

***The Evidence For Causal Association Between Exposure To  
Depleted Uranium And Malignancies Among Children In  
Basrah By Applying Epidemiological Criteria Of Causality***

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## **Abstract**

Criteria for assessing causal association in observational studies (as described by Hill) have been applied to examine the association between exposure to depleted uranium and the rising incidence of malignancies (specifically leukaemias) among children in Basrah, southern Iraq following the 1991 military aggression on Iraq. These criteria include time sequence, dose - response relationship and consonance with existing knowledge.

The rise in the incidence rate of malignancies among children have been found to be noticeable from 1995 onwards (7.8/100000 in 1995, 10.7/100000 in 1999 and 13/100000 compared to only 3.98/100000 in 1990). Such trend fulfills time sequence criterion whereby the outcome follows a latency period of almost 4 years following exposure to depleted uranium. Examination of the geographical distribution of such malignancies in Basrah over the period from 1993 to 2000 reveals that areas to the west of Basrah city (where levels of contamination of soil, plants and water with D.U are higher) have higher incidence of malignancies compared to areas east or south east. This finding fulfills dose-response criterion. The shift of the incidence of leukaemias in recent years towards younger children (below 5 years of age) supports the criteria of biological plausibility, specificity and consistency with findings from other parts of the world which have been exposed to ionizing radiation .

## ***Introduction***

The rise in the incidence rate of malignancies (specifically leukaemias) among children below fifteen years of age in Basrah following the 1991 military aggression on Iraq has been well-documented<sup>1,2</sup> .

There is circumstantial evidence that such rise is due to continued exposure to depleted uranium which has been used by the western allies in their aggression. However such evidence need to be supported by applying more rigorous scientific methodology. Sir Bradford Hill postulated what has been called criteria of causality to establish the causal association between two variables in observational studies<sup>3</sup>. These criteria include time sequence , dose response relationship, consistency , specificity and biological plausibility or consonance with existing knowledge .

In this paper we report the results of applying such criteria to data which has been gathered on the incidence of malignancies among children in Basrah for the period 1990 to 2000 to examine its association with exposure to depleted uranium .

## Methodology

It has already been mentioned earlier that a cancer registration system has been set up in the main maternity and children hospital in Basrah governorate, southern Iraq where information on all admitted, malignant cases among children below 15 years, of are recorded and analysed by authors<sup>1</sup>. It has already been mentioned that this hospital serves as the main referral centre for the management of malignancies among children in the area. Information on the incidence is updated every year and the the following indicators are calculated :

1- Annual incidence rate of malignancies per 100000 of children below 15 years of age. This is worked out by relating the registered numbers of malignancies to estimated population of children for that year

2- Percentage rise in the incidence of malignancies in general and leukaemias in particular for each year compared to the incidence in 1990 . This is calculated by the following formula:

Percentage rise in a given year =

$$\frac{\text{No. Of}}{\text{Of}} \times 100$$

3. The spatial distribution of malignancies in Basrah by working out the annual incidence rate for each district of Basrah for the periods 1993 – 1998, 1999 and 2000 .

4- The proportion of children below 5 years of age with leukaemias out of total children affected for the period from 1990 to 2000 .

## **Results**

The results of the study relevant to each criterion of causality are presented below .

### **A- Time sequence relationship**

*Table 1* presents the incidence of different types of malignancies among children in Basrah during the period from 1990 to 2000 . It can be clearly seen that a noticeable rise in total malignant is observed form 1995 onwards ( 38 in 1995 , 65 in 1999 and 92 in 2000 ) compared to only 19 cases in 1990 . The corresponding figures for leukaemias only are 25 in 1995 , 30 in 1999 and 60 in 2000 compared to 19 cases in 1990 .

The percentage rise in the in incidence of all malignant diseases and in the incidence of leukaemias are shown in fig 1 . It can be clearly seen that such rise started from 1995 onwards . The percentage rise in all malignancies compared to 1990 are 121% , 242% and 384% in 1998 , 1999 and 2000 respectively . The corresponding rise figures for leukaemias are 60% , 100% , and 300 % for the same years.

### **B- Strength of association**

The annual rates of malignancies among children in Basrah from 1990 to 2000 are shown in *table –2* .The substantial rise in such incidence rates over the years is clearly demonstrated .The

risks in 1995 , 1996 and 1999 are almost doubled compared to 1990 . In 1999 it is almost 3 times higher and in 2000 it is four times higher compared to 1999 .

### ***C- Biological plausibility and consonance with existing knowledge***

Table –3 show the proportions of children below 5 years of age with leukaemias

out of total children below 15 years of age during the period 1990 to 2000 . The shift towards younger age group can be clearly observed .More than half of cases ( 57% ) are below 5 years of age in 2000 compared to 13% in 1990 . Such shift confirms early exposure of young

population to radiation with succeeding years. It is well known that the risk of cancer among younger population exposed to radiation is higher .

