

# Mustard gas exposure in Iran–Iraq war – A scientometric study

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## ABSTRACT

**Background:** The Iranian victims of sulfur mustard attack are now more than 20 years post-exposure and form a valuable cohort for studying the chronic effects of an exposure to sulfur mustard. Articles on sulfur mustard exposure in Iran–Iraq war were reviewed using three known international databases such as Scopus, Medline, and ISI. The objectives of the study were measurement of the author-wise distribution, year-wise distribution, subject area wise, and assessment of highly cited articles. **Materials and Methods:** We searched three known international databases, Scopus, Medline, and the international statistical institute (ISI), for articles related to mustard gas exposure in Iran–Iraq war, published between 1988 and 2012. The results were analyzed using scientometric methods. **Results:** During the 24 years under examination, about 90 papers were published in the field of mustard gas in Iran–Iraq war. Original article was the most used document type forming 51.4% of all the publications. The number of articles devoted to mustard gas and Iran–Iraq war research increased more than 10-fold, from 1 in 1988 to 11 in 2011. Most of the published articles (45.7%) included clinical and paraclinical investigations of sulfur mustard in Iranian victims. The most highly productive author was Ghanei who occupied the first rank in the number of publications with 20 papers. The affiliation of most of the researchers was Baqiyatallah Medical Sciences University (research center of chemical injuries and dermatology department) in Iran. **Conclusion:** This article has highlighted the quantitative share of Iran in articles on sulfur mustard and lays the groundwork for further research on various aspects of related problems.

**Key words:** Iran–Iraq war, mustard gas, scientometric study

## INTRODUCTION

Mustard gas or sulfur mustard (SM) is a poisonous gas that falls in the group of lethal gases. It can lead to disablement

or death. It is not found naturally in the environment and remains as a liquid in cold damp conditions, but evaporates rapidly in a warm dry environment to produce a vapor that can penetrate ordinary clothing.<sup>[1-3]</sup>

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Mustard gas is a biofunctional alkylating agent, in other words, its chemicals destroy the biological molecules including proteins and nucleic acids and liquefy tissue. Essentially mustard gas damages tissue contact areas including skin (redness and itching that change to blisters), gastrointestinal tract (abdominal pain, diarrhea, fever, nausea, and vomiting), respiratory tract (sneezing, bloody nose, shortness of breath), and central nervous system.<sup>[4,5]</sup> In fact, the toxicity of sulfur mustard as a debilitating agent is of greater importance than its ability to cause death.<sup>[6]</sup> The chronic and long-term health effects of sulfur mustard exposure include extensive skin burning, permanent blindness, and repeated respiratory infections, or

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death. Also, the development of cancers, neuropsychiatric effects, immune system changes, and reproductive toxicity has been reported.<sup>[5-8]</sup> The extent of tissue injury depends on the duration and intensity of exposure.<sup>[3,7]</sup>

Mustard gas victims briefly lose their vision in a short time after exposure; therefore, it has been used to disable large numbers of soldiers in war conflicts.<sup>[4]</sup> It is uncertain when this substance was first manufactured; but 1820, 1822, and 1845 have been cited by different authors. However, it was not used efficiently as a weapon until World War I. Mustard gas as a chemical weapon has been used in many wars during the 20<sup>th</sup> century by countries including Italy (1935), Japan (1936), and Egypt (1963–1967).<sup>[2,3,7]</sup> This warfare agent was widely used by Iraq during the Iran–Iraq war between 1983 and 1988. Almost all casualties of mustard gas attacks in World War I and in the Iran–Iraq war endured long-term skin and eye burns and respiratory injuries, but the reported fatality rates were less than 2% in the exposed soldiers during World War I and 3–4% in the casualties of the Iran–Iraq war.<sup>[1,3,6]</sup> In the World War I, the casualties were more than 90,000 deaths and 1.3 million injured people.<sup>[3]</sup> Based on the information reported by Veterans and Martyrs Affair Foundation (VMAF) that is responsible for taking care of the war victims in Iran, more than 1000 tons of sulfur mustard were used in the battlefields and about 100,000 people were injured due to this agent, and even after more than two decades, still about 34,000 of them are under treatment.<sup>[1,4,8]</sup> Over decades later, the survivors are suffering from respiratory (42.5%), ophthalmic (39.3%), and cutaneous (24.5%) chronic effects. More than 20 years post-exposure, the Iranian victims of sulfur mustard form a valuable cohort for studying the pathologic and psychological chronic effects of a single or short-term exposure to sulfur mustard.<sup>[9,10]</sup> Different scientometric studies have provided input data for research policy aims of research institutions. Some of the benefits of these researches are identification of needed particular areas and providing a ground work for research planning and policy-making. Recently the Islamic Republic of Iran considerably expanded its presence in world science by showing an increase in its ISI articles (such as using scientometrics in the assessment of biological effects of depleted uranium in the first and second Persian Gulf wars).<sup>[11,12]</sup> The main purpose of the present scientometric study was to evaluate internationally published researches about sulfur mustard exposure in Iran–Iraq war using three known international databases such as Scopus, Medline, and ISI. The particular objectives were measurement of the author-wise distribution, year-wise distribution, subject area wise, and assessment of highly cited articles.

