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TOPIC PAPER

The economics of stone disease

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Abstract The rising prevalence of kidney stone disease is associated with significant costs to healthcare systems worldwide. This is in part due to direct procedural and medical management costs, as well as indirect costs to health systems, patients, and families. A number of manuscripts evaulating the economics of stone disease have been published since the 2008s International Consultation on Stone Disease. These highlight costs associated with stone disease, including acute management, surgical management, and medical management. This work hopes to highlight optimization in care by reducing inefficient treatments and maximizing cost-efficient preventative strategies.

Keywords Kidney stones · Nephrolithiasis · Economics · Cost

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Introduction

Kidney stone disease has a high prevalence with multiple factors that contribute to cost estimates of over $2 billion annually in the United States (US) alone [1]. This cost is not only related to direct procedural and hospitalization costs, but also the indirect cost to patients and society, and additional costs for prevention and medical management.

Many relevant studies have been published since the Second International Consultation on Stone Disease (Table 1). For various reasons, most are partially contradictory and add to the conflicting body of literature about costs and quality in the treatment of stones. One way to circumvent the problem of variability is to utilize decision analysis programs that allow application of varied data that can be customized to individual patients and institutions. However, these processes require the combination of several different data sources and assumptions, and varying the assumptions can dramatically alter the results. There is, nevertheless, a lot of work to do in health economic studies of urolithiasis, and joint international prospective research projects are necessary.

The purpose of this manuscript is to evaluate the financial impact of stone disease in different healthcare systems. We will also discuss potential means for reducing stone-related healthcare costs.

Cost constituents

To be able to discuss healthcare costs from a common perspective, it is important to define the terminology used; otherwise, there is no accurate way to compare costs across studies or healthcare systems. Total costs are often divided into direct and indirect costs. Direct costs can include, for

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Table 1 Original publications on economics of stone disease since the 2nd International Consultation on Stone Disease

Author	Year of data collection	Title	Sample size	Country	Term used, data source, and data processing
Saigal et al. [2]	2000	Direct and indirect costs of nephrolithiasis in an employed population: opportunity for disease management?	Claims of 834 employees who were treated for nephrolithiasis	US	Terms used: direct and indirect costs Data sources: medical and pharmacy claims of 25 US employers (Ingenix, Inc., US) and length of stay (LOS; Medstat Marketscan Health and Productivity Management Database, US)
Bensalah et al. [3]	Literature from 1977 to 2006	Cost-effectiveness of medical expulsive therapy using alpha-blockers for the treatment of distal ureteral stones	N/A	US, Europe	Data sources: Surgeon reimbursement Medicare, literature-based assumptions, Hospital Billing Department Data processing: Decision analysis model (TreeAge Pro 2004 software)
Izamin et al. [4]	2007	Comparing extracorporeal shock wave lithotripsy and ureteroscopy for treatment of proximal ureteric calculi: a cost-effectiveness study	SWL: $n = 30$ URS: $n = 37$	Malaysia	Terms used: direct and indirect costs, hospital costs (utility costs, capital costs + recurrent costs), and patient costs (administrative cost and procedure costs)
Bagrodia et al. [5]	2005–2007	Predictors of cost and clinical outcomes of percutaneous nephrostolithotomy	179 patients	US	Terms used: direct, component (indirect), and subcomponent costs Data source: Hospital Billing Department
Bagrodia et al. [6]	2005–2007	Synchronous bilateral percutaneous nephrostolithotomy: analysis of clinical outcomes, cost, and surgeon reimbursement	Synchronous bilateral procedures: $n = 15$ Staged bilateral PCNL: $n = 152$	US	Terms used: overall cost, direct cost, all cost, Surgeon reimbursement Data source: Hospital Billing Department, Medicare, and Private Insurance
Koo et al. [7]	2007–2008	Improved cost-effectiveness and efficiency with a slower shock wave delivery rate	Fast SWL: $n = 51$ Slow SWL: $n = 51$	UK	Terms used: perceived cost (direct costs) per session, actual costs (perceived costs + indirect hospital costs + costs of additional procedures) Data source: Hospital Specialty Costing Department
Raman et al. [8]	Literature from 1996 to 2007	Residual fragments after percutaneous nephrolithotomy: cost comparison of immediate second-look flexible nephroscopy versus expectant management	42 patients	US	Terms used: total direct costs (sum of individual costs, indirect costs related to the procedure, professional fees) Data sources: Medicare reimbursement (2007), loss of wages, literature-based assumptions, Hospital Billing Department Data processing: Decision analysis model (TreeAge Pro 2004 software)

