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ARTICLE

Impact of the 2024 national medical fluid shortage on urologic practice in the United States: a cross-sectional survey

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Objectives: *In September 2024, Hurricane Helene caused extensive infrastructure damage in the United States, including severe disruption to a major Baxter sterile irrigation fluid manufacturing facility in North Carolina, leading to a nationwide shortage of sterile irrigation fluids used in surgical procedures. The objective of this study was to evaluate the impact of the nationwide sterile irrigation fluid shortage on urologic practice across the United States (U.S.)*

Methods: *A descriptive, cross-sectional Research Electronic Data Capture (REDCap) survey was distributed to U.S. urologists. The questionnaire captured provider demographics, procedure delays, and practice/procedure modifications.*

Results: *Ninety-five surgeons responded. Overall, 76.8% reported an impact on practice, and 47% were directed by hospitals to cancel or reschedule cases. Over one-third rescheduled more than 10 procedures, with a median delay of two months. Benign prostatic hyperplasia (BPH) treatments and percutaneous nephrolithotomy (PCNL) were the most affected. About 36% noted a negative impact on physician–patient relationships. Nearly half (45.7%) modified outpatient procedures, primarily cystoscopies, using syringe irrigation or requesting patients arrive with full bladders.*

*Surgical adjustments (40.4%) included switching from holmium laser enucleation of the prostate (**HoLEP**) to simple prostatectomy and reducing resident involvement. Postoperatively, increased catheter traction was used to limit irrigation. Twenty-nine urologists planned to retain conservation measures such as smaller fluid bags or reduced pressurized irrigation. At survey completion, 32.6% still experienced effects of the fluid shortage.*

Conclusions: *The 2024 national fluid shortage significantly disrupted U.S. urology practice, especially endourology cases. Urologists adopted a range of clinical and surgical strategies, some of which may persist, underscoring the need for systemic preparedness to mitigate future shortages.*

Key Words: Laser, minimally invasive endoscopic combined intrarenal surgery, urolithiasis, fluid shortage, endourology

Introduction

In September 2024, Hurricane Helene made landfall in the southeastern United States (U.S.), causing widespread devastation to regional infrastructure, transportation networks, and industrial facilities. Among the most consequential disruptions for the healthcare system was the damage to a major Baxter sterile fluid manufacturing facility in North Carolina,

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a critical supplier of intravenous and irrigation fluids for hospitals nationwide. This disruption rapidly propagated through the medical supply chain, resulting in a nationwide shortage of sterile fluids essential for patient care and surgical practice.[1–4] Unlike more localized disruptions, the centralized nature of modern medical manufacturing meant that the effects of this single facility outage were felt simultaneously across hospitals, ambulatory surgery centers, and outpatient clinics throughout the country.

Sterile intravenous and irrigation fluids are foundational to nearly every aspect of modern medical care, supporting emergency resuscitation, anesthesia, perioperative management, renal replacement therapy, and countless diagnostic and therapeutic procedures. When these supplies become scarce, healthcare systems are forced to implement conservation strategies, defer elective care, ration critical resources, and modify standard clinical workflows.[5–8] Previous large-scale shortages have demonstrated that such disruptions can compromise patient safety, strain hospital operations, increase healthcare costs, and erode patient trust in the healthcare system.[9–13] During prior crises, including the COVID-19 pandemic, supply chain instability was shown to directly influence treatment decisions, staffing models, and the prioritization of care, underscoring that supply availability is a critical but often underappreciated determinant of clinical outcomes.

Among medical specialties, urology is uniquely vulnerable to fluid shortages because of its heavy reliance on sterile irrigation fluids during both outpatient and operative procedures. High-volume irrigation is essential for visualization, hemostasis, and tissue removal during procedures such as transurethral resection of the prostate (TURP), holmium laser enucleation of the prostate (HoLEP), percutaneous nephrolithotomy (PCNL), and ureteroscopy.[14] Even short interruptions in fluid availability have the potential to translate into canceled surgeries, prolonged operative times, incomplete procedures, or altered surgical strategies, with potential consequences for both clinical outcomes and patient satisfaction. Unlike some surgical specialties that can reduce operative volume without immediate clinical consequences, many urologic procedures directly address pain, infection, obstruction, and bleeding, making prolonged delays particularly burdensome for patients.

