



Spatial Distribution Analysis of Chemical Warfare Victims with the Health Demographic Policy Approach

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ABSTRACT

Aims Iraq used chemical weapons in the war with Iran, in military and civilian areas. Due to the long-term effects of these weapons, Considering over 35 years after this eight-year war, the number of chemical warfare victims is increasing. This research aimed to investigate the spatial distribution of chemical warfare victims by province.

Instrument & Methods This descriptive-analytical research study was done using data obtained from the General Department of Statistics and Information Technology of the Martyr and Veteran Affairs Foundation. The data of chemical casualties includes the number; place of residence, gender, and type of injury in 2021 that were analyzed using SPSS 20 and ArcGIS software and Moran's test.

Findings The total number of veterans in 2021 was 601330; 10.7% of them were chemical victims. Tehran (11%), Isfahan (9.67%), and Khorasan-Razavi (6.92%) provinces had the highest, and Hormozgan (0.39%), South-Khorasan (0.66%), and Sistan & Baluchistan (0.77% provinces) had the lowest. The spatial distribution of chemical warfare victims showed a cluster pattern.

Conclusion The consequences of Iraq's use of chemical weapons can be seen in all of Iran's provinces, and all provinces have chemical victims. Tehran, Isfahan, Khorasan Razavi, Kerman, West-Azerbaijan, and Khuzestan have more chemical victims than other provinces.

Keywords Chemical Warfare Victims; Health Demographic; Spatial Distribution; Veteran; War; Policy

CITATION LINKS

[1] The effects of the Imposed War on language ... [2] Qualitative analysis of emotional and familial situations of injured victims of Sardasht chemical air ... [3] Psychological health in veterans of the Iran-Iraq imposed war, 22 years after the war ... [4] The female face of war in the chemical bombing of ... [5] Investigating the Use of Iraqi Ba'athist chemical weapons in the war imposed ... [6] Prevalence of oral soft tissue lesions in the victims of chemical bombardments in ... [7] Post-traumatic Stress Disorder in Male Chemical Injured War Veterans Compared to non-chemical ... [8] Analyzing the right of states to produce and develop military weapons from the perspective of ... [9] Conflict and Health. Epidemiological findings of major chemical attacks in the Syrian war are consistent with civilian targeting: a ... [10] The statute of limitations of actions of victims of the use of chemical weapons during ... [11] Side effects and injuries caused by chemical weapons during the holy defense and the battles of the axis of ... [12] Sardasht-Iran cohort study of chemical warfare victims: Design ... [13] Mortality rate of people exposed to Mustard Gas during Iran-Iraq war in Sardasht, Iran: A 32 years retrospective ... [14] Study of surrogacy validation of Th1, Th2 in long-term skin effects of exposure ... [15] A qualitative study of the psycho-physical consequences of chemical bombardment on the victims of ... [16] Long-term effects of sulfur mustard poisoning in Iranian chemical warfare victims: A ... [17] Correlation of delayed mustard gas ocular complications with severity of skin, respiratory, hematologic, and immunologic ... [18] Quality of life of chemically-disabled war veterans involved in pulmonary complications of sulfur mustard gas in ... [19] Evaluation of serum and sputum level of IL-21 in Sardasht chemical victims and its relationship with long-term pulmonary complications (27 years after sulfur mustard ... [20] Delayed ocular complications of mustard gas in Iranian ... [21] Lawsuit proceedings for victims of use of chemical weapons in the imposed war in the judiciary of the Islamic Republic ... [22] Incidence of lung, eye, and skin lesions as late complications in 34,000 Iranians with wartime exposure to mustard ... [23] The study of experiences of chemical victims of Iraq-Iran conflict in terms of nature and structure of suffering ... [24] Investigation of the amount of change in the physical indicators of chemical veterans after participating in a regular exercise ... [25] Human costs of Iraq's chemical war against Iran; an epidemiological study [26] Spatial analysis of the development impact on internal migration - between counties - in ...

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Introduction

Wars, whether directly or indirectly, expose societies to various phenomena [1] and pose a threat to public health [2], with potential consequences that may persist in society for years [3]. In 1980, approximately 20 months after the Islamic Revolution, Iraq attacked Iran [4], marking one of the most significant historical periods for Iran. Iraq's use of chemical weapons was a major health problem of this war [5-7].

