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Report to the Chairman, Committee on Veterans' Affairs, U.S. Senate

August 1994

# OPERATION DESERT STORM

# Questions Remain on Possible Exposure to Reproductive Toxicants

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**United States**
**General Accounting Office**
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**Program Evaluation and**
**Methodology Division**

B-257726

August 5, 1994

The Honorable John D. Rockefeller IV
Chairman, Committee on Veterans' Affairs
United States Senate

Dear Mr. Chairman:

As a result of our work on reproductive and developmental hazards, you requested on January 31, 1994, that we explore recent reports that the offspring of Persian Gulf war veterans may be suffering from an increased number of birth defects or related illnesses and to determine whether the Department of Defense is adequately protecting and monitoring servicemen and servicewomen with regard to reproductive toxicants.[1] As you specifically requested, we have answered four questions:

1. What types of assessments were performed before the deployment of troops to the Persian Gulf to determine the potential for exposure to reproductive toxicants?

2. Were specific reproductive toxicants considered or identified as a result of these assessments?

3. What types of protection were provided to active duty personnel who might have been exposed to the toxicants identified, and what efforts were made to educate them about how to avoid the identified toxicants?

4. To what extent are active duty military personnel and veterans currently monitored for reproductive dysfunction that may have resulted from duty in the Persian Gulf?

As you requested, we have also listed substances likely to have been present in Operation Desert Shield and Desert Storm that could have potentially resulted in reproductive toxicity (see the section headed "Findings" below). Our response to your request follows. A description of our work, our summary findings, and our recommendations are provided below and are supplemented with additional detail in appendixes I, II, and III.

[1]See U.S. General Accounting Office, Reproductive and Developmental Toxicants: Regulatory Actions Provide Uncertain Protection, GAO/PEMD-92-3 (Washington, D.C.: October 1991).

## Background

Since their return from deployment in the Persian Gulf war, many U.S. troops have complained of health problems that they believe result from their service in the gulf region. Research has shown that U.S. troops were exposed before, during, and after the war to a variety of substances that are potentially hazardous. These include occupational hazards (such as the extensive use of diesel fuel as a sand suppressant in and around encampments, the burning of human waste with fuel oil, the presence of fuel in shower water, and the drying of sleeping bags with leaded vehicle exhaust), infectious diseases (most prominently leishmaniasis), prophylactic agents (to protect against chemical and biological weapons), depleted uranium (contained in certain ammunition and in the fragments of exploded rounds embedded in casualties), pesticides and insect repellents, possible chemical warfare agents, and a large variety of compounds contained in the extensive smoke from the oil-well fires that enveloped the region at the end of the war.

Some veterans of the Persian Gulf war believe that exposure to these elements had harmful effects on not only their own health but also on the health of their spouses and children. There are also concerns about various reproductive problems and about the incidence of birth defects thought to be abnormally high among offspring born to Persian Gulf veterans. This latter subject is the focus of this report.

## Objectives, Scope, and Methodology

To perform our work, we collected data directed to the evaluation questions listed above—that is, (1) what actions were taken before the war to assess for potential reproductive toxicants, (2) whether specific reproductive toxicants were considered or identified, (3) what types of protection and education were given to the troops against these toxicants during deployment, and (4) what monitoring efforts have been made to assess potential health effects from exposure to these toxicants. Additionally, we identified various potential reproductive toxicants in the gulf region; these were found in the various pesticides used, in a decontaminating agent, and among the compounds that constituted the smoke and residuals from the oil-well fires.

Our evaluation involved collecting data at the departments of Defense (DOD), Veterans Affairs (VA), and Health and Human Services (HHS). Our findings are based on these data as well as on interviews with veterans, a review of the reproductive and developmental toxicology literature, information contained in Senate and House hearings, and discussions with experts in the relevant subject areas. Our findings are relevant only to

reproductive effects of service in the Persian Gulf war and cannot be generalized to the broader issue of what has commonly been referred to as "gulf war syndrome."

