Original Article

Spatial epidemiological analysis of the burden of liver cancer in China

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Background: Liver cancer is one of the most common cancers in the world, with unique regional variations in disability-adjusted life years (DALY) rate, nearly 50% of liver cancer cases occur in China. Therefore, understanding the epidemiological characteristics of liver cancer is of utmost importance. In this study, to analyze the spatial distribution characteristics and clustering of the DALY rate of liver cancer in 1990 and 2017 in China based on provincial administrative divisions, and to explore its possible influencing factor.

Methods: The DALY rate data of liver cancer at the provincial level in China were collected, the global autocorrelation of the DALY rate was analyzed by Moran's I, the local autocorrelation of the DALY rate was analyzed by Getis-Ord-Gi*, and the influencing factors related to the DALY rate were analyzed by the least squares regression model.

Results: The DALY rate of liver cancer in China generally showed an increasing trend. The DALY rate increased in 22 provinces and decreased in nine provinces. In 2017, the distribution of DALY rate in all provinces showed heterogeneity, with the highest DALY rate in Guangxi (1,363.37/100,000) and the lowest in Beijing (315.78/100,000). In 2017, the low and low clustering were mainly concentrated in Inner Mongolia, Ningxia, Shanxi, Hebei, and Tianjin. The low and high clustering in Yunnan, Guizhou, and Guangdong, were surrounded by the high clustering in neighboring provinces, high and high concentration is mainly concentrated in Hunan and neighboring provinces. The results of the least square regression model showed that the per capita years of education, hepatitis B incidence and the proportion of population over 65 years old had an impact on the DALY rate of liver cancer (P<0.05).

Conclusions: The DALY rate of liver cancer in China showed an overall increasing trend. In 2017, the DALY rate of liver cancer in China had a spatial aggregation in the whole country, and the per capita years of education, the incidence of hepatitis B and the proportion of population over 65 years old had an impact on the DALY rate of liver cancer in space.

Keywords: Liver cancer; disease burden; disability-adjusted life years (DALY); spatial epidemiology; China

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Introduction

According to GLOBOCAN2020 data (1), liver cancer is the sixth most common tumor and the third leading cause of cancer death worldwide. In 2020, there were an estimated 900,000 new cases and 830,000 deaths worldwide. According to the data released by the National Cancer Center (2), both incidence and mortality rates of liver cancer in China showed a downward trend from 2000 to 2016, indicating that the vaccination of hepatitis B virus (HBV) vaccine significantly reduced the incidence of liver cancer caused by HBV infection in China (3). In recent years, the prevalence of overweight, diabetes, alcohol consumption, and smoking has increased significantly in our country. The risk factors of liver cancer seem to be changing (4), and the task of prevention and treatment of liver cancer still has a long way to go. One study has shown (5) that the disease burden of liver cancer has obvious geographical differences. However, the current epidemiological research on liver cancer focuses on the age of onset, trend analysis, and research on related risk factors. Geospatial analysis methods are applied to tumor epidemiology, and there are few studies to describe the spatial distribution of tumors and rules of changes of tumors (6,7). This study analyzed the spatial epidemiological characteristics of liver cancer at the provincial level in China, which could provide a new scientific perspective for the prevention and control of liver cancer. We present this article in accordance with the RECORD reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1240/rc).

Highlight box

Key findings

- Disability-adjusted life years rate of liver cancer in China had a spatial aggregation in the whole country.

What is known and what is new?

- Liver cancer is the sixth most common tumor and the third leading cause of cancer death worldwide.
- The spatial distribution characteristics and clustering of liver cancer in China were explored.

What is the implication, and what should change now?

- Liver cancer is heterogeneous in spatial distribution, and it still has a large disease burden.

Methods

Data source

Based on the national provincial vector map, data on the disability-adjusted life years (DALY) rate of liver cancer, gross domestic product (GDP), the per capita years of education, incidence rate of hepatitis B, and the proportion of people over 65 years old in China's provincial administrative divisions in 1990 and 2017 were collected. Among them, the DALY rate data came from the literature appendix of mortality, mobility, and risk factors in China and its processes, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017; the GDP data came from the Bulletin of National Economic and Social Development; the per capita years of education and the proportion of people over 65 years old came from the China Statistical Yearbook. The data of incidence rate of hepatitis B came from the Yearbook of China Health and Hygiene.