Although the use of any chemical weapons in warfare is prohibited due to the significant threat to health [8-9], according to published evidence, Iraq's use of chemical weapons against Iran began in a limited manner shortly after the liberation of Khorramshahr. It expanded after the Valfajr 2, Valfajr 4, Kheybar, and Badr operations [10]. Iraq's use of such weapons was not confined to military and war zones; many residential and non-military areas also came under chemical attack [11]. A notable example of such an event is the attack on Sardasht city in the West Azerbaijan province, Iran, one of the provinces bordering Iraq, in the year 1986-1987 [12-14]. In this attack, the Iraqi army bombed Sardasht city with four 350-kilogram mustard gas bombs, resulting in the injury of over 4,500 residents of Sardasht [15]. It is essential to note that even before the war, the Iraqi army had used such weapons to kill Kurdish civilians in 1974 [10].

With more than 35 years having passed since the end of the war, the population of chemical war survivors is on the rise. Individuals in all provinces of the country who suffer from chemical injuries are facing various physical and psychological challenges. The long-term consequences of human exposure to chemical gases, such as mustard gas, can manifest over several decades [16-19]. In some sources, severe physical effects can occur between 20 to 50 years after exposure to chemical weapons [20]. Considering the legal duties of the Iranian government to support its citizens [21], awareness of the dispersion of the population of chemical war survivors among provinces is of particular importance for planning medical and welfare programs for these individuals. Given the specific health and medical service needs of this group, knowledge of the spatial distribution of this population and their places of residence can assist government officials, especially health planners and policymakers, in concentrating on specific geographical areas. On the one hand, considering the differences in the intensity and type of injuries and differences in health needs, this awareness significantly influences the allocation of health and medical budgets for various regions of the country. Planning for allocating hospitals and equipment, specialized medical practitioners, financial health aid, home-based medical services, etc., can be tailored based on the dispersion of the survivors according to their type of injuries. Therefore, this study aimed to assess the provincial

dispersion status of Iranian chemical war survivors, whose injuries have been confirmed by the Medical Commission of the Foundation of Martyrs and Veterans Affairs. Also, this study aimed to show the concentration of the residence of survivors, primarily in which regions, and investigate the spatial distribution based on the type of injury.

Considering Iraq's widespread use of chemical weapons, even in non-military areas, and the presence of war soldiers from all parts of the country, the population of chemical war survivors is not concentrated in a single point or region. The goal of this research was to investigate the spatial distribution and provincial dispersion of the surviving population of the Iraq-Iran chemical war (with a focus on the injury type) and propose policy solutions to improve services for this group.

Instrument and Methods

This study was carried out in a descriptive-analytical manner using a secondary analysis method on the data of no-chemical and chemical war veterans provided by the General Directorate of Statistics and Information Technology of the Foundation of Martyrs and Veterans Affairs.

The confirmation of war-related injuries and determination of the percentage of disability is the responsibility of the medical commissions of the Foundation of Martyrs and Veterans Affairs. This institution, recognized as a legal and scientific center, defines the type of injuries based on medical diagnoses, specifically focusing on respiratory, ocular, and dermatological issues related to chemical agents, particularly sulfur mustard gas. The data encompassing all war veterans (including disabled and non-disabled) of the Iraq-Iran war were extracted based on population size, place of residence, gender, and disability percentage. Subsequently, data related to chemical war survivors were extracted based on gender, place of residence, and type of injury.

The extracted data were then analyzed in tables and charts, considering their frequency and provincial distribution in 2021-2022.

Descriptive statistical analysis was performed using SPSS 20 software. The overall spatial distribution of the population of chemical war survivors and their distribution by specific regions of injuries (eye, lung, and skin) were prepared using ArcGIS 10.8 software. The Moran I test was employed to confirm the significance of the spatial distribution.

Findings

The total population of war veterans and survivors in 2021-2022 was recorded as 644,735 individuals, comprising 601,330 (93.3%) disabled veterans and 43,405 (6.7%) non-disabled veterans.

