ORIGINAL ARTICLE

Predicting Urinary Lithiasis Cases Using Regional Bed Numbers

Xiu Lin[1], Li Na Zhang[2], Biao Li[3], Jian-hui Du[4], Xian Bin Pan[5], Bo Tian[6], Shih Pin Lee[7]

Abstract

Objective: To validate a method for predicting the number of urinary lithiasis patients based on the number of hospital beds in a region by analysing its correlation with relevant variables.

Method: The study was conducted in August and September 2023 in Guangxi Guilin region of China, and comprised data collected from governmental and organisational sources on the number of urinary lithiasis patients, hospital beds, gross domestic product per capita, education, and living standards in the specific area. Descriptive, correlation, and multiple regression statistical data along with geographic information system parameters were noted. Data was analysed using Prism 10.

Results: A positive correlation was found for the number of urinary lithiasis patients with the total population and the number of hospital beds, but no correlation was found with gross domestic product per capita. The number of urinary lithiasis patients could be calculated using the formula: $y = 0.44x - 38.252$, where y was the number of patients, and x was the number of hospital beds.

Conclusion: The detection rate of district-specific diseases as positively linked to the number of hospital beds and the area population. The method provided a benchmark for detecting common diseases in other regions and offered practical early warning option for prevention and early intervention.

Keywords: Region, Detection rate of the disease, Total number of beds, Correlations, Forecast.

(JPMA 75: S-33 [Suppl. 02]; 2025) **DOI: https://doi.org/10.47391/JPMA.SRPH-06**

Introduction

Urinary tract stones are one of the most common diseases, and need early detection and treatment.[1] Kidney stone is a disease with a high prevalence worldwide.[2,3] Urolithiasis is a common urinary tract disease that can lead to significant increase in direct or indirect healthcare costs.[4] The occurrence of kidney stones has been on the rise in the past few decades among both males and females,[5] leading to a significant financial load on healthcare systems. The magnitude of the increase is noteworthy.[6] Urinary tract stones have varying incidence rates globally. Recent research indicates that 8.8% of the population (10.6% men and 7.1% women) are affected by the condition, which is significantly more prevalent than in the past.[7] The prevalence rate of urinary tract stones in the United Kingdom is 5.8%,[8] placing it among the top three regions in the world for this condition.[9] Urinary calculi in China have a geographical distribution, primarily affecting the southern region, particularly the Guangdong province and the Guangxi Zhuang autonomous region.[10] Urolithiasis is prevalent in both inpatients and outpatients at urology departments.[11]

[1,7]Department of Public Health, International College, Krirk University, Bangkok, Thailand; [2]Ruikang Hospital, affiliated with Guangxi University of Traditional Chinese Medicine, Nanning, China; [3]Guilin Hospital, Xiangya Second Hospital, Central South University, Guilin, China; [4]Department of Urology, People's Hospital of Guang'an City, Sichuan, China; [5]Guangxi Normal University Hospital, Guilin, China; [6]Guilin Medical Safety Bureau, Guilin, China.

Correspondence: Shih-Pin Lee. e-mail: cornelius.lee@gmail.com

ORICID: 0000-0001-7582-8006

Improved detection of urinary calculi is one way countries can reduce the rapid increase in healthcare costs.[12] This can be done by identifying more appropriate methods for detecting the disease. By analysing the relationship involving the number of patients, the number of beds, per capita gross domestic product (GDP), and overall regional population, a general pattern of non-communicable chronic disease detection rate can be obtained.[13] These patterns can then be utilized to predict disease prevalence and detection rates in different regions, thereby promoting early intervention and disease prevention. Research suggests that an increased provision of healthcare resources in a particular area enhances accessibility to healthcare services for he patients, thereby increasing the possibility of them seeking medical care in hospitals. Additionally, a higher GDP per capita results in patients being able to access medical care more promptly.[14,15]

Relevant guidelines[15,16] provide a detailed overview of the prevalence, aetiology and risk factors for urinary stones, emphasising the role of geographical and medical resources, such as hospital beds, in influencing the incidence of urolithiasis.