To obtain information on the first three evaluation questions, we interviewed representatives and collected documents from the following DOD entities:

- Air Force, Office of the Surgeon General
- Armed Forces Institute of Pathology
- Armed Forces Medical Intelligence Command
- Armed Forces Pest Management Board
- Armed Forces Radiobiology Research Institute
- Army, Office of the Surgeon General
- Army Environmental Hygiene Agency
- Army Medical Research and Development Command
- Army Medical Research Institute of Infectious Diseases
- Defense Intelligence Agency
- Navy, Office of the Surgeon General
- Navy Environmental and Preventive Medicine Unit, Norfolk, Virginia
- Navy Medical Research Center, San Diego, California
- Office of the Assistant Secretary of Defense, Atomic Energy
- Office of the Assistant Secretary of Defense, Health Affairs
- Persian Gulf Veterans Coordinating Board.

We matched the information we received from the sources above as well as lists of compounds in pesticides and oil-well fires we obtained from DOD against known information on reproductive toxicants. Our data base on reproductive toxicants was drawn from our earlier report on reproductive toxicants as well as from the scientific literature.[2] This enabled us to determine which substances present in the gulf region had the potential to result in reproductive toxicity. We also conducted interviews and reviewed available literature to assess the possibility of adverse reproductive effects from other sources, such as various occupational hazards, infectious diseases, prophylactic agents, and depleted uranium, all known to be present in the region during the war.

[2]U.S. General Accounting Office, Reproductive and Developmental Toxicants.

To obtain information on the fourth evaluation question, we interviewed representatives from the following entities:

- Centers for Disease Control and Prevention
- DOD Persian Gulf Registry
- Mississippi Department of Health
- National Academy of Science, Institute of Medicine
- Persian Gulf Interagency Research Coordinating Council
- VA Family Support Program
- VA Medical Center, Birmingham, Alabama
- VA Medical Center, Jackson, Mississippi
- VA Persian Gulf Advisory Committee
- VA Persian Gulf Registry.

We also gained insights from interviews and telephone conversations with a small number of veterans and their spouses. However, these veterans voluntarily came forward to give us information on their individual experiences during and after the gulf war, and their insights into the issues pertaining to these evaluation questions may or may not be representative of the veteran population as a whole.

We conducted our review from February 16, 1994, to May 27, 1994, in accordance with generally accepted government auditing standards.

## Study Limitations

In this report, we did not ascertain cause-and-effect relationships between exposure to reproductive toxicants and reproductive dysfunction reported by veterans of the gulf war or on exposure rates for servicemen and servicewomen to these toxicants. Furthermore, we did not perform a risk assessment of these exposures and how they might relate to possible reproductive dysfunction. Lastly, information obtained from conversations with a small number of veterans may be useful in raising issues needing further clarification; however, the conversations should not be considered to represent the veteran population as a whole.

## Findings

With regard to the first evaluation question, we found that DOD performed many general assessments on potential health hazards that military personnel might be exposed to if troops were to be deployed to the Persian Gulf. Also, DOD relied on assessments performed by other entities, such as teratogenicity and reproduction studies conducted on animals by the Environmental Protection Agency (EPA) on pesticides used by DOD. However, except for the occupational health hazard assessments process,

no other assessments DOD performed specifically addressed potential reproductive toxicants in the Persian Gulf.

The health hazard assessment process within DOD does examine for reproductive toxicants during the material acquisition decision process. The process delineates specific occupational hazards and avoidance procedures for personnel involved in using such hazardous systems once they are placed in the field.

Other types of general assessments included directives on avoidance and treatment for infectious diseases, precautions on the use of pesticides, and training to defend against enemy use of chemical and biological agents. However, these activities did not specifically address potential reproductive toxicants and did not examine the possible synergistic effects of combinations of these hazards as they might relate to reproductive dysfunction.

With regard to the second evaluation question, we found that the health hazard assessment process generally endeavors to identify potential reproductive toxicants that are internal to a weapon system's development process. However, we found several potential reproductive toxicants that were unrelated to this process that DOD did not identify. These included possible reproductive toxicants from the oil fires, pesticides, and a decontaminating agent used in the gulf war.

With regard to the third evaluation question, we found that no efforts of protection for military personnel or efforts to educate service members were targeted specifically against reproductive toxicants. However, some activities covered by other directives would likely have minimized exposure to these potential reproductive hazards.