Among all disabled veterans, 350,859 individuals (58.3%) had injuries less than 25%, while 250,471

individuals (41.6%) had injuries exceeding 25%. Of the disabled veterans, 592,386 were male (98.5%) and 8,944 were female (1.5%). Chemical war survivors constituted 69,123 individuals (10.7%) of the total disabled veterans. The provinces of South

Khorasan and Hormozgan, with fewer than 500 chemical war veterans, had the lowest number. In contrast, Tehran and Isfahan provinces, with more than 5,000 chemical war veterans, had the highest incidence of chemical injuries (Figure 1 and 2).

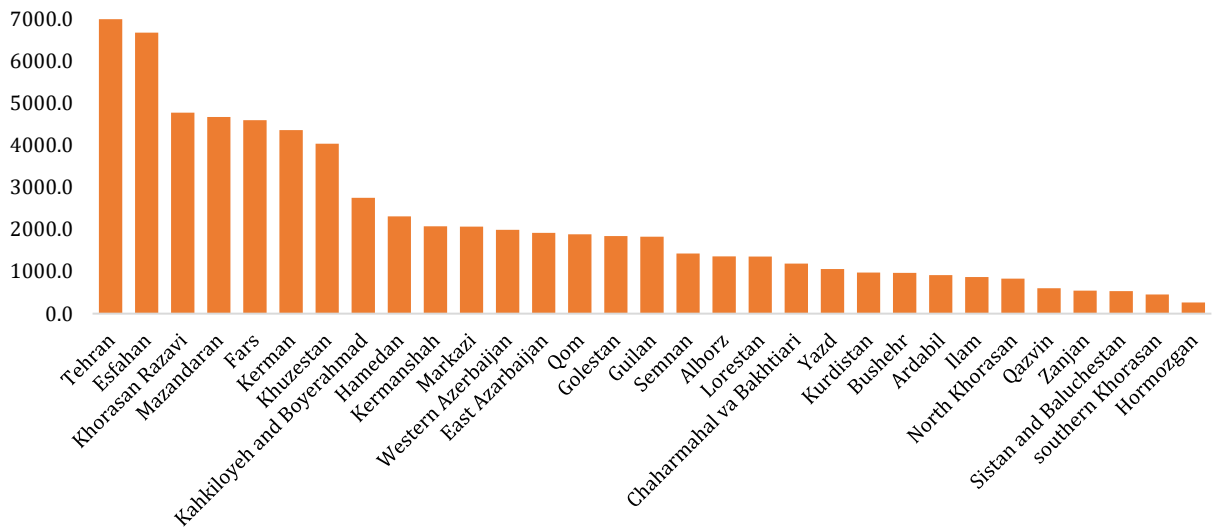


Figure 1. Distribution of the population exposed to chemical warfare agents in the provinces of Iran in 2021-2022

