Original Article

Renal stone prevalence and risk factors in Jeddah and Riyadh

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Abstract

Introduction: Nephrolithiasis is a common problem worldwide, especially in hot areas like Saudi Arabia. This retrospective study investigated the current prevalence and risk factors of renal stones in Jeddah and Riyadh, Saudi Arabia. **Methods:** A non-interventional cross-sectional study was conducted from November 2018 to June 2019 at King Abdulaziz University Hospital, Jeddah, Saudi Arabia. This study included 1031 participants (age ≥18 years) from Jeddah (n = 652, 63.30%) and Riyadh (n = 379, 36.80%). Of them, 169 (16.40%) had renal stones while 862 (83.60%) had no renal stones. All participants filled out a questionnaire distributed via social media, which contained questions regarding eating and drinking habits. **Results:** Significant differences were found between the groups regarding frequencies of intake of black tea and orange/lemon juice. The number of patients who consumed cow meat was significantly higher among those without renal stones than among those with renal stones. Significant high risk for renal stones was found in those who consumed energy drink >1 can/day, black tea >1 cup/day, and orange/lemon juice >1 glass/day.**Conclusion:** This study revealed that some eating habits play a major role in the development of urinary stones in the Saudi population. Therefore, a dietary intervention on a large scale and health, education in this regard may be helpful in preventing the 25 related to renal stones.

Keywords: Dietary habits, nephrolithiasis, renal calculi, risk factor, Saudi Arabia

Introduction

Kidney stones, also known as nephrolithiasis, are a common problem with worldwide occurrence and an especially increased prevalence in areas with hot climates such as Saudi Arabia. The pathophysiology of kidney stone starts with crystal formation in supersaturated urine, in which it later adheres to the urothelium, therefore creating the nidus for stone growth and formation.[1] Nephrolithiasis presents as sudden severe unilateral colicky flank pain that may radiate anteriorly to the lower abdomen, groin, testes, or labia and usually associated with hematuria. It may also come with nausea, vomiting, dysuria, frequency, or passage of gravel.[2,3] Risk factors for developing kidney stones include, but are not limited to, low fluid intake, hypercalciuria, high salt diet, and primary hyperparathyroidism. Fluid intake contributes to the stone formation through concentrated urine, causing supersaturation and crystallization of compounds forming stones. Another mechanism is decreasing urine output, which in return will likely cause the disposition of crystals on the urothelium. Urine output of less than 1 L/day has a markedly increased risk for stone formation. Kidney stones should not be considered a diagnosis itself but rather a symptom of an underlying abnormality. Risk factors for developing kidney stones can be categorized into non-dietary, dietary, and urinary. Non-dietary factors include having a family history of stone disease; systemic disorders such as primary hyperparathyroidism; and environmental factors, primarily in

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hot environments.[1] On the contrary, dietary factors include excessive intake of calcium, animal protein, oxalate, sodium, potassium, magnesium, and sucrose; decreased fiber intake has also been implicated as a possible risk factor.[4,5] Some dietary modifications need to be considered in high-risk patients or patients with nephrolithiasis. Low calcium intake is a known factor contributing to high urine oxalate, which is a waste product excreted through urine that contributes to stone formation. Caution must be taken when consuming animal proteins, as they are metabolized to oxalate and uric acid. Therefore, primary health care physicians being updated about risk factors plays a major role in preventing the incidence, recurrence, and development of the disease and associated complications. Physicians have an important role in educating the healthy population and those at risk through proper dietary intervention and knowledge provision.[6,7] Thus, in this study, we aimed to evaluate the prevalence of kidney stones in relation to the nutritional causal risk factors in a group of patients from Jeddah and Riyadh.

Materials and Methods

A non-interventional cross-sectional community-based survey was conducted from November 2018 until June 2019 at King Abdulaziz University Hospital, Jeddah, Saudi Arabia. Ethical approval was obtained from the Unit of Biomedical Ethics Research Committee at King Abdulaziz University, Jeddah, Saudi Arabia (Reference # No. 264-19.). The participants' approval was obtained by taking the questionnaire. They were informed about the nature of the study and the confidentiality of their responses.

A simple random sampling method was used to determine the sample size. A questionnaire was distributed via social media to participants in Jeddah and Riyadh. Participants were asked to read well and answer the questions carefully. Patients aged 18 years and above were included. This study included 1031 participants (aged ≥18 years) from Jeddah (n = 652) and Riyadh (n = 379).