Table 1 (continued)

Author	Year of data collection	Title	Sample size	Country	Term used, data source, and data processing
Chu et al. [9]	2005–2009	Preoperative stent placement decreases cost of ureteroscopy	Stented: $n=45$ Not stented: $n=59$	US	Terms used: total cost, total health care cost, actual costs, and lost workdays Data sources: Hospital Billing Department, Surgeon reimbursement Medicare Data processing: Decision analysis model (TreeAge software)
Koo et al. [10]	2009–2010	Cost-effectiveness and efficiency of shock wave lithotripsy versus flexible ureteroscopic holmium:yttrium-aluminium-garnet laser lithotripsy in the treatment of lower pole renal calculi	FURS: $n=37$ SWL: $n=51$	UK	Terms used: perceived cost (direct costs) per session, and actual costs (perceived costs + indirect hospital costs + costs of additional procedures) Data source: Hospital Specialty Costing Department
Lotan et al. [11]	Literature from 1994 to 2005	Primary prevention of nephrolithiasis is cost-effective for a national healthcare system	N/A	France	Data sources: assumptions based on literature, French price lists, and population statistics Data processing: budget-impact analysis, Markov decision analysis model (Excel)
Hollingsworth et al. [12]	1998–2006	Medicare payments for outpatient urological surgery by location of care	5% national sample of Medicare files	US	Data sources: Medicare reimbursement data for SWL in ambulatory surgery centers, Centers for Medicare and Medicaid Services, hospital outpatient departments, and physician offices
Eaton et al. [13]	2006–2009	Admission rates and costs associated with emergency presentation of urolithiasis: analysis of the Nationwide Emergency Department Sample 2006–2009	20% of us hospital emergency department visits	US	Data sources: Emergency Department charges, Nationwide Emergency Department Sample (NEDS)
Gurbuz et al. [14]	2010–2013	The cost analysis of flexible ureteroscopic lithotripsy in 302 cases	302 patients	Turkey	Terms used: direct cost (flexible scope, laser, ancillary equipment, and purchase + repair) Data source: Urology Department
Hollingsworth et al. [15]	2002–2006	Medical expulsive therapy versus early endoscopic stone removal for acute renal colic: an instrumental variable analysis	MET: $n=1,835$ Early endoscopic stone removal: $n=4397$	US	Data sources: medical claims within 6 weeks after Emergency Department visit, MarketScan Commercial Claims and Encounters Database
Pan et al. [16]	2005–2011	RIRS versus mPCNL for single renal stone of 2–3 cm: clinical outcome and cost-effective analysis in Chinese medical setting	RIRS: $n=56$ mPCNL: $n=59$	China	Terms used: "initial" hospitalization cost, overall hospitalization cost (costs directly related to the procedure), and Postoperative Outpatient Department visit cost Data source: National Healthcare Insurance system

Table 1 (continued)

Author	Year of data collection	Title	Sample size	Country	Term used, data source, and data processing
Sutherland et al. [17]	1999–2012	How much is a kidney worth? Cost-effectiveness of routine imaging after ureteroscopy to prevent silent obstruction	N/A	US	Data sources: Medicare charges (2012), assumptions from literature Data processing: Decision analysis model (TreeAge Pro software)
Ursiny et al. [18]	Literature from 2004 to 2011	Cost-effectiveness of anti-retropulsion devices for ureteroscopic lithotripsy	N/A	US	Data source: Hospital Billing Office Data processing: Decision analysis model (TreeAge 3.5 Software)