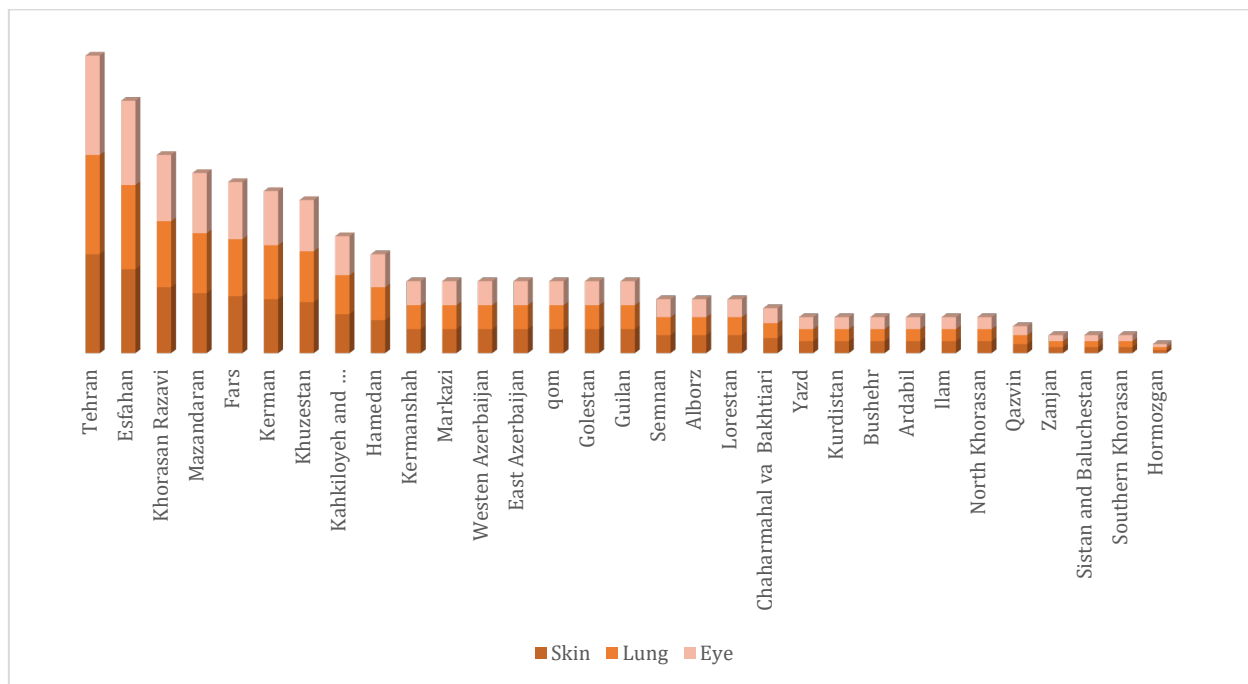


Figure 2. Comparing number of the organs involved in the chemical warfare victims by province

The highest frequency of skin injuries (89.9%) among veterans was observed in clinically treated veterans, while the lowest percentage was attributed to severely affected veterans (0.2%). The highest proportion of veterans with severe skin issues was observed in Chaharmahal Bakhtiari provinces, while the lowest was found in Ardabil, Bushehr, and Hormozgan provinces. Regarding veterans with moderate skin problems, Ilam province had the highest ratio, and the lowest was in Bushehr and North Khorasan provinces. For veterans with mild

skin injuries, West Azerbaijan province had the highest ratio, while the lowest was observed in Bushehr and Semnan provinces (Table 1). The highest frequency of lung injuries among veterans, accounting for 49.6%, was observed in clinically treated veterans, while the lowest percentage was attributed to severe respiratory injuries (0.86%). The highest proportion of veterans with severe lung issues was found in West Azerbaijan province, and the lowest was in Kurdistan and Hormozgan provinces.

Table 1. Frequency distribution of severity of the skin injuries in chemical warfare victims by province

Province	Clinically treated		Mild		Moderate		Severe	
	No.	%	No.	%	No.	%	No.	%
East Azerbaijan (n=1900)	1711	90.1	170	8.9	13	0.7	6	0.3
West Azerbaijan (n=1983)	1592	80.3	325	16.4	61	3.1	5	0.3
Ardabil (n=907)	841	92.7	60	6.6	6	0.7	0	0.0
Isfahan (n=6628)	5886	88.8	668	10.1	64	1.0	10	0.2
Albprz (n=1351)	1244	92.1	92	6.8	11	0.8	4	0.3
Ilam (n=866)	713	82.3	120	13.9	32	3.7	1	0.1
Boushehr (n=955)	914	95.7	38	4.0	3	0.3	0	0.0
Tehran (n=7869)	7121	90.5	649	8.2	81	1.0	18	0.2
Charmahal & Bakhtiari (n=1181)	1047	88.7	113	9.6	12	1.0	9	0.8
South Khorasan (n=450)	410	91.1	36	8.0	3	0.7	1	0.2
Razavi Khorasan (n=4717)	4328	91.8	346	7.3	40	0.8	3	0.1
North Khorasan (n=823)	760	92.3	61	7.4	1	0.1	1	0.1
Khuzestan (n=4007)	3757	93.8	221	5.5	22	0.5	7	0.2
Zanjan (n=541)	487	90.0	44	8.1	7	1.3	3	0.6
Semnan (n=1417)	1346	95.0	63	4.4	6	0.4	2	0.1
Sistan & Baloushestan (n=534)	477	89.3	49	9.2	7	1.3	1	0.2
Fars (n=4470)	4043	90.4	370	8.28	42	0.94	15	0.34
Qazvin (n=603)	542	89.9	56	9.29	4	0.66	1	0.17
Qom (n=1859)	1706	91.8	123	6.62	21	1.13	9	0.48
Kurdistan (n=975)	839	86.1	116	11.90	16	1.64	4	0.41
Kerman (n=4337)	3624	83.6	644	14.85	65	1.50	4	0.09
Kermanshah (n=2071)	1733	83.7	286	13.81	45	2.17	7	0.34
Kuhgiluyeh & Boyer Ahmad (n=2734)	2551	93.3	167	6.11	13	0.48	3	0.11
Golestan (n=1824)	1670	91.6	141	7.73	11	0.60	2	0.11
Gilan (n=1805)	1659	91.9	135	7.48	6	0.33	5	0.28
Lorestan (n=1348)	1247	92.5	92	6.82	8	0.59	1	0.07
Mazandaran (n=4653)	4088	87.9	519	11.15	42	0.90	4	0.09
Markazi (n=2041)	1853	90.8	163	7.99	20	0.98	5	0.24
Hormozgan (n=264)	237	89.8	21	7.95	6	2.27	0	0.00
Hamedan (n=2296)	2112	92.0	172	7.49	11	0.48	1	0.04
Yazd (n=1048)	972	92.7	65	6.20	8	0.76	3	0.29
Total (n=68457)	61510	89.9	6125	8.95	687	1.00	135	0.20