Despite the recognized importance of irrigation fluids to endourologic practice, little systematic data exist on how a nationwide fluid shortage affects urologic care delivery. While institutional alerts, professional society statements, and industry communications documented the scope of the 2024 crisis, the real-world impact on practicing urologists particularly with respect to case delays, procedural adaptations, and patient–physician relationships has not been well characterized.[15–17] Understanding these effects is essential for developing evidence-based preparedness strategies and for informing policy discussions around healthcare supply chain resilience.

Accordingly, the purpose of this study was to assess the impact of the 2024 nationwide sterile fluid shortage on urologic practice in the United States. Unlike prior institutional reports, commentaries, or proposed stewardship frameworks, this study provides national, physician-level data quantifying procedural delays, clinical adaptations, and physician-perceived effects on patient–physician relationships across diverse practice settings. By characterizing these real-world experiences, we aim to inform future preparedness strategies and contribute to broader discussions on healthcare supply chain resilience in irrigation-dependent surgical specialties.

Materials and Methods

This study was reviewed and approved by the University of Kansas Medical Center Institutional Review Board (IRB ID: STUDY00161251). The study consisted of an anonymous survey of physicians and posed minimal risk to participants. Following IRB determination, we conducted a descriptive, cross-sectional study using a one-time, web-based survey to evaluate the impact of the 2024 sterile fluid shortage on urologic practice in the United States. The survey was developed by the study investigators and administered through Research Electronic Data Capture (REDCap), a secure platform designed to support data collection for clinical research, ensure data integrity, and maintain participant confidentiality. Participation was voluntary, and an information statement was provided at the beginning of the survey. Informed consent was implied by voluntary completion of the anonymous survey, in accordance with Institutional Review Board approval (Supplemental File).

The 34-item survey was distributed to practicing urologists who were members of either the South Central Section of the American Urological Association or the World Congress of Endourology. These organizations were selected to capture a broad range of practice settings, geographic regions, and subspecialty representation, particularly among

endourologists. Survey distribution was completed and responses were collected between October 2024 through April 2025. A link to the survey was delivered electronically, and participation was voluntary. No incentives or payment were offered for participation. The full survey instrument is provided in Supplemental File.

The survey was designed to capture a broad range of information related to both provider characteristics and the perceived effects of the national fluid shortage. Demographic and practice-related variables included age, sex, geographic region, practice setting, fellowship training status, years in practice, and approximate weekly surgical volume. Additional items assessed the types of procedures routinely performed, allowing stratification of responses by practice focus and case mix.

The survey instrument was developed by the study investigators based on clinical experience during the national fluid shortage. The questionnaire was not formally pilot tested or externally validated prior to distribution. Questions were designed to be concise and unambiguous, and branching logic was used to minimize respondent burden. Likert-scale questions were selected to allow respondents to quantify the perceived magnitude of impact across multiple domains of practice; these responses were analyzed descriptively.

Specific questions focused on the impact of the fluid shortage on daily urologic practice, including whether respondents were required to cancel or postpone surgical cases, the number and type of procedures affected, and the duration of delays. Respondents were also asked about outpatient and intraoperative adaptations implemented in response to limited fluid availability, such as changes in irrigation techniques, alterations in surgical approach, or modifications to resident participation. Perceived changes in physician–patient relationships and patient satisfaction related to the shortage were also assessed.

Most survey items were measured using a 5-point Likert scale, ranging from "no impact" to "extremely impacted," allowing respondents to quantify the perceived severity of the shortage on multiple aspects of clinical practice. Open-ended fields were included to allow respondents to describe additional adaptations, concerns, or experiences not captured by predefined questions or response options.

