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Long Term Health Effects of Chemical Warfare Agents on Children following a Single Heavy Exposure

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Abstract

In the 1980s, villages in the Kurdistan region of Iraq were exposed to chemical weapons (CWs), which killed and injured thousands of civilians. There has been no clinical assessment of the long-term effects of CWs exposure on those injured. We report the first such evaluation of CW effects on long-term health of children. Patients from the CW-exposed areas were interviewed to assess previous and current clinical history and underwent clinical examination. The status of organs known to be targets of CWs, including skin, eyes, respiratory and neuromuscular systems, was assessed. Children of similar age and social background, but with no history of CW exposure, were selected as a control population. Results showed that 70% of children in the CWs group had chronic health problems in contrast to 3.3% in the unexposed group ($p < 0.0001$). Fifty-five per cent of the CW-exposed group had long-term visual impairment but none in the unexposed population. Thirty-six per cent of the CW-exposed group had chronic dermatological conditions compared with 0.8% of the unexposed group ($p < 0.0001$), 31% of the CWs group had neurological sequelae compared with 0.4% of the unexposed group ($p < 0.0001$) and 51% of the CWs group had long-term respiratory problems compared with 1.5% of the unexposed group ($p < 0.0001$). Respiratory complaints including asthma, chronic bronchitis and bronchiectasis were particularly common. Our study suggests that CWs used were probably a combination of sulphur mustard and organophosphate nerve agents. Results also indicate that the prevalence of acute and chronic health problems following exposure to CW agents appear to be higher in children compared with reported data in adults.

Keywords: chemical weapons; sulphur mustard; Nerve agents; chronic health effects; paediatrics; Kurds.

Introduction

International law has prohibited the use of chemical weapons since 1899 under the Hague Convention. However, in March 1988 Iraqi forces used chemical weapons (CW) on the Kurdish city of Halabja leading to an estimated 5000 deaths and injuring thousands.[1,2] Use of CWs against the Kurdish population occurred both before and after this in numerous attacks.[3] Iraq first used CWs against Iranian forces in 1983 and continued to do so until 1988.[4] Some of those injured by Iraqi CWs were examined by a clinical team operating under the auspices of the United Nations Secretary General. [4] In a series of 12 reports the team documented injuries consistent with the use of sulphur mustard (commonly known as mustard gas) and an anti-cholinesterase agent.[4] Subsequent investigations of Iraqi munitions by the UN Special Commission confirmed that Iraq had stockpiles of mustard gas and a range of organophosphate chemical warfare nerve agents including sarin, tabun and VX.[5] The nerve agents are anti-cholinesterase compounds.

No official investigation was conducted to assess the specific CWs used against the Kurdish population. However, two private investigations have provided some of this evidence. The first was by a journalist who collected a range of environmental samples including soil, clothing and wool. This analysis indicated the presence of mustard gas and its thermal breakdown products together with two explosives.[1] Almost four years later a team of investigators from the organisations of Middle East Watch and Physicians for Human Rights collected a series of soil samples and munitions debris from craters alleged to have been caused by chemical bombs. Analysis of the samples by the UK Chemical Defence Establishment revealed the presence of mustard gas breakdown products in samples from two of the craters and sarin breakdown products in samples from two further craters.[6]

The ongoing conflict in Iraq has presented major challenges for any investigation of the health of populations away from major conurbations and presents continuing difficulties for investigators. The use of chemical weapons against the Kurdish population in 1988 created enormous fear and resulted in the migration of millions of people to safe havens in neighbouring countries. Amongst those fleeing were many of those injured by chemical weapons which meant that they went untreated for a time, but also that they were away from any medical clinic which might retain their clinical history. Given the known clinical effects of exposure to chemical weapons[4,] we were aware that there was a population of children in Kurdistan who had been exposed to chemical weapons, but for whom there was no published record of exposure, nor any follow-up to determine whether there were any longer-term health problems. Cognisant of the difficulties of both finding affected individuals in a country with an ongoing military conflict and of establishing exposure to chemical weapons many years after exposure, we nevertheless considered it important to investigate possible longer term health effects.

Our aim was to establish whether children were affected more, or less adversely than adults by exposure to chemical weapons. Our report here documents how we used a questionnaire approach and interviews with either affected individuals, or their carers at the time, to establish exposure to chemical weapons, together with

medical examinations to establish current health status. As a result our report is the first published scientific assessment of the effect of chemical weapons on the health of a Kurdish population who were children at the time of their exposure. The children were aged 10 or under at the time of exposure to chemical weapons and we document both the acute symptoms experienced by the children when they were exposed as well as long-term health effects which many still suffer from.