Table 2. Frequency distribution of severity of the lung injuries in chemical warfare victims in the provinces of Iran

Province	Clinically treated		Mild		Moderate		Severe	
	No.	%	No.	%	No.	%	No.	%
East Azerbaijan (n=1900)	820	43.5	815	43.2	225	11.9	27	1.4
West Azerbaijan (n=1983)	763	39.4	887	45.8	252	13.0	36	1.9
Ardabil (n=907)	426	47.5	386	43.0	76	8.5	9	1.0
Isfahan (n=6628)	3155	48.2	2615	40.0	697	10.7	77	1.2
Albprz (n=1351)	707	53.0	497	37.2	112	8.4	19	1.4
Ilam (n=866)	238	27.6	528	61.3	91	10.6	4	0.5
Boushehr (n=955)	518	55.6	362	38.9	46	4.9	5	0.5
Tehran (n=7869)	3549	45.7	3376	43.4	749	9.6	99	1.3
Charmahal & Bakhtiari (n=1181)	520	44.2	491	41.8	154	13.1	11	0.9
South Khorasan (n=450)	257	58.0	130	29.3	54	12.2	2	0.5
Razavi Khorasan (n=4717)	2610	56.3	1494	32.2	496	10.7	39	0.8
North Khorasan (n=823)	500	61.8	246	30.4	57	7.0	6	0.7
Khuzestan (n=4007)	2273	57.2	1418	35.7	255	6.4	25	0.6
Zanjan (n=541)	287	53.5	192	35.8	49	9.1	8	1.5
Semnan (n=1417)	682	48.8	604	43.2	105	7.5	6	0.4
Sistan & Baloushestan (n=534)	231	44.3	226	43.3	60	11.5	5	1.0
Fars (n=4470)	2961	67.8	1073	24.55	290	6.64	46	1.05
Qazvin (n=603)	271	45.4	282	47.24	39	6.53	5	0.84
Qom (n=1859)	781	43.3	831	46.09	176	9.76	15	0.83
Kurdistan (n=975)	367	38.0	475	49.17	122	12.63	2	0.21
Kerman (n=4337)	2007	47.2	1774	41.69	453	10.65	21	0.49
Kermanshah (n=2071)	978	47.7	785	38.31	265	12.93	21	1.02
Kuhgiluyeh & Boyer Ahmad (n=2734)	1140	42.2	1367	50.55	184	6.80	13	0.48
Golestan (n=1824)	905	50.4	761	42.37	120	6.68	10	0.56
Gilan (n=1805)	865	48.8	803	45.34	87	4.91	16	0.90
Lorestan (n=1348)	675	50.7	573	43.05	80	6.01	3	0.23
Mazandaran (n=4653)	2262	49.0	1884	40.77	448	9.69	27	0.58
Markazi (n=2041)	1024	50.9	765	38.02	218	10.83	5	0.25
Hormozgan (n=264)	128	48.5	116	43.94	20	7.58	0	0.00
Hamedan (n=2296)	1155	50.8	885	38.90	223	9.80	12	0.53
Yazd (n=1048)	444	42.7	464	44.62	125	12.02	7	0.67
Total (n=68457)	33499	49.6	27105	40.15	6328	9.37	581	0.86

