Original Article
http://mjiri.iums.ac.ir
Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2021(31 Aug);35.110. https://doi.org/10.47176/mjiri.35.110

Epidemiology incidence and geographical distribution of Meningitis using GIS and its incidence prediction in Iran in 2021

Ghobad Moradi[1], Seyed Mohsen Zahraei[2], Zaher Khazaei[3], Parvin Mohammadi[4], Sirous Hemmatpour[5], Katayoun Hajibagheri[6], Fatemeh Azimian[2], Hasan Naemi[7], Elham Goodarzi[8]*

Received: 15 Feb 2020 Published: 31 Aug 2021

Abstract

Background: Meningitis is classified as a medical emergency where the identification and early treatment of bacterial meningitis can eliminate serious consequences, such as hearing loss, memory problems, learning disabilities, brain damage, seizures, and death. The purpose of this study was to investigate the incidence and geographical distribution of meningitis using Geographic Information system (GIS) and to predict its incidence in Iran in 2021.

Methods: This was a descriptive analytical study. Information on pertussis was obtained from the Center for Communicable Diseases Control during 2010-2015. In the next step, ArcGIS 9.3 was used to prepare geographic maps of the disease incidence and frequency. Then, the disease prediction map was drawn using the Raster Calculator tool.

Results: The results showed that the highest incidence of meningitis during 2010-2015 was in Qazvin, Qom, and Kurdistan provinces. The incidence of meningitis in Iran increased from 9.77 in 2010 to 10.33 in 2015. Based on the modeling results for Iran, Qom, Qazvin, Kurdistan, Hamadan, and Mazandaran provinces with 78.89%, 74.68%, 70.07%, 43.97%, and 22.93% of their areas (Km^2) are at high risk for meningitis in the coming years, respectively.

Conclusion: According to the results of this study, it can be concluded that Qom, Qazvin, Kurdistan, Hamedan, and Mazandaran provinces are at risk of the disease. Monitoring vaccination in high-risk groups can partially prevent the incidence of the disease in these areas.

Keywords: Incidence Rate, Meningitis, GIS, Iran

Conflicts of Interest: None declared
Funding: Kurdistan University of Medical Sciences

Cite this article as: Moradi G, Zahraei SM, Khazaei Z, Mohammadi P, Hemmatpour S, Hajibagheri K, Azimian F, Naemi H, Goodarzi E. Epidemiology incidence and geographical distribution of Meningitis using GIS and its incidence prediction in Iran in 2021. *Med J Islam Repub Iran.* 2021 (31 Aug);35:110. https://doi.org/10.47176/mjiri.35.110

Introduction

Meningococcal meningitis is a type of acute central nervous system infection that is caused by Neisseria meningitides (1). The disease causes approximately 171,000 deaths worldwide annually. If not treated, it will lead to death in 50% of the cases (2). Children always have the highest percentage of infections. Bacterial meningitis remains an important cause of mortality despite increased access to potent and advanced antibiotics. Overall, mortal-

Corresponding author: Elham Goodarzi, goodarzi.e@lums.ac.ir

1. Social Determinants of Health Research Center, Research Institute for Health Development, Kurdistan University of Medical Sciences, Sanandaj, Iran
2. Department of Vaccination and Vaccine Preventable Diseases, Center for Communicable Disease Control, Ministry of Health and Medical Education
3. Department of Public Health, School of Medicine, Dezful University of Medical Sciences, Dezful, Iran
4. Department of Medical Sciences, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran
5. Department of Pediatrics, Faculty of Medicine, Kurdistan University of Medical Sciences, Sanandaj, Iran
6. Department of Infectious Disease, Faculty of Medicine, Kurdistan University of Medical Sciences, Sanandaj, Iran
7. Cellular and Molecular Research Center, Sabzevar University of Medical Sciences, Sabzevar, Iran
8. Social Determinants of Health Research Center, Lorestan University of Medical Sciences, Khorramabad, Iran

↑What is "already known" in this topic:
Bacterial meningitis remains an important cause of mortality despite increased access to potent and advanced antibiotics.

→What this article adds:
Some provinces are at risk of bacterial meningitis disease in 2021 year. Monitoring vaccination in high-risk groups can partially prevent the incidence of the disease in these areas.

ity rates from bacterial meningitis in children are reported to be 20% to 30%, which reduces with age up to 25 years (3). Complications of the disease include blindness, hearing loss, neurological disorders, decreased consciousness, and paralysis (4).