The questionnaire developed by the authors after modification of previous questionnaires consisted of questions regarding dietary habits, such as frequency of consumption of water, low sodium water, coffee, green or black tea, energy drinks, carbonated drinks (sodas), orange/lemon juice, red and white meats, fish, vegetables, chocolate, fast food, chips, and popcorn. In addition, there were questions regarding intake of vitamin A, C, or iron supplements.

Statistical analysis

Data analysis was carried out using Statistical Package for Social Sciences software version 20 (SPSS Inc., Chicago, IL, USA) and MedCalc software. Extracted data were coded, cross-checked, and then entered on a daily basis. Data are expressed as mean+/- standard deviation (minimum-maximum) or number (%) as appropriate. Comparison between patients with and without renal stones was made using the Chi-square test for non-parametric parameters and unpaired Student "t" test for parametric parameters. Odds ratio (OR) and 95% confidence interval (95% CI) for risk factors of renal stones were calculated using MedCalc, and $P \leq 0.05$ was considered significant.

Results

No significant difference was found in daily water intake, types of water (bottled or tap water), and intake of low sodium water between participants with and without renal stones (P = 0.907, P = 0.051, and P = 0.137, respectively). In both groups, daily water intake was mostly less than 1 L/day (42% and 38.70%, respectively); participants used bottled water (89.90% and 93.90%, respectively), and did not drink baby water (62.10% and 64.20%, respectively). With regard to coffee consumption, most of the participants drank more than 1 cup/day (37.60%), with no significant difference between participants with and without renal stones regarding the frequency of drinking coffee (P = 0.327). Consumption of more than one can of energy drink was more highly represented in patients with renal stones, with the difference being statistically significant (P = 0.0001). No significant differences were found between the two groups in terms of consumption of carbonated drinks (P = 0.673), green tea (P = 0.096), red meat (P = 0.207), chicken (P = 0.911), chocolate (P = 0.636), fast food (P = 0.723), chips (P = 0.114), multivitamins (P = 0.203), oral calcium (P = 0.291), and iron (P = 0.517). Meanwhile, significant differences were found between participants with and without renal stones regarding the frequencies of consuming black tea (P = 0.012), orange/lemon juice (P = 0.007), fish (P = 0.001), vegetable (P = 0.044), and popcorn (P = 0.034). Participants without renal stones who consumed cow meat were significantly higher than in those with renal stones (34.30% versus 27.20%, P = 0.042) [Table 1]. Risk factors for renal stones are shown in Table 2. Significantly high risk for renal stones was found in consumption of energy drink >1 can/day (OR 10.179; 95% CI 3.998-5.916, P = 0.0001), black tea >1 cup/day (OR 2.160; 95% CI 1.419-3.289, P = 0.0003), and orange/lemon juice >1 glass/day (OR 3.061; 95% CI 1.187-7.892, P = 0.021) and 1 glass/day (OR 2.042; 95% CI 1.119-3.724, P = 0.020). Meanwhile, significantly low risk was found in female participants (OR 0.338; 95% CI 0.238-0.480, P = 0.0001), age group 18–30 years (OR 0.605; 95% CI 0.428-0.854, P = 0.004), and rare consumption of orange/lemon juice (OR 0.556; 95% CI 0.397-0.779, P = 0.0006).

Discussion

Drinking habits

This study did not demonstrate a significant difference regarding the amount of water consumed and the development of renal stones. Supersaturation of the urinary environment with stone-forming constituents is a prerequisite for calculus formation, and increased fluid consumption results in the excretion of a higher volume of urine, which is less supersaturated with stone-forming constituents. Patients with renal stones are