Table 3. Frequency distribution of severity of the eye injuries in chemical warfare victims by province

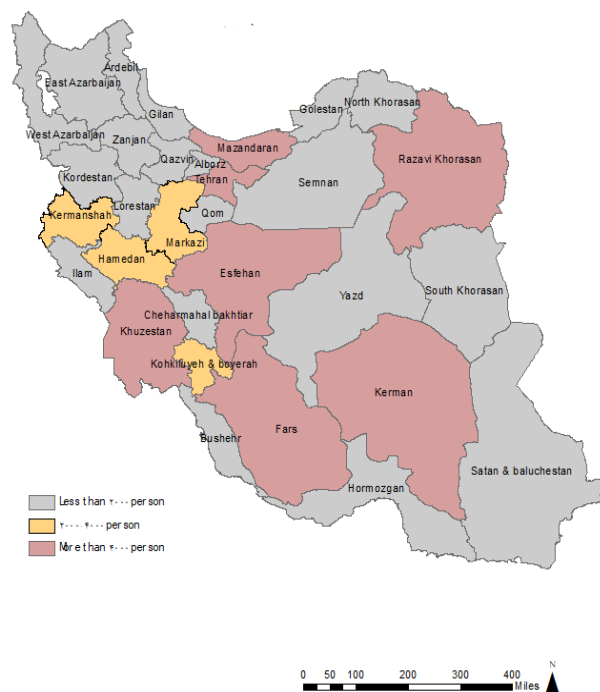
Province	Clinically treated		Mild		Moderate		Severe	
	No.	%	No.	%	No.	%	No.	%
East Azerbaijan (n=1900)	1591	82.7	308	16.0	14	0.7	10	0.5
West Azerbaijan (n=1983)	1600	80.9	359	18.2	12	0.6	6	0.3
Ardabil (n=907)	764	83.5	140	15.3	4	0.4	7	0.8
Isfahan (n=6628)	4895	73.2	1678	25.1	48	0.7	63	0.9
Albprz (n=1351)	1227	90.2	127	9.3	4	0.3	2	0.1
Ilam (n=866)	803	92.3	64	7.4	2	0.2	1	0.1
Boushehr (n=955)	817	85.0	142	14.8	2	0.2	0	0.0
Tehran (n=7869)	6960	88.1	884	11.2	23	0.3	30	0.4
Charmahal & Bakhtiari (n=1181)	1029	86.5	149	12.5	5	0.4	6	0.5
South Khorasan (n=450)	372	81.8	82	18.0	1	0.2	0	0.0
Razavi Khorasan (n=4717)	4126	86.8	593	12.5	25	0.5	12	0.3
North Khorasan (n=823)	744	90.1	79	9.6	3	0.4	0	0.0
Khuzestan (n=4007)	3249	80.4	755	18.7	14	0.3	22	0.5
Zanjan (n=541)	479	87.2	68	12.4	0	0.0	2	0.4
Semnan (n=1417)	1240	87.6	173	12.2	1	0.1	2	0.1
Sistan & Baloushestan (n=534)	472	88.7	58	10.9	2	0.4	0	0.0
Fars (n=4470)	4061	88.4	462	10.05	28	0.61	44	0.96
Qazvin (n=603)	534	88.3	68	11.24	2	0.33	1	0.17
Qom (n=1859)	1690	90.2	166	8.86	8	0.43	10	0.53
Kurdistan (n=975)	867	89.3	95	9.78	4	0.41	5	0.51
Kerman (n=4337)	3660	97.9	52	1.39	20	0.53	8	0.21
Kermanshah (n=2071)	1897	91.9	160	7.75	4	0.19	4	0.19
Kuhgiluyeh & Boyer Ahmad (n=2734)	2450	89.1	283	10.29	10	0.36	8	0.29
Golestan (n=1824)	1642	89.3	191	10.39	5	0.27	1	0.05
Gilan (n=1805)	1655	91.0	155	8.52	3	0.16	6	0.33
Lorestan (n=1348)	1239	91.6	111	8.21	1	0.07	1	0.07
Mazandaran (n=4653)	3951	84.5	704	15.07	6	0.13	12	0.26
Markazi (n=2041)	1819	88.1	240	11.62	3	0.15	3	0.15
Hormozgan (n=264)	187	69.3	78	28.89	3	1.11	2	0.74
Hamedan (n=2296)	2031	88.0	262	11.35	9	0.39	7	0.30
Yazd (n=1048)	890	84.4	159	15.07	2	0.19	4	0.38
Total (n=68457)	58941	86.3	8845	12.94	268	0.39	279	0.41

Regarding veterans with moderate respiratory problems, Chaharmahal & Bakhtiari province had the highest ratio, and the lowest was in Bushehr and Gilan provinces. For veterans with mild respiratory injuries, Ilam province had the highest ratio, while the lowest was observed in Fars and South Khorasan provinces (Table 2).