Descriptive statistics were used to summarize survey responses. Continuous variables are reported as medians with ranges, and categorical variables are presented as frequencies and percentages. Analyses were performed using de-identified data exported from Research Electronic Data Capture (REDCap). Given the descriptive nature of the study, no inferential statistical tests were performed.

Results

A total of 95 urologists from across the United States completed the survey between November 2024 and April 2025. Respondent demographics, training history, and practice characteristics are summarized in Table 1. Overall, 73 respondents (76.8%) reported that their urologic practice was directly impacted by the national sterile fluid shortage, indicating that the effects of the disruption were widespread and not limited to isolated institutions or geographic regions.

A substantial proportion of respondents reported significant disruption to surgical scheduling. Nearly half of the surveyed urologists (47%; 45 of 95) indicated that they were instructed by hospital administrators to postpone or cancel operative cases because of limited fluid availability. Among these respondents, more than one-third (36.4%; 16 of 45) were required to reschedule more than 10 procedures. The median reported delay was two months, with a wide range from zero to 4.5 months. Despite this variability, nearly all respondents (95%) reported that their patients were ultimately rescheduled within three months. This finding suggests that, while most institutions were eventually able to accommodate postponed cases, the interim delays represented a substantial disruption to routine care. The types of procedures most commonly affected by postponement or cancellation are summarized in Table 2, with benign prostatic hyperplasia (BPH) procedures and PCNL being the most frequently impacted.

In response to these disruptions, urologists reported multiple adaptations in the outpatient setting. For example, 45.7% of respondents indicated that they modified their routine cystoscopy practices. Common strategies included replacing standard gravity-based irrigation with manual instillation of pourable saline using 60-cc syringes and instructing patients to arrive with a full bladder in order to reduce or eliminate the need for irrigation fluid during diagnostic cystoscopy. These approaches were implemented in an effort to maintain diagnostic capacity, while conserving scarce irrigation resources during the shortage.

Intraoperative practices were also substantially altered. Forty percent of respondents (43 of 95) reported implementing intraoperative modifications because of the fluid shortage. These included changing surgical approach, such as shifting from HoLEP

TABLE 1. **Respondent demographics, training, and practice type**

Demographics	
Age (years), median (IQR)	49 (41–57)
Sex, *n* (%)	
Male	80 (87.9%) (80/95)
Female	11 (12.1%) (11/95)
No response	2 (2.1%) (2/95)
AUA section, *n* (%)	
Mid-Atlantic	7 (8.5%)
New England	5 (6.1%)
New York	7 (8.5%)
North central	9 (11.0%)
Northwestern	1 (1.2%)
Southcentral	37 (45.1%)
Southwestern	12 (14.6%)
Western	6 (7.3%)
Fellowship trained	
Yes	69 (74.2%)
No	24 (25.8%)
Fellowship type, *n* (%)	
Endourology	50 (72.5%)
URPS	3 (4.3%)
GURS	2 (2.9%)
Andrology	1 (1.4%)
Pediatric urology	10 (14.5%)
Urologic oncology	3 (4.3%)
Other	
Practice, *n* (%)	
Academic/University	65 (69.1%)
Hospital	
Public or private	20 (21.3%)
Hospital	12 (12.8%)
Private practice	0 (0%)
Research only	1(1.1%)
Other	
Number surgical procedures each week, median (IQR)	10 (7–13)

URPS: Urogynecology and reconstructive pelvic surgery
GURS: Genitourinary reconstructive surgery
AUA: American urological association
IQR: Interquartile range

to open or robotic simple prostatectomy in selected patients, as well as limiting resident participation in order to decrease operative time and fluid utilization. Postoperatively, respondents reported increased reliance on catheter traction in BPH cases as a strategy to minimize the need for continuous bladder irrigation.