The incidence of meningitis worldwide is estimated to be 20 cases per 100,000 people; that is, about 1.2 million; the incidence and causes vary across geographic regions (5). Most outbreaks occur in sub-Saharan Africa. The epidemic of meningococcal infections in Africa, New Zealand, and Singapore indicates that the infection is still a major health problem or a global outbreak. Australia, Norway, the Netherlands, China, Egypt, and Saudi Arabia are among the areas where the disease epidemic occurred (6).

In Iran, the average incidence rate reached from 1.3 in 1988 to 2.7 per 100,000 people in 2008. According to the studies conducted in Iran, the prevalence of pneumococcal meningitis in children under 10 years old is 36% and in those over 10 years old is 20%. There is insufficient information on the epidemiology of bacterial meningitis in Iran. In Iran, meningitis is most likely considered a public health hazard associated with severity of illness, mortality, and high costs for health care providers because of the lack of a routine vaccination program for meningeal diseases, such as pneumococcus (7).

Monitoring infectious diseases has become one of the top priorities in the health care systems (8). As public health and disease dissemination issues are directly related to the geography of the region and always have a spatial dimension, the geographic information system (GIS) can play a significant role in managing and planning public health issues and studying disease propagation (9). The GIS is a useful application that can investigate the causes by presenting the geographical distribution pattern of the disease and quantitatively and qualitatively illustrates the spatial distribution of the illness. In this way, it can help health and treatment decisions to prevent and control the disease (9-12). Therefore, the purpose of this study was to investigate the incidence and geographical distribution of meningitis using the GIS and to predict its incidence in Iran in 2021.

Methods

This was a descriptive analytical study with applied results. The research uses spatial and climatic information and incidence rate of meningitis in Iran. Initially, the information on meningitis was obtained from the Center for Communicable Diseases Control during 2010-2015. The incidence and frequency table for bacterial meningitis was prepared for each year and the incidence rate was calculated for 100,000 people in Iran. In the next step, the GIS was used to prepare geographic maps of the disease incidence and frequency. To prepare the spatial database for the disease, the vector map of Iran's administrative divisions for 2017 used by the National Mapping Organization was used to link descriptive information about the disease to the spatial data in the GIS environment. The geographical locations were verified through Google Earth. When the geographic database of the disease was developed, descriptive information, such as incidence and frequency of the disease, was added to the GIS descriptive table using Excel. Next, a spatial analysis was prepared to map the incidence and frequency distribution of disease during 2005-2015 in the GIS environment through Symbology functions. With the information of each province, the incidence and frequency map of the disease was prepared for the whole country. To plot the disease prediction map, it was assumed that the probability of disease occurrence was higher in regions with the highest incidence and the highest incidence of the disease in a statistical period. Therefore, using the Raster Calculator tool, the fuzzy map of the disease over a given period was multiplied by the disease recurrence map, and the disease prediction map was eventually drawn (13). The map shows the most likely areas for disease incidence in red.

With the information of each province available, the incidence and frequency of disease was developed for the whole country. In order to plot the map of interpolation, the inverse distance interpolation method was used (14).

High-Risk Points Analysis

The Getis-Ord-Gi* statistic was used for an appropriate spatial distribution of hot and cold spots. A disease is recognized as a hot spot when its figures and those of its surrounding conditions are fairly high. When the Getis-Ord-Gi* statistic is calculated to be 1, 2, and 3, the CI is estimated at 99%, 95%, and 90%, respectively (15).

As the incidence data are obtained based on the findings of routine health care system, the difference in incidence that was observed in different provinces can be largely dependent on the sensitivity of the health care system to record and report cases in these provinces.

Results

The results showed that 59.6% of patients with meningitis were men, 71.5% were urban dwellers, and the outcome of treatment in 71.7% of cases was recovery (Table 1).

The results show that most meningitis cases during 2010-2015 were reported in June and May (Fig. 1).

The results showed that the highest incidence of menin-

Table 1. Demographic information of Meningitis patients in Iran during 2010-2015

Variable		Frequency (%)
Sex	Female	18805 (40.4)
	Male	27370 (59.6)
Place of residence	City	33254 (71.5)
	Village	13239 (28.5)
	Treated	33313 (71.7)
Outcome	Death	949 (2)
	Unknown	12231 (3.26)

gitis during 2010-2015 was in Qazvin, Qom, and Kurdistan provinces (Table 2, Map 1).