The highest frequency of eye injuries among veterans was observed in clinically treated veterans with 86.3%, while the lowest percentage was attributed to severe eye injuries (0.41%). The highest proportion of veterans with severe eye problems was found in Fars and Isfahan provinces, and the lowest was in Bushehr, South Khorasan, North Khorasan, and Sistan & Baluchestan provinces. Regarding veterans with moderate eye problems, Hormozgan province had the highest ratio, and the lowest was in Zanjan and Semnan provinces. For veterans with mild eye injuries, Hormozgan province had the highest ratio, while the lowest was in Kerman and Ilam provinces (Table 3).

Chemical veterans had a relatively uniform distribution across the country. The lowest number of chemical veterans in 2021-2022 was observed in the northwestern and southeastern regions of the country, while the central regions had the highest number of the veterans. Considering the impact of differences in the resident population in provincial centers, a more detailed examination of the spatial distribution of chemical veterans was conducted

using the ratio index of veterans (per 10,000 population; Figure 3).

**Figure 3.** Spatial distribution of the number of Iranian chemical warfare victims

The spatial distribution of the chemical injury rate in the country was diverse, and the provincial

dispersion of chemical veterans was concentrated in the central and western border regions (Figure 4).

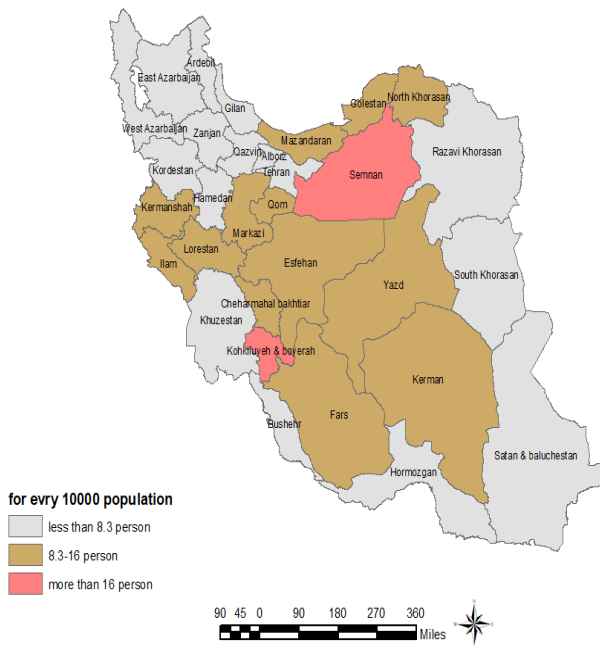
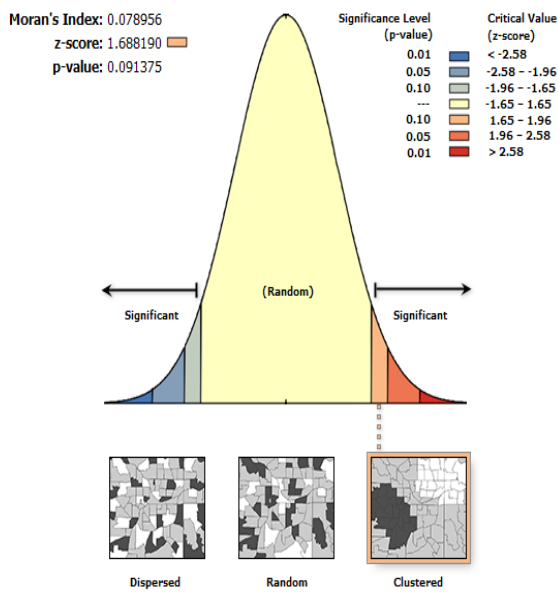