FURS flexible ureterorenoscopy, *MET* medical expulsive therapy, *mPCNL* mini-percutaneous nephrolithotripsy, *N/A* not applicable, *PCNL* percutaneous nephrolithotomy, *RIRS* retrograde intrarenal stone surgery, *SWL* shock wave lithotripsy, *URS* ureteroscopy

example, a procedure, a service, or the treatment of a medical condition. Indirect or overhead costs comprise all other costs that are incurred regardless of a specific procedure or service. This can include, for example, administrative costs, facility maintenance, and loss in productivity due to disability. Indirect costs are important but difficult to measure and control, since they are impacted by multiple factors.

In addition, it is important to recognize that cost and charges are often interchanged incorrectly. Charges are prices set for a service that incorporate profit margins, and thus are higher than the cost. Since there are variable cost-to-charge ratios for different services based on institutional goals, it is usually less accurate to compare charges.

International perspectives

The 2015 Organization for Economic Cooperation and Development (OECD) health report showed that the US ($8713 per capita) spent two and a half times all other OECD countries average ($3453 per capita) for healthcare, and about 40% more than the second highest spender, Switzerland ($6325 per capita) [19]. Such discrepancies either imply more care or more expensive care, but regardless, make it important to consider the healthcare environment when comparing different systems. Furthermore, inflation is an important factor; when comparing the international literature; both the time period analyzed and the location need to be evaluated.

For example, in the year 2000, costs reported for shock wave lithotripsy (SWL) in the United Kingdom (UK) were three times as high as ureteroscopy (URS), but vice versa in Switzerland [20]. In other work, costs reported for URS with laser lithotripsy varied 50-fold between the most expensive country, US ($8108), and the least expensive country, Germany ($150) [21]. Since there are only a handful of companies that sell equipment, such as ureteroscopes and shock wave lithotripters globally, these extreme differences do not reflect real costs, but instead, mirror differences in the cost-charge-claim-reimbursement system and subsidization in different national health systems. To bundle them in a mixture of “billing costs”, institutional costs and national healthcare cost may serve today only to illustrate that data comparison can be meaningless.

Acute management

Many patients with stone disease are diagnosed after presenting to the emergency department (ED) with flank pain or hematuria. Using the National Hospital Ambulatory Medical Care Survey (NHAMCS), the Urologic Diseases of America project estimated that there are 226 ED visits for stone disease per 100,000 populace per year at a cost of $490 million per year [1]. Areas of study related to the acute management of stone disease include overall hospitalization and medical management cost.

Hospitalization cost for acute stone management is directly related to the frequency of admission, and worldwide, there is a significant variability in admission rates. For example, approximately 69% of patients with urolithiasis receive inpatient hospital care in Germany [21] compared with only 29% in the US [22] and 38% in Sweden [23]. While some patients require admission due to pain or concerns for infection, data from the Urologic Disease in America project found that only 25% of individuals admitted with a diagnosis of nephrolithiasis submitted a claim for surgical treatment [2]. Improving identification of patients that require admission for acute surgery could optimize economic expenditure in the acute setting.

Due to the high cost of surgery and the indirect costs associated with loss of work and repeated ED visits, there is considerable desire to reduce time and increase likelihood of spontaneous stone passage. Medical expulsive therapy (MET), with either alpha-blockers or calcium-channel blockers, has been shown to improve stone passage by 65% [24], along with decreasing pain, hospitzalizaion, and endoscopic treatment [25–27]. Several studies have evaluated the cost-effectiveness of MET.