Importantly, several of these adaptations were not viewed as temporary. Nearly one-third of respondents (25 of 95; 30.9%) indicated that they planned to continue using at least one practice change that had been implemented during the shortage, even after fluid supplies returned to normal, as evidenced in Tables 3 and 4. This suggests that the crisis prompted reassessment of long-standing practice patterns and may lead to durable changes in how urologic care is delivered.

The fluid shortage was also perceived to have a meaningful impact on the patient–physician relationship. More than one-third of urologists (36.1%) reported a negative effect on patient trust and satisfaction. When asked to rate the impact on their relationships with patients, 60 respondents (63.8%) reported no impact, 21 (22.3%) reported slight impact, 11 (11.7%) reported moderate impact, and 2 (2.1%) reported significant impact; no respondents reported extreme impact. In addition, nearly one-third of respondents (32.6%) indicated that the consequences of the fluid shortage were still ongoing at the time they completed the survey, suggesting that the effects of the disruption extended well beyond the immediate aftermath of Hurricane Helene.

Discussion

To our knowledge, this study represents the first systematic effort to quantify the national impact of the 2024 sterile fluid shortage on urologic practice in the United States using physician-reported data. While prior publications largely consisted of institutional experiences, commentaries, or proposed stewardship frameworks, addressing medical supply shortages and their clinical impact, this survey captures real-world disruptions, clinical adaptations, and physician-perceived relational effects across diverse practice settings during a prolonged national supply chain failure.[5–8] Similar patterns of limited early reporting during healthcare shortages have been observed in prior drug supply disruptions.[18]

Although this survey included respondents from multiple AUA sections, the sample was disproportionately composed of fellowship-trained endourologists and urologists practicing in the South Central region. According to national workforce data from the American Urological Association, endourology represents a smaller proportion of

TABLE 2. **Physician reported surgical procedure types rescheduled due to fluid shortage**

Procedure category	Number of providers reporting impact	%
BPH	39	88.6%
Percutaneous nephrolithotomy (PCNL)	18	40.9%
Ureteroscopy	11	25.0%
Cystoscopy (without resection)	9	20.5%
Bladder tumor resection	9	20.5%
Robotic cases	0	0%
Open cases	1	2.3%

Note. Percentages calculated among the 45 respondents who rescheduled procedures. BPH: Benign prostatic hyperplasia.

TABLE 3. **Short-term adaptations to fluid shortage**

Adaptations	Num. (n = 43)	%
1-L bags, less fluid, smaller bags	14	32.5%
Using only 60cc syringes for irrigation in clinic	9	20.9%
Patient comes with full bladder for clinic cystoscopy	2	4.6%
Change type of fluid	9	20.9%
Limit teaching	2	4.6%
Others	7	16.2%

Note. Respondents could select multiple options.

TABLE 4. **Long-term adaptations planned to continue after shortage**

Adaptations	Num. (n = 29)	%
Syringe irrigation or irrigation fluid from smaller bags	9	31%
More attention to not waste fluid	9	31%
En-bloc HoLEP	2	6.8%
Shorten surgery time	2	6.8%
Others	7	24.1%

Note. Respondents could select multiple options. HoLEP: Holmium Laser Enucleation of the Prostate.

the overall urologic workforce, and geographic distribution is more evenly dispersed across sections. As such, the magnitude of impact reported in this study may reflect an overrepresentation of irrigation-intensive subspecialties and regions more heavily affected by institutional policies. These findings should therefore be interpreted as reflective of high-volume, irrigation-dependent practices rather than the entirety of U.S. urology.

Nearly three-quarters of respondents reported meaningful disruption to their practice, underscoring the magnitude of the shortage. Urology, and

endourology in particular, is uniquely vulnerable to fluid scarcity due to the high-volume irrigation requirements of procedures such as TURP, HoLEP, and PCNL. Similar procedure-specific vulnerabilities during supply shortages have been reported across multiple medical specialties, where resource-dependent interventions are disproportionately affected.[5,6,19] The predominance of postponed BPH and PCNL cases observed in this study reflects the specialty-specific dependence of urology on irrigation fluids and highlights the disproportionate burden placed on irrigation-intensive procedures during periods of resource constraint.