The results indicated that the incidence of meningitis in Iran increased from 9.77 in 2010 to 10.33 in 2015 (Fig. 2).

According to the latest information on the incidence of the disease (incidence in 2015), Qazvin, Qom, Kurdistan,

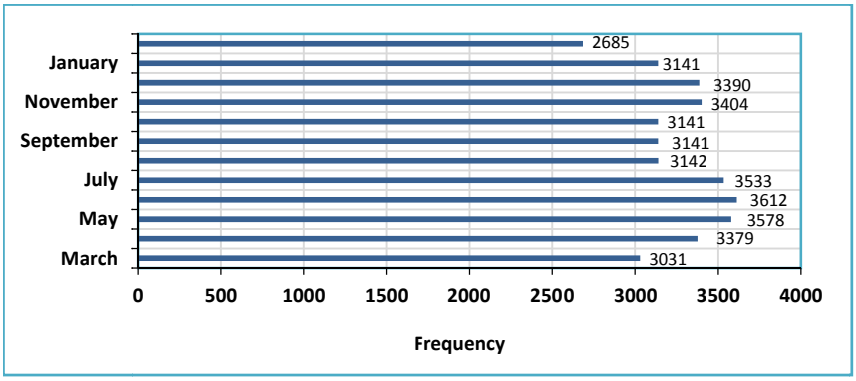


Fig. 1. Meningitis frequency according to the months reported

Table 2. Incidence of Meningitis per 100,000 population in Iran during 2010-2015

Province	2010	2011	2012	2013	2014	2015
East Azerbaijan	4.16	3.84	11.19	6.96	4.52	4.77
West Azerbaijan	2.47	2.86	3.33	4.97	4.28	3.82
Ardebil	2.33	4.25	4.53	3.55	1.57	2.49
Isfahan	4.05	3.03	6.46	11.56	9.47	9.47
Alborz	2.61	2.61	2.32	3.04	4.16	4.24
Ilam	8.83	11.29	16.52	7.73	1.91	1.20
Bushehr	3.00	2.52	2.37	3.99	3.18	5.52
Tehran	4.97	5.28	4.67	6.28	5.69	5.87
Chaharmahal va Bakhtiari	8.69	9.83	11.39	12.80	8.23	8.15
Southern Khorasan	4.87	7.99	6.75	6.80	16.18	11.83
Khorasan Razavi	13.69	11.16	10.90	11.31	9.74	7.57
Northern Khorasan	8.64	6.80	7.86	9.23	14.02	32.67
Khuzestan	5.20	3.57	6.03	7.32	9.27	4.03
Zanjan	7.86	10.04	11.11	12.92	19.10	20.23
Semnan	6.90	5.71	14.66	10.60	20.09	18.72
Sistan and Baluchestan	1.56	1.85	1.39	1.50	0.84	0.36
Fars	7.56	8.11	6.96	7.70	5.43	3.58
Qazvin	142.05	115.89	70.92	82.14	76.41	82.00
Qom	25.40	27.17	23.89	33.61	46.29	52.79
Kurdistan	67.05	47.05	48.07	53.24	53.35	46.25
Kerman	2.12	1.70	3.32	4.56	4.69	5.04
Kermanshah	2.54	7.04	7.32	7.44	4.82	5.06
Kohgiloyeh and Boyerahmad	5.51	8.04	7.32	12.19	4.19	6.54
Golestan	1.26	0.96	1.60	3.10	1.44	1.42
Gilan	1.99	1.77	2.48	2.95	3.05	3.26
Lorestan	1.60	1.94	17.29	17.31	16.16	16.80
Mazandaran	18.60	18.31	17.68	21.23	20.73	22.47
Markazi	3.50	3.68	3.57	2.70	2.95	2.31
Hormozgan	0.52	0.25	0.62	1.40	1.19	0.88
Hamedan	18.03	28.56	39.25	35.23	38.13	39.05
Yazd	16.65	19.93	17.85	17.97	18.46	15.06
Whole country	9.77	9.17	9.75	10.97	10.58	10.33

