

Post-war environmental pollution as a risk factor of congenital disorders in Iraq: A study review

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ABSTRACT

Background: Several years of war with the recent terrorist conflicts have cumulatively affected Iraq's land, air, water, and health infrastructure, and a substantial rise in the incidence of congenital defects has been reported in the period following the Gulf War in 1991, which was principally accredited to the environmental contamination by depleted uranium.

Aim: The aim is to review some published works of literature that are specifically concerned with environmental pollution after the war in Iraq as a possible risk factor for developmental disorders.

Patients and Methods: In addition to the published articles, this review includes a direct descriptive data of congenital anomalies, which was obtained from Al-Khansaa, Al-Salaam, Al-Batool Teaching Hospitals of Obstetrics and Gynecology, and General Mosul Hospital in Mosul city over a period of 12 months, starting from October 2017 to October 2018.

Results: All of the research related to this topic were discussed, and most of them revealed that a higher incidence of congenital disorders was detected among people exposed directly or indirectly to post-war environmental pollution by depleted uranium (DU) and other chemical constituents. From the analysis of the scientific publications, we observed that Basrah, Baghdad, Falluja, Mosul and Al-Anbar are predominantly affected by war contamination. The study revealed that there were 317 cases of birth defects out of the 44,372 newborns delivered over a period of one year after war in Mosul; thus, the overall percentage of congenital disorders was 0.71%, and defects of the nervous system were the most prominent, among which anencephaly was the predominant condition. The highest percentage of anomalies was detected in the maternal age of 21–26 and more in female newborns.

Conclusion: We must decrease parental exposure to the possible teratogens through prenatal counseling and public education about the penalties of environmental pollution in order to arrange practical guidelines for public health and to alleviate the outcome of pregnancy.

Keywords: pollution, congenital, post-war, environmental, review

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INTRODUCTION

Several years of war and recent conflicts in Iraq have killed and wounded thousands of people and damaged industrial areas and agricultural lands by producing hotspots of environmental pollution, which subsequently crippled the health infrastructure. ⁽¹⁾ A new conception about the influences of exposure to environmental pollutants, particularly during early pregnancy, on the embryological development is well established. ⁽²⁾ Congenital defects are structural, functional or metabolic disorders present at birth. ⁽³⁾ In developed countries, congenital defects are the main cause of perinatal morbidity and mortality. ⁽⁴⁾ Many surveys have reported that 303,000 newborns worldwide die within 4 weeks of birth every year due to various types of birth defects; alternatively, these anomalies cause significant disabilities that may impact the individual, health-care systems, and societies. ⁽⁵⁾

Although the exact underlying etiology of birth defects are still unknown, gene defects or chromosomal disorders account for 20%, while up to 80% are due to the impact of environmental teratogens during gestation. ⁽⁶⁾ Many published works of literature revealed that environmental pollutants may produce genetic mutations predisposing birth defects; thus, a combination of environmental and genetic factors has been suggested as the cause. ⁽⁷⁾ A multifactorial etiology of birth defects has been considered since the recognition of thalidomide as a potent human teratogen about fifty years ago. ⁽⁸⁾

Recently, an unexplained rise in the percentage of congenital defects in numerous bombed Iraqi cities was reported, and valid studies have been issued. ⁽⁹⁾ Iraq suffered from environmental pollution by depleted uranium (DU), which is harming public health through the raised

