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Original Article

Spatial and Temporal Analysis of Gallbladder Stone Cases at dr. Soekardjo Hospital, West Java: An Evidence-Based Study

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Abstract

Background : Gallbladder stone cases in East Priangan area have significantly increased due to diet, lifestyle, and stress levels of the community. However, studies on the seasonal variation of gallbladder stone cases remains limited, particularly in Indonesia.This study aims to investigate the occurrence of gallbladder stone cases in East Priangan, West Java, Indonesia, based on the medical reports in 2022–2023. Furthermore, the dispersal of gallbladder stone cases is mapped as spatial and temporal distributions.

Methods : This study employed an observational, cross-sectional design. Data was collected from the medical records at dr. Soekardjo General Hospital of Tasikmalaya between January 2022 and December 2023. Data used in this study were available data of 2,032 visit records, comprising 1,311 visits in 2022 and 991 visits in 2023, for both inpatient and outpatient care. Two types of statistical tests were used in this study: the Chi-Square test and Moran's I value.

Results : The Global Moran's I test revealed clusters in the spatial distribution of gallbladder stone for both 2022 (I = 0.434) and 2023 (I = 0.521). Additionally, monthly variations ($p = 0.001$), age ($p = 0.023$), and gender ($p = 0.001$) were found to be statistically significant factors influencing the risk of gallbladder stones.

Conclusion : The spatial distribution of gallbladder stone was concentrated in the certain clusters. Moreover, there were significant correlations between monthly variations, age, and gender with gallbladder stones.

Keywords : cholelithiasis, digestive health, evidence-based study, gallbladder stone, spatial analysis, temporal analysis.

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INTRODUCTION

Gallbladder stones are among the most common gastroenterological disorders worldwide.[1] This disease could threaten a person's life due to an obstruction of the bile flow through the biliary system. Many experts on the digestive health system are still debating the causes of gallbladder stones, whether the bile contains excessive cholesterol and bilirubin, or is incorrectly emptying the gallbladder. Gallstones develop when certain substances in the bile, such as cholesterol and calcium bilirubinate, are present in concentrations that approach the limits of their solubility.[2] This supersaturation can occur due to several factors, including cholesterol supersaturation and bile concentration. Surgery is usually required to remove the gallbladder stones if the symptoms show in the patient. Gallbladder stones affect 6% of people worldwide, with an incidence greater in South America and among women.[3] In the US, the prevalence of gallbladder stone disease increases by 10–20% in adults, and more than 300,000 annually cost direct and indirect surgery, estimated to be 6.5 billion USD.[4,5] Medical records from 1995 show that as many as 5% to 15% of people in Europe suffered from gallbladder stone diseases.[6] Gallbladder stone occurrence varies from 3% to 10% in Asian countries; for instance, Taiwan, Mainland China, Japan, and Northern India are approximately 5.0%, 10.7%, 3.2%, and 7.1%, respectively.[7,8] The information on gallbladder stone cases in Indonesia is still limited and unclear which is considered comparable to that of other Asian countries.[9,10]

The risk factors linked with gallbladder stones vary between nations due to changes in genetic, nutritional, environmental, behavioral, and socio-economic conditions.[11] According to medical experts, the 4F (female, fat, forty, and fertile) is a predictive factor for gallbladder stone patients.[4] The prevalence of gallbladder stone diseases is roughly twice as high in females as it is in males, due to physiological differences, low nutritional status, rising biological stress, poor sanitation and hygiene, lack of access to healthcare, and inactive lifestyles.[12] Excess body weight (fat) can also induce a prolithogenic condition and increase the likelihood of either gallstone development or existing gallbladder stone becoming symptomatic.[13] Comparing slightly overweight women (24–25 kg/m^2) to people of normal weight, the risk factor for gallbladder stone disease was 1.7; however, in overweight women (32 kg/m^2), it rose rapidly by 6.0.[14]