## MATERIALS AND METHODS

In a scientometric study, articles related to sulfur mustard gas were reviewed using known international databases such as ISI, Medline, and Scopus. A suitable search strategy (Iran–Iraq war and mustard gas were entered in the key words field) was used to download records for the years 1988–2012. A total of 143 records were downloaded from the online Scopus ( $n = 98$ ), Web of Science ( $n = 29$ ), and Medline ( $n = 15$ ) databases.

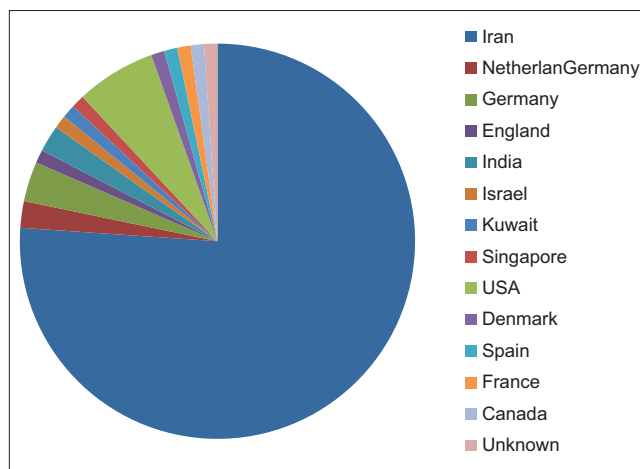
After removing duplicates and overlapping records, 98 papers were obtained. Then 9 articles that were not relevant were omitted and finally 89 articles were included in this study. Of these 89 papers, there was 1 review article on animals, only 1 study about marine pollution, 2 researches included the *in vitro* characteristics of mustard gas, 4 studies were about animals (swine and guinea pigs, mouse), 70 studies were on humans, and 11 researches included other different fields. Because of the diversity of the assessed specimens in the studied articles, we categorized them into four distinct groups. Articles on blood, semen, and lavage fluid were placed in the first group. Those dealing with the pathological complications were placed in the second group. In the third group, the papers were based on questionnaires' information. Articles that included autopsies formed the fourth group. The analysis is based on all documents including original articles, case reports, case series, proceedings papers, and reviews. Then the records were downloaded using Microsoft Excel software and all the document information were examined analytically for publishing authors, country of origin, subject category, publication date, and the most cited items. The results were visualized as tables and figures.

## RESULTS

### Total number of published items

During the 24 years under examination (1988–2012), the published items originated from 12 countries, with Iran (70 items), the United States (6 items), Germany (5 items), the United Kingdom (UK), France, Israel, Canada, Singapore, Denmark, Kuwait, and Spain producing only one item each. Country of origin and the number of published articles dealing with mustard gas are given in Figure 1.

Ninety-one papers have been published in the field of mustard gas on Iranian subjects in Iran–Iraq war. Original article (47) was the most used document type forming 52.8% of all the publications, followed by proceedings papers ( $n = 17$ , 18.4%), reviews ( $n = 16$ , 17.4%), case reports ( $n = 7$ , 8.5%), and case series ( $n = 4$ , 4.3%). All the articles (91, 100%) were published in English.