incidence of cancers and birth defects. ⁽¹⁰⁾ In the period following the 1991 Gulf War, a high prevalence of congenital defects in Basrah—a result of intense fighting in 2003—had been reported in Al Basrah Maternity Hospital. ⁽¹¹⁾ Furthermore, other cities in Iraq were exposed to intermittent bombing, the most prominent of which was Fallujah city in 2004. ⁽¹²⁾ Subsequently, increasing reports of congenital anomalies have been made, and many workers have suggested that the pollution produced by bombing has played a significant role in the congenital defect catastrophe in Iraq. ⁽¹³⁾ After the war, severe contamination was caused by the toxic substances released by military actions that turned the desert sands into light dust, which reached the Iraqi towns as dust storms following bombardment. ⁽¹⁴⁾ Damage to oil infrastructure has created hotspots of pollution; thus, Iraqi people are likely to be exposed to heavy metals, toxic compounds, and particulate matter, which may seriously affect their health. ⁽¹⁵⁾ The sources of drinking and agricultural water have been contaminated with oil products from oil spills, which has had serious consequences on agriculture and livings. ⁽¹⁶⁾ The destruction of Al-twaitha nuclear research site in the 1991 Gulf War resulted in extensive radioactive pollution at the site and in its adjacent areas. ⁽¹⁷⁾ However, the precise adverse effects of the pollutants on reproductive outcomes and their impact mechanisms are still unknown; however, some specific pollutants of higher risk and period of exposure might be considered.

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This paper reviews some published works of literature and explores direct descriptive data of congenital anomalies that were obtained from Al-Khansaa, Al-Salaam, Al-Batool Teaching Hospitals of Obstetrics and Gynecology, and

General Mosul Hospital in Mosul city over a period of 12 months, starting from January 2017 to January 2018. The aim was to investigate the possible association of post-war pollution in Iraq with the incidence of various congenital anomalies in order to generate hypotheses for future research, which should focus on the possible underlying mechanisms and to evaluate the role of antenatal screening, particularly for the high-risk population.

MATERIALS AND METHODS

In addition to the published articles, this review includes a cross-sectional biometric study that comprises the recorded cases of birth defects out of 44,372 newborns delivered in Mosul city over a period of 12 months, starting from October 2017 to October 2018, in the neonatal care unit of Al-Khansaa, Al Salaam, and Al Batool Teaching Hospitals of Obstetrics and Gynecology, and General Mosul Hospital. All the babies, including the stillborn, delivered with congenital defects during the period of study from all the hospitals were included, while abortion and minor anomalies were excluded. Data collection was performed by reviewing the labor ward records using a designed formula; each one was composed of two parts of information for each case. Neonatal characteristics include live or stillbirth, sex, weight and existence of other congenital anomalies. Maternal characteristics such as maternal age, parity, type of pregnancy (single or multiple), mode of delivery, history of parental consanguinity, drug consumption—such as antithyroid, cytotoxic, or any teratogenic drugs that might predispose congenital anomalies—exposure to prenatal X-ray radiation, chronic illness, and history of congenital malformations in other members of their family. The gross congenital defects were

categorized according to the system followed, including nervous, gastrointestinal, and skeletal genitourinary and congenital heart disease. Statistical analysis and interpretation of data were performed using simple descriptive statistics (T-test and the Chi-square tests).

RESULTS

The reviewed articles about the post-war patterns of congenital defects in Iraq revealed that the overall prevalence of congenital defects significantly varies among different governorates in Iraq according to geographical variation. In Basrah and Al-Anbar, the prevalence rate of congenital defects was 8.5 per 1000 births in 1998. ⁽¹⁹⁾ In 2007, the incidence of 13 per 1000 births was recorded in Baghdad. ⁽²⁰⁾ These rates are generally less than those recorded in Bahrain (18 per 1000 live births), United Arab Emirates (15 per 1000 live births in 1994) and Iran (17 per 1000 live births in 2004). ^(21,22) However, a record from the Erbil governorate publicized an unpredicted elevated rate of 23.9 per 1000 live births from 1990 to 1999; such a high incidence rate could be attributed to accurate reporting, as the study was conducted on the newborns in the intensive care unit. ⁽²³⁾ The cause of such regional differences may be attributed to environmental, ecological, and economic risk factors. ⁽²⁴⁾ A study from Al-Basrah for the period of 1999–2000 recorded a rate of 10 births with congenital defects per 1000 births, and 50% of the affected babies had defects in their nervous system; similar findings were detected in the Al-Anbar, Erbil, and Duhok governorates. ^(25,26) Whereas, in 2000, a higher percentage of neural tube defects (NTDs) was recognized in Al-Diwaniyah. ⁽²⁷⁾ Musculoskeletal malformations constituted 1.4 per 1000 births in 1999 in Al-Basrah and 1.36 per 1000 births in 2000 in