Gallbladder stones are ten times more common in adults over 40 (Forty) years old due to a reduction in the activity of cholesterol 7 α-hydroxylase, the limiting enzyme for bile acid production.[15,16] As enzymatic activity decreases and biliary cholesterol accumulates, the aging person experiences cholesterol saturation, and decreases gallbladder emptying mobility.[17] Fertile women, who have one or more child(ren), are assumed to be at higher risk due to excessive estrogen levels and the link between gallbladder stones and pregnancy.[18] Biliary sludge (a precursor to gallbladder stones) and gallbladder stones occur at rates of up to 30% and 12%, respectively, throughout pregnancy and postpartum, and 1–3% of pregnant women have a cholecystectomy due to clinical symptoms or difficulties during the first year after birth.[19]

East Priangan is an area in West Java Province that includes four districts and two cities, namely the regencies of Garut, Tasikmalaya, Sumedang, and Ciamis; and the cities of Tasikmalaya and Banjar. The economic growth in this strategic region is advancing rapidly, with a positive trend of 4.80−5.20% in 2023.[20] Food consumption rates among consumers in East Priangan significantly increases, particularly using social media. For instance, based on data from Badan Pusat Statistik Tasikmalaya in 2023, household consumption in Tasikmalaya City was 69.84%, and the average food consumption per capita was 51.93 percent.[21] The rapid economic growth and culinary businesses offering fast food have allegedly escalated the digestive system disorder in East Priangan. Gallbladder stone cases are believed to be more common among people who prefer to eat low-fiber fast food.

This study aims to investigate the occurrence of gallbladder stone cases in East Priangan, West Java, Indonesia, in 2022−2023. Furthermore, the dispersal of gallbladder stone cases is mapped as spatial and temporal distributions.

METHODS

This analytic observational with a cross-sectional study was used in this research by using daily hospital admission data on gallbladder stone cases from the medical record unit of dr. Soekardjo General Hospital, Tasikmalaya. This referral general hospital provides follow-up medical treatment from the clinic and hospital in East Priangan. The data provided by the hospital consists of the number of admissions and diagnoses, with additional personal information such as age, gender, and original region (see Table 1). This study utilizes the available data of 2,032 visit records, comprising 1,311 visits in 2022 and 991 visits in 2023, for both inpatient and outpatient care at dr. Soekardjo General Hospital, Tasikmalaya. Ethical approval for this study was obtained from Medical College, Faculty of Medical and Health, Muhammadiyah University of Jakarta, and written informed consent was obtained from dr. Soekardjo General Hospital, Tasikmalaya, for patient information to be published in this article. All data included met the criteria of residency in East Priangan (covering Garut Regency, Tasikmalaya Regency, Ciamis Regency, Pangandaran Regency, Tasikmalaya City, and

TABLE 1
Total recorded data of gallbladder stone cases during 2022–2023 in East Priangan, West Java

Characteristics	Number of Admissions	
	2022	2023
Age Group, n (%)		
<5	13 (1)	8 (1)
5 – 14	12 (1)	5 (1)
15 – 24	57 (4)	72 (7)
25 – 34	184 (14)	179 (18)
35 – 44	305 (23)	173 (17)
45 – 54	310 (24)	248 (25)
55 – 64	275 (21)	194 (20)
65 – 74	120 (9)	84 (8)
75 – 84	35 (3)	25 (3)
85 – 94	0 (0)	3 (0)
Gender, n (%)		
Male	456 (35)	354 (36)
Female	855 (65)	637 (64)
Regional Origin, n (%)		
Garut Regency	27 (2)	13 (1)
Tasikmalaya Regency	506 (39)	423 (43)
Ciamis Regency	146 (11)	131 (13)
Pangandaran Regency	0 (0)	4 (0)
Tasikmalaya City	624 (48)	407 (41)
Banjar City	8 (1)	13 (1)

Banjar City). Subsequently, the data was processed and displayed in spatial and temporal distribution, visualizing the gallbladder stone cases in East Priangan.