Such directives included the proper use of chemical suits and training on handling of ammunition that contained depleted uranium. However, in recent reports, we have noted shortcomings in these areas: (1) the Army did not have a formal plan or adequate facilities to decontaminate, dispose of, and quickly repair vehicles contaminated with depleted uranium and (2) some reserve units were not adequately equipped to survive and sustain operations in a chemical warfare environment.[3]

[3]U.S. General Accounting Office, Operation Desert Storm: Army Not Adequately Prepared to Deal With Depleted Uranium Contamination, GAO/NSIAD-93-90 (Washington, D.C.: January 1993), and U.S. General Accounting Office, Chemical Warfare: Soldiers Inadequately Equipped and Trained to Conduct Chemical Operations, GAO/NSIAD-91-197 (Washington, D.C.: May 1991).

DOD also communicated guidance on the hazards of the oil-well fires through briefings and announcements over Armed Forces Radio. However, because the oil fires were unanticipated and the smoke from the fires was widespread, it was not possible to fully protect service members from these hazards. This is important because our findings note that substances found in the oil-well fires, pesticides, and decontaminating agents are known reproductive toxicants (see the list at end of this section).

With regard to the fourth evaluation question, we found that some activities were undertaken to monitor servicemen and servicewomen for adverse reproductive effects after their deployment to the gulf. However, we believe these efforts have major shortcomings or raise concerns on several counts.

First, the monitoring efforts did not address most forms of reproductive dysfunction. For example, the examinations that were part of the overall monitoring efforts did not test for such problems as infertility, miscarriage, and other forms of reproductive dysfunction. However, the original VA registry did question veterans as to whether there was evidence of birth defects among the veterans' children and whether women who became part of the registry were pregnant while in the gulf.

Second, the VA's original questionnaire for its Persian Gulf registry, a standard examination given to all Persian Gulf veterans who present themselves to a VA hospital and request to become part of the registry, did not include questions relating to issues of infertility and miscarriage. The VA has recently decided to revise this questionnaire to include these items.[4]

Despite this revision, the VA has not decided whether the 20,000 veterans who have already responded to an earlier, and less complete, questionnaire will be queried. If they are not, it is possible that the revised and expanded data will not be collected from the very veterans who are most likely to have had adverse health effects—that is, those who first sought to be included in the VA's registry.

Third, some gulf veterans have reported that they were not aware of the VA and DOD registries while others have stated that they had been discouraged from participating in the registries. Some veterans also reported fearing

[4]A questionnaire completed during the VA registry examination now asks respondents if there have been any infertility problems or miscarriages, as well as whether offspring of the respondent have had any birth defects.

the loss of their positions during the military's downsizing if they reported for examinations conducted for the registries.

The exact extent of these problems is unknown, and DOD officials have stated that DOD is, in fact, encouraging service members who are ill to take part in the DOD and VA registries. Furthermore, DOD's comprehensive clinical evaluation program established procedures for identification, referral, clinical evaluation, and reporting of examination results of military personnel experiencing unexplained health problems following service in the gulf. The program also recognized and established a list of patients' rights, including respectful treatment, privacy and confidentiality, explanation of care, and mechanisms for handling patients' complaints.

Fourth, a study conducted jointly by the VA, the Centers for Disease Control and Prevention (CDC), and the Mississippi State Department of Health assessed a high incidence of birth defects reported by reserve units in Mississippi that were deployed to the Persian Gulf war. The study concluded that there was not an abnormally high incidence of birth defects among this group when compared to a comparison group taken from the Atlanta Metropolitan Congenital Defect Monitoring Program.[5]

Concerns regarding this study include, first, that the study sponsors decided not to conduct a before-and-after comparison of birth outcomes for the group in Mississippi (conceptions before and after service members were deployed to the gulf). The sponsors thought that it would have been very difficult to obtain a complete and accurate set of medical records for this group. While such a before-and-after study would have had its own complications, it might have shed additional light on the possible reproductive effect of the gulf war on these veterans. Next, the comparability of the Mississippi group to the Atlanta comparison group may be questionable, since the former may have been a healthier set of individuals than those found in the metropolitan Atlanta data base. Thus, if the rate of serious birth defects of the Mississippi reservists turned out to be no higher than predicted by the Atlanta group, it is very unclear as to whether this would or would not indicate a problem among the Mississippi veterans. Finally, the size of the Mississippi group is quite small. Any conclusive determination whether these veterans and their children are experiencing abnormally high reproductive dysfunction would require far more extensive research and testing than has been done or is currently planned.