Baghdad; gastrointestinal and genitourinary defects accounted for 11.9% with a rate of 1 per 1000 live births in Al-Anbar. (28) Such a variance in the incidence of congenital disorders involving predominantly different bodily systems among different regions in Iraq is attributed to the impact of various

rates of neural tube defects in various areas. (30) Furthermore, accurate methods of recording, collection of data, and type of declaration of fetal deaths may contribute to such variations in the prevalence of congenital defects. (31)

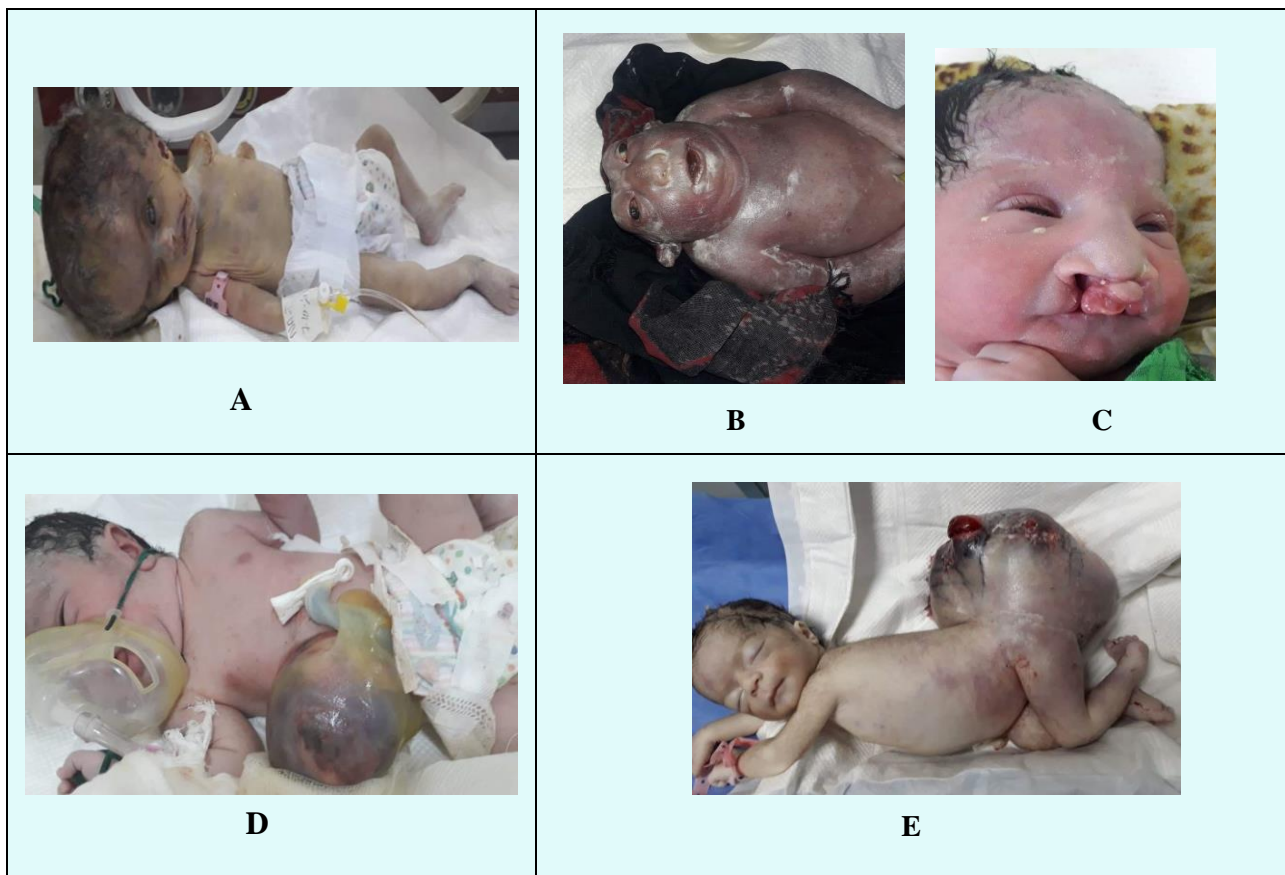


Figure 1: Some types of congenital anomalies in newborn. (A) Hydrocephalus, (B) Anencephaly, (C) Cleft lip and palate, (D) Omphalocele , (E) Sacrococcygeal teratoma

socioeconomic and nutritional statuses and adequate antenatal care in addition to other factors, including pollution and chemical agents. (29) Registries of congenital defects reported wide differences in the prevalence according to geographical areas in Iraq, which may provide evidence of etiological factors such as variations in the detected incidence

Our study in Mosul city revealed 317 cases of birth defects out of 44,372 newborns delivered over a period of one year after the war in Mosul; thus, the overall percentage of congenital disorders was 0.71%; the defects of the nervous system were the most prominent, among which anencephaly was the predominant condition (Fig.1,Table 1). The highest percentage of anomalies was detected in the primigravida with the maternal age being 21–26 (Fig. 2, Table 2, 3). A recent study—carried out by Devi et al. in 2018 (32) revealed nearly similar result