This study employed two types of statistical tests: the Moran's I and Chi-square test. Spatial autocorrelation tests was employed to analyse the distribution of gallbladder stone diseases. The Moran's I method was used to quantify the spatial autocorrelation in this study by using GeoDa, an open-source software designed for spatial data analysis.[22] This method is a proven and one of the most popular methods to analyse spatial autocorrelation problems in the disease epidemiology studies.[23] The Global Moran's I statistic helps identify overall patterns in the data distribution and is visualized through a Moran scatter plot.[24] The Moran scatter plot classifies spatial autocorrelation into four quadrants. The upper-right and lower-left quadrants represent positive spatial autocorrelation, where similar values are clustered in neighbouring locations. These are referred to as high-high (hot-spot) and low-low spatial autocorrelation (cold-spot). Conversely, the lower-right and upper-left quadrants indicate negative spatial autocorrelation, where dissimilar values are adjacent. These are termed high-low and low-high spatial autocorrelation.[24]

Local clusters and outliers are identified using the Local Indicator of Spatial Association (LISA) method, which has two key features.[25] First, it offers a statistical value for each location along with an assessment of its significance. Second, it ensures that the sum of the local statistics is proportional to a corresponding global statistic. The LISA can be visualized in the significance and cluster map. The significance map highlights areas with a notable local statistic, using progressively darker shades of green to represent higher levels of significance. It begins with $p<0.05$ and displays all relevant

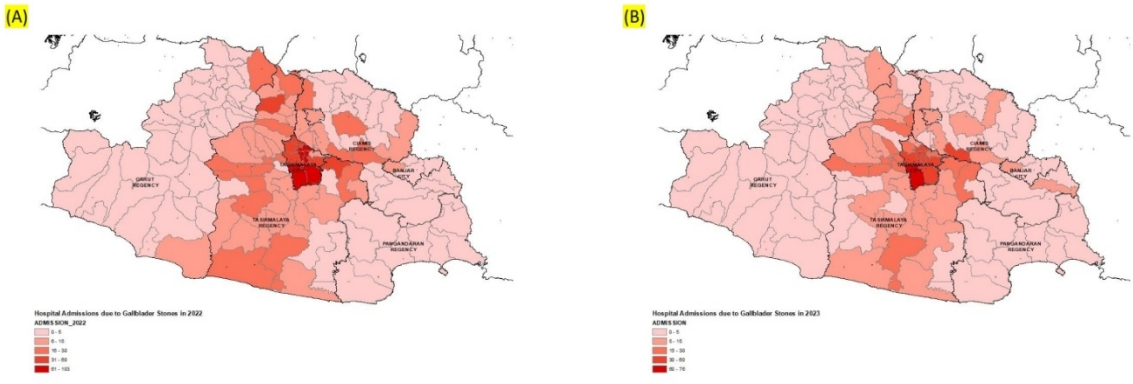

Figure 1. Spatial dispersal of gallblader stone cases in East Priangan, West Java in (a) 2022 and (b) 2023

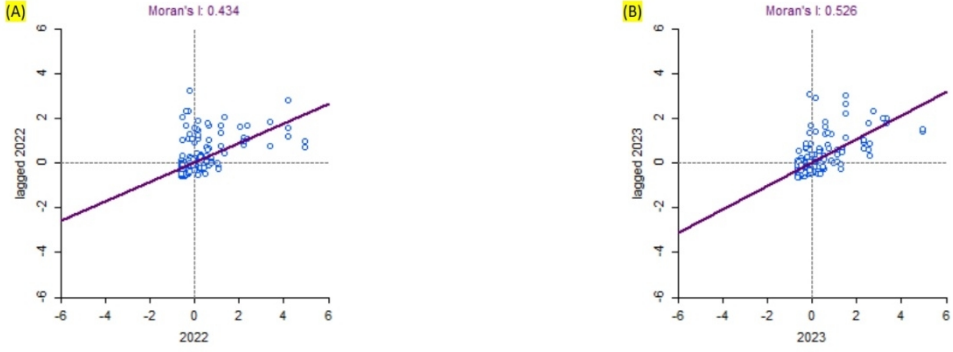

Figure 2. Univariate Global Moran's I value for gallbladder stone dispersal in (a) 2022 and (b) 2023

significance categories, determined by the number of permutations used. The cluster map further enhances the visualization by indicating the type of spatial association, which is derived from the value's position and its spatial lag on the Moran scatter plot.