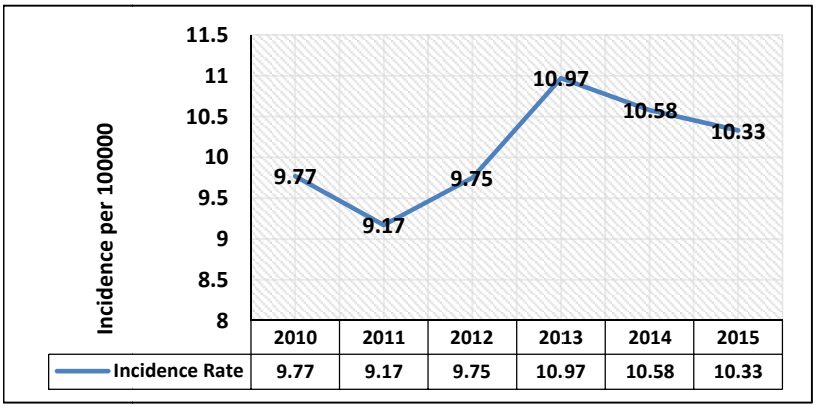
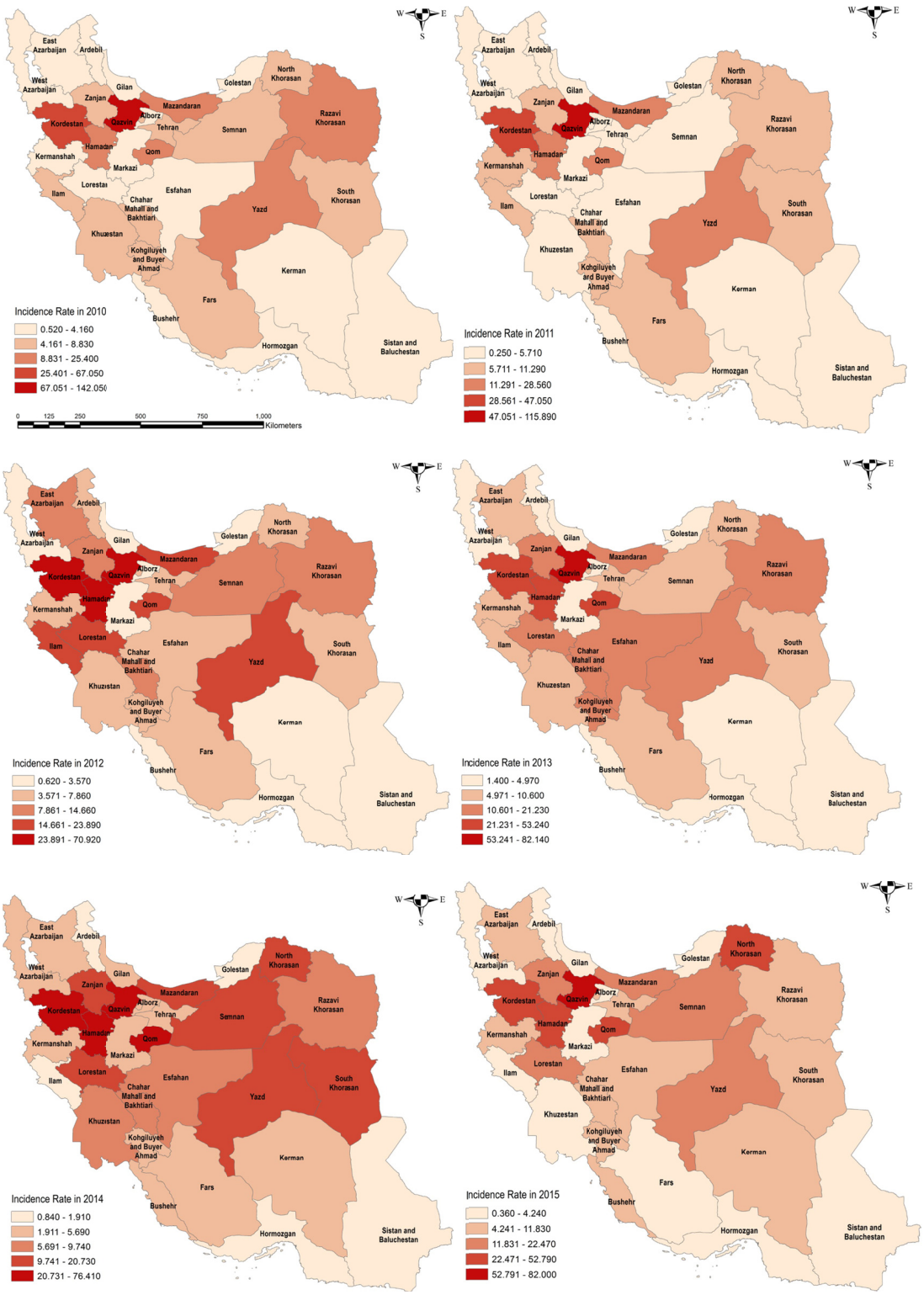
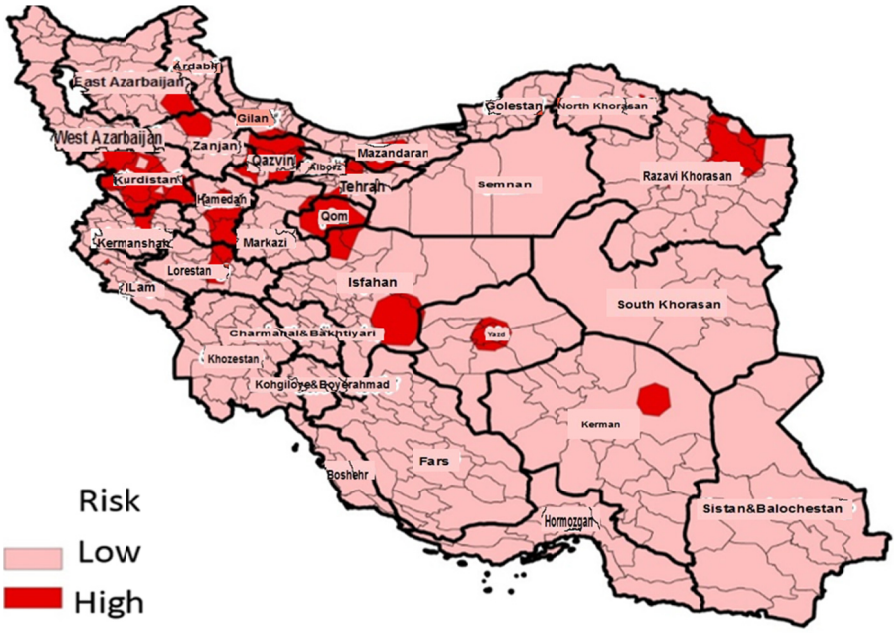