that could be explained by the convention of early marriage in our society. Other studies explained a higher risk for older mothers, which can be due to irregular recombination process of genetic material leading to abnormal chromosome disorders such as Down Syndrome. (33)

The number and percentage of females born with congenital anomalies is higher than male, and a majority of the 317 newborns with congenital anomalies were live births at full term (Table 2).

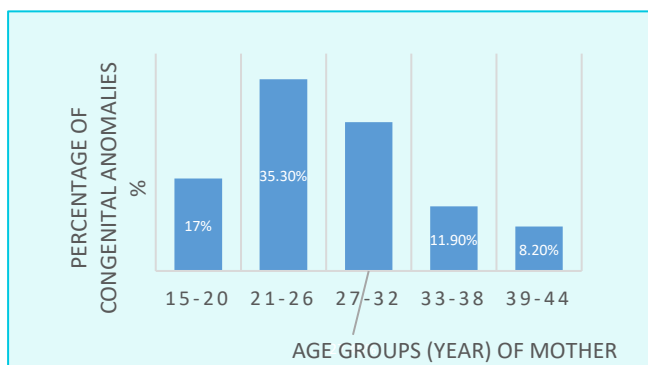


Figure 2: Percentage of congenital anomalies according to the maternal age

Table 1: Distribution of congenital anomalies according to the system involvement

	No. of patients (n = 317)	Total No. of patients out of 317
Multiple congenital abnormalities	82 (25.38%)	82 (25.38%)
Central nervous system: Anencephaly Spina bifida Hydrocephalus Microcephaly Encephalocele	(11.04%)35 (7.88%)25 (6.3%)20 (4.73%)15 (1.57%)5	100 (31.54%)
Gastrointestinal tract: Omphalocele Imperforated anus Ectopia vesica Gastroschiasis	(3.15%)10 (8(2.52%) 7(2.20%) 5(1.57%)	(9.46%)30
Skeletal: Club foot Polydactaly Syndactaly Achondroplasia Osteogenesis imperfect Amelia	(3.15%)10 7(2.20%) 3(0.94%) 2(0.63%) 2(0.63%) 1(0.31%)	25 (7.88%)
Renal: Congenital hydronephrosis Congenital agenesis Congenital polycystic kidney	7(2.20%) 5(1.57%) 3(0.94%)	15(4.73%)
Face: Cleft lip: Cleft lip and palate	3(0.94%) 2(0.63%)	5 (1.57%)
Congenital heart disease	(3.15%)10	10(3.15%)
Hydrops fetalis	(3.15%)10	10(3.15%)
Down’s Syndrome	(2.52%)8	8 (2.52%)
Congenital diaphragmatic hernia	5 (1.57%)	(1.57%)5
Conjoined twin Craniopagus Thoracopagus	5 (1.57%)	(1.57%)5
Cystic hygroma	4(1.26%)	4(1.26%)
Sacroccygeal teratoma	3(0.94%)	3(0.94%)

