Over time	1.016	1.012, 1.021	<0.001**
	Onset	0.961	0.817, 1.13	0.63
	Peri-COVID	0.982	0.967, 0.998	0.029*
Proportion with ICU				
Overall	Over time	1.005	0.990, 1.020	0.52
	Onset	0.750	0.581, 0.968	0.027*
	Peri-COVID	1.014	0.988, 1.039	0.29

Over time = variable trend over entire study period (pre- and peri-COVID periods). Onset = level change in variable trend at COVID onset. Peri-COVID = change in variable trend from pre-COVID period to peri-COVID period. *Significant association between time parameter and variable at $p<0.05$. **Significant association at $p<0.001$. CI: confidence interval; IRR: incidence rate ratio.