Table 1: Comparison of habits of participantswith and without renal stone

Parameters	Total	Renal stone (*n*=169, 16.40%)	Norenal stone (*n*=862, 83.60%)	*P*
daily water intake				0.907
none	14 (1.40%)	2 (1.20%)	12 (1.40%)	
less than 1 L	405 (39.30%)	71 (42.00%)	334 (38.70%)	
more than 1 L	376 (36.50%)	61 (36.10%)	315 (36.50%)	
2 L	134 (13.00%)	21 (12.40%)	113 (13.10%)	
more than 2 L	102 (9.90%)	14 (8.30%)	88 (10.20%)	
type of water				0.051
tap water	70 (6.80%)	17 (10.10%)	53 (6.10%)	
bottled water	961 (93.20%)	152 (89.90%)	809 (93.90%)	
drinking low sodium water (baby water)				0.137
yes	89 (8.60%)	17 (10.10%)	72 (8.40%)	
no	658 (63.80%)	105 (62.10%)	553 (64.20%)	
occasionally	222 (21.50%)	31 (18.30%)	191 (22.20%)	
rarely	62 (6.00%)	16 (9.50%)	46 (5.30%)	
coffee				0.327
daily (>1 cup)	391 (37.90%)	60 (35.50%)	331 (38.40%)	
daily (1 cup)	316 (30.60%)	46 (27.20%)	270 (31.30%)	
occasionally (twice a week)	156 (15.10%)	29 (17.20%)	127 (14.70%)	
rarely	168 (16.30%)	34 (20.10%)	134 (15.50%)	
energy drinks				0.0001
daily (>1 can)	20 (1.90%)	13 (7.70%)	7 (0.80%)	
weekly	56 (5.40%)	5 (3.00%)	51 (5.90%)	
rarely	955 (92.60%)	151 (89.30%)	804 (93.30%)	
Carbonated Drinks (soda)				0.673
daily (>1 can)	48 (4.70%)	10 (5.90%)	38 (4.40%)	
daily (1 can)	90 (8.70%)	14 (8.30%)	76 (8.80%)	
weekly	261 (25.30%)	45 (26.60%)	216 (25.10%)	
monthly	15 (1.50%)	4 (2.40%)	11 (1.30%)	
rarely	617 (59.80%)	96 (56.80%)	521 (60.40%)	
green tea				0.096
daily (>1 cup)	57 (5.5%)	15 (11.70%)	42 (6.50%)	
daily (1 cup)	59 (5.70%)	11 (8.60%)	48 (7.40%)	
rarely	659 (63.90%)	102 (79.70%)	557 (86.10%)	
occasionally (twice a week)				
black tea				0.012
daily (>1 cup)	136 (13.20%)	37 (27.00%)	99 (16.40%)	
daily (1 cup)	241 (23.40%)	37 (27.00%)	204 (33.80%)	
Rarely	364 (35.30%)	63 (46.00%)	301 (49.80%)	
orange/lemon juice				0.007
daily (>1 glass)	19 (1.80%)	7 (4.10%)	12 (1.40%)	
daily (1 glass)	58 (5.60%)	16 (9.50%)	42 (4.90%)	
occasionally (twice a week)	362 (35.10%)	58 (34.30%)	304 (35.30%)	
rarely	592 (57.40%)	88 (52.10%)	504 (58.50%)	
red meat				0.207
daily (more than 1 meal per day)	22 (2.10%)	6 (3.60%)	16 (1.90%)	
weekly	511 (49.60%)	85 (50.30%)	426 (49.40%)	
monthly	149 (14.50%)	20 (11.80%)	131 (15.20%)	
rarely	150 (14.50%)	19 (11.20%)	131 (15.20%)	
type of red meat				
lamb	169 (19.00%)	32 (18.93%)	164 (19.03%)	0.538
sheep	749 (72.60%)	126 (74.60%)	623 (72.30%)	0.306
cow	342 (33.20%)	46 (27.20%)	296 (34.30%)	0.042
chicken meat				0.911
daily (more than 1 meal per day)	81 (7.90%)	13 (14.30%)	68 (16.00%)	
weekly	378 (36.70%)	67 (73.60%)	311 (73.30%)	
monthly	22 (2.10%)	5 (5.50%)	17 (4.00%)	
rarely	34 (3.30%)	6 (6.60%)	28 (6.60%)	

Contd...

Table 1: Contd...