Fig. 2. Trend of meningitis incidence in Iran during 2010-2015



Map 1. Meningitis incidence in Iran during 2010-2015

and North Khorasan provinces had the highest incidence in 2015. Based on the GIS maps of the whole country, 7.4% of the total area of Iran (120669.6 km^2) comprising parts of Isfahan, Alborz, Ilam, East Azarbaijan, West Azarbaijan, Tehran, Khorasan Razavi, North Khorasan, Zanjan, Semnan, Qazvin, Qom, Kurdistan, Kerman, Kermanshah, Kohgiluyeh & Boyer Ahmad, Gilan, Lorestan, Mazandaran, Markazi, Hamedan, and Yazd provinces are at high risk for Malta fever in the coming years (2021). Based on the modeling results in Iran, Qom, Qazvin, Kurdistan, Hamadan, and Mazandaran provinces with 78.89%, 74.68%, 70.07%, 43.97%, and 22.93% of their areas, respectively, are at high risk for meningitis in the coming years (Map 2).



Map 2. Prediction of high-risk areas for meningitis incidence in Iran in 2021

Discussion

Meningitis can be life threatening. It is classified as a medical emergency, where the identification and early treatment of bacterial meningitis can eliminate serious consequences, such as hearing loss, memory problems, learning disabilities, brain damage, seizures, and death (16). Viral meningitis could improve without treatment, but bacterial meningitis is very serious and requires prompt antibiotic treatment. Since bacterial infections are the most serious and dangerous ones, finding the source of infection is an important part of the treatment plan. Therefore, identifying high-risk areas can help reduce the incidence of the disease. In recent years, significant progress has been made in identifying the pathophysiology of bacterial meningitis and treatment methods. However, bacterial meningitis remains an important cause of mortality and morbidity. Therefore, monitoring infectious diseases, especially central nervous system infections, is an important priority in the health care systems (17-19).