[5]This program contains data on birth defects reported by hospitals in the Atlanta metropolitan area since 1968 and is the most comprehensive data base on birth defect rates presently available.

Fifth, a study to be conducted by the Navy Medical Research Center in San Diego, California, plans to examine differences in birth outcomes between gulf veterans and a comparison sample of military personnel who were not deployed to the gulf. However, this study will not examine records from reserve components and will not collect data on other indexes of reproductive dysfunction such as infertility and miscarriage rates. This may be important because the majority of gulf war veterans who have complained of illnesses and potential reproductive problems are from reserve and guard units.

We have identified several substances present in the war environment that, according to a number of studies, may cause reproductive dysfunction.[6] These substances, which fall under three hazard categories, are noted below along with their link to reproductive dysfunction. Additionally, their link to reductions in reproductive capacity or reports that they produce malformations when given to mammals during pregnancy are denoted according to the scientific work performed on these substances.

## Pesticides

- Carbaryl, paternal and maternal, malformations
- Diazinon, malformations
- Dichlorvos, paternal and maternal, malformations
- Ethanol, paternal
- Lindane, paternal and maternal
- Warfarin, developmental.

## Oil Fires and Soil Samples

- Arsenic, paternal and maternal, developmental
- Benzene, paternal and maternal
- Benzo (a) pyrene, paternal and maternal
- Cadmium, paternal, developmental
- Di-n-butyl phthalate, paternal
- Hexachlorobenzene, developmental
- Hexachlorocyclopentadiene, embryofetal
- Hexachloroethane, embryofetal
- Lead, paternal and maternal, developmental
- Mercury, paternal and maternal, developmental
- Nickel, paternal and maternal
- Pentachlorophenol, embryofetal

[6]It is not known at this time what the concentration levels were from these compounds and what specific units may have been exposed to dangerous levels.

- Toluene, paternal and maternal, developmental
- Xylene, paternal and maternal.

## Decontaminating Agents

- Ethylene glycol monomethyl ether, paternal and maternal.

Several compounds found in the Persian Gulf war are reported to also affect host defense mechanisms (hexachlorobenzene, lindane, malathion).[7] It has been suggested that the synergistic effects of long-term, heavy exposure to the multiple substances present in the Persian Gulf war could result in a weakening of the immune system's ability to fight against the hazards noted above.

Some scientific inquiry has now begun regarding such effects—in particular, the increased toxicity of certain pesticides when combined with other compounds such as pyridostigmine. The relationship of these study results and potential reproductive dysfunction is unknown.

A main compound (ethylene glycol monomethyl ether) found in a decontaminating agent (DS2) produced by the U.S. Army Chemical and Biological Defense Agency and used during the gulf war may cause central nervous system depression and liver damage. Additionally, although not definitively established in humans, exposure to this compound may have reproductive effects (including teratogenesis).

From the findings above, it is clear that neither has reproductive and developmental dysfunction among the veteran community as a result of the Persian Gulf war been disproven nor can it be ruled out. The basis for this uncertainty is threefold: (1) certain potential reproductive toxicants were indeed present in the region during the deployment of U.S. troops; (2) in the case of some of these toxicants, the exposures may have been widespread but were of unknown intensity; and (3) the studies performed to date are unfinished, cannot be generalized, or are too weak methodologically to demonstrate convincingly that there are or are not abnormally high reproductive dysfunction rates among Persian Gulf veterans and their families.

[7]Although malathion is not listed as a possible reproductive toxicant, it is noted in the scientific literature as a substance that can alter immune function.

# Recommendations

## Present Efforts

In regard to present efforts to ascertain any possible reproductive effects from service in the gulf war, we recommend that the Secretary of Veterans Affairs direct that theVA use the revised questionnaire to reregister the 20,000 veterans who have already had a VA registry examination. This should be done in order to obtain information on problems of infertility and miscarriages.