Parameters	Total	Renal stone (*n*=169, 16.40%)	Norenal stone (*n*=862, 83.60%)	*P*
fish				0.001
daily (more than 1 meal per day)	3 (0.30%)	3 (1.80%)	-	
weekly	308 (29.90%)	51 (31.50%)	257 (30.20%)	
monthly	382 (31.20%)	57 (35.00%)	325 (38.10%)	
rarely	322 (31.20%)	52 (31.90%)	270 (31.70%)	
vegetables				0.044
daily (1 meal)				
daily (more than 1 meal per day)	159 (15.40%)	18 (10.70%)	141 (16.40%)	
weekly	309 (30.00%)	55 (32.50%)	254 (29.50%)	
monthly	57 (5.50%)	14 (8.30%)	43 (5.00%)	
rarely	56 (5.40%)	14 (8.30%)	42 (4.90%)	
chocolate				0.636
daily (more than 1 per day)	122 (11.80%)	22 (19.00%)	100 (15.90%)	
daily	5 (0.50%)	1 (0.90%)	4 (0.60%)	
weekly	381 (37.00%)	53 (45.70%)	328 (52.30%)	
monthly	84 (8.10%)	12 (10.30%)	72 (11.50%)	
rarely	151 (14.60%)	28 (24.10%)	123 (19.60%)	
junk (fast) food				0.723
daily (more than 1 meal per day)	24 (2.30%)	4 (2.70%)	20 (2.50%)	
weekly	484 (46.90%)	75 (51.00%)	409 (51.80%)	
monthly	165 (16.00%)	22 (15.00%)	143 (18.10%)	
rarely	264 (25.60%)	46 (31.30%)	218 (27.60%)	
chips				0.114
daily (more than 1 per day)	5 (0.50%)	-	5 (0.60%)	
weekly	335 (32.50%)	58 (40.30%)	277 (33.90%)	
monthly	204 (19.80%)	21 (14.60%)	183 (22.40%)	
rarely	416 (40.30%)	65 (45.10%)	351 (43.00%)	
popcorn				0.034
daily (more than 1 per day)	3 (0.30%)	2 (1.20%)	1 (0.10%)	
daily	4 (0.40%)	1 (0.60%)	3 (0.40%)	
weekly	156 (15.10%)	33 (20.10%)	123 (14.50%)	
monthly	223 (21.60%)	29 (17.70%)	194 (22.90%)	
rarely	625 (61.90%)	99 (60.40%)	526 (62.10%)	
multivitamins that contain vitamin C or A	311 (30.20%)	56 (33.10%)	255 (29.60%)	0.203
yes				
oral calcium	246 (23.90%)	37 (21.90%)	209 (24.20%)	0.291
No				
iron	206 (20.00%)	34 (20.10%)	172 (28.00%)	0.517
no				

Data are expressed as mean +/- SD (minimum-maximum) or number (%) as appropriate. A Chi-square test was used to compare participants with and without kidney stones

advised to increase their fluid intake, especially water, to decrease the risk of stone recurrence.

There is consensus that a daily intake of fluid should be at a level that results in at least 2.0 to 2.5 L of urine output.[8] Dai *et al.*[9] reported a strong protective effect of fluid intake on preventing stone formation in men. Men drinking >2,000 mL/day were half as likely to have renal stones compared with men drinking <500 mL/day. Apart from the total fluid intake, more studies have focused on the role of specific beverages on renal stones, but their results were conflicting.

Consumptions of coffee, tea, fruit juice, and soda were not associated with renal stones after adjusting for confounding factors.[9] Increased fluid intake has been demonstrated to have a positive effect on two urinary inhibitors, citrate, and Tamm-Horsfall protein. Hydration augments urinary citrate excretion, which was thought to result from an increased fluid flux in the proximal tubule to the cells of this portion of the nephron. The ensuing intracellular alkalosis blunts citrate reabsorption, leading to increased excretion of citrate. Depending on the degree of physical activity and surrounding temperature, drinking 2.5 to 3.0 L evenly distributed over the day, is necessary. In a large prospective study of men who had no history of renal stones, an inverse association between fluid intake and the risk of urinary stone formation was observed during four years of follow-up.[10]

Results demonstrate that patients with urinary stones consumed more bottled water than tap water, but no significant differences