Methods

Study Design

This retrospective case-cohort epidemiological study focuses on the current health status of individuals who were 10 years of age or younger when exposed to CWs in 1987-1988. All those in that age group, who were present in the following towns and villages in Northern Iraq: Halabja, Gop-Tappa, Sewseenan, Dookan, Jaafaran, Sheikh Wassan, Mala-Jaffakan in Mergapan, and the Baddenan Region (Figure 1 and Table 1), at the time of the attack were invited to participate in the study. The regional Kurdish authorities and others have documented these locations as affected by CWs.[1, 2, 3, 6] Participation in the study was voluntary. The study was approved by the North Birmingham Research Ethical Committee.

Sample Population

At each town or village included in the study, lists of previous and current residents were obtained from the local municipalities. The team then approached all the residents who lived in these towns/villages during the attacks of CWs, and who had been present and were 10 years old or younger on the day of the attacks. These individuals were given information about the proposed study and leaflets were provided explaining the study in detail. A few days later, individuals were approached a second time for consent in participating in the study and informed written consent obtained from those who agreed to take part. The study team conducted the interviews and clinical examinations either in the homes of the participants, or in the local health centres as preferred by the participants themselves.

The Baddenan region lies close to the Turkish and Iranian borders. Due to the remoteness of this region, travelling to these villages was hazardous. It was necessary therefore for a group of officials from the Environmental Health Office to escort the team. In addition, local administrative health authorities facilitated our efforts by providing security and increasing awareness of our study among the local population.

Inclusion and Exclusion Criteria

All individuals who were 10 years of age or younger when exposed to CWs in 1987-1988 in the above listed towns were invited for participation in the study. Participants who were current or previous smokers, had a history of occupational dust exposure, or suffered from systemic illnesses affecting the target organs prior to the exposure, were excluded from the study. Smokers were defined as smoking more than 1 cigarette or pipe daily for at least one year and ex-smokers were defined as having smoked previously and quit for at least one

year. Occupational dust exposure was defined as any job related to toxic fume inhalation, mineral or industrial dust exposures.[7]

Data Collection

The study team consisted of a toxicologist from the UK, a consultant Paediatrician from the UK, three local paediatricians and one nurse. Data collection and clinical examinations began in August 2002 and ended in December 2010. Information on the incidence and local prevalence of certain conditions, such as asthma, became available to the team in December 2014. 18 patient forms sent to Tehran for postage to the UK were lost in transit, and these patients were excluded from the study. To collect the data, a member of the team (JT) made repeated trips to Iraq for 2-3 weeks at a time to lead the data collection team.

Questionnaires

A questionnaire designed to collect information about exposure to CWs and their effects was used by the study team.[8] This was based on a version from 1996 used to investigate allegations of the use of CWs by Serbian forces on Bosnian soldiers escaping Srebrenica.[9] A section of the questionnaire invited interviewees to describe events in their own words. The aim was to piece together a complete chronology of events. More direct questioning subsequently took place to elicit the interviewee's state of health. A carer's account was recorded in cases where the patient was too young to remember events at the time of exposure.

Clinical Interview and Examinations

One clinician from the study team conducted medical examinations whilst another recorded the clinical history to ensure the independence of the information. Part of the patient questionnaire was designed to collate information on clusters of clinical signs patients had experienced shortly after and within a few weeks of exposure to CWs. Previous studies suggested that both sulphur mustard and nerve agents had been used and questions were framed to identify the effects of these agents on target organs including the respiratory tract, eyes, skin, nervous and neuromuscular systems.[10,11] Other possible systemic effects - including those on the gastrointestinal tract and the immune system - were also assessed and included in the history and/or the clinical examination.[12,13] Interviews recorded the presence or absence of acute clinical signs following the exposure. These signs are listed in Table2. The presence of major congenital malformations in the offspring of those previously exposed to CWs were recorded.[14]

Chronic Illness Identification

Chronic disease identified as part of the study included respiratory illnesses (asthma, chronic obstructive pulmonary disease, and bronchiectasis), visual damage (corneal scarring and damage) and any neurological or dermatological conditions.