Research methods

The Arcgis10.7 software was used to map the DALY rate data to the vector map of provincial administrative divisions in China. The natural discontinuance method was used to segment the DALY rate, the thematic map of the DALY rate was made for visualization analysis at the provincial level, the Moran index was used to conduct the global and local spatial autocorrelation analysis of the DALY rate, and the least square regression model was used to analyze the possible influencing factors of the DALY rate of liver cancer.

Global autocorrelation

Global autocorrelation is an index to comprehensively measure spatial autocorrelation of the whole research area, which can indicate the average degree of spatial difference between each unit and the surrounding area. Moran's I index is used to measure global spatial autocorrelation, and the calculation method is as follows:

$$I = \frac{n\sum_{i=j}\sum_{j=1}\omega_{ij}\left(x_i-\bar{x}\right)\left(x_j-\bar{x}\right)}{\sum_{i=1}\sum_{j=1}\omega_{ij}\sum_{i=1}\left(x_i-\bar{x}\right)^2} \quad [1]$$

where: n is the total number of research units; x_i and x_j represent their respective attribute values; $\bar{x}$ for the regional average; ω_{ij} is the space weight matrix, which defines the adjacency relation of space elements. The value range of Moran's I coefficient is [−1, 1]. When its value is greater than 0, it indicates that there is a spatial positive correlation in the studied area, and the closer the value is to 1, the stronger the spatial positive autocorrelation is, and the value of the research object shows an aggregate distribution. When its value is less than 0, it indicates the spatial negative correlation exists in the studied region. The closer the value is to −1, the stronger the spatial negative autocorrelation is, and the value of the studied object presents discrete and mutually exclusive distribution. When its value is close to 0, the value of the research object is randomly distributed without autocorrelation (8).

Local spatial autocorrelation

Since the global Moran's I index is the average value of local Moran's I, in order to avoid individual correlation relationships being covered by global autocorrelation relationships when the distribution of local observed values is highly uneven, further local spatial autocorrelation analysis was carried out to reveal the spatial aggregation phenomenon of local space and identify specific aggregation regions. The formula of local Moran's I is as follows:

$$I_i = \frac{n\left(x_i - \bar{x}\right)\sum_i \omega_{ij}\left(x_j - \bar{x}\right)}{\sum_i \left(x_i - \bar{x}\right)^2} = Z_i \sum_i \omega_{ij} Z_j \qquad [2]$$

where Z_i is a standardized observation. Other variables have the same meaning as Eq. [1].

Local spatial autocorrelation can be divided into four modes: high-high (H-H), low-low (L-L), high-low (H-L), and low-high (L-H). H-H means that the spatial unit with the observation value higher than the mean value is surrounded by the spatial unit with the observation value higher than the mean value. L-L indicates that the low-value unit is surrounded by the low-value unit. H-L and L-H respectively indicate that the high-value unit encloses the low-value unit and the low-value unit surround the high-value unit (9).

Statistical analysis

Arcgis10.7 software was used to analyze the data, natural discontinuity method was used to segment the DALY rate of thematic map, Moran's I was used to analyze the global autocorrelation, Getis-Ord-Gi* were used to analyze the local autocorrelation, and the least square regression model was used to analyze the influencing factors related to the dependent variables. P<0.05 was statistically significant.

Results

DALY rate of liver cancer in 1990 and 2017 in China by region

In 1990, the area with the highest DALY rate of liver cancer was Guangxi, with a DALY rate of 968.36/100,000, followed by Jiangsu, Jiangxi, Anhui, and Chongqing. Shaanxi had the lowest DALY rate of liver cancer, with a DALY rate of 260.41/100,000. Xinjiang, Hebei, and Beijing also had low DALY rates. In 2017, Guangxi still had the highest DALY rate of liver cancer, with a DALY rate of 1,363.37/100,000, followed by Heilongjiang, Sichuan, Hubei, and Liaoning. Beijing had the lowest DALY rate of liver cancer, with a DALY rate of 315.78/100,000. Shanghai, Xinjiang, and Shanxi also had low DALY rate.