## Future Efforts

In regard to work yet to be conducted, we recommend that

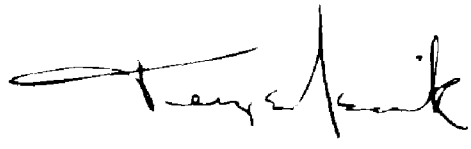
- the Secretary of Defense ensure that DOD, working in concert with EPA and HHS, make additional scientific inquiry on the possible synergistic effects of multiple exposures to hazards found in the Persian Gulf and the effects on the human immune system from these hazards as they relate to possible reproductive dysfunction.
- the Secretary of Defense explore approaches to collect baseline data on birth outcomes and other reproductive indexes such as infertility and miscarriage rates of active duty and reserve military personnel so that these data are available for future comparability studies. This information should also include the collection of baseline data on exposure levels to potential reproductive toxicants in order to ascertain when exposures rise to dangerous levels in future conflicts. In order to ascertain any differences in health status, this information should be collected both before and after future conflicts.
- DOD develop procedures to better ensure that troops are informed of possible reproductive toxicants before deployment and that efforts are undertaken to monitor exposure levels to such hazards.

# Agency Comments

As requested, we did not ask for official comments from DOD, VA, or HHS regarding this report. As we arranged with your office, we plan no further distribution until 30 days from the report's date of issue, unless you publicly announce its contents earlier. We will then send copies to the secretaries of Defense, Veterans Affairs, and Health and Human Services and to others who are interested. We will also make copies available to others upon request.

If you have any questions or would like additional information, please call me at (202) 512-2900 or Kwai-Cheung Chan, Director of Program Evaluation in Physical Systems Areas, at (202) 512-3092. Other major contributors are listed in appendix IV.

Sincerely yours,



Terry E. Hedrick
Assistant Comptroller General

# Contents

# Appendix IV Major Contributors to This Report

## Abbreviations

| | |
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| AFIP | Armed Forces Institute of Pathology |
| CDC | Centers for Disease Control and Prevention |
| DIA | Defense Intelligence Agency |
| DOD | Department of Defense |
| EPA | Environmental Protection Agency |
| FDA | Food and Drug Administration |
| GAO | General Accounting Office |
| HHS | Health and Human Services |
| NRC | Nuclear Regulatory Commission |
| VA | Veterans Affairs |
| VOC | Volatile organic compound |

# Assessments Before Deployment

In this appendix, we provide detail about our first and second evaluation questions: What types of assessments were performed before the deployment of troops to the Persian Gulf to determine the potential for exposure to reproductive toxicants, and were specific reproductive toxicants considered or identified? Military personnel who were deployed to the Persian Gulf war were exposed to a variety of hazards. We discuss some of these hazards and the types of assessments DOD performed before troop deployment.

## Occupational Hazards

Each service has an occupational hazard assessment program that is part of each weapon's procurement process. If toxicants (such as CARC, or chemical agent-resistant coatings, paint) are found to be present during assessments, then warnings and training are afforded personnel who perform duties with the weapon and its toxicants. For example, the health hazard assessment report for the armored gun system outlines the health hazards of concern (chemical substances, temperature extremes, radiation energy, acoustic energy, oxygen deficiency, and whole-body vibration) and ways to mitigate or avoid these hazards (for oxygen deficiency, the report recommends ensuring that "the personnel heater blower is turned on and drawing outside air whenever crew members are inside the crew compartment with the hatches closed"). The examples below from each of the services highlight some of the activities that arise through the health hazard process for occupational hazards.

The assessments performed through the Army's preventive medicine regulation (Army Regulation 40-5) are part of the reproductive hazards program as it pertains to the overall health hazard assessment program. This includes actions such as informing employees about potential work area reproductive hazards, identifying work areas or occupations that present potential reproductive hazards, informing women about the availability of job accommodation or transfer in the event of pregnancy, and assessing the employee's job assignment and work environment when pregnancy is known.

The Navy's guide on reproductive hazards in the workplace (Technical Manual NIHC-TM-92-2) lists occupational chemical and biological reproductive hazards. Additionally, the Navy has drafted a chapter on occupational reproductive hazards for its occupational safety and health program manual (OPNAVINST 5100.23C CH-1) that outlines control of reproductive hazards in the workplace, hazard abatement, training, medical surveillance, and counseling. As noted in this draft regulation, no

one can be denied employment because of potential exposure to reproductive hazards. Nevertheless, hazard identification, abatement, training, surveillance, and counseling are all part of the effort to inform personnel of potential reproductive toxicants.

The Air Force is currently revising its regulations (AFR160-12(C4)) on the care of pregnant personnel. Other pertinent information on occupational hazards is presented in the Air Force safety occupational health standard (161-117) and hazard communication guidelines. This includes the monitoring of personnel by physicians, bioengineers, and military public health officers.