Asthma was defined as a clinical syndrome characterised by increased responsiveness of the tracheo-bronchial tree to a variety of stimuli. The clinical signs include an episodic cough, wheezing and dyspnoea.[15] The clinical

diagnosis of asthma was supplemented by the measurement of the peak expiratory flow rate (PEFR) carried out three times on each patient with the highest recording taken. A response to the bronchodilators with a minimal 15-20% improvement in the PEFR was regarded as a positive response favouring a diagnosis of asthma.[16]

Chronic bronchitis was defined as a condition of chronic or recurrent excess mucus secretion into the bronchial tree accompanied by chronic cough, occurring on most days for at least 3 months of the year for at least two consecutive years.[17] Bronchiectasis was defined as an irreversible, abnormal dilatation of sub-segmental airways. High-resolution computerised tomography, normally used to evaluate bronchiectasis was not available at the time of the study. Hence the team depended on the chest radiograph signs of bronchiectasis, reported as increased abnormal Broncho-vascular markings with focal areas of oligaemia and ring shadows representing dilated bronchi .[17, 18].

The severity of any neurological disorders was assessed by using a modified description based on the system used by Davies et al. The participants were considered as normal when there were no neurological abnormalities, or were described according to the presence of an abnormal gait, ataxia, muscular waste, or paresis/paralysis causing incapacitation .[19]

The unexposed group

This group included volunteers who were living in the Kurdistan region of Iraq. They were of the same ethnicity, lived in the villages/towns/cities of the same region, and had similar standards of living. Some of the participants may have been exposed to conventional weapons, but they denied any exposure to CWs or their presence at any time in the areas which were exposed to CWs. Once again, participants in this group who were current or previous smokers, or had a history of occupational dust exposure, were excluded from the study. The unexposed group had a full clinical examination and answered the same questionnaire as the exposed group. These subjects came from the following locations: Kirkuk, Sulaymania, Say Saddiq, Chamchamal and Sarchinar. These cities and towns had never been attacked by CWs (see map).

Statistical Analysis

Statistical analysis was carried out using SPSS 20. Student's t-test was used for analysis of continuous data and Pearson's Chi-squared test were used for analysis of categorical data as appropriate. Two-tailed p values less than 0.05 were deemed as statistically significant.

Results

Patient Numbers and Demographics

A total of 349 individuals who were 10 years or younger at the time of exposure to the CWs were identified. Five individuals were excluded from the study. Two individuals refused to participate, including one from Halabja and one from Sewseenan. One further case from Gop Tappa became uncontactable. One case was a smoker and

thus excluded. This left a total of 344 patients studied in the exposed group. The total number of participants in the unexposed group was 517.

Of the 344 participants in the exposed group, 126 (37%) were from Halabja, 79 (23%) were from Gop Tappa, 51 (15%) were from Sewseenan/Jaafaran, 47 (14%) were from Sheikh Wassan, 20 (6%) were from the Baddenan region and 21 (6%) were from Mala Jaffakan in Mergapan. In the unexposed group, 418 (81%) participants were from the Sulaymania region (72 km north of Halabja), 94 (18%) were from Kirkuk (181 km south of Halabja) and 5 (1%) were from other areas. Figure 1 shows the locations of the groups examined.

The mean age of the exposed group at the time of the study was 20.0 years (SD = 3.4) and the mean age of the group at the time of exposure was 4.9 years (SD = 3.4). In comparison, the mean age of the unexposed group at the time of the study was 20.89 years (SD = 3.3) ($p = 0.11$ Student's t-test). In the exposed group, at the time of exposure there were 4 babies below 1 month of age (1%), 41 children between 1-12 months (13%), and 115 children between 1-5 years (35%). The remaining 166 were between 5-10 years (50%). There were 171 males (33%) and 346 females (67%) in the unexposed group, and 142 males (41%) and 202 females (59%) in the exposed group, ($p=0.01$, Pearson Chi Squared test).

Immediately after exposure to CWs, 10 children (3%) took refuge in the local mountainous area until the following day. 334 individuals (97%) took refuge in the mountains of a different area within Iraq's northern Kurdistan region. 289 (83%) subsequently escaped to a neighbouring country, with the majority becoming refugees in Iran.

Following the CWs attack, 4 cases (0.9%) received immediate medical treatment. These four were children from Sewseenan. They lived at the edge of their village and were able to escape into nearby mountains where they received treatment from doctors with the Kurdish resistance fighters (Peshmerga) within a few hours of the attack. 200 subjects (62.5%) received medical help when they arrived at refugee camps a week following exposure.