In 1990 and 2017, the DALY rate of liver cancer in China showed an overall increasing trend, from 649.16/100,000 in 1990 to 789.61/100,000 in 2017. Hubei had the most obvious increase, with a change rate of 88.20%, followed by Shaanxi and Heilongjiang. There were also some provinces showing a downward trend, with Shanghai falling by 31.58%, Xizang and Beijing also showing a downward trend (*Figure 1*).

Global spatial autocorrelation analysis

In 1990, there was no significant global autocorrelation of DALY rate of liver cancer in China (P>0.05). In 2017, the DALY rate of liver cancer showed spatial clustering, and the Moran's I value was 0.15, with significant global autocorrelation (P<0.05) (*Table 1* and *Figure 2*).

Local spatial autocorrelation analysis

In 1990, the low and low aggregation of DALY rate of liver cancer in China was mainly concentrated in Inner Mongolia, Beijing, Tianjin, and Ningxia, while the low aggregation rate was mainly manifested in Fujian and Hubei, surrounded by high aggregation provinces, high and high clusters of DALY rate was mainly in Hunan, Jiangxi, Zhejiang, and Guangdong. In 2017, the low and low clustering of DALY rate of liver cancer in China was mainly concentrated in Inner Mongolia, Ningxia, Shanxi, Hebei, and Tianjin. The low and high clustering mainly

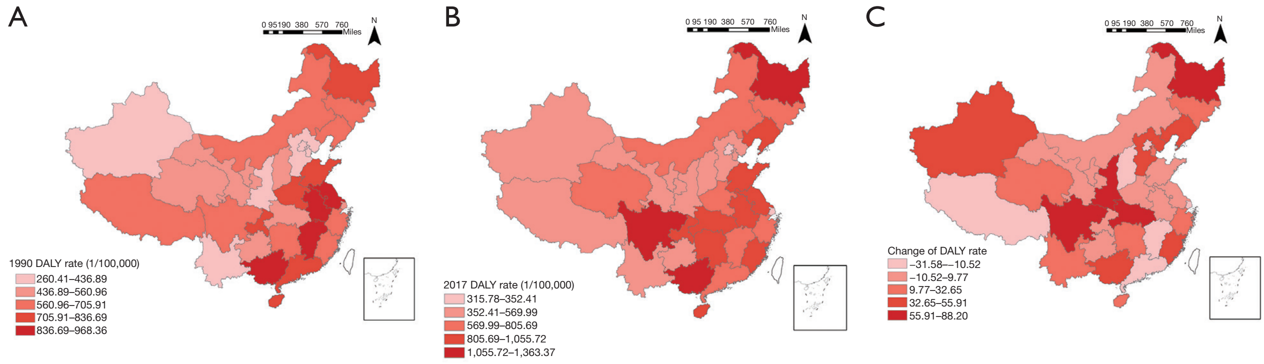

Figure 1 DALY rate of liver cancer in different regions of China in 1990, 2017, and it's change rate. (A) DALY rate of liver cancer in 1990; (B) DALY rate of liver cancer in 2017; (C) DALY rate of liver cancer's change rate. DALY, disability-adjusted life years.

Table 1 Global autocorrelation analysis of liver cancer

Year	Moran's I	*Z* value	P value
1990	0.04	0.90	0.36
2017	0.15	2.42	0.01

showed that the low clustering levels of Yunnan, Guizhou, and Guangdong were surrounded by high clustering in neighboring provinces, high and high clusters of DALY rate was mainly manifested in in Hunan and surrounding provinces (*Figure 3*).

Least squares regression model analysis

In this study, four influencing factors, the per capita years of education, GDP, incidence of hepatitis B, and proportion of population above 65 years old were selected to analyze the impact on the DALY rate of liver cancer in 2017, and the variance inflation factor (VIF) was less than 2, indicating that all the independent variables were not collinear in the model. The results showed that the per capita years of education, the incidence of hepatitis B and the proportion of population over 65 years old had an impact on the DALY rate of liver cancer ($P<0.05$), among which the incidence of hepatitis B and the proportion of population over 65 years old were positively correlated with the DALY rate of liver cancer, and the per capita of years of education was negatively correlated with DALY rate of liver cancer, and GDP had no effect on the DALY rate of liver cancer ($P>0.05$) (*Table 2*).