Figure 4. Spatial distribution of the rate of Iranian chemical warfare victims (per 10,000 population) by province



Given the z-score of 1.688189183, there is a less than 10% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary	
Moran's Index:	0.078956
Expected Index:	-0.033333
Variance:	0.004424
z-score:	1.688190
p-value:	0.091375

Figure 5. General Moran's spatial autocorrelation test of dispersion pattern of the rate of chemical warfare victims by province

The chemical injury rate in the country was 1.68 per 10,000 population, with a significant level of 0.09, indicating the presence of a cluster pattern in the distribution of chemical injury rates. However, the spatial distribution of the population in the country did not follow a cluster pattern. In other words, the distribution pattern of the population of chemical veterans did not resemble the population distribution pattern of the country (Figure 5).

Discussion

This study aimed to investigate the spatial distribution and provincial dispersion of the surviving population of chemical veterans from the Iran-Iraq War (with a focus on the injury type) and to propose policy solutions to improve services for this group. According to a study in 2003-2004, during the years 1980 to 1988, Iran was subjected to chemical attacks 387 times, resulting in nearly 60,000 individuals suffering physical and psychological injuries from these attacks [22]. In another report, it is mentioned that over 100,000 individuals have been affected by chemical injuries [23-25]. With more than 30 years passing since the end of the war, the number of individuals recognized as chemical veterans by medical commissions is increasing, indicating a growing occurrence of consequences resulting from exposure to chemical weapons. If in 2015-2016, the number of chemical veterans reported was 63,417 (out of 554,990 individuals), this figure increased to 66,954 (out of 601,330 individuals) in 2021-2022. In other words, during this period, 3,537 individuals were added to the population of chemical veterans, confirmed by the Medical Commission of the Foundation of Martyrs and Veterans Affairs.

The concentration of chemical veterans and their residence in central regions or more developed areas is considerable considering the uneven distribution of development levels in the country and, consequently, the unequal distribution of facilities and services [26], especially healthcare facilities, and the needs of this segment of society for these facilities and services. Although there was no significant difference in the spatial pattern of chemical injury cases, which indicates the lack of significance in this spatial distribution, overall, the population of chemical veterans is higher in provinces with larger populations. Tehran, Khorasan Razavi, Isfahan, and Fars are the provinces with the highest population of chemical veterans. Additionally, western and southern provinces have more chemical veterans than eastern provinces.

The data include individuals identified by the Medical Commissions of the Foundation of Martyrs and Veterans Affairs as having chemical injuries. Individuals who did not meet the criteria for confirming chemical injury or lacked the necessary legal documentation were not included in the study, which can be considered a limitation of this research.

Given the importance of planning for the treatment of chemical injury survivors, one of the most crucial steps towards meeting the health needs of this population is the establishment of specialized healthcare centers or allocating a portion of specialized hospitals to address the urgent and vital needs of chemical injury survivors, especially in regions of the country that have experienced the highest number of injuries. Considering the impact of the type of injury on the demand for healthcare services, the distribution of facilities and specialized physicians should be based on the dispersion of chemical injury cases by injury type. Alongside these practical measures, these initiatives' excessive medical and healthcare costs must also be considered, so an annual budget allocation for these services should be considered for each region.

Considering the long-term consequences of some types of injuries, comprehensive community identification and screening measures should be a priority to prevent acute and severe cases before the intensity of the injury occurs. In addition to healthcare needs, cultural and social issues, and appropriate interventions are also important. Given the physical and behavioral limitations of some types of injuries, some chemical injury survivors cannot participate in public places and many recreational centers. Considering the importance of leisure time and social participation in the lives of these individuals, cultural and social programs suitable for the physical conditions of this group of war-injured survivors should be considered. The programs should be planned according to each region's social and cultural context. To implement these measures, attention should be paid to the location and appropriateness of the physical conditions of chemical injury survivors. Therefore, in addition to providing these programs with suitable spaces, attention should be paid to adapting public spaces for the presence of chemical injury survivors.

Conclusion

The repercussions of Iraq's use of chemical weapons are evident in all provinces of Iran, and individuals with chemical injuries are present in all provinces. Tehran, Isfahan, Khorasan Razavi, Kerman, West Azerbaijan, and Khuzestan provinces have the highest number of chemical injury survivors.

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