In the unexposed group, 454 individuals (88%) were exposed to conventional weapons but not to CWs. During the conflict, 10 (3%) remained in the same city, 114 (22%) became internally displaced, taking refuge in the mountains, and 393 (76%) fled to a neighbouring country, with the majority becoming refugees in Iran. Table 1 describes the demography, educational level and type of exposure in the two groups.

Description of Acute Illness Reported Following CWs Exposure

A summary of specific acute symptoms reported by individuals or their carers relating to various organ symptoms is shown in Table2. Over 90% of individuals reported acute visual involvement, nearly 60 % reported dermatological involvement, over 80% reported respiratory difficulties and over 70% reported acute neurological symptoms. Some 316 exposed subjects (94%) reported general clinical symptoms which included

the following breakdown: nausea (54%), retching (68%), vomiting (79%), epigastric pain (41%), diarrhoea (39%), tenesmus (11%) and involuntary defecation (23%).

Chronic Diseases Encountered

241 individuals (72%) in the exposed group suffered from chronic health problems at the time of the study. In comparison, in the unexposed control group 17 individuals (3.3%) were identified as having chronic conditions ($p<0.0001$, Pearson's Chi Squared Test). The various conditions identified at the time of the study are shown in Table 3, categorised according to chronic visual involvement, neurological, dermatological and respiratory problems. It is worth noting that some patients had more than one chronic condition.

Over half of the exposed group were left with long-term visual problems. The majority of these consisted of a feeling of irritation, grittiness, congestion and lacrimation in the eyes with repeated conjunctivitis. Approximately a third of patients exposed to CWs had chronic dermatological conditions. About one third of the exposed group were also left with long-term neurological sequalae, with 8 patients (2%) suffering from conditions affecting their mobility, such as paresis, paralysis and muscular wasting. These 8 patients also suffered from epilepsy, ataxias with muscular cramps and had a history of prolonged convulsions during their acute illnesses. Inability to concentrate, memory problems, sleep disturbances, anxiety, irritability, depression, and problems with information processing and psychomotor tasks were found in 23% of the cases. Respiratory complaints were common, with a large proportion of patients (51%) suffering from asthma, chronic bronchitis and/or bronchiectasis. There were two cases of cancer in the exposed group, with one patient diagnosed with squamous cell carcinoma of the skin, and the other with a bronchogenic adenocarcinoma.

Discussion

Most of the literature on the health effects of exposure to CWs describes the impact on adults, most of whom were soldiers when exposed. There is also a substantial literature on the acute effects of exposure to chemical weapons in World War 1;volunteer soldier exposure in World War 2; effects on Iranian forces as well as effects of civilian exposure to sarin in Japan in 1995.[10,11,20-23] The literature on the chronic health effects caused by CWs is increasing as clinicians document ocular, respiratory, dermatological and other effects on cohorts of victims.[20-23] However, the literature on the acute and chronic effects of CWs on children is sparse.[11]

Age is a major factor affecting an individual's response to toxins and environmental factors. Toxico-dynamic responses to chemicals as well as metrics of exposure, absorption, metabolism, distribution and target organ-susceptibility are age related.[24] One previous study has shown differences in acute clinical signs between children and adults exposed to mustard gas. It reports a more rapid onset of symptoms among children, with facial involvement being the dominant area affected and an increased severity of ophthalmic manifestations.[11] Children also presented with more frequent pulmonary and gastrointestinal symptoms compared with adults.[11] Our study focuses on acute and chronic effects of exposure to CWs on children who were 10 years of age or younger at the time of their exposure and fills in much needed knowledge about long-term effects.

Following exposure, the majority of survivors became refugees. Many internal refugees were fearful of seeking medical attention at hospitals and external refugees did not receive any medical care until their arrival in neighbouring countries. A quarter of exposed participants also fled to the mountainous regions and received only limited first aid. None of the participants in the exposed group were able to make any medical notes available to the team. Consequently, our study has relied on participants' (or carers') self-reporting of the presence of clinical signs and symptoms at the time of exposure.

The severity of chronic medical problems appears to be correlated with the severity of acute signs and symptoms at the time of exposure to chemical weapons[25].Given the complexities in conducting the study, the absence of participants' medical records from the time they were exposed, and the interval between exposure and the date of the study, it was difficult for the study team to assess the relationship between the severity of acute effects and subsequent chronic health problems with an accuracy comparable to other studies[25,26] . However, the presence of severe chronic signs in exposed participants indicates the likelihood that many were acutely ill and sustained heavy exposure to CWs.