Discussion

Spatial epidemiology is increasingly used in medical research, such as assessing the availability of medical resources (10), exploring spatial patterns of disease, discovering spatial clustering of disease, and identifying influencing factors that can explain disease clustering and regional differences in disease (11,12). It provides basic data for health policy makers to determine priorities, allocate medical resources and decide on disease prevention and control interventions (13). Spatial analysis-based studies have been conducted in the field of oncology research to assess the association between influencing factors and tumor disease burden (14,15). These studies report the regional differences of tumor disease burden and propose the influencing factors that can be considered to solve this problem by showing the regional differences of tumor disease burden and proposing factors that can explain the regional differences. However, up to now, China has not yet evaluated whether there are provincial spatial distribution characteristics and spatial aggregation of liver cancer, or whether the influencing factors can explain the regional differences of the disease burden of liver cancer in China. Therefore, this study analyzed the spatial distribution characteristics and clustering of the DALY rate of liver cancer in 1990 and 2017. In addition, we explored factors that may explain the spatial variation of DALY rate in liver cancer.

The results of this study showed that in 1990, the province with the highest DALY rate of liver cancer in China was Guangxi, followed by Jiangsu, Jiangxi, and Anhui.

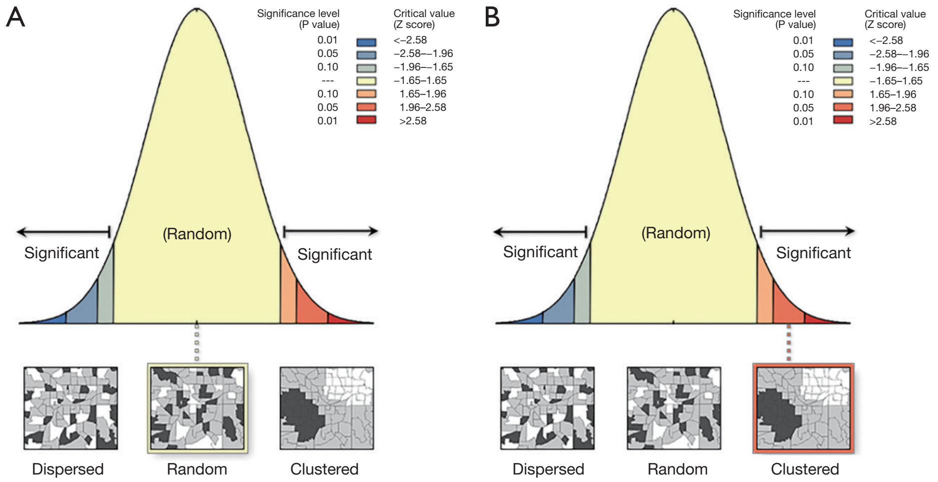

Figure 2 Global autocorrelation analysis of liver cancer. (A) Global autocorrelation results in 1990; (B) global autocorrelation results in 2017.

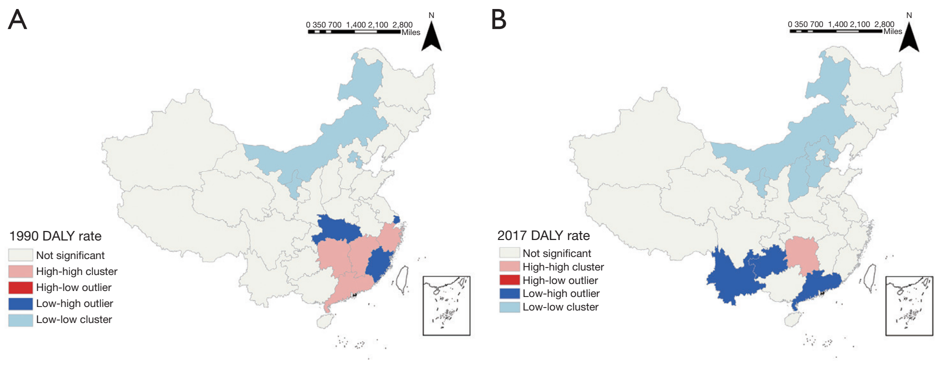

Figure 3 Local autocorrelation analysis of liver cancer. (A) Local autocorrelation results in 1990; (B) local autocorrelation results in 2017. DALY, disability-adjusted life years.