Thus, in regard to occupational hazards, assessments performed before the deployment of troops to the Persian Gulf war to evaluate for potential reproductive toxicants would be performed through such programs as the health hazard assessment program of each service.

## Infectious Diseases

The Armed Forces Military Intelligence Center and the Army Institute of Research, Division of Preventive Medicine, performed work on infectious diseases endemic to the Persian Gulf region and outlined ways in which service personnel should attempt to avoid or minimize exposure to diseases such as leishmaniasis and malaria. In regard to such diseases, the information forwarded to medical personnel before troop deployment did not outline any possible reproductive side effects (except for sexually transmitted diseases).

## Prophylactic Agents

DOD provided three prophylactics against the possible use of chemical and biological agents. Anthrax and botulinum toxoid vaccines and pyridostigmine pills were given to soldiers to counteract the effects of chemical or biological weapons if Iraq used such agents.

Studies on animals had been performed on the safety and efficacy of the anthrax vaccine, and it was approved by the Food and Drug Administration (FDA) in 1972. The botulinum toxoid vaccine (an investigational drug) has been given to more than 3,000 people as a result of potential exposure to the bacterial toxin over the past 20 years at the Army Medical Research Institute of Infectious Diseases. CDC has also given this vaccine thousands of times to individuals who work where exposure is likely. According to DOD, no serious long-term side effects have been reported in these instances. As a result, DOD has not conducted long-term

studies on reproductive problems associated with receiving these vaccines from these occupational settings.

Pyridostigmine, an investigational drug, has been used for decades to treat patients with myasthenia gravis (a neuromuscular disease). There has been no documentation to suggest any serious long-term adverse reproductive effects from exposure to pyridostigmine in these patients and, thus, no long-term studies have been conducted on such possible reproductive effects. DOD's decision to use this drug in the Persian Gulf war was based on this history.

However, DOD did perform studies before and after the war on the use of pyridostigmine over short periods of time and found short-term side effects such as gastrointestional problems, headaches, and muscle cramps. These studies excluded women and also men who might be hypersensitive to pyridostigmine (those with asthma or high blood pressure, on medication, and smokers). It may be important to include women as well as men since efficacious dose levels may depend on weight. Also, possible reactions to pyridostigmine for those hypersensitive to the drug were not investigated to ascertain any possible adverse reactions (see appendix III).

In other words, in regard to prophylactic agents, no assessments were performed by DOD on the possible reproductive effects of these agents before troops were deployed to the Persian Gulf war. For the vaccines, DOD has noted that work has not been done because no evidence from use in occupational settings has suggested any possible adverse reproductive effects. Also, we found no studies that have been performed on possible adverse reproductive effects on healthy individuals who take pyridostigmine, and DOD excluded potentially useful groups from its studies on pyridostigmine.

## Oil-Well Fires and Petrochemicals

DOD did not assess the potential reproductive effects of exposure to oil-well fires before deployment because such fires were not expected. There were also no studies on other petroleum exposure reported in the Persian Gulf war—using diesel fuel as a sand suppressant, drying sleeping bags with leaded exhaust, and so on—because these activities were not standard operating procedures that soldiers were trained to perform.

## Depleted Uranium

The Army conducted studies before deployment on exposure rates for soldiers in Abrams tanks, which contain depleted uranium in portions of

their armor and ammunition. These studies found that soldiers in equipment that contained depleted uranium were not exposed to radiation that exceeded Nuclear Regulatory Commission (NRC) standards from either the ammunition carried by the tanks or the armor plating. Thus, no studies were performed that might have ascertained any potential reproductive effects, because DOD had determined, based on NRC standards, that exposure rates were not high enough to produce any such effects.

## Pesticides

The pesticides DOD used in the Persian Gulf war were commercially available products registered, approved, and labeled by EPA that had undergone safety and efficacy studies. These products would have had to pass EPA's guidelines on safety and efficacy, including animal studies on teratogenicity and reproduction, as well as chronic toxicity studies that assess mutagenicity.