Beyond procedural delays, the shortage prompted widespread modifications in outpatient and intraoperative care. In the clinic, many urologists adopted low-fluid cystoscopic techniques, including syringe-based irrigation or reliance on a full bladder to preserve diagnostic capacity while conserving resources. In the operating room, respondents reported altering surgical approaches, limiting trainee participation, and modifying postoperative management to reduce irrigation requirements. Comparable crisis-driven adaptations have been described in other clinical settings during fluid shortages, where clinicians were forced to modify standard workflows in the absence of adequate supplies.[11,20] These findings illustrate how supply shortages can influence not only scheduling logistics but also surgical decision-making and clinical workflow.

Importantly, not all adaptations carry equivalent implications. Some changes such as increased awareness of fluid waste or selective use of smaller irrigation volumes may represent efficiency-enhancing practices that could be safely sustained beyond crisis conditions. In contrast, other adaptations, including reduced resident participation or shifts from minimally invasive endourologic procedures to more invasive alternatives, raise concerns regarding surgical education, perioperative morbidity, length of stay, and healthcare costs. Recent work has proposed structured, evidence-based stewardship frameworks to guide procedural prioritization and irrigation utilization in endourology during periods of scarcity.[14] In the absence of such frameworks, conclusions regarding the safety or sustainability of long-term practice changes should be considered hypothesis-generating rather than definitive.

While certain conservation strategies may improve efficiency, the safety and long-term efficacy of sustained adaptations such as routine syringe irrigation, reduced irrigation volumes, or altered operative techniques have not been formally evaluated. Uncritical adoption of these measures outside of crisis conditions may carry unintended consequences, including compromised visualization, increased complication risk, or altered procedural outcomes. Prospective studies are required before widespread implementation can be recommended.

The fluid shortage was also perceived by physicians to negatively affect patient trust and satisfaction. These physician perceptions of their patient relationships likely reflect the cumulative impact of delayed procedures, altered care plans, and uncertainty surrounding rescheduling rather than documented patient-level outcomes. Although objective patient experience measures were not assessed in this study, prior reports from other clinical domains have demonstrated that intravenous fluid shortages can adversely affect patient safety, length of stay, and healthcare utilization.[12,13] Together, these findings suggest that the relational and experiential consequences of supply shortages may extend beyond the immediate clinical disruption.

From a systems perspective, similar vulnerabilities in healthcare supply chain resilience have been described across multiple industries and healthcare systems worldwide,[21] the 2024 sterile fluid shortage exposed vulnerabilities inherent in centralized manufacturing and just-in-time supply models, mirroring challenges observed during prior crises such as the COVID-19 pandemic and the nationwide intravenous fluid shortages following Hurricane Maria.[22] Broader analyses of healthcare supply chains have consistently demonstrated that efficiency-driven models often lack resilience when faced with large-scale disruptions in medical supply production and distribution.[23–25] The concentration of sterile fluid production within a limited number of facilities created a single point of failure, with downstream effects felt across hospitals and outpatient centers nationwide.

Beyond centralized manufacturing, additional vulnerabilities include limited hospital-level emergency stockpiling standards for high-volume irrigation fluids, dependence on just-in-time inventory management, and the absence of cross-regional redistribution frameworks tailored to specialty-specific needs. For irrigation-intensive specialties such as urology, future preparedness strategies should incorporate procedure-based triage algorithms distinguishing urgent oncologic, obstructive, and infection-related interventions from elective stone or BPH procedures. Specialty-specific conservation protocols, predefined thresholds for irrigation allocation, and regional stockpiling

guidelines may improve resilience without compromising patient safety or surgical education.