Table 2: Odds ratio for the risk factors of renal stones

Parameters	Renal stone (*n*=169, 16.40%)	Norenal stone (*n*=862, 83.60%)	Or, 95% CI	*P* of OR
Daily water intake				
None	2 (1.20%)	12 (1.40%)	0.848 (0.188-3.825)	0.831
<1 L	71 (42.00%)	334 (38.70%)	1.145 (0.819-1.601)	0.427
>1 L	61 (36.10%)	315 (36.50%)	0.980 (0.696-1.382)	0.912
2 L	21 (12.40%)	113 (13.10%)	0.997 (0.606-1.64)	0.991
>2 L	14 (8.30%)	88 (10.20%)	0.794 (0.441-1.433)	0.444
coffee				
daily (>1 cup)	60 (35.50%)	331 (38.40%)	0.883 (0.626-1.245)	0.478
daily (1 cup)	46 (27.20%)	270 (31.30%)	0.820 (0.568-1.185)	0.291
occasionally (twice a week)	29 (17.20%)	127 (14.70%)	1.199 (0.771-1.865)	0.421
rarely	34 (20.10%)	134 (15.50%)	1.368 (0.900-2.080)	0.142
energy drinks				
daily (>1 can)	13 (7.70%)	7 (0.80%)	10.179 (3.998-25.916)	0.0001
weekly	5 (3.00%)	51 (5.90%)	0.485 (0.191-1.233)	0.129
rarely	151 (89.30%)	804 (93.30%)	0.605 (0.347-1.056)	0.077
black tea				
daily (>1 cup)	37 (27.00%)	99 (16.40%)	2.160 (1.419-3.289)	0.0003
daily (1 cup)	37 (27.00%)	204 (33.80%)	0.904 (0.608-1.345)	0.619
Rarely	63 (46.00%)	301 (49.80%)	1.140 (0.809-1.607)	0.455
orange/lemon juice				
daily (>1 glass)	7 (4.10%)	12 (1.40%)	3.061 (1.187-7.892)	0.021
daily (1 glass)	16 (9.50%)	42 (4.90%)	2.042 (1.119-3.724)	0.020
occasionally (twice a week)	58 (34.30%)	304 (35.30%)	0.959 (0.678-1.357)	0.814
rarely	88 (52.10%)	504 (58.50%)	0.556 (0.397-0.779)	0.0006

Data are expressed as mean +/- SD (minimum-maximum) or number (%) as appropriate. Chi-square test was used between patients with and without renal stones. CI, confidence interval; OR, odds ratio

were observed in the consumption between patients and healthy control.This may be because patients with urinary stones are routinely advised to increase their fluid intake inorder to decrease the risk of stone recurrence; therefore, bottled water appears to be a better way to ensure that the recommended amount of water is taken during the day. Moreover, when drinking bottled water, patients have a more accurate perception of the total amount of water consumed. In any case, the consumption of bottled water should be monitored with particular attention, i.e., regarding the brand of the water consumed, since several brands of water have different concentrations of sodium. It is appropriate to recommend not only to increase water consumption but also to study the labels of available brands to choose the one with the lowest sodium content; the consumption of high concentrations of sodium increases the excretion of calcium and potassium along with citrate, resulting in a change in urinary pH that will eventually increase the risk of stone formation.[11,12]

The results of our study showed that consumption of energy drinks and black tea is associated with a higher risk of developing renal stones. Conflicting evidence exists regarding the effect of various beverages on the risk of urinary stone formation. Curhan *et al.*[13] assessed data from an epidemiological study and observed no association between soda intake and the risk for stone formation in men, while a clinical trial in healthy subjects conducted by Rodgers[14] suggested an increased risk in men resulting from a significant increase in urinary oxalate excretion by 60 μmol/24 h after consumption of 2.0 L of regular (non-diet) cola beverage.

Ferraro *et al.*[15] found a relationship between fluid intake and renal stone formation, which depends on the type of beverage consumed. Higher consumption of sugar-sweetened soda was associated with a higher incidence of renal stones, which may be caused by the fructose content. Since caffeine induces hypercalciuria, it affects hydration, and may aggravate hypertension. Patients should be recommended to consume caffeinated beverages in moderation and to drink water before or along with coffee.