The results showed that the highest incidence of meningitis during 2010-2015 was in Qazvin, Qom and Kurdistan provinces. The incidence of meningitis in Iran increased from 9.77 in 2010 to 10.33 in 2015. Based on the modeling results for Iran, Qom, Qazvin, Kurdistan, Hamadan, and Mazandaran provinces with 78.89%, 74.68%, 70.07%, 43.97%, and 22.93% of their areas are at high-risk for meningitis in the coming years, respectively. The study results showed that the highest incidence of meningitis during 2010-2015 was in Qazvin, Qom, and Kurdistan Province, respectively. It may be that the disease care system is more dynamic in these provinces and the infected cases are reported more fully to the Disease Management Centers and the Department of Vaccine-preventable Diseases (20, 21).

Investigations in Iran in 2004 showed that Khorasan, Qom, and Qazvin provinces had the highest incidence rate with more than 4 cases per 100,000 population. There have been 2 major changes in the epidemiology of acute bacterial meningitis in recent years. The first is the reduction of the incidence of Haemophilus meningitis in countries where the Haemophilus influenzae type b vaccination program is widespread (22). The incidence of meningitis has increased in recent years. Since the beginning of 2008, medical universities across the country made electronic reports directly on the Portal of Infectious Diseases Management, resulting in a dramatic increase in case reports as compared to previous years. As a result, we have witnessed an increasing trend in the incidence of the disease in recent years.

In recent years, all of the cases of meningitis, whether purulent or nonpurulent, have been reported as an overall amount, which has led to an increase in the number of cases. Since the beginning of 2008, a traditional reporting method of meningitis has been changed to an electronic reporting method so that medical universities of the country could register their reports directly in the Center for Communicable Diseases Control portal electronically. As a result, a considerable increase was observed in reporting the number of diseases compared to 2 to 3 years ago. On the other hand, in recent years, incidence cases have been reported based on definition of suspected, probable, and definitive cases. However, before 2008, the reported cases were limited to definitive cases, which may partly justify the increase in reporting the disease in recent years.

Based on the modeling results for Iran, it was found that Qom, Qazvin, Kurdistan, Hamadan, and Mazandaran provinces, with 78.89%, 74.68%, 70.07%, 43.97%, and 22.93% of their areas, are at high-risk for meningitis in the coming years, respectively. The reason for this difference may be found in vaccination programs. Some types of meningitis, such as meningococcal, influenza B, pneumococcal, or emulsion virus infection may be prevented

through immunization. Vaccination of young men before their military service term and vaccination before traveling to pilgrimage areas is effective in reducing the incidence of the disease (23, 24).

Conclusion

According to the modeling results related to provincial areas, the provinces of Qom, Qazvin, Kurdistan, Hamedan, and Mazandaran are at high-risk of meningitis in Iran in the coming years, respectively. Therefore, implementation and further monitoring of vaccination programs in these areas can prevent the disease incidence.

Acknowledgment

This paper was based on the results of a research project with the ethical of code IR.MUK.REC.1395.184 approved by Kurdistan University of Medical Sciences. The close cooperation of the Center for Communicable Diseases Management, Ministry of Health and Medical Education, distinguished Deputies of Health Affairs of the Medical Sciences Universities, responsible experts and specialists in the Prevention and Fighting of the Infectious Diseases Groups of Iranian provinces, experts, technicians, specialists, and the staff at the health centers and health houses of Iran, as well as the collaboration of all those involved in the project are greatly appreciated.

Conflict of Interests

The authors declare that they have no competing interests.