Bensalah et al. utilized a decision analysis model based on the likelihood of spontaneous passage of ureteral stones from published meta-analyses, and direct costs from the US [3]. They found that MET with tamsulosin resulted in an $1132 cost advantage over observation, and MET maintained its cost advantage even in countries where the cost of URS is much lower than in the US. Dauw et al. evaluated indirect costs associated with MET versus early endoscopic stone removal [28]. In the matched cohort analysis, the patients treated with MET had a 6% predicted probability of filing a claim for short-term disability compared to 16.5% in the early endoscopic stone removal cohort ($p < 0.0001$). Among the patients who filed for short-term disability, those prescribed medical expulsive therapy had on average one fewer day of disability than those treated surgically (0.9 versus 1.8 days, $p < 0.001$). They concluded that an initial trial of MET is associated with significantly lower indirect costs to the patient compared to early endoscopic stone removal. Finally, Hollingsworth and colleagues used claims data from 2002 to 2006 and identified adult men with acute renal colic, of which 1835 and 4397 men underwent MET or early endoscopic stone removal, respectively [15]. They found that 6-week payments were tenfold lower for men on MET, but these men were more likely to have a repeat ED visit compared to those who underwent endoscopic stone removal (68.8 vs. 39.6%, respectively, $p = 0.025$). Despite the benefits of MET, there is still a lack of universal adoption. Data from 2000 to 2006 were analyzed from the NHAMCS of ED visits for stones [29]. While use of MET increased throughout the study period, the overall prevalence of use was exceedingly low at 1.1% (95% CI 0.6–1.9%). This implied a missed opportunity to spare approximately 260,000 individuals annually from stone surgery, its risks, and increased cost.

Surgical therapy

Surgical interventions comprise a large portion of the overall costs of managing stone patients. Using claims data for privately insured, non-elderly patients with nephrolithiasis, it was estimated that 25% of these patients will undergo a surgical procedure [2]. However, the distribution of procedures plays a significant role in determining the cost of surgical management as different procedures are associated with different costs.

In 2005, an analysis of the data from the Centers for Medicare and Medicaid Services (CMS) and the Center for Health Care Policy and Evaluation (CHCPE) found similar distribution of procedures for stone disease among patients with urolithiasis [1]. The reported rate of SWL was 54% for both, URS was 41% in CMS, and 42% in CHCPE, and PCNL accounted for 4% of procedures in CMS and 6% in CHCPE. However, this distribution is likely changing as improved endoscopic technology increases utilization of PCNL and URS. A recent review of the Nationwide Inpatient Sample (NIS) database demonstrated a 54% increase in the utilization of PCNL between 1999 and 2009 [30]. In addition, CMS claims data revealed that the use of URS for the treatment of ureteral stones increased from 62.9% in 2001 to 70.2% in 2010, coinciding with a decline in SWL from 34.9% in 2001 to 29.3% in 2010 [31].

This change in distribution is significant from a cost perspective due to the fact that the success rates and reimbursement associated with each procedure vary. In 2000, the rates of reimbursement by a private payer in the United States for PCNL, URS, and SWL were estimated to be $3624, $1425, and $2295, respectively [2]. Furthermore, the surgical setting also influences cost. The total payment for URS performed in an ambulatory surgery center (ASC) was $634 compared to $2129 in a hospital [12]. The disparity for SWL is even greater, with $943 at an ASC versus $4754 in a hospital. In addition, a recent analysis of claims data from the Healthcare Cost and Utilization Project State Ambulatory Surgery Database in Florida showed that not only has there been a migration of these procedures to ASCs, in areas where an ASC was built the total number of procedures performed increased [32]. During the time period studied, the percent of SWL and URS performed at an ASC increased from 8.9 to 24.5% ($p < 0.001$)

and from 9.9 to 22.0% ($p < 0.001$), respectively. Although this would seem to have a positive impact on the overall cost of treating ureteral stones, the overall rate of stone surgery increased 64% more in areas where an ASC was built compared to areas where an ASC was not built. Therefore, though the costs associated with performing the procedure at an ASC are lower, the increase in the number of procedures performed may counteract this effect.