The team studied the cases of 344 of individuals who were 10 years of age or younger when exposed to CWs. This is by no means the total number of children exposed to CWs in the Kurdistan region in the 1980s. There are no figures of the exact number of those affected, and there are no exact statistics on the total number of children in that age group who lived in the exposed areas prior to CW exposure. There are also no statistics on the number of children who died as a result of CW exposure among this age group. However, it is estimated that a significant proportion of the estimated 5,000-8,000 deaths following the CW attack were of children, as indicated by photographic evidence[1,2].

The spectrum of acute clinical signs in our population following CW exposure is highly suggestive of effects on target organs, including the skin, eyes and respiratory tract, and match what has been described in other studies on adults.[10, 11] The absence of any other obvious identifiable factors for the symptoms experienced, suggest that CW exposure was responsible for our participants' acute clinical conditions at the time of exposure. Given the retrospective nature of this study, data on contact with any infectious pathogen at the time they were exposed to chemical weapons was not available. However, the exposed group's clinical histories did not suggest any infections prior to their exposure to CWs.

Investigations of Iraqi munitions by the UN Special Commission confirmed that Iraq had stockpiles of mustard gas and a range of other CWs including sarin, tabun and VX.[5] The eyes, skin and respiratory tract are well-documented targets for sulphur mustard (SM).[4],[10,11] Nerve agents (NAs), as their name implies, affect the

nervous and neuromuscular systems.[10] SM , sarin and their breakdown products have been detected in soil samples collected in Kurdish areas of northern Iraq.[1,2,6] Both SM and NAs are known to have been held by Iraqi forces.[1,2,5,6] Nausea, retching and vomiting were reported to have occurred in the acute phase in the majority of the cases we examined – a finding consistent with exposure to either/both SM or NAs.[10, 11] Involuntary defecation is a symptom of nerve agent exposure.[10] Most of the acute visual problems documented were seen in those exposed to SM, although eye pain when focussing also occurs after nerve agent exposure.

The skin signs and symptoms reported by the exposed participants are a common finding following mustard gas exposure.[10,11] Itching, rashes, dusky erythema and blistering have been noted to occur within 24 hours of exposure to SM, whereas black pigmentation and desquamation are later signs.[10,11] Rhinorrhoea, sore throat, coughing and wheezing, which occurred in a high proportion of the exposed group, are a common finding after mustard gas exposure. Aside from a sore throat, all other signs are also found in individuals exposed to nerve gas.[10] Dyspnoea, a symptom of nerve gas inhalation, can also occur after SM exposure and was reported in 73% of our exposed participants. The information we gathered together with the clinical data collected in this study suggest that it is more probable than not that the children were exposed to both SM and organophosphate nerve agent(s).

Chronic health problems were observed in 72% of the exposed group compared with only 3% of the unexposed group. In our exposed cohort 55.5% had chronic ocular problems, 36% had chronic dermatological conditions and 31% had a neurological complaint; these figures are all higher than comparable prevalence reported in adult populations exposed to CWs.[20-23] A possible explanation for this is that children are more severely affected when exposed to CWs and are therefore more likely to end up with chronic illnesses.

Since the inhalation of vapour or aerosol is a significant route of exposure to CWs, the respiratory tract is likely to be injured upon exposure, with the laryngeal and tracheo-bronchial mucosa primarily affected.[20-23] In the exposed group, 51% of subjects had chronic respiratory problems, with 43% suffering from asthma, 14% from chronic bronchitis and 14% from bronchiectasis. Another respiratory complication noted in other studies of victims of mustard gas exposure was the Bronchiolitis Obliterans Syndrome (BOS)[23]. However, whilst some of the cases we viewed with respiratory conditions had similar clinical signs and symptoms to BOS we were unable to make a confirmatory diagnosis as there were no facilities for either pulmonary function tests, nor facilities for CT scan imaging in the area when we conducted our study. Chronic dermatological conditions in our series included; repeated painful erythematous papular rashes, with some cases progressing to ulceration, scarring, hypo or hyperpigmentation, alopecia and nodules. The lesions were largely found on the extremities, trunk and head and neck, and were consistent with previous reports of the effect of SM in adults[20].