The Chi-Square test was used to evaluate the following hypotheses: (a) whether age and gender influence the occurrence of gallbladder stone disease, and (b) whether seasonal variations affect the temporal distribution of gallbladder stone disease. Hypothesis (a) was tested using 96 randomly selected samples from each group (gallbladder stones and non-gallbladder stones admissions). The sample size was calculated using the cross-sectional study formula, assuming a type 1 error rate with a 95% confidence level, proportion in a population of 0.5 (for unknown proportions), and a tolerable error margin of 10%. If the *p-value* is less than 0.05, the hypothesis is accepted; otherwise, if the *p-value* exceeds 0.05, the hypothesis is rejected.[26]

Hypothesis (b) was tested using the full sample of 2,302 participants. The samples were categorized based on monthly distribution and divided into seasonal groupings for both tropical and non-tropical regions. The testing method followed the approach used in Khan *et al.*'s study, where Chi-square test was applied to analyze the seasonal variability of gallbladder stones.[27] The seasons were defined as spring (March−May), summer (June−August), fall (September−November), and winter (December−February). Since this study was conducted in a tropical region, seasonal effects were also examined based on the typical tropical seasonal patterns: dry season (March−August) and wet season (September−February). A Chi-square goodness-of-fit test was employed to evaluate the seasonality of acute gallbladder stone cases while accounting for variations in the number of days per season. The day counts used for each season were 92 for spring, 92 for summer, 91 for fall, and 90.25 for winter.

RESULTS AND DISCUSSIONS

Spatial Dispersal of Gallbladder Stone Cases

Spatial analysis was used to obtain the dispersal of gallbladder stone cases in East Priangan. Figure 1 indicates that Tasikmalaya City was recorded as the highest number of hospital admissions, with 624 (48%) in