Ferraro *et al.*[15] found an inverse association between consumption of orange juice and the development of renal stones. Orange juice is rich in potassium citrate, and it favorably affects urine composition and the risk of stone formation by increasing citraturia, delivering an alkali load comparable with the load obtained by administering potassium citrate.[16,17] Orange juice is also rich in fructose; however, the beneficial effects of citrate might offset the calciuria, or other effects of fructose compared with other juices that are comparably richer in fructose than citrate (e.g., apple juice).[15]

According to the results of our study, consumption of animal protein as red meat, including sheep and cow meat, was not more common in patients with renal stones. A large body of evidence suggests that diet plays an important role in stone formation, especially for non-hereditary renal stones. Data from epidemiological studies provide evidence for a strong correlation between the incidence of renal stones and the consumption of animal protein,[18] that may cause the body to release more

calcium, uric acid, and citrate in the urine, particularly in diets with high protein content (> 2.0 g/kg/d).[19]

The consumption of protein-rich foods of animal origin is mostly associated with an increased intake of fat, cholesterol, and purines. Hyperuricemia and hyperuricosuria are suggested as the most important risk factors for the formation of uric acid stones and may contribute to the development of calcium oxalate urolithiasis.[20] Animal protein induces stone formation, and reports indicated different mechanisms. Protein ingestion generates renal acid load that gives rise to metabolic acidosis whereby the urinary excretion of citrate is reduced and the excretion of calcium increased by bone resorption. Inhibition of calcium reabsorption also occurs in the distal tubules caused by acidosis. Further excessive intake of animal protein increases the glomerular filtration rate, and this hyperfiltration contributes to increased urinary excretion of oxalate, calcium, and urate.[21]

Our study suggests that daily consumption of vegetables more frequently than once per day would provide protection against the development of renalstones. Moreover, rare vegetable consumption increases the risk of developing kidney stones compared with weekly or monthly consumption; therefore, the lower the consumption of vegetables, the higher the risk of kidney stone development. Previous studies reported that vegetables and fruits with high fiber content were beneficial for preventing stone formation,[22] whereas excessive consumption of oxalate in vegetables and fruits was directly related to renal stones.[23] Dai *et al.*[9] reported that rootstock food, tubers, and fruits were not associated with renal stones. A similar result was found with frequent intake of vegetables on a normal daily level (1–3 times per day), yet their result indicates that consuming leafy vegetables >3 times a day may result in renal stones in both men and women.[9] Although daily vegetable intake was recommended, excessive consumption of vegetables should be avoided, as even a small increase in oxalate intake can affect oxalate excretion and lead to stone formation.[9]

As regards chocolate consumption, our study confirms that chocolate provides a high risk of kidney stone formation. Although no significant differences were observed, the study group had a slightly higher consumption rate. According to Robertson,[18] chocolate consumption can increase the risk of formation of urinary stones since it can rapidly increase the urinary oxalate, resulting in the formation of abnormal crystals and agglomerates of calcium oxalate, which is the most important risk factor for calcium oxalate stone formation.

In the analysis of dietary supplement consumption, vitamins and calcium were not associated with renal stones in either sex. Vitamins B, C, D, and E were suggested to have protective effects against renal stones in previous studies, although the findings were inconsistent.[24] The effect of calcium intake on renal stones was the most controversial aspect in previous reports. Some researchers believe that calcium can reduce the risk of renal stone formation by decreasing gastrointestinal oxalic acid salt intake[10,25] whereas other studies claim the opposite conclusions.[10] The explanation of the null association in this study may be partly caused by the low exposure rate of dietary supplements; alternatively, dietary supplements might take a long time to produce effects on renal stones.

Key points

Kidney stones are a common disease all over the world, especially in regions with hot climates such as Saudi Arabia.

- risk factors include dietary, non-dietary, and urinary factors
- certain eating habits play a major role in the development of renal stones
- physicians have an important role in preventing the incidence, recurrence, and the development of the disease and associated complications
- dietary intervention and health education in this regard may help in preventing the development of urinary stone formation

Conclusions

This study revealed that some eating habits play a major role in the development of urinary stones in the Saudi population. Insufficient fluid intake and diets rich in animal protein are suggested to be important determinants of stone formation. Therefore, a dietary intervention on a large scale and health education in this regard may be helpful in preventing the development of urinary stone formation in Saudi Arabia. There are some limitations to this study, including that the data collected from two cities, the relatively small number of patients, and the retrospective nature of the study. Ongoing research is needed to address and resolve controversies surrounding the roles of different beverages and nutritional factors in the development of renal stones.

Author contributions

Conceptulization: SA, Methodology: NA, Analysis: DH, Writing-original draft preparation: NN, Writing-review and editing: AI, Supervision: OS.

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Conflicts of interest

There are no conflicts of interest.

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