DOD did not assess the risks of these products in regard to reproductive toxicity independently from EPA. Additionally, according to a DOD representative, most products used were below the toxicity levels found in commercially available products and after-action reports from the DOD medical community did not highlight any troops complaining of symptoms that would mirror pesticide overexposure. Lastly, this representative noted that symptoms from acute pesticide poisoning were not similar to the complaints experienced by those who were complaining of "Desert Storm syndrome."[1] However, these symptoms do, in fact, mirror some of the most common complaints made by those in the VA Gulf registry. Actual exposure levels in the gulf are unknown and, thus, any EPA guidelines on proper use and exposure rates may or may not have been followed. Additionally, the long-term effects of exposure to these compounds and whether EPA reviews for safety and efficacy were performed for similar conditions of use found in the gulf war are unknown.[2]

As noted previously, some of the items DOD used could possibly affect male and female reproductive capacity, and the concentration of exposure to these pesticides in the war are unknown. The exposures in the gulf could have been high and widespread given certain instructions, such as

[1]Symptoms from pesticide overexposure include sweating, muscle spasms, and hard breathing.

[2]EPA guidelines on labeling requirements specify that where a human hazard exists, precautionary statements are required to indicate the particular hazard, the routes of exposure, and the precautions to be taken to avoid accident, injury, or damage.

on the use of repellents, which state that the "entire uniform exterior must be sprayed until it looks wet."

## Chemical and Biological Agents

DOD identified approximately 48 studies that examined the effects of small amounts of nerve agents being administered to humans (70 percent of which involved Sarin). There were also studies that examined accidental exposure to Sarin in manufacturing settings and in depot workers. These studies suggest that mustard agent can affect DNA and could cause genetic damage, thus making it a potential reproductive toxin.[3] There have been no studies examining the effects of prolonged exposure (lasting several weeks) to very low levels of chemical and biological agents, which is what some have argued may have occurred in the Persian Gulf war.

However, DOD strenuously disputes such arguments regarding exposure to chemical or biological agents through either offensive use by Iraq or fallout from bombed chemical facilities. Additionally, a Defense Science Board task force on Persian Gulf war health effects noted that it found no evidence that either chemical or biological warfare was deployed at any level against the United States or that there was any exposure of U.S. service members to such agents.

In regard to assessments of reproductive toxicants performed before deployment, several studies have examined the effects of chemical agents on humans exposed in occupational settings. However, the Army has concluded that the studies have been insufficient to determine the nature of any reproductive toxicity or developmental malformation to such exposure.

## Synergistic Effects of Hazardous Exposure

No assessments were made before the deployment of troops of the potential effects of being exposed to multiple sources of hazards (prophylactics, insecticides, occupational hazards, chemical agents, and so on) and their possible effects on reproductive dysfunction. It has been suggested that multiple exposure might result in symptoms that would not normally appear if an individual were exposed simply to one of the hazards. Furthermore, a National Institutes of Health workshop concluded that the biological, chemical, physical, and psychological complexity of the Persian Gulf environment appears to have had complex health results

[3]C. M. Pechura and D. P. Rall, Veterans at Risk: The Health Effects of Mustard Gas and Lewisite (Washington, D.C.: National Academy Press, 1993).

for primary military personnel (for information on this workshop, see appendix III).

From the information we have noted above, we concluded that before troops were deployed to the gulf, assessments were performed on many hazards. However these assessments did not include possible exposure to reproductive toxicants except for work performed during occupational health hazard assessments.

# Protection and Education Against Toxicants

In this appendix, we provide detail about our third evaluation question: If reproductive toxicants were considered or identified, what types of protection were provided to active duty personnel against the toxicants, and what efforts were made to educate them about how to avoid the toxicants? (Whether or not DOD considered such toxicants, we were asked to provide a list of likely substances that could have potentially resulted in reproductive toxicity. A list of substances we found present in the region is given in the body of the letter.) Here, we outline the protection and education afforded troops during deployment for the hazards noted in appendix I.

## Occupational Hazards

Protection and training of DOD personnel for occupational hazards were part of the health hazard assessment process noted in appendix I. Such programs are intended to train and educate soldiers on the hazards associated with the toxicants present in their work environment. However, some activities would not have been covered by such programs (laying diesel fuel around encampments as a sand suppressant, burning human waste with fuel oil, leaking fuel into shower water, drying sleeping bags in leaded exhaust, and so on). It is unclear what effect, if any, such activity would have in regard to reproductive effects.