Table 2: Distribution of congenital anomalies according to the characteristics

Variables	No. (n=317)	Percentage (%)
Sex:		
Female	162	51.1%
Male	155	48.8%
Birth status:		
Live birth	263	82.9%
Still birth	54	17.1%
Gestational age:		
Full term	120	37.9%
Preterm	197	62.1%
Type of deliveries:		
Single	314	99%
Multiple	3	1%
Mode of delivery:		
Normal vaginal delivery	237	74.7%
Cesarean section	80	25.3%
Weight of newborn(Kg):		
(2-2.9)	173	54.5%
(3-3.9)	125	39.4%
(4-4.9)	19	6.1%

DISCUSSION

The finding that the overall prevalence of congenital anomalies among newborns in Mosul city is 0.71% is nearly similar to the prevalence recorded by Taboo's 2012 study, which was also conducted in Mosul city. (34) The central nervous system is the most frequently affected biological system, followed by the digestive and musculoskeletal systems. These findings agree with that of Eke et al. (35) on the epidemiology of congenital anomalies in Nigeria. The highest prevalence of anomalies related to the musculoskeletal system relates to a study from Saudi Arabia, (36) and the genitourinary system finds agreement in a study conducted in Taiwan. (37) Furthermore, the dissimilarity in the conventions of consanguineous marriage among different populations, criteria of the study samples, and methods of diagnosis may explain the outcomes as well. (38)

Sources of post-war pollution in Iraq and their specific impact on birth defects

The Gulf War in 1991 was a preface to a new kind of environmental pollution, particularly the exposure to DU and other chemical agents. (39) The Iraqi population suffered from difficult economic conditions that might have exaggerated teratogenic effects such as poverty and malnutrition. (40)

Depleted Uranium

Recently, many researchers worldwide have focused on the role of DU in the environmental pollution. (41) Around 1959, the progress of DU weapons began in the United States, and in the United Kingdom, it happened in the beginning of the 1960s. (42) The American army began to use DU metal in dynamic energy due to its bill and accessibility. (43) DU weapons were used in the war in Bosnia in the 1999, the war in Kosovo, the attack of Afghanistan in 2002, and the invasion of Iraq in 2003. (44) However, during the Gulf War in 1991, more than 440,000 kg of DU was fired by the US and the UK armed forces. (45) The comprehensive mechanisms by which DU affects the metabolic functions of the human cells remain to be adequately explored, but many researchers have confidently suggested a cellular and molecular toxicity of DU. (46)

Ingestion of food or drinking water contaminated by DU or the inhalation of contaminated air and dust are the most critical pathways of exposure to environmental DU for the general public, whereas direct dermal contact is an insignificant pathway because DU cannot permeate the skin to enter the bloodstream; however, there is a possibility of entry via the exposed injuries. (47)

Table 3: Distribution of congenital anomalies according to the maternal characteristics

	No. (n = 317)	Percentage (%)
Parity:		
Primigravida	160	50.4%
Para 1-Para3	107	33.8%
More than Para 3	50	15.8%
Chronic diseases:		
Yes	60	19%
No	257	81.1%
Exposure to radiation:		
Yes	30	9%
No	287	91%
Drug intake:		
Yes	170	53.6%
No	147	46.4%
Consanguinity:		
Yes	162	51.1 %
No	155	48.9%
Family history:		
Yes	268	84.6%
No	49	15.4%
Residence:		
Urban	226	71.3%
Rural	91	28.7%