Long-term ocular manifestations in the exposed group are consistent with what is reported in other cohorts exposed to mustard gas.[20] The literature suggests that severe acute ocular signs are usually associated with long-term chronic problems and as the severity of exposure increases, so too does the likelihood of long-term

injury.[26]The prevalence of chronic neurological complications in our cohort were similar to the chronic signs reported previously in animals exposed to either mustard gas or a nerve agent.[27] It is also interesting to note that 14% of exposed participants were suffering from repeated infections, eruptions of herpes zoster and mouth ulcers, as previous reports indicate that immuno-suppression and altered host-defence responses with depression of cell-mediated immunity have been reported in both animal and human studies following exposure to CWs.[13,28] There is no previous clear evidence linking CWs to teratogenic effects.[12] However, our study demonstrated significant major congenital malformations in the offspring of 14 women (4%) in the exposed group. In the unexposed group, no cases of major congenital malformations were reported. However, as the individuals studied at the time of the study were in their early 20s, the majority of participants in both exposed and unexposed groups had not yet started a family. Given that our cohort was exposed in childhood it will be important to reassess them at a later stage, to assess whether exposure to CWs will influence the incidence of congenital malformations in their offspring.

One limitation of this study is that the team were only able to identify a similarly aged unexposed control population through children attending primary and secondary school education. Entry to education was voluntary and all unexposed participants tended to be healthy. There were no local statistics available to determine the prevalence of chronic health conditions in this age group. Hence the prevalence of conditions we report in our unexposed group is unlikely to reflect the prevalence of these conditions in the population generally and is likely to be an underestimate. Another limitation of this study was selection bias. Following CW exposure, 76% became refugees in neighbouring countries which meant that they generally had no medical care until their arrival at their sanctuary. Some lived in refugee camps near borders with neighbouring countries, and received medical care at the camps. 24% were displaced internally, and fled to the mountains to hide from the Iraqi authorities. Overall only a few had medical treatment at hospitals in the countries where they became refugees, and this prevented us confirming CW exposure for the vast majority through medical records. Methodologies for retrospective detection of exposure to CWs are available[29]. However, these advanced techniques were not available to the team to use for verification. Hence the only means of identifying appropriate patients were as we describe, and this makes it difficult to overcome any self-reporting bias.

Collecting the data for this study was difficult and took several years. It was difficult to ensure the safety and security of the team in some of the remote locations. A number of the towns and villages studied were in remote mountainous areas with primitive road access. Some were still also at risk of attacks from artillery, land mines and fighter planes. Travel to and from Kurdistan from Europe took an average of 4 to 5 days at the time during the study period. The journey involved flying to one of Iraq's neighbouring countries and then crossing the Iraqi border by car or boat. On a few occasions, CDs, patient forms and cameras were confiscated by border officials, meaning that important data either had to be recollected or was permanently lost and had to be excluded from the study.

In summary, this is the only available study to date looking at the acute and chronic effects of CWs exposure in the northern Kurdish region of Iraq. Furthermore, it is the only study looking at long-term effects of CWs exposure in children in the northern Kurdish region of Iraq and one of the few studies looking into the chronic effects of CWs on children. The study suggests that the CW agents used in Northern Iraq were likely to be a combination of SM and the NAs. It demonstrates that a large proportion of children who survive CW exposure are left with chronic disease of the ocular, respiratory, nervous and dermatological systems. As well as illustrating the profound effects of CWs exposure on children aged ten and below, this study also suggests that prevalence of acute and chronic health problems following exposure to chemical weapons appears to be higher in children compared with that previously reported in adults.

Conflicts of interest

Alastair Hay has conducted numerous investigations of alleged chemical weapons use and is currently Chair of the UK Chemical Weapons Convention Advisory Committee.

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Table 2: Summary of Acute Illness Experienced in Study Group following Exposure to CWs.

System	Symptoms	No. Participants (%)	System	Symptoms	No. Participants (%)
Ocular		**312 (94)**	**Respiratory**		**288 (85)**
	Grittiness	200 (5)		Rhinorrhoea	230 (68)
	Eye ball pain	222 (65)		Sore throat	155 (46)
	Congestion	292 (85)		Coughing/sneezing	155 (46)
	Oedema	258 (75)		Wheezing	217 (64)
	Conjunctivitis	259 (76)		Bronchopneumonia	250 (73)
	Lacrimation	288 (85)		Dyspnoea	250 (73)
	Photophobia	269 (80)		Tachypnoea	229 (67)
	Blepharospasm	160 (47)		Expectoration	169 (50)
				Cyanosis	135 (40)
				Hoarse Voice	159 (46)
Dermatological		**198 (59)**	**Neurological**		**249 (74)**
	Erythema	150 (45)		Convulsions	69 (20)
	Rash	127 (38)		Headaches	146 (43)
	Itching	110 (33)		Ataxia/difficulty in walking	103 (31)
	Blisters	173 (50)		Paralysis	15 (4)
	hyper pigmentation	194 (58)		Fasciculation	24 (7)
	Desquamation	134 (40)		Confusion/drowsiness	129 (38)
	Ulcerations	269 (80)		Nightmares/insomnia/disorientation	79 (23)
	Hypersensitivity	72 (21)		Restlessness/anxiety/muscular cramps	311 (92)
				Tremor/jitteriness	76 (23)
				Slurred speech	74 (22)
				Coma	129 (38)

Percentages are shown in brackets.