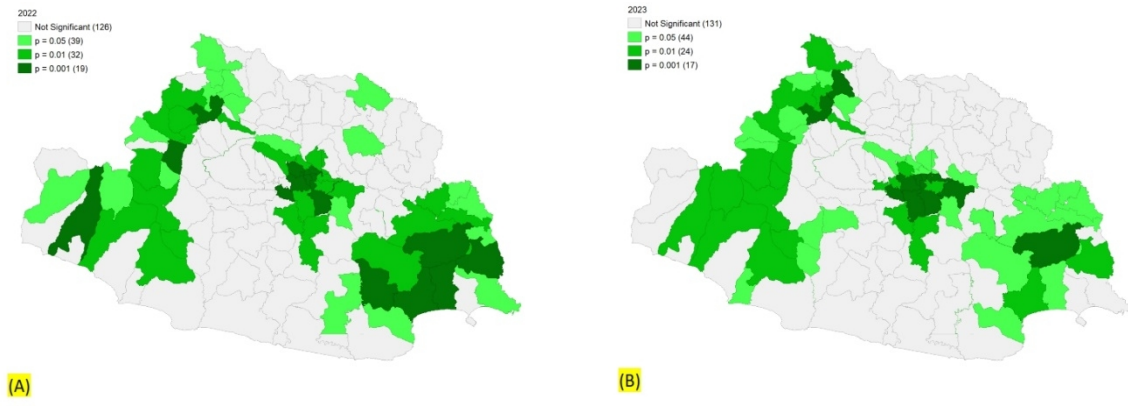

Figure 3. Significance map of gallbladder stones in (a) 2022 and (b) 2023

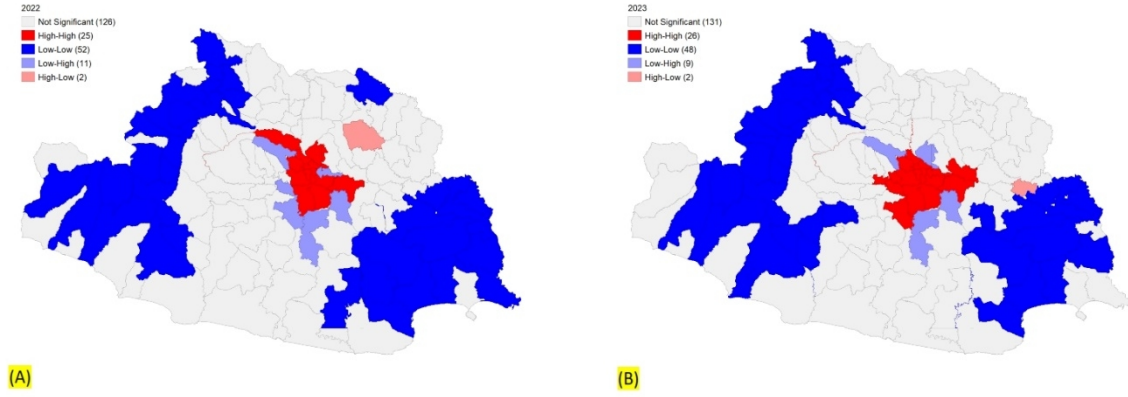

Figure 4. Cluster map of gallbladder stone dispersal in (a) 2022 and (b) 2023

2022 and 407 (41%) in 2023, followed by Tasikmalaya Regency with 506 (39%) visits in 2022 and 423 (43%) in 2023. Ciamis Regency also had a significant number of admissions with 146 (11%) cases in 2022 and 131 (13%) cases in 2023 (see also Table 1). Conversely, the gallbladder stone cases in Garut Regency, Pangandaran Regency, and Banjar City demonstrates fewer hospital admissions, likely due to the greater distance to dr. Soekardjo General Hospital of Tasikmalaya, making it less accessible compared to the nearby Tasikmalaya City and surrounding areas. Additionally, this may be due to the presence of referral general hospitals in both Garut Regency and Banjar City, specifically dr. Slamet General Hospital of Garut and Banjar City General Hospital.

Spatial autocorrelation testing shows positive Global Moran's I value for gallbladder stone case distributions in 2022 (0.434) and 2023 (0.526), indicating the presence of clusters across East Priangan (see Figure 2). The significance map highlights areas with high statistical significance (p<0.05), revealing a strong spatial connection between data points across sub-districts and helping to identify cluster locations (Figure 3). The cluster map (Figure 4) shows that the highest concentration of gallbladder stone cases, known as a hot-spot, is in Tasikmalaya City and its surroundings. In contrast, a cold-spot, or low case cluster, was observed in Garut Regency, Pangandaran Regency, and parts of Ciamis Regency and Banjar City. Areas like Tasikmalaya Regency and parts of Ciamis Regency, with lower significance, show weaker spatial connections between gallbladder stone case distributions across sub-districts.

In large regions, fast food often becomes popular due to busy lifestyles and irregular eating habits. People may not consume enough high-fiber foods, which can lead to health issues like gallbladder stones. DietR high in saturated fats––found in fried foods, red meats, and full-fat dairy products––raises the risk of gallbladder stones. Refined sugars and carbohydrates, such as those in pastries and sugary drinks, also contribute to this risk, with high fructose being particularly harmful. Low fiber intake intensifies the problem, as fiber helps manage bile acid and cholesterol, reducing gallbladder stone risk.