Although there is no considerable proof of hereditary defects resulting from the exposure of parents to DU, studies have indicated that exposure to DU causes a breakdown of DNA strands, which increases with the increasing

concentration of radioactive particles left by DU munitions. (48) Thiebault et al., in their 2007 study, suggested that uranium is genotoxic and induces apoptosis in the normal cells. (49) Examining the health status of populations from regions contaminated with DU revealed serious health problems, including breast cancer, lymphoma, leukemias, neurological disabilities, renal diseases, and perinatal deaths. (50) Other studies suggested that DU is cytotoxic, and it was extracted from the epithelium of the lung tissue of Gulf War veterans. (51)

Basrah was the most heavily exposed governorate to the assault with DU in Iraq throughout the Gulf War in 1991. (52) In 1990, the reported prevalence of birth defects was 3 per 1000 births, which increased to 7.8 in 1998, and then to 13.5 per 1000 births from 1999 to 2000; these comparative studies on the prevalence of birth defects in Basrah before and after the Gulf War indicated that DU apparently contributed to the raised incidence of birth defects. (53) Similarly, Diwaniyah was exposed to bombing with DU weapons during the Gulf War in 1991; a study from Diwaniyah revealed that the prevalence of neural tube defects (NTDs) was 8.4 per 1000 births in 2000 compared to 5.5 per 1000 births during 1998–1999; the workers did not ignore the DU, but they investigated other relevant possible causes of NTDs. (27) The lower frequency of congenital defects described in Basrah prior to the 1991 Gulf War does not essentially reflect a definite low incidence of birth defects in Iraq, since such findings can be attributed to inefficient statistics and the incomplete registration of congenital defects in Iraqi hospitals at the time. (54) Post war, elevated rates of NTDs in Iraq might be the result of accurate reporting of birth defects and increased awareness about the

dangerous health problems resulting from the war. ⁽⁵⁵⁾ In Baghdad, birth defects were found to occur at a rate of 10 per 1000 births after reviewing the records obtained from three maternity hospitals over the period of January 1987 to June 1988. ⁽⁵⁶⁾ In the Al-Anbar governorate, 33 babies were delivered suffering from NTDs, including anencephaly, spina bifida and encephalocele in Al-Ramadi Maternity and Children's Hospital between November 2007 and November 2008. ⁽⁵⁷⁾ Following the battles in Fallujah in 2004, some reports regarding the increased prevalence of congenital anomalies and cancer were considered to be a result of environmental contamination by DU in Fallujah. ⁽⁵⁸⁾ A study on infant mortality to monitor birth defects in Fallujah showed a rate of 80 per 1000 live births, which revealed the general deterioration of health in Iraq after the war. ⁽¹³⁾ Little is known about the nature of the weapons used in Al-Anbar during the US attack in 2004, but there were reports of a rapid surge in the rates of cancer and leukemia after 2005. ⁽⁵⁹⁾

Chemical agents

Alkylating agents like sulfur mustard were employed in chemical weapons in numerous fights during the 20th century; victims exposed to high doses of this chemical may die within hours or weeks. ⁽⁶⁰⁾ Mustard gas is a toxic, vesicant, blistering, alkylating nucleophile, which was used extensively during the Gulf War; it destroys the cells by alkylation DNA and causes damage to the immune system. ⁽⁶¹⁾ The Iraqi forces used chemical weapons and nerve gas in their attack on Halabja. However, no published articles are available about the prevalence of congenital defects in Kurdistan. ⁽⁶²⁾ In 2011, Apostoli and Catalani ⁽⁶³⁾ mentioned that heavy metals (such as lead, mercury, arsenic, cadmium, chromium, nickel,