Partly because they are difficult to measure, indirect costs are often overlooked in studies evaluating cost-effectiveness of treatment modalities. In an employed population, Saigal and colleagues investigated the lost work hours related to nephrolithiasis among 834 employees with complete absentee data [2]. The average annual work loss related to the nephrolithiasis was calculated as 19.0 h per year. The average work loss related to hospitalization and ambulatory care visit for upper nephrolithiasis were calculated as 47.9 (30.9–64.9) h and 5.1 (4.4–5.9) h, respectively. They estimated that kidney stone treatment leads to 3.1 million lost workdays per year (among the privately insured) at an indirect cost of approximately $775 million per year. This highlights that indirect costs remain a significant aspect in the total cost of urolithiasis care.

It is difficult to generalize the economics of the surgical management of stone disease due to the fact that there is great worldwide variability. In an international survey regarding the costs associated with the management of stones in ten countries, Chandhoke and colleagues found that the charges for SWL ranged from $373 to $9924, while URS with laser lithotripsy ranged from $205 to $8108 [20]. In this survey, SWL was more costly than URS in five countries, equal in three and less costly in two. In the countries where there was a difference in charges, the disparity between the charges ranged from as low as $200 in Germany ($360 for SWL and $160 for URS) to a high of $1814 in the United Kingdom ($2740 for SWL and $926 for URS). This makes it challenging to conclude broadly what is the most cost-effective treatment modality, as the major factor in cost is related to the reimbursements and charges for each specific healthcare system.

Renal calculi

The management of renal calculi continues to evolve as endoscopic technology continues to improve. However, because different treatment modalities have various success rates, the need for secondary procedures can greatly increase the costs associated with the treatment of a given stone. Pan et al. evaluated the cost-effectiveness of mini-PCNL versus URS for the treatment of renal stones 2–3 cm in size [16]. They found that the stone free rate at 4 weeks was significantly different, 71.4 versus 96.6% ($p < 0.0001$), favouring PCNL. The average number of procedures was significantly higher in the URS group as well, 1.18 versus 1.03 ($p = 0.035$). Despite lower hospitalization costs and laboratory/radiology costs for URS, the overall costs for the two procedures were similar, $1857.71 for URS versus $1999.21 for PNL ($p = 0.205$), due to the higher re-treatment rate for URS.

A similar study performed in the US found a significantly greater cost for PCNL [33]. Hyams and Shah compared the costs of patients undergoing PCNL or URS for stones between 2 and 3 cm in size. The estimated costs for PCNL were $19,845 compared to $6675 for patients undergoing URS ($p < 0.0001$). Interestingly, in this series, the mean number of procedures for patients undergoing PCNL was 1.6 versus 1.1 for URS ($p = 0.003$). The success rate (defined as stone free or residual fragments <2 mm) was significantly greater for PCNL compared to URS (89 versus 47%, $p = 0.01$). The primary component responsible for the greater cost of PCNL in this study was the cost associated with inpatient hospitalization for PCNL ($10,790). The need for secondary procedures also contributed a great deal to the increase in cost.

Comparing SWL and URS for lower pole stones <2 cm treated in the United Kingdom, Koo et al. demonstrated similar stone free rates (64.9 and 58.8%, respectively) as well as re-treatment rates (16.2 vs. 21.6%, respectively) [10]. In their cost analysis, they noted that although procedural costs were similar (£249 vs £292, respectively), including all other expenses made URS signficantly more costly (£2602 vs £426, $p < 0.001$). However, this could be explained by a significnat difference in length of stay (URS—2.8 days, SWL—0.25 days), which might not be applicable to all practices.

There are other variables that can predict and influence the costs of surgical treatment of renal stones. Bagrodia and colleagues specifically evaluated a number of preoperative clinical factors in regard to their impact on cost and clinical outcome for PCNL [5]. With a median direct cost of $6719, only stone size was an independent predictor of cost on multivariate model. Compared to patients with stones <2 cm in size, those with a stone >2 cm in size had a 17% higher direct cost, and those with a staghorn calculus had a 55% higher direct cost. The primary contributor to this increase cost was the greater need for second-look flexible nephroscopy.