The predictive value of Hounsfield Units (HUd) in

Table: The number of beds in medical institutions, the number of urinary tract stone patients and the GDP per capita of the region.

	NPUTS (person /times)	NBMI (beds)	GDP pc (thousands of yuan)	NHB pc (person /times)	Population (thousands)
Minimum	2160	659	3.8	0.0032	14
Maximum	68108	29700	6.8	0.0091	496
Range	65948	29041	3.0	0.0059	482
Mean	9730	4243	4.8	0.0051	75
Std. Deviation	17034	7732	0.77	0.0017	124
Std. Error of Mean	4553	2066	0.20	0.00045	33
Coefficient of variation	175%	182%	16%	33%	167%
Geometric mean	5587	2088	4.7	0.0049	43
Geometric SD factor	2.4	2.8	1.2	1.4	2.5
Skewness	3.6	3.2	1.3	1.1	3.4
Kurtosis	13	11	3.1	0.99	12

NPUTS: Number of patient utilisation per time slot, NBMI: Number of beds in medical institutions, GDP: Gross domestic product, NHB: Number of hospital bed, SD: Standard deviation.

computed tomography (CT) scans for determining stone composition and outcomes in nephrolithotomy highlights the importance of accurate diagnostic tools in managing urolithiasis, which can be correlated with the availability of medical resources, like hospital beds.[16-18]

The role of systematic reviews and consensus in developing effective treatment protocols has been emphasised in literature, and it can be influenced by the availability of healthcare resources, including hospital beds. The use of regional healthcare data, including the number of hospital beds, to predict the incidence of urinary stones, demonstrates the potential of data-driven approaches in healthcare planning, showing how predictive modelling can help allocate resources more effectively.[19]

Utilising geographic information system (GIS) technology, the spatial distribution of urolithiasis cases can be detected in relation to healthcare resources, identifying patterns that can inform resource allocation and healthcare planning.[20]

The current study was planned to validate a method for predicting the number of urinary lithiasis patients based on the number of hospital beds in a region by analysing its correlation with relevant variables, showcasing the potential of advanced data analysis in improving patient outcomes and optimising resource allocation.

Material and methods

The study was conducted in August and September 2023 in Guangxi Guilin region of China, and comprised data collected from governmental and organisational sources on the number of urinary lithiasis patients, hospital beds, gross domestic product per capita, education, and living standards in the specific area. The participating healthcare institutions were Guang'an People's Hospital, Guang'an Central Hospital, Guang'an Traditional Chinese Medicine Hospital, Guang'an Maternal and Child Health Hospital, and Guang'an Mental Health Centre. The institutions are well-regarded in the region, and provide a range of medical services to meet diverse healthcare needs. The institutions were affiliated with the Medical Insurance Bureau (MIB), ensuring standardised and reliable data. Data was collected on patient demographics, diagnostic information, and treatment outcomes by accessing hospital databases and official health records after getting approval from the ethics review board of each hospital.

To understand the factors influencing the disease detection rate (DDR), data was collected from the Medical Security Bureau (MSB) and local government as well. This included the number of beds in medical institutions (NBMIs), the number of urinary tract stone patients (NUTSPs), GDP per capita (GDP-pc), and the number of hospital beds available per capita (NHB-pc). The link between the occurrence of kidney stones and the distribution of various factors, such as water quality, climate, soil, diet and ethnicity across different regions was evaluated using a GIS-based approach. These variables were used as weights and design elements to provide a comprehensive analysis. For instance, the consumption of acidic foods may become potential factors for the formation and onset of calcium oxalate stones.[21] The prevalence of urinary tract stones in the region was compared with the national data in China which has a prevalence of 5.8%.[22]

By using the collected data, patterns were generated to estimate how frequently specific diseases, like urinary tract stones, were detected in the region. Logistic regression models were employed to identify factors associated with the prevalence of urinary tract stones. The research model also accounted for complex survey structures, ensuring that the analysis was robust and accounted for any potential bias in the data-collection process.