Table 2 Influence of factors on DALY rate of liver cancer

Characteristics	Regression coefficients	Standard deviation	*t*	VIF	P value
Per capita years of education	–85.41	37.43	–2.28	1.19	0.03
Incidence rate of hepatitis B	2.10	1.02	2.06	1.39	0.04
Proportion of population over 65 years old	81.04	25.12	3.22	1.87	0.003
GDP	0.01	0.01	0.06	1.29	0.95

DALY, disability-adjusted life years; VIF, variance inflation factor; GDP, gross domestic product.

The province with the lowest DALY rate was Shaanxi, while Xinjiang, Hebei, Beijing also had lower levels. In 2017, the province with the highest DALY rate of liver cancer in China was still Guangxi, followed by Heilongjiang, Sichuan, and Hubei. The province with the lowest DALY rate was Beijing, and Shanghai, Xinjiang and Shanxi were also low. It can be seen that the disease burden of liver cancer in China varies greatly at different times and regions. The disease burden of liver cancer in the central region was higher than that in the western and eastern regions, and that in coastal regions was higher than that in inland regions. From 1990 to 2017, the province with the fastest increase in the DALY rate was Hubei, which increased by 88.20%. The DALY rate of liver cancer in Shaanxi and Heilongjiang also increased rapidly. It is necessary to continue to pay attention to provinces where the rate of liver cancer DALY increases rapidly, and through scientific decision-making to curb the rapid increase in the DALY rate of liver cancer.

Studies have shown (16,17) that the disease burden of liver cancer can be spatially clustered. According to the results of global spatial autocorrelation, the DALY rate of liver cancer in 1990 was distributed randomly, and in 2017 was distributed non-randomly, indicating that in recent years, the DALY rate of liver cancer at the provincial level gradually showed spatial autocorrelation and aggregation. The clustering of liver cancer in China in 1990 and 2017 was not the same in different provinces. In 2017, the low and low clustering were mainly manifested in Inner Mongolia, Ningxia, Shanxi, Hebei, and Tianjin. The low and high clustering in Yunnan, Guizhou, and Guangdong, were surrounded by the high clustering in neighboring provinces, high and high concentration is mainly concentrated in Hunan and neighboring provinces. The risk factors of liver cancer in China were mainly HBV. If the intervention measures with the vaccination of hepatitis B vaccine can be implemented on a large scale, then liver cancer may become the second globally effectively controlled cancer after cervical cancer (18-20). Provinces with high concentration are undoubtedly the primary task of liver cancer prevention and control, and a variety of effective measures should be taken from different aspects. For example, more health care resources need to be allocated to these provinces to help improve the HBV/hepatitis C virus (HCV) vaccination rate and improve the quality of care for patients with hepatitis (21,22). In addition, if the prevalence of hepatitis is not high in provinces with a high burden of liver cancer, case-control study can further investigate the main risk factors for a high burden of liver cancer disease (23).

In this study, the least square regression model was used to analyze the influencing factors of the DALY rate of liver cancer. Results showed that the incidence rate of hepatitis B and the proportion of the population over 65 years old were positively correlated with the DALY rate of liver cancer, and the per capita years of education was negatively correlated with DALY. Studies have found that (24,25), the incidence and death rate of tumors increased with age. The high burden of cancer in the elderly may be due to the decline of the immune system and poor nutritional status in the elderly. In addition, the elderly has more basic diseases, which will aggravate the death of malignant tumors. Therefore, the burden of tumor disease in the elderly is higher than that in the young. It is indicated that 10–25% of HBV carriers may develop liver cancer (26). Globally, chronic HBV infection is the leading cause of liver cancer, especially in East Asian and African countries (27). Every year, 83.2% of liver cancer deaths are attributed to known risk factors, 77.7–88.0% of which are caused by HBV and HCV infection (28). The National Cancer Center of China analyzed the viral infection markers of 1,823 patients with liver cancer confirmed by pathology, and the results showed that HBV infection accounted for 86.0% (22). In China, with the introduction of hepatitis B vaccine into the child immunization management in 1992 and the immunization program in 2002, the hepatitis B prevalence in the younger age group has decreased significantly, However, in recent years, the overweight, diabetes, alcohol consumption and smoking rates of Chinese residents have increased significantly, and the risk factors of liver cancer seem to be changing. Therefore, the burden of liver cancer in China still accounts for a large proportion in the world (29). In recent years, one study has analyzed the relationship between education level and tumor disease burden and found that compared with people who have completed college education, people who have completed primary education have a higher risk of cancer (30). These surveys show that people with low education level have higher unhealthy lifestyles, such as unhealthy diet, lack of physical exercise and smoking (31). In addition, people with higher education level have higher social status, while people with lower education level have lower social status. People with lower social status will be exposed to more unhealthy occupational environments, which will also lead to higher incidence rate than people with higher education level (32). In addition, people with higher education level are more likely to accept regular cancer screening, and have higher compliance with cancer screening, which can move the threshold of cancer incidence forward, reduce tumor mortality, and decrease the burden of cancer (33).

