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# Strategic Review - Analysis of Mortality Rate Caused by Depleted Uranium

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***Abstract*— Purpose: This article reviewed the contemporary knowledge about the effects of the depleted uranium on the human health. The aim was to analyze the mortality and cancer rate caused by depleted uranium. We considered military conflicts where depleted uranium was used in armour-piercing ammunition and in uranium processing workers.**

**Materials and methods:**
**Search engines: PubMed and Google Scholar were used for the paper searching. Journals were analyzed for the incidence Standardized Mortality Ratio (SMR) and confidence Interval (CI) as well as information about the cancer caused. Programs used: Excel and GraphPrism.**

**Results: 10 articles were taken into consideration and were reviewed. There is higher overall cancer incidence and mortality rates in general population which increased during the last 20 years. Also, the incidence of lung cancer and blood cancers is higher compared to the general population due to the direct inhalation.**

**Conclusion: In the end, we can conclude that according to this reviewed data, there is an increase during the last 20 years in the cancer mortality connected to the increase of depleted uranium usage. Also, per the reviewed data, direct inhalation of depleted uranium is hazardous to the organism.**

***Keywords- Depleted Uranium; Uranium; War; Cancer; Human Health; Military; Mortality***

## I. INTRODUCTION

Uranium is a natural element that is present in Earth crust since it is formed, as well as in the all soils, rocks, lakes, rivers, plants and animals. [1] When uranium is finally divided it is pyrophoric metal, and in that state it could react with water. It is a heavy, silvery-white and slightly paramagnetic metal. Uranium is slightly softer than steel and in nature it is mainly present in oxidized form, since it is easily oxidized in air and becomes coated with a layer of oxide. [2]
Natural uranium has three isotopes: $^{238}U$, $^{235}U$, and $^{234}U$.
On the controlled fission of the $^{235}U$ in the fuel is based current generation of nuclear power reactors at concentrations enriched to some fivefold greater than occurring in the nature. The remainder of that enrichment process is depleted uranium (DU), where worldwide stock of depleted uranium contains more than 1½ million tons. One amount of it was used to dilute weapons grade uranium (~90% $^{235}U$) into reactor grade uranium (~5% $^{235}U$). Uranium could decay into many other radioisotopes, called progeny, until it finally ends up as stable (nonradioactive) isotopes of lead. Due to its long radioactive half-life in comparison to the age of the solar system, uranium is considered to be a naturally occurring primordial radio-element. [3].
Since the uranium is pyrophoric metal, it is combustible and ignites readily when it is finally divided in air. This property is also typical for some metals such as aluminum (Al) and iron (Fe).
Uranium could form fine dust that contains mixture of uranium oxides, when it is used in military armour or projectiles, or when present in an air crash or fire in which significant heat is generated. All isotopes of uranium have the same physical characteristics, such as melting point, boiling point, and volatility. They all undergo the same chemical reactions in nature, but the radioactive properties (half-life, specific activity, decay mode etc.) of all uranium isotopes are however different. [4]
DU, natural uranium and enriched uranium differ only in isotopic composition in their pure form. They are undergoing identical chemical reactions in the environment, and having the same biological, biochemical and chemical effects on the human body, because of that there are nearly no differences in chemical behavior. If there are present small differences, it is due to the small mass differences between uranium isotopes. [5] DU is only available about from 1940. It is a by-product of uranium enrichment required for nuclear industry. As such it can only contain very low levels of many of the naturally occurring radioactive decay products of uranium.
Militarily depleted uranium was first used for the Gulf War in 1991, and later it was used in Iraq as well as in the Balkan conflicts. Depleted uranium is thought to be responsible for the number of symptoms and diseases that appeared in the Veterans who participated in those conflicts. Controversy is still present, even though the research has been conducted in many countries and by many international agencies on the possible health effects of uranium and depleted uranium. [6]

Reports of leukemia and various different cancers among servicemen who were partially involved in the 1991 Gulf War or in the more recent operations in the Balkans measure a constant interest, as is the chance, but slight, that depleted uranium (DU) is one of the causal and crucial factors [25,27].

Nowadays, with constant growth of human population the challenges on healthcare are rising as well. Beside the importance of managing devices in healthcare [28-30] constant development of new treatment methods is crucial. Personalized medical care for patient and management of chronical diseases using machine learning techniques is one of the issues that is addressed with more attention over the past years. [31-33] Assessment of impact of DU on people is crucial in establishing quality environment for working and living as well as prevention of numerous diseases and disorders. Studies of many groups of uranium miners are conducted over a few years in the USA, Canada and also the Czech Republic. Knowledge from these researches are the topic of several detailed reviews, together with that by the USA National Research Council Committee on Biological Effects of Ionizing Radiation. In common with earlier reviews, this committee concluded that exposure to radon progeny in uranium mines was a cause of lung cancer [26,27].