**Figure 1: Country of origin and the number of published articles dealing with mustard gas**

### Distribution of authors

The most highly productive author was Ghanei, who occupied the first rank in publications (20 papers). He was followed by to Ballali Mood and Emadi (8 papers), Aslani and Soroush (7 papers), Hafezi (6 papers), Davoodi and Poursaleh (4 papers), and Mahmoudi, Attaran, Harandi, Hassan, and Hosseini khalili (3 papers). The number of authors who have published articles dealing with mustard gas in Iran–Iraq war is given in Table 1.

### Highly cited articles

The number of citations of mustard gas in articles on Iran–Iraq war published until 2012 is given in Table 2. The affiliation of most of the researchers is Baqiyatallah Medical Sciences University (research center of chemical injuries and dermatology department) in Iran.

### Distribution of samples in articles

The distribution of samples in articles was as follows: Assessment of biological fluids such as blood, semen, and lavage fluid ( $n = 22, 31.4\%$ ), articles about the pathological complications of mustard gas ( $n = 6, 8.6\%$ ), papers based on questionnaires' information ( $n = 5, 7.1\%$ ), and articles on autopsy ( $n = 3, 4.2\%$ ).

**Table 1: Authorship pattern among researchers of mustard gas in Iran -Iraq war**

Rank	Authors	No of papers	Percentage
1	Ghanei	20	5.9
2	Ballali Mood and Emadi	8	2.4
3	Aslani and Soroush	7	2
4	Hafezi	6	1.7
5	Davoodi and Poursaleh	4	1.2
6	Mahmoudi, Attaran, Harandi, Hassan, and Hosseini khalili	3	0.9
7	Other authors	24	7.1
8	Other authors	264	80.8
Total		336	100

Most of the published articles ( $n = 32, 45.7\%$ ) included clinical and paraclinical investigations of mustard sulfur in Iran–Iraq war victims.

### Subject area wise

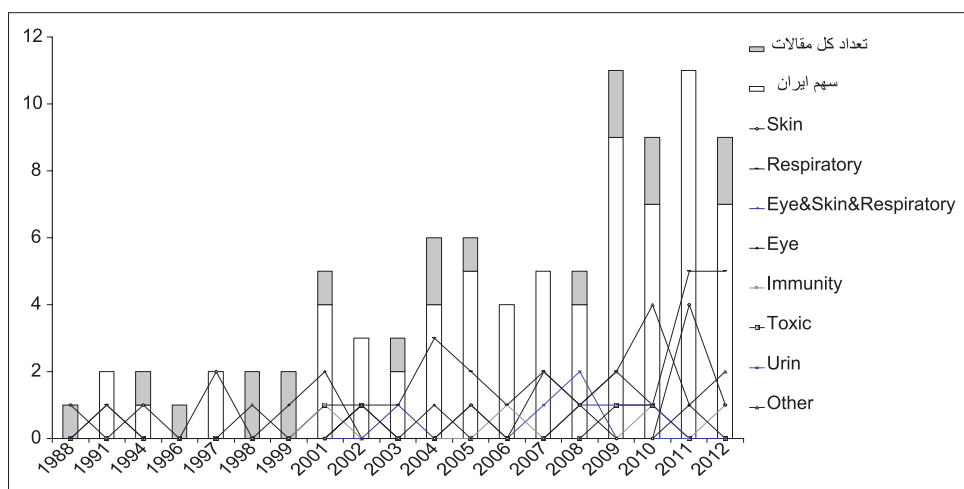
The main domains of articles have been classified as: Respiratory disorders, immune system changes, ophthalmic, urinary tract, and skin complications or infections, reproductive toxicity, oncology, and other long-term chronic effects [Figure 2].

## DISCUSSION

The capability of the all countries throughout the world is measured by their amount of scientific information and production. Therefore, promotion of different fields of science and technology, particularly in developing countries, is important. The countries can improve their scientific metrics level in the science world rankings for considering as active contributors in the world of science.<sup>[13]</sup>

The present study provides the first scientometric analysis of mustard gas in the literature of Iran–Iraq war. Our findings show that all the publications included Iranian subjects and we did not find any paper on the causalities of Iraq. However, Iraq used this warfare on civilians of this country.<sup>[14]</sup> During the 24 years under examination (1988–2012), the most published items originated from Iran because all the available cases were Iranian veterans.<sup>[4]</sup>