This paper inevitably has some limitations and shortcomings. This study is to study the relationship between certain factors and diseases at the group level. With the group as the observation and analysis unit, by describing the exposure of certain factors and the frequency of diseases in different populations, it is possible that the research results caused by mixed factors and other reasons are inconsistent with the real situation. In addition, because more detailed data cannot be obtained, this study did not consider the classification of liver cancer into hepatocellular carcinoma and intrahepatic cholangiocarcinoma for more specific analysis.

Conclusions

This paper explored the spatial epidemiology of the burden of liver cancer in China to provide a theoretical basis for the prevention and control of liver cancer. We found regional differences in the disease burden of liver cancer in China. The decisive factors for liver cancer were the proportion of the population over 65 years old, the incidence of hepatitis B, and the per capita years of education. The results of this study provide evidence for the need to identify modifiable risk factors and implement appropriate allocation of medical resources in areas with high burden of liver cancer. Our analysis based on individual level data in subsequent study is expected to find more effective solutions to address regional inequities and reduce the burden of liver cancer.

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Footnote

Reporting Checklist: The authors have completed the RECORD reporting checklist. Available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1240/rc

Peer Review File: Available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1240/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1240/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin 2021;71:209-49.
2. Zheng R, Zhang S, Zeng H, et al. Cancer incidence and mortality in China, 2016. J Natl Cancer Cent 2022;2:1-9.
3. Xiao J, Wang F, Wong NK, et al. Global liver disease burdens and research trends: Analysis from a Chinese perspective. J Hepatol 2019;71:212-21.
4. Marengo A, Rosso C, Bugianesi E. Liver Cancer: Connections with Obesity, Fatty Liver, and Cirrhosis. Annu Rev Med 2016;67:103-17.
5. Feng C, Liu J, Ran H, et al. Spatial and temporal analysis of liver cancer mortality in Yunnan province, China, 2015-2019. Front Public Health 2022;10:1010752.
6. Chien LC, Yu HL, Schootman M. Efficient mapping and geographic disparities in breast cancer mortality at the county-level by race and age in the U.S. Spat Spatiotemporal Epidemiol 2013;5:27-37.
7. Rocha-Brischiliari SC, Andrade L, Nihei OK, et al. Spatial distribution of breast cancer mortality: Socioeconomic disparities and access to treatment in the state of Parana, Brazil. PLoS One 2018;13:e0205253.
8. Chen Y. New approaches for calculating Moran's index of spatial autocorrelation. PLoS One 2013;8:e68336.
9. Chen Y. New framework of Getis-Ord's indexes associating spatial autocorrelation with interaction. PLoS One 2020;15:e0236765.
10. Hashtarkhani S, Kiani B, Bergquist R, et al. An age-integrated approach to improve measurement of potential spatial accessibility to emergency medical services for urban areas. Int J Health Plann Manage 2020;35:788-98.
11. Kirby RS, Delmelle E, Eberth JM. Advances in spatial epidemiology and geographic information systems. Ann Epidemiol 2017;27:1-9.

