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Depleted uranium and cancer in Danish Balkan veterans deployed 1992–2001

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ABSTRACT

In a population based retrospective cohort study we studied cancer risk in Danish soldiers deployed to the war in the Balkans. In particular, leukaemia, earlier linked to ammunition enforced with depleted uranium (DU) in other deployed soldiers, was a concern.

Military personnel, 13,552 men and 460 women, without known cancer at first deployment to the Balkans, January 1, 1992 to December 31, 2001 were followed through December 2002.

We found 96 cases of cancer, 84 among men (standardised incidence ratio (SIR) 0.9) and 12 among women (SIR 1.7). Only four male bone cancers (SIR 6.0), with three during the first year of follow-up, exceeded expectations.

Earlier reports on increased risk of leukaemia and testis cancer among deployed military personnel to the Balkans are not corroborated by our study. Quick and open communication about potential risks, a health check, a telephone counselling line and careful monitoring, and diminished anxiety all helped contain the 'Balkan syndrome' in Denmark.

1. Introduction

Military personnel from Denmark have increasingly been involved in international operations during the past 14 years. Since January 1992 a large number of soldiers have been deployed to the Balkans (Croatia, Bosnia, Kosovo, Albania and Macedonia).

Alarming media reports in 2001[1] on leukaemia cases among soldiers deployed to the Balkans from Italy [30 cases], Belgium [9 cases], Spain [8 cases], France [5 cases], The Netherlands [2 cases], Denmark [2 cases] were linked to the use of depleted uranium (DU) enforced armour-piercing projectiles used by the NATO operated US Air Force's A-10 Thunderbolt aircraft. Altogether, 10,000 30 mm DU rounds (3.3 tons of DU) were fired at 12 sites in Bosnia-Herzegovina in 1994–95 and 31,000 DU rounds (10.2 tons of DU) at 85 locations in Kosovo in 1999.[2] At impact uranium particles would have been dispersed into the air, and traces of plutonium and radioactive uranium-236 were reported in the dust in target areas for the DU ammunition.[3] The aerosol at impact and the dust is where a risk of exposure is present.[4] Even if a team from the International Atomic Energy Agency concluded that in the most contaminated areas the concentration of DU particles was not high enough to elevate cancer risk, and that it was difficult to distinguish between DU and natural uranium in the specimens taken by teams from the United Nations Environmental programme,[5] concern about the health of the deployed forces remained.

Immediate action was taken by the armed forces in Denmark[6] establishing an open telephone counselling line and an offer of an independent health examination by the soldiers own GP. Also, the research community responded early[7] with

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an overview of the magnitude of risk to be expected in the possibly exposed population, taking both the low dose and the nature of alpha-radiation into consideration.[8,9] As part of the immediate action, this study was launched as collaboration between the Defence Health Services and the Danish Cancer Society. The aim was to follow-up the cohort of military personnel deployed to the Balkans for cancer and other health problems, both short and long term.

2. Material and methods

Individual deployments occurring from January 1, 1992 to December 31, 2001 were identified in the files of the National Defence. The deployments related to 15,091 persons. Some 1002 persons had been deployed to other destinations before the Balkan conflict, and were excluded from this study. Some 12 persons with obvious errors in the recording of dates of deployments were excluded from the study base, as were 27 with the wrong ID number. Thirty-eight persons with cancer diagnosed before deployment to the Balkans were likewise excluded, as the treatment of cancer might bias results when looking for possible radiation induced cancers from the shells. Finally 14,012 persons were included with Albania (1%), 'Balkan' (2%), Bosnia (45%), Kosovo (12%), Croatia (38%) and Macedonia (3%) as the destinations of their first deployment period, whilst later deployments could be in any of the above.

The identity of each person was checked in the Central Population Registry files by linkage of the unique personal ID number given to all Danish citizens as of 1968. Follow-up status was obtained through this register by December 31, 2002, as alive, or with the date of emigration, death or lost to follow-up.