A gradual growth trend was found in all documents and articles searched by keywords. The number of articles devoted to mustard gas and Iran–Iraq war research increased more than 10-fold from 1 in 1988 to 11 in 2011. The positive trend in the research papers published on endodontic, orthopedic and Behçet's disease is evident in the scientometric studies conducted by Eghbal *et al.* Janmohammadi, and Shahram.<sup>[15-17]</sup> As a matter of fact, Iran has presented one of the fastest growth rates in scientific production in the whole



**Figure 2: The number of published articles related to main domains including: Respiratory disorders, immune system changes, ophthalmic, urinary tract, and skin complications or infections, reproductive toxicity, and other long-term chronic effects (such as heart disorders, oncology, autopsy)**

**Table 2: The articles on mustard gas in Iran-Iraq war cited until 2012**

Rank	Author name	Country	Affiliation	No. paper	Citation
1	Balali Mood	Iran	Mashhad University of Medical Sciences, Medical Toxicology Research Center	8	729
2	Ghanei	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	20	459
3	Hefazi	Iran	Mashhad University of Medical Sciences, School of Medicine	5	263
4	Noort	The Netherlands	Netherlands Organisation for Applied Scientific Research-TNO, Delft	4	221
5	Benschop	The Netherlands	Netherlands Organisation for Applied Scientific Research-TNO, Delft	3	218
6	Soroush	Iran	Department of Physiology, Shahed University	10	186
7	Haines	Hungary	Department of Pharmacology, University of Debrecen, Debrecen	3	165
8	Mahmoudi	Iran	Mashhad University of Medical Sciences, Immunology Research Center	3	164
9	Khateri	Iran	Janbazan Medical and Engineering Research Center	2	162
10	Kehe	Germany	Bundeswehrkrankenhaus München, Section X5	3	161
11	Aslani	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	7	155
12	Attaran	Iran	Mashhad University of Medical Sciences, Lung Disease and Tuberculosis Research Center	2	98
13	De Jong	The Netherlands	Netherlands Organisation for Applied Scientific Research-TNO, Delft	2	96
14	Harandi	Iran	Department of Neurology, Shahid Beheshti Medical University	3	68
15	Safarinejad	Iran	Clinical Center for Urological Disease Diagnosis, Private Clinic Specialized in Urological and Andrological Genetics	2	63
16	Balszuweit	Germany	Institut für Pharmakologie und Toxikologie der Bundeswehr	2	47
17	Thiermann	Germany	Institut für Pharmakologie und Toxikologie der Bundeswehr	2	47
18	Fidder	The Netherlands	Netherlands Organisation for Applied Scientific Research-TNO, Div. of Chem. and Biol. Protection, Rijswijk	2	46
19	Mars Groenendijk	The Netherlands	Netherlands Organisation for Applied Scientific Research-TNO, Delft	2	46
20	Van Der Schans	The Netherlands	Netherlands Organisation for Applied Scientific Research-TNO, Delft	2	46
21	Emadi	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	7	33
22	Davoodi	Iran	Department of Dermatology, Baqiyatallah Medical Sciences University	4	33
23	Mortazavi	Canada	Department of Medicine, McMaster University, Hamilton	2	31
24	Hassan	Iran		3	28
25	Hosseini khalili	USA	Hartford Hospital, Division of Cardiology, Hartford	3	26
26	Shohrati	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	2	26
27	Ebtekar	Iran	Department of Biostatistics and Social Medicine, Zanjan University of Medical Sciences	2	24
28	Ghazanfari	Iran	Department of Immunology, Shahed University	2	17
29	Shoja	Iran	Daneshgahe Tabriz	2	14
30	Ghassemi-Broumand	Iran	Shahid Beheshti Medical University, Faculty of Rehabilitation	2	13
31	Vijayaraghavan	India	Department of Pharmacology and Toxicology, Defence Research and Development Establishment India, Gwalior	2	9
32	Jafari	Iran	Baqiyatallah Medical Sciences University, Applied Neuro Sciences Research Center	2	4
33	Panahi	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	2	4
34	Smith	USA	US Army Medical Research Institute of Chemical Defense, Cell and Molecular Biology Branch, Aberdeen Proving Ground	2	3
35	Alaeddini	Canada	University of Toronto	2	2
36	Poursaleh	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	4	1
37	Emadi	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	3	1
38	Kafashi	Iran	Baqiyatallah Medical Sciences University, Research Center of Chemical Injuries	2	1
39	Babamahmoodi	Iran	Mazandaran University of Medical Sciences, Antimicrobial Resistance Research Center	2	0
40	Izadi	Iran	Baqiyatallah Medical Sciences University, Health Research Center	2	0