Data was analysed using Prism 10. Data was subjected to correlational analysis as well as causal inference. $P<0.05$ was considered statistically significant

Results

The analysis of the records revealed a positive correlation between the number of urinary tract stone patients (NUTSPs) and both the total population and the number of hospital beds per capita (NHB-pc), with a correlation coefficient of 0.65 ($p<0.01$). Logistic regression analysis indicated that a higher number of hospital beds per 1,000 people was associated with an increased detection rate of urinary tract stones. GIS analysis identified the Guangxi Guilin region as predominantly characterized by karst terrain, which is associated with relatively high water hardness. Additionally, cultural dietary habits, including a preference for acidic foods, were noted as potentially influential.

In 2022, the region included 11 counties (cities) and 6 urban districts, with a total population of 4.956 million, 29,700 hospital beds, and an NHB-pc of 5.99%. The regional GDP was 24.358 million yuan, and the GDP per capita (GDP-pc) was 49,200 yuan. Medical records indicated that 68,108 patients with urinary stones sought treatment and were reimbursed through medical insurance, resulting in a per capita medical treatment rate of 13.74%.

Further statistical analysis showed a significant correlation between population and urinary tract stone prevalence ($p<0.0001$), described by the equation Y=0.4400 * X-38.25, with F=187.0, $R^2=0.9397$, and a 95% confidence interval (CI) for the slope of 0.3699–0.5101. The deviation from zero was significant, and the relationship did not deviate from linearity. A separate analysis of water hardness yielded the equation Y=0.007258 * X+3.982, with F=1126, $p<0.0001$, $R^2=0.9895$, and a 95% CI of 0.006787–0.007729. Similarly,

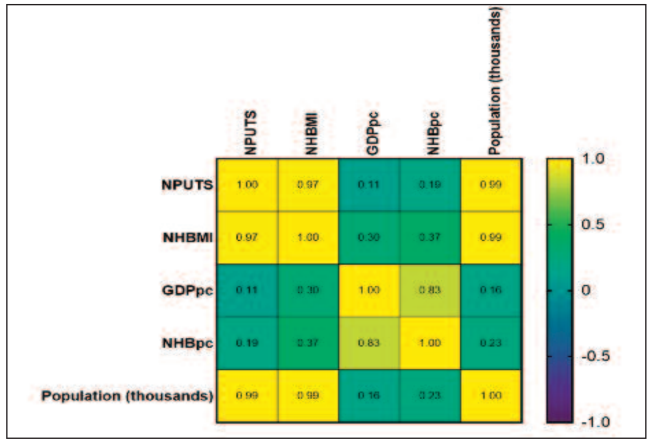

Figure-2: Correlation analysis chart between the number of beds in medical institutions, the number of patients with urinary tract stones, GDP per capita, and the number of hospital beds per capita in the region.