This distinctive archive contains tissue samples and protocols of 28 995 autopsy cases, of which 5974 were lung tumors, covering the years 1957–94. This archive has been analyzed for three time periods for cohorts of 10 303, 2284 and 227, characterized by radon exposure ranges in units of WLMs per year of 30–300, 5–100 and 1–4 [27]

The main effect induced by a low level of DU contamination in apo-E deficient mice was the lowered value in hepatic gene expression of the enzyme CYP7B1 (−23%) and nuclear receptors LXR (−24%), RXR (−32%), HNF4 (−21%) when compared to unexposed ones. These modifications on cholesterol metabolism did not lead to increased disturbances that are specific for apolipoprotein E-deficient mice, suggesting that chronic DU exposure did not worsen the pathology during this experimental model. Finally, the results of this study indicate that even for a sensitive pathologic model the exposure to a low dose of DU has no relevant impact. The results confirm the results of our first study administrated on healthy laboratory rodents wherever a sub-chronic contamination with low dose DU did not affect in vivo the metabolism of cholesterol [34].

DU is genotoxic, inducing DNA double strand breaks, chromosome damage and mutations, however the mechanisms of genotoxicity or repair pathways involved in protecting cells against DU-induced damage remain unknown. The aim of the study was to investigate the effects of homologous recombination repair deficiency on DU-induced genotoxicity using RAD51D and XRCC3-deficient Chinese hamster ovary (CHO) cell lines. Cells deficient in XRCC3 (irs1SF) exhibited similar cytotoxicity after DU exposure compared to wild-type (AA8) and XRCC3-complemented (1SFwt8) cells, but DU induced more break-type and fusion-type lesions in XRCC3-deficient cells compared to wild-type and XRCC3-complemented cells. Surprisingly, loss of RAD51D did not affect DU-induced cytotoxicity or genotoxicity. DU induced selective X-chromosome fragmentation irrespective of RAD51D status, but loss of XRCC3 nearly eliminated fragmentation observed after DU exposure in wild-type and XRCC3- complemented cells. Thus, XRCC3, but not RAD51D, protects cells from DU-induced breaks and fusions and also plays a role in DU-induced chromosome fragmentation [35-37].

## II. MATERIALS AND METHODS

The main aim of this work was to analyze whether depleted uranium may have effects on the human health and whether it changes the rate of mortality. For this literature review search engines such as Science Direct, Medline and PubMed were used. During the search keywords: depleted uranium; uranium; war; cancer; human health; military; mortality were typed, and only journals with full free text were taken into the consideration. The articles used for this review were mostly published between 2000 and 2016 with one significant article from 1996. As for the parameters, we mostly focused on the articles that reviewed the effects after war, examination of patients, as well as articles with animal trials. Additional information was gathered from the references of the selected articles.

Journals were analyzed for the incidence of: all leukemia, lung cancer, kidney cancer, Hodking’s lymphoma and melanoma, also for the increase and decrease in the mortality rate. 20 papers were analyzed. The incidence of exposure, as well as the incidence of mortality caused by depleted uranium in those papers was analyzed by using Standardized Mortality Ratio (SMR) and the confidence Interval (CI).

## III. RESULTS

We have reviewed 10 articles from 10 cases of mortality rate of depleted uranium from different countries and cities; *Loomis et al. (1996) [13], Macfarlane et al.(2005) [18], Busby et al. (2005-2009) [20], Storm et al. (2006) [10], Boice et al. (2007) [14], Zhou et al. (2010) [9], Silver et al. (2013) [12], Zablotska et al. (2014) [8], Zhivin et al. (2016) [7], Capocaccia et al.(2016) [19].*

While reviewing those articles we based the data collection on the cancer types and mortality rates caused by depleted uranium. Table 1 represents the Standardized mortality ratio (SMR) and confidence interval (CI) as its estimation of cancer types and people involved in the studies. Additionally, caused cancers in specific studies were mentioned in comparison to the SMR and CI.

In Table 1. We observe the incidence of different mortality rates among 10 countries and cities in the period of 2000-2017 with one addition from 1996. The focus is to show the range and differences between each and the overall change during the years. We also focused to analyze the specific conditions that have the most impact when it comes to exposure to depleted uranium.