Using the unique personal ID number, cross-linkage with the Danish Cancer Register was performed, and observed cancer cases in the cohort were extracted and coded according to the 7th international classification of diseases. The Danish Cancer Register covers all cancers and all of Denmark with a renowned high quality.[10]

Using date of first deployment as the starting point, and last known vital status date as the end point (being either date of death, emigration, lost to follow-up or alive December 31, 2002) we calculated the expected number of cancer cases by multiplying the age, sex and period specific person years from the cohort with the corresponding incidence rates of the Danish population. The standardised incidence ratio (SIR), the ratio between observed and expected cancers, was computed, as were 95% confidence limits of the SIR, assuming a Poisson distribution of the observed cancers as described by Breslow and Day.[11]

3. Results

A total of 14,012 persons, 13,552 men and 460 women, comprising 93,820 person years at risk, had been deployed to the Balkans 1992–2001 (Table 1). The cohort is relatively young, with a mean age at start of follow-up of 26.4 years (range 18–65 years). Most persons were only deployed once and for 6 months.

We observed 96 cancer cases, 84 among men versus 89.6 expected and 12 among women versus 7.0 expected (Tables 2a and 2b). There was no statistical significant increased risk of cancer of the lungs, kidneys, testicles, lymphomas or leukaemia's, the most likely sites related to radiation or those seen in other cohorts, and only a few sites in men (salivary glands, rectum, liver metastasis and bladder) had a SIR of 2 or above – however, the estimates are based on few cases and confidence limits are wide. In women the number of cases was small and non-statistically significant elevated SIR's, based on one or two cases, were seen for cervix and corpus uteri, kidney, brain and melanoma.

Based on four cases and a SIR of 6.0, bone cancer in men was the only significantly elevated site. All cases were verified

Table 1 – Danish military personnel deployed to the Balkans[a] 1992–2001

	Men	Women	Total
Number of personnel	13,552	460	14,012
Mean age (years)	26.3	31.2	26.4
Range age (years)	18–65	18–59	18–65
Person years	91,121	2699	93,820
Years in service	8412	287	8699
1.Deployment (%) < 6 mth	879 (6.5)	33 (7.1)	912 (6.5)
1.Deployment (%) 6 mth	5312 (39.2)	142 (30.1)	5454 (39.0)
1.Deployment (%) 7 mth	5721 (42.2)	230 (50.0)	5951 (42.5)
1.Deployment (%) > 7 mth	1640 (12.1)	55 (12.0)	1695 (12.1)
Total number of deployments	18,722	606	19,328

a Albania, 'Balkan', Bosnia, Kosovo, Croatia, Macedonia.

Table 2a – Cancer among Danish military personnel deployed to Balkans 1992–2001, men

Cancer	ICD-7	O[a]	SIR[b]	95% CI[c]
Total	140–209	84	0.9	0.7–1.1
Tongue	141	1	2.0	0.0–10.9
Salivary glands	142	1	3.6	0.1–19.9
Stomach	151	2	1.6	0.2–5.6
Colon	153	4	1.3	0.3–3.2
Rectum	154	5	2.7	0.9–6.4
Liver	155	1	1.8	0.0–9.8
Liver, not primary	156	1	3.3	0.1–18.6
Pancreas	157	1	1.0	0.0–5.3
Lung	162.1	2	0.4	0.0–1.4
Prostate	177	1	0.6	0.0–3.3
Testis	178	24	1.2	0.8–1.8
Kidney	180	2	1.1	0.1–4.1
Bladder	181	7	2.2	0.9–4.5
Melanoma	190	5	0.7	0.2–1.7
Brain and CNS	193	9	1.2	0.5–2.2
Thyroid	194	1	1.1	0.0–6.1
Bone[d]	196	4	6.0	1.6–15.3
Metastases	198	1	1.2	0.0–6.4
Unspecified	199	1	1.4	0.0–7.5
Non-Hodgkin lymphoma	200,202	3	0.8	0.2–2.3
Hodgkin's lymphoma	201	3	1.0	0.2–2.9
Myeloma	203	1	1.9	0.0–10.6
Leukaemia	204	4	1.4	0.4–3.5

a Observed number of cases.
b Standardised incidence ratio.
c 95% confidence interval.
d 3 cases observed within 1 year of deployment. SIR excl. 1 year of observation is 1.7 (95% CI: 0.0–10.1).