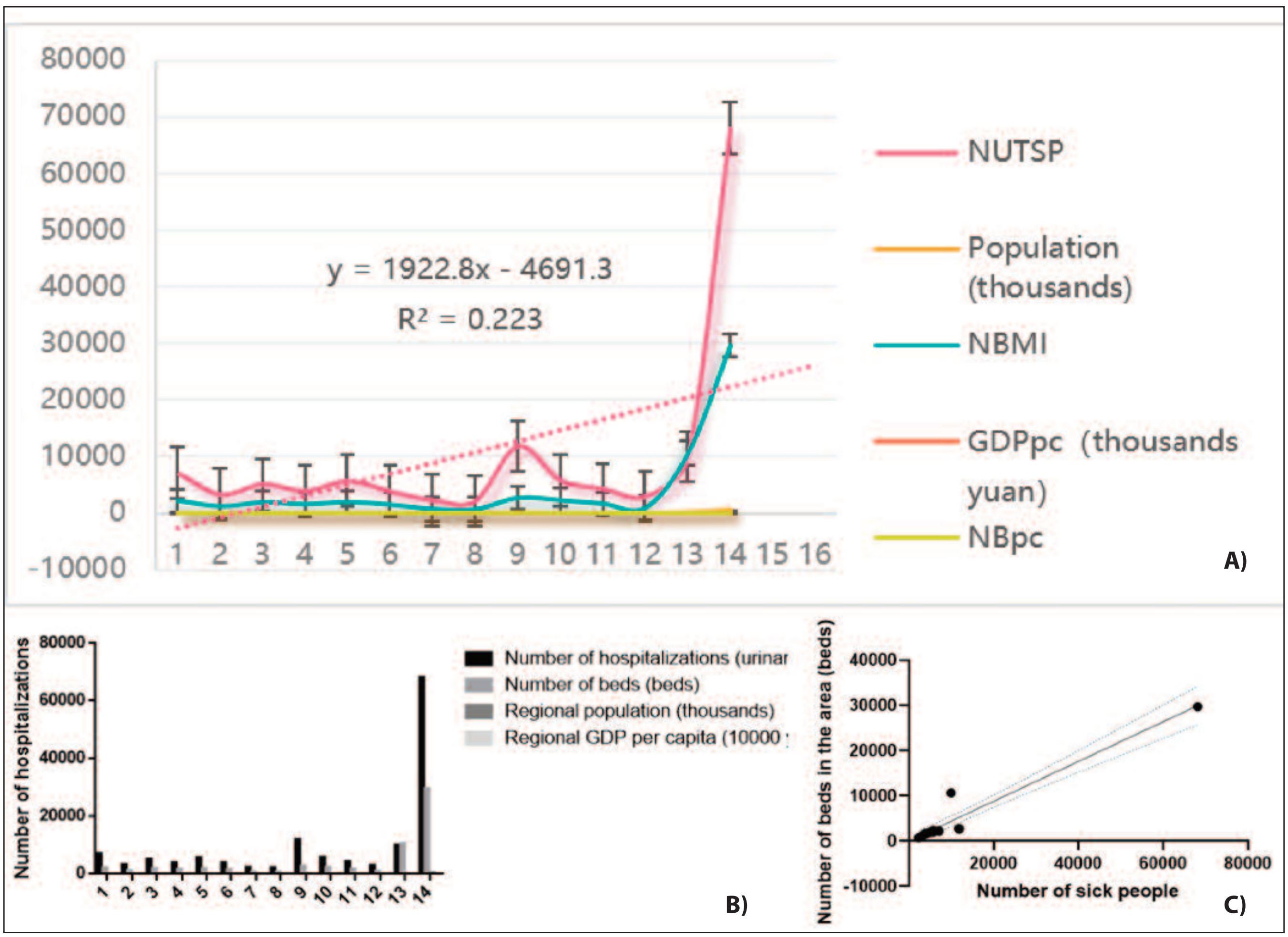

Figure-1: [A] key healthcare and economic indicators for a region, including hospitalizations, beds, population, and GDP per capita, visualized over time. [B]: Schematic diagram of the correlation between the number of times urinary tract stones are found and the number of regional beds, regional population, and regional per capita GDP. [C]: The relationship between the number of patients and the number of beds in a region. There is a positive correlation between the number of stone patients in a specific area and the number of beds in the area in 2022. The coefficient *r* is 0.9694, and the r square is 0.9397. The *p*-value is 0.0001<0.05.].