In response to the 2024 shortage, multiple professional organizations, regulatory agencies, and industry stakeholders issued guidance on fluid conservation and mitigation strategies.[1–4] While these efforts provided important general recommendations, they largely lacked specialty-specific prioritization frameworks tailored to irrigation-intensive surgical fields such as urology. The findings of this study underscore the need for proactive preparedness strategies, including diversified manufacturing, regional stockpiling of high-volume consumables, and formalized irrigation stewardship models that incorporate clinical urgency, procedural resource intensity, and training considerations.

Collectively, these results emphasize that supply chain resilience is a patient safety issue. Developing structured approaches to resource stewardship, communication, and procedural prioritization will be critical to mitigating the impact of future shortages on patient care, surgical training, and physician–patient trust.

Limitations

This study has several limitations. The sample size was modest, and respondents were predominantly fellowship-trained endourologists, which may overestimate the magnitude of impact compared with general urology practice and limits generalizability to lower-volume practices, non-endourologic subspecialties, and non U.S. healthcare systems. The reliance on self-reported survey data intro duces the potential for recall and response bias, including the possibility that urologists more severely affected by the shortage were more likely to participate. The absence of statistical weighting to adjust for geographic or subspecialty distribution further limits the ability to extrapolate these findings to the national urologic workforce.

In addition, the survey did not assess objective patient-level outcomes such as complication rates, emergency department visits, renal function deterioration, hospital readmissions, or progression of untreated disease. As such, conclusions regarding clinical impact are limited to physician-reported perceptions rather than measured patient outcomes. The true downstream consequences of delayed or modified care during the shortage remain unknown and warrant prospective investigation using clinical and administrative datasets.

Conclusions

The 2024 national sterile fluid shortage following Hurricane Helene had a profound and multifaceted impact on urologic practice in the United States. Endourological and BPH-related procedures were particularly affected, with widespread case delays, procedural modifications, and changes in outpatient care. Urologists responded with a range of adaptive strategies to maintain patient care under constrained conditions, and many of these strategies may persist beyond the immediate crisis, reshaping aspects of routine urologic practice.

These findings highlight the urgent need for improved supply chain resilience, proactive fluid stewardship frameworks, and coordinated national preparedness strategies. Strengthening these systems will be essential not only to protect patient care during future shortages but also to preserve surgical training, maintain physician–patient trust, and ensure the long-term sustainability of modern endourological practice.

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Author Contributions

Conceptualization: Bristol B. Whiles, Colby Souders, Wilson R. Molina, David A. Duchene, Donald Neff, Maxton Thoman; Data curation: Lucas B. Vergamini, Nicholas Choi, Emily Elliott; Formal analysis: Lucas B. Vergamini, Pedro Z. Padovani, Bristol B. Whiles; Methodology: Bristol B. Whiles, Colby Souders; Project administration: Bristol B. Whiles; Supervision: Bristol B. Whiles; Validation: Pedro Z. Padovani; Writing: Pedro Z. Padovani. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

The data supporting the findings of this study are available from the corresponding author upon reasonable request. The survey instrument used for data collection is provided as a supplementary file.

Ethics Approval

This study was reviewed and approved by the University of Kansas Health System Institutional Review Board (IRB ID: STUDY00161251). The study involved an anonymous survey of physicians and posed minimal risk to participants. Participation was voluntary, and an information statement was provided at the beginning of the survey. Informed consent was implied by voluntary completion of the anonymous survey, in accordance with Institutional Review Board approval (Supplemental File).

Conflicts of Interest

Pedro Z. Padovani, Lucas B. Vergamini, Maxton Thoman, Emily Elliott, Colby Souders and Nicholas Choi declare no conflicts of interest. Donald Neff: Consultant for Karl Storz. David A. Duchene: Consultant for Intuitive Surgical. Wilson R. Molina: Consultant for Boston Scientific, Olympus and Karl Storz. Bristol B. Whiles: Consultant for Mokan Labs, LCC, and Boston Scientific and Karl Storz.

Supplementary Materials

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