Finally, the decision to leave a nephrostomy tube at the end of PCNL can also impact cost. Feng and colleagues performed a prospective randomized trial comparing standard PCNL, mini-PCNL, and tubeless PCNL [34]. They found that of the three techniques, tubeless PCNL was associated with the lowest overall cost.

Ureteral calculi

Much like renal stones, stone size, and location play a large role in determining cost for the treatment of ureteral stones due to success and re-treatment rates. Studies examining the cost-effectiveness of SWL versus URS for distal ureteral stones have, in general, favoured URS due to higher stone free rates and lower re-treatment rates [35–37]. The same analysis holds true for proximal ureteral stones. In a retrospective analysis of 220 patients who underwent either SWL or URS for proximal ureteral stones, Parker and colleagues found that the total cost for SWL was $15,583 compared with $9378 for URS, ($p < 0.0001$) [38]. This was largely due to the need for re-treatment in the SWL group; however, they found a significant lower cost for URS even when just the initial procedure was considered, $7575 versus $9507, ($p < 0.0001$). In a similar retrospective study, Wu et al. found that SWL was associated with a significantly greater cost than URS for proximal ureteral stones regardless of size [39]. Comparison of these two studies also reinforces the point at how difficult it is to generalize costs between nations. The mean overall cost for treating a proximal ureteral stone >1 cm in Taiwan was $1711 for SWL and $1153 for URS. In the US, the total charges for treatment of a proximal ureteral stone >1 cm were $16,900 for SWL and $10,000 for URS [38].

In 2002, Lotan and colleagues published a decision analysis evaluating the cost-effectiveness of different treatment options for stones located in the distal, mid, and proximal ureter [40]. They found that URS had a higher success rate for stones located in the distal and mid ureter, and SWL was slightly more effective at treating stones in the proximal ureter. However, URS was more cost-effective than SWL despite stone location. The cost of URS for treating a ureteral calculus was $2645 compared with $4225 for SWL. The analysis determined that the cost of URS would have to increase more than $1400, $1700, and $1850 or the success rate would have to decrease by 28, 36, and 39% for distal, mid, and proximal stones, respectively, for its cost to be equivalent to SWL.

One can conclude that the cost of a procedure depends not only on the initial cost but also on need for auxiliary procedures, and as such, the success rate of the initial procedure plays a major impact on overall cost. Ureteroscopy appears to be the most cost-effective approach for most ureteral stones.

Medical evaluation and management

There exists good evidence for the prevention of recurrent calcium stones using medication and dietary interventions [41]. However, the variable cost of medications makes it difficult to determine the cost-effectiveness of medical therapy. Data from the Medical Expenditure Panel Survey (MEPS) estimated that the total annual amount spent on prescription medications for urolithiasis in the United States during the years 1996–1998 ranged from $4 million to $14 million dollars [1]. However, these estimates may include those not used specifically for the prevention of stones.

A number of decision analysis models have been developed to examine the cost-effectiveness of medical therapies for the prevention of stones. As discussed previously, a limitation is that these models make numerous assumptions based on prior published reports. In addition, some models do not take into consideration the effectivenss of dietary intervention alone.

Chandhoke examined the cost-effectiveness of medical therapy for the prevention of calcium based stones in a number of countries [20]. He obtained cost data for surgical interventions, medical evaluation, and medications in ten countries. He found that the cost of medical management varied greatly between countries with the United States being most costly ($8200) and Canada being least costly ($1400). The cost of surgical therapy also varied greatly between countries making it difficult to generalize whether or not medical management is cost-effective.