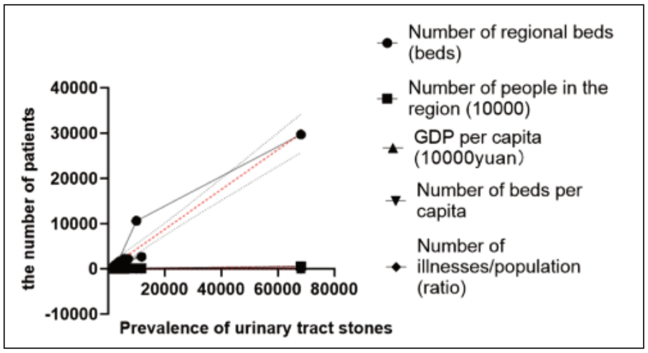

Figure-3: Correlation between number of patients and number of beds, population, GDP per capita, number of beds per capita, the ratio of number of patients to the population in the region, etc.

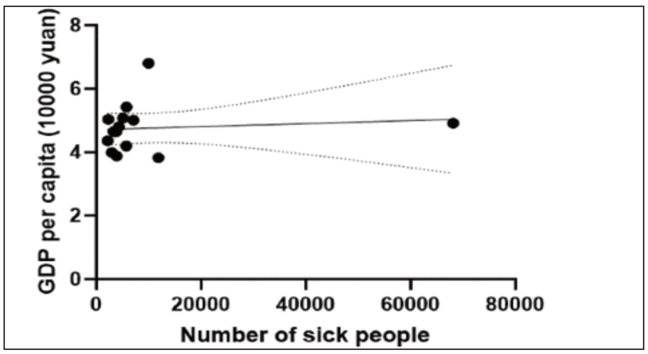

Figure-4: The relationship between the number of patients and GDP per capita (10000 yuan) in a region

There is no correlation between the number of stone patients in a specific area and GDP per capita (10000 yuan) in the area in 2022. The *r* square is 0.01105. The *p*-value is 0.7207>0.05.

the deviation from zero was significant, but the relationship remained linear.

The correlation between the number of urinary stone patients and GDP-pc was not significant (p=0.72, R^2 = 0.01), suggesting limited economic influence on disease prevalence. The relationship between the number of patients and NHB-pc was described by the equation Y=1.886e-008 * X+0.004903, with F=0.4548, p=0.5128, R^2=0.03652, and a CI of -4.206e-008–7.978e-008. Although the deviation from zero was significant, the relationship was linear. Similarly, the correlation between the number of patients and the ratio of illnesses to population was described as Y=4.889e-009 * X+0.01322, with F=0.01095, p=0.9371, R^2=0.0009119 and a CI of -9.690e-008–1.067e-007. No significant deviation from linearity was observed.

To account for potential confounders such as population size and hospital capacity, a multiple regression model was employed. This analysis confirmed the lack of a significant correlation between the number of urolithiasis patients and GDP-pc, further supporting the conclusion that economic factors have minimal influence on disease prevalence.

While these results highlight significant statistical relationships, they reflect correlations rather than causal inferences. The assumptions underlying these analyses, including linearity, were validated within the study but may not fully capture complex real-world dynamics. Non-significant results, such as those related to GDP-pc, emphasize the need for further investigation into other potential drivers, such as environmental and genetic factors. This comprehensive approach underscores the multifaceted nature of urolithiasis prevalence in the Guangxi Guilin region.

Discussion

The current study found that the number of patients with urolithiasis was positively correlated with the total population and the number of hospital beds in the region, but no significant correlation was found with GDP-pc. The correlation analysis showed that for every increase in the number of hospital beds, there was a proportional increase in the number of patients with urolithiasis (p<0.0001). This aligned with previous studies, which reported a similar relationship between increased hospital capacity and higher DDR due to better healthcare access.[23-27]

Additionally, a positive correlation was found between the total population and the prevalence of urolithiasis (p<0.0001). These results were consistent with studies indicating that regions with larger populations tended to have higher prevalence rates of urinary stones due to better access to healthcare services.[28]

In contrast, there was no significant relationship between the prevalence of urolithiasis and GDP-pc (p=0.72). The result was contrary to findings that showed regions with higher economic status tended to have better healthcare access, which could enhance DDR.[29] However, it is possible that while GDP-pc reflects overall economic conditions, it may not directly impact healthcare accessibility or disease awareness in specific regions.