Table1: Demographic differences between exposed and control groups.

	Exposed Group: No. Participants (%)		**Unexposed Group: No. Participants (%)**
Age at exposure to CWs			
0-1 Month	4 (1%)		
1-12 Months	41 (13%)		
1-5 yrs.	115 (35%)		
>5 yrs.	166 (51%)		
Gender			
Male	142 (44.38%)		171 (33%)
Female			
Education			
Primary	282 (88.1%)		517 (100%)
High School	172 (53.7%)		502 (97.1%)
University	42 (13. 3%)		318 (61.5%)
Place of exposure			
Halabja	124(38.13%)		
Gop Tappa	78(23.75%)		
Sheikh Wassan	46(14%)		
Sewseenan/Jaafaran	48(14%)		
Baddenan	20(3.75%)		
Mala Jaffakan	21(6%)		
Control group place of living:			
Sulaymania			418(80.85%)
Kirkuk			94 (18.18%)
Others			5(0.97%)
Combat experience before CW attack			
CWs	0		0
Conventional weapons	316(98.7%)		454 (87.98%)
Emergency treatment after exposure	200 (62.5%)		35 (6.77%)
<24 H	4 (1.25%)		2 (0.39%)
24-72 H	28		
3-7 days	99		
> 1 week	73		
Hospital admissions following attack			
< 1 week	22		
1 - 4 week	59		
> 4 weeks	35		
Family members lost			
Parents	105		
Siblings	89		
> 4	15		
Smell of CWs reported as like			
Garlic	114 (35.63%)		
Fresh apple	240 (75%)		
Rotten egg	47 (14. 7%)		
Others	134 (41.88%)		
Medical help received in Iran	124		
Treated by doctors with Peshmerga	41		
Treated secretly in Iraq	81		

Table 3: Chronic Conditions Identified in Exposed Group *versus* Unexposed Group

System	Condition	Exposed Group (n=344)	Unexposed Group (n=517)	p value
Visual No (%)		**191 (55.5)**	**0 (0)**	
	Visual Field Defects	25 (7)		
	Repeated Conjunctivitis	144 (42)		
	Blepharospasm	28 (8)		
	Congestion/ grittiness/lacrimation	164 (48)		
	Eyeball Pain	69 (20)		
	Photophobia/Poor Pupillary Response	24 (7)		
	Keratitis/Corneal Scarring	14 (4)		
Dermatological No (%)		**124 (36)**		
	Repeated painful papular rash & Ulceration	19 (5.5)		
	Scarring	14 (4)		
	Hyperpigmentation	75 (22)		
	Repeated Rash	79 (23)	4 (0.8)	<0.0001
	Alopecia/Nodules/Papules	26 (8)		
	Skin Cancer	1 (0.3)		
Respiratory No (%)		**172 (51)**	**8 (1.5)**	<0.0001
	Asthma	144 (43)	8 (1.5)	
	Chronic Bronchitis	48 (14)	0 (0)	
	Bronchiectasis	46 (14)	0 (0)	
	>4 Chest infections per year	140 (41)	0 (0)	
	Bronchogenic cancer	1 (0.3)	0 (0)	
Neurological No (%)		**106 (31)**	**2 (0.4)**	<0.0001
	Neuropathic pain/Paraesthesia/Numbness	**53 (16)**	**0 (0)**	
	Confusion & Agitation	80 (23)	0 (0)	
	paresis/muscle wasting	34 (10)	1 (0.2)	<0.0001
	Fasciculation/tremor	28 (8)	0 (0)	
	Epilepsy/Fits	14 (4)	1 (0.2)	<0.0001
Other No (%)		**103 (29.9)**	**3 (0.6)**	<0.0001
	Congenital Malformations in Offspring	14 (4)		
	Premature/Small for gestational age Offspring	7 (2)		
	Repeated Herpes Zoster/Mouth Ulceration	47 (14)	3 (0.6)	<0.001
	Chronic abdominal pain/bowel symptoms	42 (12)		

This table demonstrates the percentages of patients in the exposed and unexposed groups suffering from the outlined Dermatological, Respiratory, Neurological and Ocular chronic conditions at the time the study was conducted. The percentages are shown in brackets. P values less than 0.05 were deemed as statistically significant.