TABLE 2
Chi-square Test Result of Seasonal and Monthly Variability of Gallbladder Stones

Variable		Number of Days	Gallbladder Stones	*p*
Season (tropical)	Dry	184	1161	0.984
	Wet	181.25	1141	
Month	Jan	31	180	0.001
	Feb	28	217	
	Mar	31	248	
	Apr	30	99	
	May	31	109	
	Jun	30	144	
	Jul	31	242	
	Aug	31	319	
	Sep	30	194	
	Oct	31	173	
	Nov	30	192	
	Dec	31	185	

Therefore, regular meals are advised for maintaining gallbladder health.[28] Studies show that less physical activity is linked to a higher risk of symptomatic gallbladder stones and gallbladder surgery. For instance, men can reduce their risk of symptomatic gallbladder stone by 34% through 30 minutes of endurance exercise five times a week. Additionally, 2–3 hours of recreational exercise weekly might lower the need for gallbladder surgery by about 20%.[29]

Temporal Dispersal of Gallbladder Stones

The temporal analysis shows that hospital admission trends for gallbladder stones were similar in 2022 and 2023 (see Figure 5). After adjusting for the different number of days in each month, the monthly variation in gallbladder stone cases was statistically significant across the year ($P < 0.001$). However, seasonal variations were not statistically significant compared to monthly variations, with *p-values* of 0.984 (see Table 2).

At dr. Soekardjo General Hospital of Tasikmalaya, the number of hospital admissions for gallbladder stone case decreased during dry season in March to April and reached maximum in August (see Figure 5). This is slightly contrast with a review of 12 studies conducted between 1990 and 2017 across seven countries (Saudi Arabia, England, Pakistan, the United States, Taiwan, and Germany) which shows that gallbladder stone cases typically increase during the summer and decrease during winter.[30] Similarly, Khan *et al*.[27] found a rise in gallbladder stone cases during the summer months in Pakistan from 1988 to 2018, and this trend was also observed in England during the British summer from 2010 to 2019.[31]

Khan *et al*. have proposed that seasonal variations in gallstone-related infections may be linked to increased bacterial infections during warmer temperatures.[27] This could lead to more cases of acute gallbladder stones in the summer. However, seasonal variations in gallstone disease are a complex phenomenon with multiple contributing factors. While numerous studies have been conducted, the exact causes of these patterns remain unclear. Factors such as human behaviour, microbial virulence, foodborne illness rates, and immune responses are likely contributing to seasonal patterns in gallstone disease.[32–35] The combination of these factors likely explains the higher incidence of infectious diseases in the summer. A more comprehensive understanding of the underlying causes of seasonal infectious disease patterns could contribute to the development of more effective prevention and intervention strategies.

However, studies on the seasonal variation of gallbladder stone cases remains limited, particularly in Southeast Asia, and especially in Indonesia. Since most studies on the seasonal variability of gallbladder stones have been conducted in non-tropical regions, comparative studies on the effects of seasonal variability on gallbladder stone cases in Indonesia are scarce. There