References

1. Ghotaslou R, Farajnia S, Yeganeh F, Abdoli OS, Ahangarzadeh RM, Barzegar M. Detection of acute childhood meningitis by PCR, culture and agglutination tests in Tabriz, Iran. Acta Med Iran. 2012;50(3):192-196.
2. Ceyhan M, Yildirim I, Balmer P, Borrow R, Dikici B, Turgut M, et al. A prospective study of etiology of childhood acute bacterial meningitis, Turkey. Emerg Infect Dis. 2008;14(7):1089.
3. Theodoridou MN, Vasilopoulou VA, Atsali EE, Pangalis AM, Mostrou GJ, Syriopoulou VP, et al. Meningitis registry of hospitalized cases in children: epidemiological patterns of acute bacterial meningitis throughout a 32-year period. BMC Infect Dis. 2007;7(1):101.
4. Van de Beek D, Cabellos C, Dzupova O, Esposito S, Klein M, Kloek A, et al. ESCMID guideline: diagnosis and treatment of acute bacterial meningitis. Clin Microbiol Infect. 2016;22:S37-S62.
5. Brouwer MC, Tunkel AR, van de Beek D. Epidemiology, diagnosis, and antimicrobial treatment of acute bacterial meningitis. Clin Microbiol Rev. 2010;23(3):467-92.
6. Artenstein AW, LaForce FM. Critical episodes in the understanding and control of epidemic meningococcal meningitis. Vaccine. 2012;30(31):4701-7.
7. Abdinia B, Rezaee MA, Oskouie SA. Etiology and antimicrobial resistance patterns of acute bacterial meningitis in children: a 10-year referral hospital-based study in northwest iran. Iran Red Crescent Med J. 2014;16(7):225.
8. Janati A, Hosseiny M, Gouya MM, Moradi G, Ghaderi E. Communicable disease reporting systems in the world: a systematic review article. Iran J Public Health. 2015;44(11):1453.
9. Seif A, Rashidi M, Rozbahani R, Daheshti N, Poursafa P. GIS application in medical researches a solution for prevention from disease. J Esfahan Univ Med Sci. 2011;29(164):1-10.
10. Tanser FC, Le Sueur D. The application of geographical information systems to important public health problems in Africa. Int J Health Geogr. 2002;1(1):4.
11. Cromley EK. GIS and disease. Annu Rev Public Health. 2003;24(1):7-24.
12. Pordanjani SR, Atamaleki A, Amiri M, Khazaei Z, Fallahzadeh H, Alayi R, et al. Study on epidemiological status, spatial and temporal distribution of human brucellosis in kohgiluyeh and Boyer-Ahmad Province during 2011–2017. Adv Hum Biol. 2020;10(1):22.
13. Khoshdel A, Nourifard M, Pezeshkn R, Salahi Moghaddam A. Mapping of important diseases communicable in Iran. Health Develop J. 2012;1(1):31-46.
14. Setianto A, Setianto A, Triandini T, Triandini T. Comparison of kriging and inverse distance weighted (IDW) interpolation methods in lineament extraction and analysis. Asian Appl Geol. 2013;5(1):21-9.
15. Getis A, Ord JK. The analysis of Spatial Association by use of Distance Statistics. Geogr Anal. 1992;24(3):189-206.
16. Martin NG, Sadarangani M, Pollard AJ, Goldacre MJ. Hospital admission rates for meningitis and septicaemia caused by Haemophilus influenzae, Neisseria meningitidis, and Streptococcus pneumoniae in children in England over five decades: a population-based observational study. Lancet Infect Dis. 2014;14(5):397-405.
17. Khajeh A, Sharifi-Mood B, Soleimani GR. Pediatric Meningoencephalitis; A Research on Patients Hospitalized in Zahedan, Southeastern Iran. Int J Infect. 2015;2(2):258.
18. Grenón SL, Salvi MG, Regueira MM, Fossati MS. Pneumococcal meningitis in children under 15 years of age in Misiones (Argentina). Sixteen year's epidemiological surveillance. Rev Argent Microbiol 2014;46(1):14-23.
19. Houri H, Pormohammad A, Riahi SM, Nasiri MJ, Fallah F, Dabiri H, et al. Acute bacterial meningitis in Iran: Systematic review and meta-analysis. PloS One. 2017;12(2):e0169617.
20. Jesri N, Rezaei F, Saghafipour A, Asghari H, Noroozei M. Spatial Analysis of Bacterial Meningitis in Iran Using Geographical Information System. J Mazandaran Univ Med Sci 2016;25(132):309-14.
21. Piroozi B, Mohamadi Bolban Abad A, Moradi G. Assessing health system responsiveness after the implementation of health system reform: a case study of Sanandaj, 2014-2015. Iran J Epidemiol. 2016;11(4):1-9.
22. Rasulinejad M SM, Mehrdad H, Jafari S. Epidemiological study of bacterial meningitis and determination of their antibiotic resistance pattern in Tehran. . Iran J Infect Dis Trop Med. 2005;7(16):87-96.
23. Ghotaslou R, Yeganeh-Sefidan F, Salahi-Eshlaqi B, Ebrahimzadeh-Leylabadlo H. Etiology of acute bacterial meningitis in Iran: A systematic review. Acta Med Iran 2015;53(8):454-61.
24. Karami M, Ghalandari M, Poorolajal J, Faradmal J. Early detection of meningitis outbreaks: Application of limited-baseline data. Iran J Public Health 2017;46(10):1366.