In line with prior research, the current study confirmed that the prevalence of urinary stones was more closely tied to the availability of healthcare resources rather than economic indicators, like GDP-pc.[30] For instance, a study in South Korea demonstrated that increased hospital bed capacity was associated with higher DDR of various diseases due to more extensive screening programmes.[31] On the other hand, research in low-income regions highlighted that economic constraints and insufficient healthcare infrastructure contributed to lower DDRs.[32]

The findings suggest that healthcare resources in a region should be allocated based on actual patient needs rather than solely on economic metrics, like GDP-pc. The DDR is influenced not just by the number of hospital beds, but also by socioeconomic factors, such as education and health literacy. Higher economic levels and better education in certain areas correlate with increased public health awareness, encouraging early participation in health screenings.[33] This supports the results of studies indicating that regions with better health literacy tended to detect diseases earlier.[34]

The evidence highlighted the importance of public health initiatives aimed at increasing health literacy, especially in economically disadvantaged regions, to improve DDRs and outcomes.[35]

Conclusion

There was a strong correlation between the number of urinary stone patients and the number of hospital beds in the region. Economic status, education and healthcare infrastructure significantly influenced DDRs. The availability of hospital beds, constrained by local economic and cultural factors, played a key role in determining the number of diagnosed cases. Estimating disease prevalence could be effectively done by considering regional healthcare resources, such as hospital bed capacity. This approach could be extended to other diseases, providing a useful method for assessing healthcare burden in different areas.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: Guangxi Key Laboratory of Spatial Information and Geomatics, Guilin, China.