world during the past two decades.<sup>[17]</sup> Lately, in the country, the number of published articles has significantly increased in the basic and applied sciences involving medical fields. Iran stood in the second position among Islamic countries with respect to the number of published papers.<sup>[18]</sup> It was also predicted that if we can keep our satiation in growth rate in the number of publications reached in recent years, by 2013, Iran could be among the top 10 countries in the world in scientific publications.<sup>[19]</sup> Of course, we have to pay attention to the quality of publications. If the growth in quantity results in a decline in quality, we are moving toward a downfall and our scientific basis will suffer as an outcome.

Chronic and long-term effects of mustard gas in Iranian war victims and some efforts such as improving the research and training programs in the country have effectively promoted the development of this field.<sup>[20]</sup> The lowest number of publications was between the years 1988 to 1999 (1 or 2 articles) because these years were the first period of coverage of records and one can expect that the year 1999 might have witnessed more productivity [Figure 1]. About 50% of the published articles included clinical and paraclinical investigations of sulfur mustard in Iran–Iraq war victims because it is the earliest and simplest method in medical investigations, and the lowest number of articles included autopsy (4.2%). Religious ethical issues in the country may be the cause of limited research in this field. Iraq extensively used sulfur mustard agents against Iran years 1983 to 1988 and injured more than 50,000 victims. So, the highest number of articles was published by Iranian researchers and most of the SM studies in other countries were restricted to review articles or were performed in Iranian victims.<sup>[4]</sup>

The highest number of articles was in the category of respiratory and lung diseases. Various studies have been performed on the short- and long-term clinical symptoms of chemical victims, but there are few studies discussing the basic cellular and molecular mechanisms of the long-term clinical manifestations of mustard exposure. Also psychosomatic and lifestyle long term effects in SM patients are not determined. About 34,000 SM victims are living in Iran that the pulmonary and ophthalmic disorders are the most common symptoms in them.<sup>[4,21]</sup>

The Baqiyatallah Medical Sciences University of Tehran, Iran, was ranked the first in the number of affiliations of articles with highest citations and was the flagship in lung and respiratory researches. It is probably due to the admission of a great number of chemical war casualties in Baqiyatallah hospital in Iran. Iran has strong independent research ability because of having unique SM victims.<sup>[4]</sup> Commonly the number of citations is considered for assessment of an article, that a researcher or an institute has shown interested that. Number of citations is not a fundamental scale of the important position and quality of articles; it expresses the strength, durability, and defects of research activities and is often used for researches. Being cited means that a published article appears as a reference in the article of another author.

Therefore, the number of citations of a specific paper is a crude evaluation of the significance of the paper within the scientific community, although such lists practically do not infer real ranking because various papers gather their citations over different time periods.<sup>[22]</sup>

The quantitative and qualitative evaluation of journals and articles may be considered as a gold standard for the progress of science in different countries. The scientometric studies, especially in medical sciences, have important roles such as planning the correct policies to create an appropriate milieu. It may also be used for rating the universities and research centers according to their scientific outputs and can be useful in the selection of appropriate thesis topics for medical students. In the present study dealing with mustard gas papers, we obtained some significant points on the research trends and performances of mustard gas in Iran–Iraq war from 1988 to 2012. This study provides a systematically structural picture, as well as clues to the influence of various mustard gas research topics. There are scanty data about the long-term health effects of exposure to mustard gas and significant toxic effects of mustard gas on the environmental ecosystems such as soil and water microbiota. (Today the war zones of our country are changed to tourist areas.) Therefore, more efforts in these fields are required.

## CONCLUSION

The final conclusion of this research has been highlighted the quantitative share of Iran in mustard gas related articles and lays the groundwork for further researches on the different aspects of this poisonous gas.

It is recommended that the concerned investigators, research centers, or universities of Iran take more efforts in the assessment of other pathological and psychological chronic effects of exposure to mustard sulfur in Iranian victims as a valuable unique cohort group, as soon as possible and before they die.

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