Another international decision analysis model compared the costs of prevention in ten different countries [42]. The authors compared the cost-effectiveness of conservative measures alone, empiric treatment with potassium citrate, and metabolic evaluation with directed therapy. They found that the cost-effectiveness of these strategies for both first time and recurrent stone formers varied greatly between countries. For instance, in the United Kingdom, there was a little cost difference between conservative therapy and empiric therapy due to the low cost of medication. In other countries, the use of medication significantly increased the cost of empiric therapy or directed therapy following metabolic evaluation. The authors conclude that the relative cost of interventions (surgery versus medications) and resource allocation in different health systems ultimately determine the cost-effectiveness of different prevention strategies.

Lotan and colleagues developed a decision tree model evaluating the cost-effectiveness of different preventative strategies for recurrent stones in the US [43]. They compared conservative treatment (dietary modifications alone), empiric therapy with potassium citrate, simplified metabolic evaluation followed by treatment, and comprehensive metabolic evaluation followed by treatment. Not unexpectedly, they found conservative therapy was the least costly, but associated with the highest recurrence rates. They concluded that for first-time stone formers, conservative therapy without metabolic evaluation was cost-effective and efficacious. However, for recurrent stone formers, conservative therapy was associated with an unacceptably high recurrence rate. The authors recommended simplified metabolic evaluation followed by directed treatment, since it was more cost-effective than a comprehensive evaluation and provided more medical information than empiric drug therapy alone for similar cost.

In another decision analysis model, Lotan and Pearle compared the cost of ad hoc surgical management of stones with primary prevention strategies to reduce the risk of recurrence [44]. The costs of management included the cost of an ED visit, MET, and surgical intervention, as well as lost wages related to the ER visit and surgery. Based on their model, in order for a primary prevention strategy to reach cost-equivalence with ad hoc surgery, the annual incidence of stones would need to reach 4.3% or the cost of preventative therapy would need to be $23 per year. The authors conclude that primary prevention may be cost-effective in a high-risk population if the cost of prevention is sufficiently low and the effectiveness is high. The authors acknowledge that the analysis is limited due to the number of assumptions on incidence, recurrence rates, and risk reduction with prevention of stones needed to perform the analysis.

Regarding only conservative measures, there have been two recent analyses which have demonstrated the overall cost savings comparing high fluid intake (>2 L per day) versus low fluid intake (<2 L per day) for the French healthcare system. In one analysis, high fluid intake was evaluated as primary prevention of stones [11]. In this analysis, the use of high fluid intake by 100% of the population resulted in an estimated cost savings of €273 million and 9265 fewer stones. If only 25% of the population increased their fluid intake to >2 L per day, the cost savings would still amount to €68 million. In the second analysis, high fluid intake was evaluated for cost-effectiveness for prevention of recurrent stones [45]. If one assumes 100% compliance of a high fluid intake regimen, the cost savings for preventing recurrent stones would be €49 million. Even if compliance was only 25%, there would still be a cost savings of €10 million.

Given the low cost associated with conservative therapy, it seems reasonable that all patients with stones should receive dietary counselling aimed at prevention of further stone episodes. For patients with recurrent stones or those who are at high risk of recurrence, it is unclear if metabolic evaluation followed by directed therapy is cost-effective when compared to treating recurrent stones on an as needed basis. However, given the rising prevalence of stones and the morbidity associated with surgical interventions, it seems reasonable to offer a simplified metabolic evaluation with directed therapy in this high-risk population regardless of cost-effectiveness. Further studies are needed to definitively determine the economic impact of medical strategies aimed at prevention on the overall economic burden from stone disease.

Conclusions

Economic considerations related to stone disease have a considerable impact on overall healthcare costs. The disease has a high lifetime prevalence which is rising in part due to increase in associated diseases, such as obesity and diabetes. Further consideration will be necessary to try to optimize care by reducing expensive treatments, such as admissions and surgery, and reducing recurrences by individualizing medical management and conservative treatments. As rates of disease increase, identifying high-risk populations for preventative therapies may prove cost-effective.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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