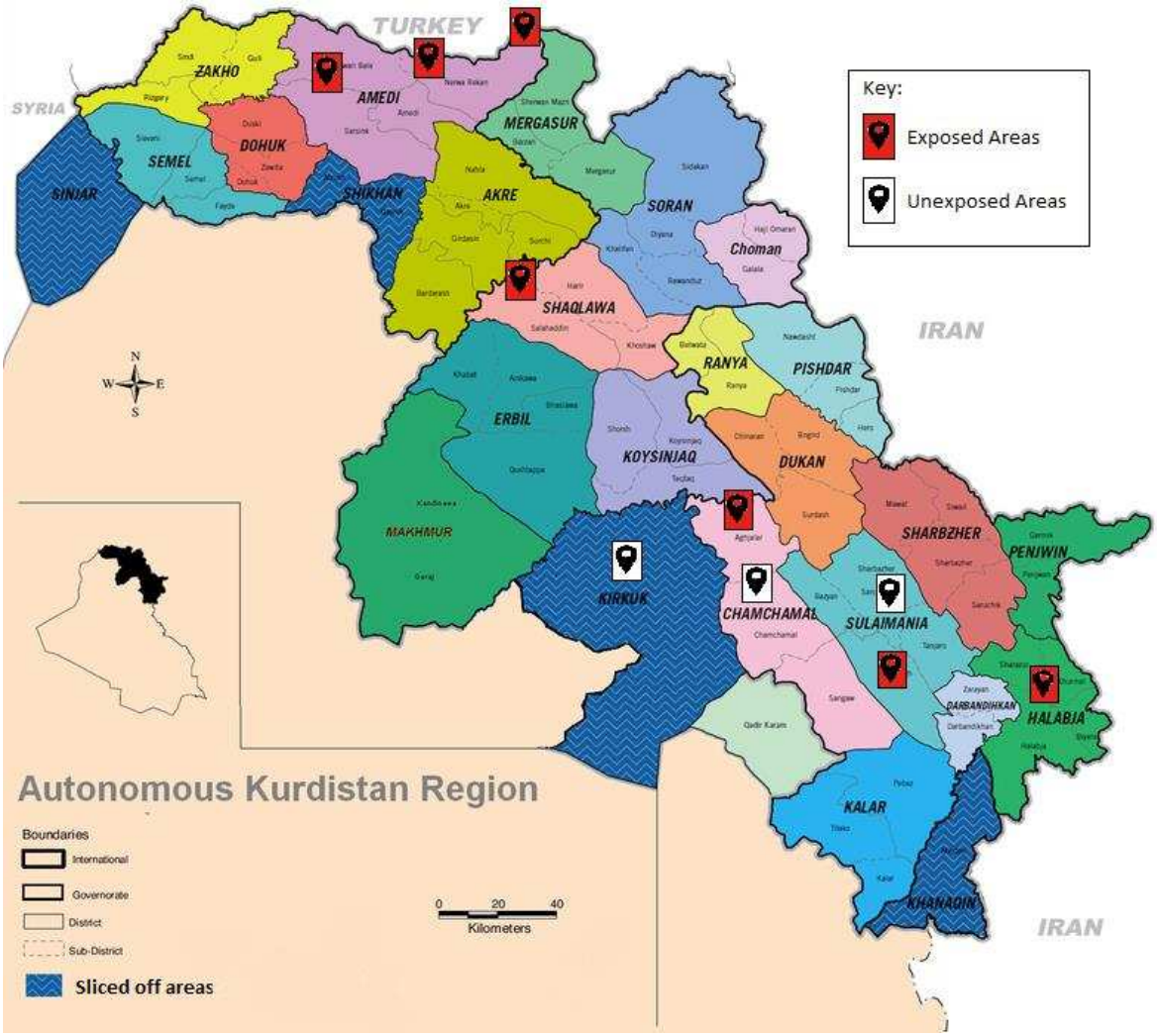

Figure 1: Map of the autonomous region of Kurdistan in Northern Iraq. White arrows indicate areas exposed to CWs in the 1988 attacks. Areas denoted with red arrows indicate regions with no CW exposure from which the control participants were sampled.