References

1. Efati Z, Shahangian SS, Darroudi M, Amiri H, Hashemy SI, Aghamaali MR. Green chemistry synthesized zinc oxide nanoparticles in Lepidium sativum L. seed extract and evaluation of their anticancer activity in human colorectal cancer cells. Ceram Int 2023;49:32568-76. doi: 10.1016/j.ceramint.2023.07.221
2. Li Q, You T, Chen J, Zhang Y, Du C. LI-EMRSQL: Linking information enhanced Text2SQL parsing on complex electronic medical records. IEEE Trans. Reliab 2024;73:1280-90. doi: 10.1109/TR.2023.3336330
3. Zhou Y, Fu XM, He DL, Zou XM, Wu CQ, Guo WZ, et al. Evaluation of urinary metal concentrations and sperm DNA damage in infertile men from an infertility clinic. Environ Toxicol Pharmacol 2016;45:68-73. doi: 10.1016/j.etap.2016.05.020
4. Xue Q, Xu DR, Cheng TC, Pan J, Yip W. The relationship between hospital ownership, in-hospital mortality, and medical expenses: an analysis of three common conditions in China. Arch Public Health 2023;81:19. doi: 10.1186/s13690-023-01029-y
5. Zhao X, Zhang Y, Yang Y, Pan J. Diabetes-related avoidable hospitalisations and its relationship with primary healthcare resourcing in China: A cross-sectional study from Sichuan Province. Health Soc Care Community 2022;30:e1143-56. doi: 10.1111/hsc.13522
6. Luo J, Ahmad SF, Alyaemeni A, Ou Y, Irshad M, Alyafi-Alzahri R, et al. Role of perceived ease of use, usefulness, and financial strength on the adoption of health information systems: the moderating role of hospital size. Humanit Soc Sci Commun 2024;11:516. doi: 10.1057/s41599-024-02976-9
7. Stamatelou K, Goldfarb DS. Epidemiology of Kidney Stones. Healthcare (Basel) 2023;11:424. doi: 10.3390/healthcare11030424
8. Chaowen L, Yongping H, Huawu H, Gaomeng W, Baode L, Zhengfang L, et al. Analysis of composition of the urinary calculi in 614 cases of single center in western Guangxi. Chin Youjiang Med J 2019;47:250-3.
9. Zeng G, Mai Z, Xia S, Wang Z, Zhang K, Wang L, et al. Prevalence of kidney stones in China: an ultrasonography based cross-sectional study. BJU Int 2017;120:109-16. doi: 10.1111/bju.13828
10. Li J, Li K, Gao C, Huang Z. An Epidemiological Study of Kidney Calculi in Western Guangdong. Curr Chin Sci 2022;2:68-75. doi: 10.2174/2210298102666220104111451
11. Raheem OA, Khandwala YS, Sur RL, Ghani KR, Denstedt JD. Burden of Urolithiasis: Trends in Prevalence, Treatments, and Costs. Eur Urol Focus 2017;3:18-26. doi: 10.1016/j.euf.2017.04.001
12. Radmehr S, Dehghani F, Bai Y, Yang X, Li J. The impact of intermittent and continuous training on the levels of CIDE and Perilipin-1 proteins and their effect on the size of lipid droplets in the visceral adipose tissue of obese male rats. Eur J Hum Mov 2024;52:43-53. doi: 10.21134/eurjhm.2024.52.4.
13. Thai B, McNicholas S, Shalamzari SS, Meng P, Picone J. Towards a More Extensible Machine Learning Demonstration Tool. In: 2023 IEEE Signal Processing in Medicine and Biology Symposium (SPMB). Philadelphia, Pennsylvania: IEEE; 2023. doi: 10.1109/SPMB59478.2023.10372731.
14. Ebrahimi A, Pourkargar DB. An adaptive distributed architecture for multi-agent state estimation and control of complex process systems. Chem Eng Res Des 2024;210:594-604. doi: 10.1016/j.cherd.2024.09.014.
15. Bemidinezhad A, Radmehr S, Moosaei N, Efati Z, Kesharwani P, Sahebkar A. Enhancing radiotherapy for melanoma: the promise of high-Z metal nanoparticles in radiosensitization. Nanomedicine (Lond) 2024;19:2391-41. doi: 10.1080/17435889.2024.2403325
16. Assaran AH, Akbarian M, Amirahmadi S, Salmani H, Shirzad S, Hosseini M, et al. Ellagic Acid Prevents Oxidative Stress and Memory Deficits in a Rat Model of Scopolamine-induced Alzheimer's Disease. Cent Nerv Syst Agents Med Chem 2022;22:214-27. doi: 10.2174/1871524923666221027100949
17. Forqani MA, Akbarian M, Amirahmadi S, Soukhtanloo M, Hosseini M, Forouzanfar F. Carvacrol improved learning and memory and attenuated the brain tissue oxidative damage in aged male rats. Int J Neurosci 2024;134:1242-9. doi: 10.1080/00207454.2023.2257877
18. Mehrnia M, Kholmovski E, Katsaggelos A, Kim D, Passman R, Elbaz MSM. Novel Self-Calibrated Threshold-Free Probabilistic Fibrosis Signature Technique for 3D Late Gadolinium Enhancement MRI. IEEE Trans Biomed Eng 2025;72:856-69. doi: 10.1109/TBME.2024.3476930.
19. Akbarian M, Hosseini M, Mirzavi F, Amirahmadi S, Arab FL, Rajabian A. Punica granatum peel supplementation attenuates cognitive deficits and brain injury in rat by targeting the Nrf2-HO-1 pathway. Food Sci Nutr 2022;11:168-80. doi: 10.1002/fsn3.3049
20. Dabouri Farimani F, Hosseini M, Amirahmadi S, Akbarian M, Shirazinia M, Barabady M, et al. Cedrol supplementation ameliorates memory deficits by regulating neuro-inflammation and cholinergic function in lipopolysaccharide-induced cognitive impairment in rats. Heliyon 2024;10:e30356. doi: 10.1016/j.heliyon.2024.e30356
21. Rothman KJ. The origin of Modern Epidemiology, the book. Eur J Epidemiol 2021;36:763-5. doi: 10.1007/s10654-021-00790-0
22. Ye Z, Zeng G, Yang H, Li J, Tang K, Wang G, et al. The status and characteristics of urinary stone composition in China. BJU Int