vanadium, copper, and lithium) exert a wide range of contrary effects on reproduction and development, which depend on the duration of exposure, accumulation in various organs, and interference with specific developmental processes. A team of researchers tested the samples of hair collected from parents of children born with major congenital defects between 2009 and 2010 in General Hospital of Fallujah; the contamination of the such children's parents' environment by uranium was investigated by using Inductively Coupled Plasma Mass Spectrometry as well as samples of water and soil were analyzed to determine uranium isotope ratios; they noticed significantly higher levels of Co, Mg, Ca, Fe, Zn, Al, and Hg in the hair samples and concluded that uranium may be a primary or secondary relevant factor. ⁽³¹⁾ The blood level of lead in children delivered with NTDs in the Al-Anbar governorate was higher ⁽⁶⁴⁾ than that of the participants of a study in the UK, which revealed no relationship between the high content of lead in the local water supply and the incidence of NTDs. ⁽⁶⁵⁾ The war on Al-Ramadi city with the use of white phosphorus or DU led to a high incidence of various birth defects such as anencephaly, congenital heart disease, missing limbs, or single eye. ⁽⁶⁶⁾

Impact of post-war damage of infrastructure on the incidence of birth defects in Iraq

Damage to oil infrastructure, including pipelines, refineries, and wellheads, has produced localized hotspots of pollution due to the release of a wide range of heavy metals and toxic compounds, which may have serious implications on health. ⁽⁶⁷⁾

Our study in Mosul city revealed that the overall percentage of congenital disorders was 0.71% over a period of one year after the war,

from 2017 to 2018, compared to a previous study by Taboo in 2012 ⁽³⁴⁾ that had recorded a lower incidence of birth defects. Such findings can explain how civilians living in Mosul, Ramadi, Tikrit, and Fallujah have suffered from the intense fighting that resulted in severe damage to industrial and residential areas. ⁽⁶⁸⁾ ISIS fought to gain control over the oil wells of northern Iraq and destroyed the oil installations in Kirkuk with suicide attacks. ⁽⁶⁹⁾ Water infrastructure such as the Mosul Dam and Haditha Dam has been damaged during the fight; ISIS flooded some areas in order to disrupt the movement of ground forces; they also cut off the water supply, destroyed agriculture, and disrupted the electricity sourced from dams. Furthermore, they directly contaminated water sources by releasing diesel into them, rendering it toxic for humans and plants to consume. ⁽⁷⁰⁾ The attacks with explosive devices in Mosul and Al-Ramadi created hazardous health risks by the debris produced from the destruction of the commercial and industrial areas. ⁽⁷¹⁾ Monitoring the economic and environmental penalties of war put a great burden on the Iraqi state to access professional health infrastructure. ⁽⁷²⁾

CONCLUSIONS

Mosul, Ramadi, Tikrit, Fallujah, and Basrah have been exposed to environmental contamination from toxic waste products left after intense fighting, resulting in severe damages to industrial and residential areas as well as serious health problems. The reviewed studies from Iraq reported that exposure to post-war environmental pollution by DU and other chemical constituents may increase the risk of birth disorders among people exposed directly or indirectly to contamination. Efforts

are required to offer solutions for public health to prevent birth defects through prenatal counseling and widespread public education. Higher recognition of the impact of toxic remnants of war can help identify and assist the affected population and provide support to researchers and civil society organizations aiming to reinforce the protection of the environment both during and after the conflict.

RECOMMENDATIONS

The Iraqi government should provide economic resources and upgrade skills to support health care and monitor the environment in and around the contaminated areas. Civil organizations should conduct a widespread environmental assessment after the war as reflected by the policies of environmental protection that were recently undertaken by the International Law Commission. States should review current military practices that contribute to environmental health risks, including reviews of weapon development and targeting policies. Humanitarian organizations should improve the techniques of data collection to minimize the health risks caused by the toxic remnants of war.

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