### ***D-Dose – response relationship***

This criterion can be clearly ascertained by examining the geographical variation in the incidence rates of malignancies among children in Basrah over the period from 1990 to 2000. Table-4 demonstrates such distribution .

It can be seen that areas where higher level of background radiation was measured ( such as Al-Zubeir west of Basrah city and Al-Hartha , north of the City ) have higher incidence rates . Such rates are noticeable in 1999 and 2000 .

## **Discussion**

The demonstration of the causal association between cancer and a risk factor has always been based on epidemiological evidence.

Application of Hill's criteria of causality has provided strong evidence for causal association between lung cancer and smoking or mortality due to cardiovascular disease among British doctors in relation to smoking <sup>4</sup> .

In this study the circumstantial evidence provided earlier on the relation between rising incidence of cancer among children in Basrah and exposure to depleted uranium <sup>1,2</sup> is further supported by the application of Hill's criteria of causality . Time sequence relationship criterion is fulfilled by the noticeable rise in such incidence of leukaemias starting from 1995 i.e. almost after 4 years of exposure to ionising radiation, a period equivalent to the latency period of this type of malignancy . Strength of association is demonstrated by the sustained rise in the risks of occurrence of malignancies among children in Basrah over the last 10 years. This reflects the results of cumulative exposure to radiation among the local population .

Earlier measurements of background radioactivity of soil , plant and water samples taken from different areas of Basrah<sup>5</sup> showed that areas west of Basrah had higher level of background radioactivity compared to eastern areas.

The results of the spatial distribution in Basrah of malignancies is consistent with the finding fulfilling dose–response criterion i.e. areas with higher level of exposure had higher level of cancer among children. The shift of incidence of leukaemias towards younger children is consistent with findings from other studies about childhood leukaemias

among people living in the vicinity of nuclear reactors<sup>6,7</sup>. Thus the criteria of consistency and biological plausibility are fulfilled.

In conclusion, the evidence provided in this paper further supports the circumstantial evidence described earlier about the causal association between exposure to depleted uranium and the incidence of malignancies among children in Basrah, southern Iraq.

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**Table 1 Incidence of malignant disease among children in Basrah**

Year	1990	1993	1994	1995	1996	1997	1998	1999	2000
Leukae	15	15	14	25	24	24	24	30	60
Lymph	2	4	1	5	8	8	9	19	13
Brain	1	4	3	2	5	6	2	2	3
Wilms	1	3	2	4	1	0	0	3	0
Neurobl	0	0	0	0	0	3	4	6	3
Others	0	1	1	0	0	2	3	5	13
Total	19	27	21	36	38	43	42	65	92

**Table 2 Incidence rate of malignant diseases among children in Basrah from 1993-2000 compared to 1990.**

Years	Childr	No. of ma	Incide nc
1990	476	19	3.9
1993	518	27	5.2
1994	533	21	3.9
1995	459	36	7.8
1996	565	38	6.7
1997	581	42	7.2
1998	627	42	6.6
1999	605	65	10.
2000	704	92	13.

**Table 3 *Proportion of children below five years with leukaemia in Basrah 1990-2000***

<b>Year</b>	<b>Total</b>	<b>&lt; 5</b>	<b>%</b>
<b>1990</b>	<b>15</b>	<b>2</b>	<b>13.3</b>
<b>1993</b>	<b>15</b>	<b>5</b>	<b>33.3</b>
<b>1994</b>	<b>14</b>	<b>5</b>	<b>35.7</b>
<b>1995</b>	<b>25</b>	<b>10</b>	<b>40.0</b>
<b>1996</b>	<b>24</b>	<b>10</b>	<b>41.7</b>
<b>1997</b>	<b>24</b>	<b>10</b>	<b>41.7</b>
<b>1998</b>	<b>24</b>	<b>10</b>	<b>41.7</b>
<b>1999</b>	<b>30</b>	<b>14</b>	<b>46.7</b>
<b>2000</b>	<b>60</b>	<b>34</b>	<b>56.7</b>

**Table (4): *Geographical distribution of annual incidence rates of malignant diseases among children 2000***

	<b>Children &lt; 15</b>	<b>No. of cases</b>	<b>Annual Incidence Rate Per 100,000</b>
<b>Centre of Basrah</b>	<b>295596</b>	<b>28</b>	<b>9.47</b>
<b>Alhartha</b>	<b>56186</b>	<b>24</b>	<b>42.7</b>
<b>Qurna</b>	<b>77581</b>	<b>10</b>	<b>12.89</b>
<b>Al-Mudina</b>	<b>57417</b>	<b>1</b>	<b>1.74</b>
<b>Al-Zubier</b>	<b>120443</b>	<b>25</b>	<b>20.76</b>
<b>Abu Al-Khassib</b>	<b>67088</b>	<b>2</b>	<b>2.98</b>
<b>Shat-Alarab</b>	<b>29703</b>	<b>2</b>	<b>6.7</b>

**Fig (1) :Percentage rise in the incidence of malignancies in general and leukaemias among children in Basrah with reference to the year 1990**