All countries that analyzed people that were participating in Gulf Wars, or were analyzing Gulf War exposed populations show a higher incident rate than the population that was not directly exposed as we can observe from the SMR and CI values for Iraq. The population of workers that was directly exposed to depleted uranium or uranium radiation also shows higher values as shown in Figure 1. In Figure 1. We presented the mean value of the SMR and CI values as well as the result of their linear regression expressed in percentage. The linear regression is supposed to show the connection of one variable with the other by means of their reciprocal ability to affect each other. In Figure 2. We can observe that during 20 years, SMR and

CI in addition to the exposure to the radiation (exposure to Gulf War) do increase together.

Table 1. Incident and Mortality Rates

| Reference | Country/City | SMR | CI | Cancer |
|---|---|---|---|---|
| Loomis et al. (1996) [13] | Oak Ridge, Tennessee | 1.04-1.38 | 0.60-2.17 | Hodgkin's lymphoma, thyroid cancer |
| Macfarlane et al.(2005) [18] | Cohorot study | 1.05-2.05 | 0.83-4.61 | Oesophagus, braub |
| Busby et al. (2005-2009) [20] | Iraq | 4.22 | 2.8-6.6 | Leukemia, breast cancer |
| Storm et al. (2006) [10] | Denemark | 0.9 | - | Bone cancer |
| Boice et al. (2007) [14] | Colorado | 0.9-1.0 | 1.39-2.78 | Lung cancer |
| Zhou et al. (2010) [9] | US | 0.56-0.75 | 0.71–0.80 | Melanom |
| Silver et al. (2013) [12] | Ohio | 1.25 | 1.09 - 1.42 | Lung cancer |
| Zablotska et al. (2014) [8] | Eldorado | 0.65 | 0.40 - 1.01 | Hematologic cancer |
| Zhivin et al. (2016) [7] | France | 0.69 | 0.65 - 0.74 | Lung cancer |
| Capocaccia et al.(2016) [19] | Italy | 0.56-0.95 | 0.77-1.18 | - |

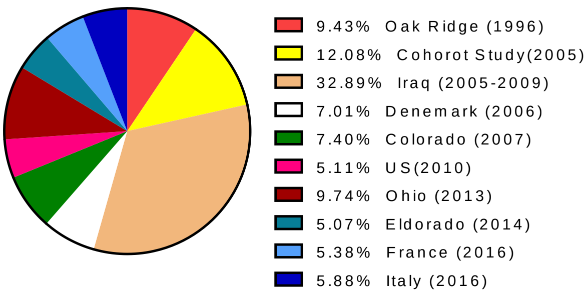


Figure 1. Incidence of mortality mean value expressed in percantage

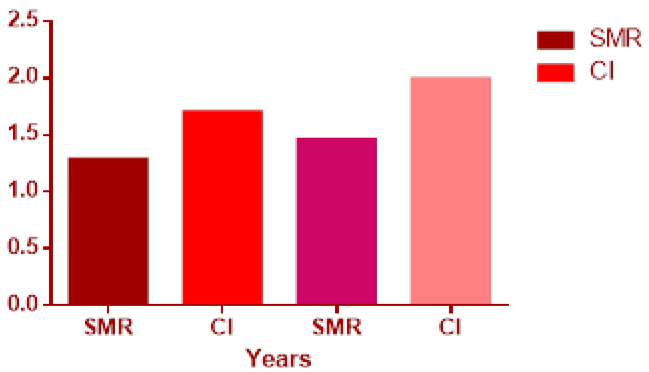


Figure 2. Comparison of SMR and CI mean values during time

## IV. Conclusion

Despite its low radiation, depleted uranium is said to have hazardous effects on human health after longer exposure. Studies and cases were reported where depleted uranium in Gulf War regions has severe effects than in other exposure situations.

This literature review aims to identify whether depleted uranium influences human health by the means of mortality increase or decrease. For this study we have focused on Standardized mortality ratio (SMR) and confidence interval (CI) in combination with cancer mortality. Also we aimed to observe the possibility of SMR and CI connection with DU, and its increase or decrease during the years. Additionally to observe the region of the highest presence of DU Side-effects.

In the end, we can conclude that, per this reviewed data, there is link between direct exposure to depleted uranium and cancer mortality. Gulf War exposed regions do show a higher mortality incidence range in comparison to other. SMR and CI are connected to the DU increase in the observed cases, however, other parameters and detailed studies must further be conducted to analyze this problem.

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