Table 2b – Cancer among Danish military personnel deployed to Balkans 1992–2001, women

Cancer	ICD-7	O[a]	SIR[b]	95% CI[c]
Total	140–209	12	1.7	0.9–3.0
Colon	153	1	4.2	0.1–23.3
Lung	162.1	1	2.3	0.1–13.0
Breast	170	3	1.5	0.3–4.3
Cervix uteri	171	2	4.4	0.5–15.9
Corpus uteri	172	1	5.1	0.1–28.1
Kidney	180	1	15.6	0.4–86.7
Melanoma	190	2	4.0	0.5–14.4
Brain & CNS	193	1	3.0	0.1–16.9

a Observed number of cases.
b Standardised incidence ratio.
c 95% Confidence interval.

as primary; however, three bone cancers were diagnosed within the first year since the deployment date. Excluding these three cases as unrelated to possible radiation exposure due to the short latency, the SIR dropped to 1.7 (not significant (ns)).

4. Discussion

Our cohort is young, and the observed cancer pattern reflects this fact. The follow-up period in terms of radiation induced cancers or other environmental exposure related to deployment to the Balkans is short. However, if a significant radiation exposure had been present, an excess of leukaemia's would be expected. This is not the case, but nevertheless, the number of observed leukaemia cases have doubled from two to four when compared to the early Danish report,[7] where we should expect three. This is a 30% increase in risk. However, this is not statistically different from expectations. Our study is thus in agreement with others on deployed soldiers to the same area,[12] and with follow-up on Gulf war veterans,[13] where ammunition enforced by DU was used, as well as being in agreement with studies of workers with decades of exposure to uranium.[8,14] Furthermore, the media reported number of leukaemia cases was reportedly in error. In Italy it was mixed up with the total number of cancer cases and overall, less cancer occurred than expected, as was also the case in Belgium.[2] However, no proper analysis has been published.

We observed fewer lung cancers than expected (ns) among the male soldiers most likely to be engaged in operations. Lung cancer excess would in theory be expected if there had been a significant exposure to DU from dust or in the air.[4,15] Had we observed an increased risk, it would have been necessary to adjust for smoking, which is impossible in a register based linkage study such as ours. It is unknown to us if smoking habits among military personnel differ from those of the general population; however, it is unlikely they smoke less. So far, neither smoking nor other exposures have given rise to appreciable elevated incidence.

The bone cancer incidence was, to our surprise, elevated in our cohort. Increased risk for bone cancers was seen among workers after large intakes of radium (after many years of exposure and follow-up) and after external radiation exposure treating childhood cancer.[14] Since three out of four of the bone cancer cases were diagnosed within the first year since the date of deployment, exposure in the Balkans is unlikely to be behind these findings and the cause of these cancers must be found years before deployment.

Testis cancer was found in excess among Swedish soldiers deployed to the Balkans (SIR 1.7 ns)[12] based on a total of eight cases. An increased risk was also observed among US Gulf war veterans.[16] Testis cancer is by far the most frequent cancer in our cohort. We observed 24 cases and expected 19.3, giving rise to a SIR of 1.2 (ns). As in Sweden this is not different from what is to be expected in the underlying national population. Further follow-up in Sweden did not find any new cases.

Cancer incidence is not increased among Danish military personnel deployed to the Balkans. In particular, cancers of the lung and kidney and leukaemia's (those that in theory would be expected had the radiation exposure been significant) are not seen. However, to fully exclude a risk of solid cancers, longer follow-up will be needed. The 'Balkan syndrome', similar to the 'Gulf syndrome', with anxiety, insomnia and fatigue, may be related to the stressful environment arising when confronted with possible serious somatic effects as reported in the media.[17] The syndrome has not been prominent in Denmark. The National Defence responded to the media by instantly opening up a counselling hot line, where the first two personnel with leukaemia (and later two more) made themselves known, before the cancer registry was able to pick them up. At the same time a general health survey was offered to all veterans and all active soldiers deployed to the Balkans. Altogether, 3744 used this offer and among these no somatic illness that could be related to deployment was found. The lesson learnt is the need for better and faster risk communication, as well as careful health checks including information on life style before and after deployment to war zones. Files of deployed personnel should also be established as a routine to enable register based short and long term follow-up.

Conflict of interest statement

None declared.

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