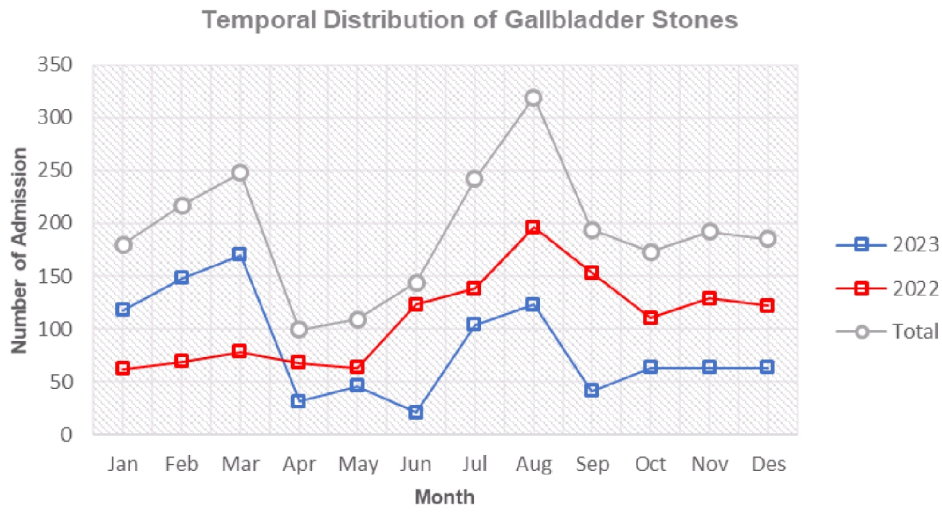

Figure 5. Temporal dispersal of gallblader stone cases in East Priangan, West Java in 2022 and 2023 (p<0.001)

TABLE 3
Chi-square test result of age and gender with gallbladder stone cases

Variable		Gallbladder Stones		Non-Gallbladder Stones		*p*
		n	%	n	%	
Age	5 – 14	1	1	1	1	0.023
	15 – 24	7	7	13	14	
	25 – 34	13	14	15	16	
	35 – 44	20	21	29	30	
	45 – 54	17	18	24	25	
	55 – 64	27	28	11	11	
	65 – 74	6	6	2	2	
	75 – 84	5	5	1	1	
65 – 74	Male	26	27	57	59	0.001
	Female	70	73	39	41	

is no study that directly explains about seasonal variability of gallbladder stone in Indonesia.

Age Disparity of Gallbladder Stone Cases

The Chi-square test demonstrated a significant association between age and the occurrence of gallbladder stones at Dr. Soekardjo General Hospital in Tasikmalaya (p = 0.023) (see Table 3), with an average age of 41 ±14 years old. The age group of 55–64 had the highest number of hospital admissions with 28% visits among all categories. This result aligns well with previous studies. Atsariyah *et al*. identified the significant relationship between age and gallbladder stones, with an average age of 50 ± 13.84 years. In 2017, the incidence of gallbladder stones in China increased from 7.4% among individuals under 30 years of age to 43.1% in those aged 50 to 70.[36] A similar trend was observed in Sevinc *et al*.'s study, where the prevalence of gallbladder stones rose with age, reaching 32.1% among 106 cases out of a total of 330.[37] These findings also support Ansari-Moghaddam's study, which indicates that patients over 45 years old are at a higher risk of developing gallbladder stones compared to those aged 30 to 44.[38]

Gender Disparity of Gallbladder Stones

In this study, the Chi-square test identifies a significant link between gender and the presence of gallbladder stones at dr. Soekardjo General Hospital of Tasikmalaya, with a *p-value* of 0.001 (see Table 3). The results show significant gender differences in gallstone risk: women account for 73% of all admissions, while men make up just 27%. These findings are consistent with previous research. For example, Atsariyah *et al*. reported a similar gender split, with 64% of gallstone patients being women and 36% being men, though the study found no significant effect of gender on gallstone formation (P<0.224).[39] In contrast, Song *et al*.'s research in China in 2017 revealed that gender significantly influenced gallstone prevalence (p<0.001), with 50.6% of cases (199,820) in women and 49.4% (194,827) in men.[36] Moreover, Ansari-Moghaddam *et al*. found that women were 2.73 times more likely to develop gallbladder stone than men (95% CI; 1.34–5.56).[38]

CONCLUSION

This study found that hospital admissions for gallbladder stones at dr. Soekardjo General Hospital of Tasikmalaya were spatially clustered (Global Moran's I = 0.434 in 2022 and I = 0.521 in 2023). Hot spot clusters were identified in Tasikmalaya City, while surrounding regions exhibited cold-spot clusters. In Tasikmalaya Regency, cases were randomly distributed with no significant clustering (p < 0.05). Additionally, monthly variations significantly affect the incidence of gallstone cases (p < 0.001), which decreased during dry season from March to April, but reached maximum in August. Furthermore, age (p < 0.05) and gender (p < 0.001) significantly influenced gallstone risk, with female sex and individuals aged 55–64 being more susceptible.

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