12. Tessema ZT, Tesema GA, Ahern S, et al. A Systematic Review of Areal Units and Adjacency Used in Bayesian Spatial and Spatio-Temporal Conditional Autoregressive Models in Health Research. Int J Environ Res Public Health 2023;20:6277.
13. Jia P, Lakerveld J, Wu J, et al. Top 10 Research Priorities in Spatial Lifecourse Epidemiology. Environ Health Perspect 2019;127:74501.
14. Kiani B, Hashemi Amin F, Bagheri N, et al. Association between heavy metals and colon cancer: an ecological study based on geographical information systems in North-Eastern Iran. BMC Cancer 2021;21:414.
15. Roquette R, Painho M, Nunes B. Spatial epidemiology of cancer: a review of data sources, methods and risk factors. Geospat Health 2017;12:504.
16. Zhang Y, Li Z, Shao Z, et al. Analysis of inpatients' characteristics and spatio-temporal distribution of liver cancer incidence in Wuwei, Gansu Province, from 1995 to 2016: A long-term span retrospective study. Medicine (Baltimore) 2020;99:e18870.
17. Sifaki-Pistolla D, Chatzea VE, Frouzi E, et al. Evidence-Based Conceptual Collection of Methods for Spatial Epidemiology and Analysis to Enhance Cancer Surveillance and Public Health. Int J Environ Res Public Health 2022;19:12765.
18. Shi JF, Cao M, Wang Y, et al. Is it possible to halve the incidence of liver cancer in China by 2050? Int J Cancer 2021;148:1051-65.
19. de Martel C, Maucort-Boulch D, Plummer M, et al. World-wide relative contribution of hepatitis B and C viruses in hepatocellular carcinoma. Hepatology 2015;62:1190-200.
20. Global prevalence, treatment, and prevention of hepatitis B virus infection in 2016: a modelling study. Lancet Gastroenterol Hepatol 2018;3:383-403.
21. Cui F, Shen L, Li L, et al. Prevention of Chronic Hepatitis B after 3 Decades of Escalating Vaccination Policy, China. Emerg Infect Dis 2017;23:765-72.
22. Wang M, Wang Y, Feng X, et al. Contribution of hepatitis B virus and hepatitis C virus to liver cancer in China north areas: Experience of the Chinese National Cancer Center. Int J Infect Dis 2017;65:15-21.
23. Global Burden of Disease Liver Cancer Collaboration; Akinyemiju T, Abera S, et al. The Burden of Primary Liver Cancer and Underlying Etiologies From 1990 to 2015 at the Global, Regional, and National Level: Results From the Global Burden of Disease Study 2015. JAMA Oncol 2017;3:1683-91.
24. Swain CK, Padhee S, Sahoo U, et al. Changing patterns of cancer burden among elderly across Indian states: Evidence from the global burden of disease study 1990-2019. Aging Med (Milton) 2023;6:254-63.
25. Pan R, Zhu M, Yu C, et al. Cancer incidence and mortality: A cohort study in China, 2008-2013. Int J Cancer 2017;141:1315-23.
26. Villanueva A. Hepatocellular Carcinoma. N Engl J Med 2019;380:1450-62.
27. Maucort-Boulch D, de Martel C, Franceschi S, et al. Fraction and incidence of liver cancer attributable to hepatitis B and C viruses worldwide. Int J Cancer 2018;142:2471-7.
28. Islami F, Chen W, Yu XQ, et al. Cancer deaths and cases attributable to lifestyle factors and infections in China, 2013. Ann Oncol 2017;28:2567-74.
29. Cao MD, Liu CC, Wang H, et al. The population-level economic burden of liver cancer in China, 2019-2030: prevalence-based estimations from a societal perspective. Cost Eff Resour Alloc 2022;20:36.
30. Dong JY, Qin LQ. Education level and breast cancer incidence: a meta-analysis of cohort studies. Menopause 2020;27:113-8.
31. Larsen IK, Myklebust TÅ, Babigumira R, et al. Education, income and risk of cancer: results from a Norwegian registry-based study. Acta Oncol 2020;59:1300-7.
32. Morriscey C, Hajizadeh M. Income and education inequalities in cervical cancer incidence in Canada, 1992-2010. J Public Health (Oxf) 2021;43:814-23.
33. Vesco KK, Whitlock EP, Eder M, et al. Risk factors and other epidemiologic considerations for cervical cancer screening: a narrative review for the U.S. Preventive Services Task Force. Ann Intern Med 2011;155:698-705, W216.

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