2020;125:801-9. doi: 10.1111/bju.14765

23. Tan S, Yuan D, Su H, Chen W, Zhu S, Yan B, et al. Prevalence of urolithiasis in China: a systematic review and meta-analysis. BJU Int 2024;133:34-43. doi: 10.1111/bju.16179
24. Rukin NJ, Siddiqui ZA, Chedgy ECP, Somani BK. Trends in Upper Tract Stone Disease in England: Evidence from the Hospital Episodes Statistics Database. Urol Int 2017;98:391-6. doi: 10.1159/000449510
25. Heers H, Turney BW. Trends in urological stone disease: a 5-year update of hospital episode statistics. BJU Int 2016;118:785-9. doi: 10.1111/bju.13520
26. Geraghty RM, Jones P, Somani BK. Worldwide Trends of Urinary Stone Disease Treatment Over the Last Two Decades: A Systematic Review. J Endourol 2017;31:547-56. doi: 10.1089/end.2016.0895
27. Hsiao CY, Chen TH, Lee YC, Hsiao MC, Hung PH, Chen YY, et al. Urolithiasis Is a Risk Factor for Uroseptic Shock and Acute Kidney Injury in Patients With Urinary Tract Infection. Front Med (Lausanne) 2019;6:288. doi: 10.3389/fmed.2019.00288
28. Moftakhar L, Jafari F, Ghoddusi Johari M, Rezaeianzadeh R, Hosseini SV, Rezaianzadeh A. Prevalence and risk factors of kidney stone disease in population aged 40-70 years old in Kharameh cohort study: a cross-sectional population-based study in southern Iran. BMC Urol 2022;22:205. doi: 10.1186/s12894-022-01161-x
29. Scotland KB, Armas-Phan M, Dominique G, Bayne D. Social Determinants of Kidney Stone Disease: The Impact of Race, Income and Access on Urolithiasis Treatment and Outcomes. Urology 2022;163:190-5. doi: 10.1016/j.urology.2021.08.037
30. Wróbel G, Kuder T. The role of selected environmental factors and the type of work performed on the development of urolithiasis - a review paper. Int J Occup Med Environ Health 2019;32:761-75. doi: 10.13075/ijomeh.1896.01491
31. Shin N, Kwag T, Park S, Kim YH. Effects of operational decisions on the diffusion of epidemic disease: A system dynamics modeling of the MERS-CoV outbreak in South Korea. J Theor Biol 2017;421:39-50. doi: 10.1016/j.jtbi.2017.03.020
32. Kironji AG, Hodkinson P, de Ramirez SS, Anest T, Wallis L, Razzak J, et al. Identifying barriers for out of hospital emergency care in low and low-middle income countries: a systematic review. BMC Health Serv Res 2018;18:291. doi: 10.1186/s12913-018-3091-0
33. Edelman CL, Kudzma EC. Health promotion throughout the life span, 10th ed. Amsterdam, Netherlands: Elsevier Inc, 2021; pp 736.
34. Zhang S, Zhao L. The impact of public art education on college students' mental health literacy. Front Public Health 2024;12:1427016. doi: 10.3389/fpubh.2024.1427016
35. Jones RP. Addressing the Knowledge Deficit in Hospital Bed Planning and Defining an Optimum Region for the Number of Different Types of Hospital Beds in an Effective Health Care System. Int J Environ Res Public Health 2023;20:7171. doi: 10.3390/ijerph20247171