

# The health hazards of depleted uranium munitions

## Part 1

Depleted uranium munitions are used on the battlefield to destroy heavy armour. They were deployed in the Gulf War in 1991 and again in the Balkans in the late 1990s. They have the potential to disperse toxic and weakly radioactive material over wide areas, which may be hazardous to health. The Royal Society has published the first of two reports examining our scientific understanding of the issues involved.

### Summary

There has been a substantial amount of public discussion on the health effects of the use of depleted uranium (DU), especially on the battlefield. The Royal Society therefore convened an independent expert Working Group to review the present state of scientific knowledge about the health and environmental effects of DU, in order to inform public debate.

This is the first of two reports. It deals with the amounts of DU to which soldiers could be exposed on the battlefield, the risks from radiation, and what we know from epidemiological studies. We consider past and potential future exposures, the most likely exposures and the 'worst-case' exposures that cannot be excluded. Our second report, to be published later this year, will address the risks from toxic poisoning and environmental issues including risks to civilian populations.

The group has consulted widely. It has focused on what is known scientifically about aspects that are relevant to health and has not considered the merits of using DU in munitions. Nor does this report analyse Gulf War syndrome, which has been the subject of other reports.

DU is a toxic and weakly radioactive heavy metal that may have adverse consequences to human health, particularly if it enters the body through inhalation, ingestion or wounding. On the battlefield it is used in kinetic energy weapons designed to penetrate the armour of tanks and other vehicles. On impact substantial amounts of DU may be dispersed as particles that can be inhaled and as shrapnel. Our approach has been to estimate the typical levels of exposure on the battlefield over a wide range of scenarios, and the worst-case exposures that individuals are unlikely to exceed. From these we calculate the potential health risks from radiation. We have also considered epidemiological studies of occupational exposures to uranium in other situations as an independent source of information on the risks of inhaling DU particles, although we recognise that the parallels may not be precise.

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Based on our own estimates of intakes of DU, we have drawn the following conclusions:

- a) Except in extreme circumstances any extra risks of developing fatal cancers as a result of radiation from internal exposure to DU arising from battlefield conditions are likely to be so small that they would not be detectable above the general risk of dying from cancer over a normal lifetime.
  - b) The greatest exposures will apply only to a very small fraction of the soldiers in a theatre of war, for example those who survive in a vehicle struck by a DU penetrator. In such circumstances, and assuming the most unfavourable conditions, the lifetime risk of death from lung cancer is unlikely to exceed twice that in the general population.
  - c) Any extra risks of death from leukaemia, or other cancers, as a result of exposure to DU are estimated to be substantially lower than the risks of death from lung cancer. Under all likely exposure scenarios the extra lifetime risks of fatal leukaemia are predicted to be too small to be observable.
  - d) Many soldiers on a battlefield may be exposed to small amounts of DU and the risks of cancer from such exposures are predicted to be very low. Even if our estimates of risk for these conditions are one hundred times too low, it is unlikely that any excess of fatal cancer would be detected within a cohort of 10,000 soldiers followed over 50 years.
- a) Epidemiological studies complement assessments of actual exposures and radiation risks. Although epidemiological studies of occupational exposure to uranium are not sensitive enough to detect small increases in overall risks of cancer, they nevertheless tend to confirm our calculations of the risks derived from estimates of actual exposures to DU.

These are our main conclusions. But there are still uncertainties that need to be resolved, particularly in the estimates of DU intakes that could occur in different situations on the battlefield. Most of these uncertainties arise as a consequence of the paucity of good experimental data on the amounts of DU that may be inhaled within and close to tanks struck by a DU penetrator, and the almost complete lack of any measurements of DU in urine samples taken soon after exposure to a DU impact aerosol. It is likely that the greatest exposure to radiation resulting from inhaled DU particles will be to the lungs, but making worst-case assumptions, predicted radiation doses to the thoracic lymph nodes are about ten times higher than those to the lungs. The widely held view that lymph nodes have a low sensitivity to radiation regarding carcinogenesis has been challenged by others. We have therefore identified a

number of areas where further research is necessary, and a number of other actions that would help in assessing further the hazards that may arise from the use of DU in munitions. This work would also be relevant to the assessment of toxicological risks. Our main recommendations for future research include:

- better estimates of the levels of DU, and the properties of DU aerosols, resulting from test firing under realistic conditions into heavy-armour tanks;
- experimental information on intakes of DU from resuspension of depleted uranium dust in contaminated vehicles;
- the development and validation of models to enable DU exposures to be predicted in a wide range of circumstances;
- new independent assessments of the resultant risks, particularly from high exposures, when further experimental data are available;
- long-term in vivo studies of the dissolution of DU oxides;
- a detailed review of the effects of radiation from radioactive particles in lymph nodes, including any possible carcinogenic effects.

Our other recommended actions include:

- the identification of any UK veterans with high level exposures, and their invitation to participate in an independent evaluation programme;
- the publication of protocols for improved and expeditious monitoring of the health of soldiers subjected to high level exposures in any future conflict.

In conclusion, this first report indicates that the radiological risks from the use of DU in munitions are for the most part low, but that for small numbers of soldiers there might be circumstances in which risks are higher, and it is for this reason that further work should be undertaken to clarify their extent.

The Royal Society welcomes comment on this report. Comments should be sent in the first instance to the Director Science Policy, The Royal Society, 6 Carlton House Terrace, London SW1Y 5 AG; e-mail [depleteduranium@royalsoc.ac.uk](mailto:depleteduranium@royalsoc.ac.uk).

Copies of the report (80 pages) are available post-free from the Royal Society at £17.50 each. Orders should be sent to Jacqueline Knapp, The Royal Society, 6 Carlton House Terrace, London SW1 5AG, telephone 020 7451 2645, email [sales@royalsoc.ac.uk](mailto:sales@royalsoc.ac.uk).

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Technical annexes to the report may be found at [www.royalsoc.ac.uk](http://www.royalsoc.ac.uk).