## Infectious Diseases

The Army Institute of Research, Division of Preventive Medicine, provided a pamphlet to all medical personnel deployed to the Persian Gulf entitled "The Threat of Disease and Non-Battle Injury to U.S. Military Personnel on Operation Desert Shield." It included information on the medical threat assessment for each disease as well as recommendations on treatment. For example, it was recognized that permethrin should be applied to bed netting because the mesh used around tents was too large to be a barrier to small sand flies (which carried leishmaniasis) and that the entire uniform exterior had to be sprayed with permethrin repellent "until it looks wet."

## Prophylactic Agents

The botulinum toxoid vaccine and pyridostigmine pills were investigational drugs and, as such, it was required by law that their use be given with informed consent. However, FDA gave DOD a waiver on informed consent because obtaining it during wartime "would not have been feasible." The reasons DOD gave on applying for the waiver were that it was essential that all troops receive treatment because chemical agents could be lethal, that protection of each individual was also important to others

whose safety depended on the integrity of the unit and the ability of all persons to perform their assigned duties and allowing choice could jeopardize the lives of others, and that the success of the military goals depended on preserving the health and capability of the military force.

As a result of the consent waiver, DOD did not provide service members a choice as to whether they would or would not receive the botulinum toxoid vaccines or pyridostigmine pills.[1] Information on the packets of pyridostigmine pills (21 pills) given to the troops did indicate that they should be taken once every 8 hours and that it was "dangerous to exceed the stated dose." Thus, military personnel were given packets that contained the proper number of pills for the required dose levels, and information contained on the packet outlined proper dosage for pyridostigmine, but the instructions did not outline how long the pills should be taken.

## Oil-Well Fires and Petrochemicals

DOD provided guidance on the hazards of the oil-well fires during the deployment of U.S. troops to the gulf. This included advising military personnel on how to avoid smoke plumes when possible and frequent washing to keep skin free of soil and soot. Medical personnel were also alerted to possible lung irritation from exposure to the oil fires. Guidance was also given on protective measures such as using goggles, disposable face masks, or scarves; rolling down sleeves when encountering smoke from the oil fires; restricting physical activity; and staying away and upwind from burning wells.

This information was communicated through fax and teletype messages to the field, briefings, and announcements over Armed Forces Radio. However, the extent to which troops received or adhered to the guidance is unknown. Also, as noted in appendix I, DOD training practices did not expect exposure to oil-well fires or other hazards containing petroleum products. These latter hazards included human waste burned with leaded fuel oil, fuel leaked into shower water, and kerosene heaters lit with leaded fuels. The extent of these hazards is not known.

## Depleted Uranium

Training and education afforded soldiers on the hazards of depleted uranium should have occurred prior to troop deployment in the gulf. This would have included information on the handling of depleted uranium

[1]The anthrax vaccine was an FDA approved drug, and thus, DOD did not have to receive a consent waiver in order to give this vaccine to service members.

ammunition and amounts of radiation to which soldiers would be exposed. However, in regard to external exposure (not embedded) to depleted uranium we recently concluded that "the Army has not effectively educated its personnel in the hazards of depleted uranium, contamination and in proper safety measures appropriate to the degree of hazard."[2] Additionally, training is limited to Abrams tank personnel, munitions handlers, and explosive ordinance disposal personnel and does not extend to all members of military occupations that might come into contact with contaminated systems.

## Pesticides

A pamphlet provided by the Walter Reed Army Institute of Research Division of Preventive Medicine that was to be given to medical care personnel in the gulf war outlined the proper usage of DEET and permethrin, the major pesticides used in the Persian Gulf. It also noted how military personnel should avoid exposure to pests endemic to the region by applying insecticides to sand fly habitats around human dwellings. For example, directions were provided in this pamphlet on the proper use of a DEET-containing repellent lotion for skin and a clothing repellent, permethrin. However, as noted previously, the extent to which such information was provided to medical personnel is unknown.

A DOD official stated that the products used were all commercially available and had been used extensively by both DOD and the public. Also, according to this official, concentrations of the pesticides were lower than those used in agricultural settings because DOD was aware that usage in a military setting would result in these pesticides being in much closer proximity to humans than is usual in normal agricultural uses.

## Chemical and Biological Agents

DOD provided chemical monitors and chemical suits in the event of a chemical attack. Training was provided before deployment on the proper usage of chemical suits and the proper way to detect and confirm a chemical attack through the use of chemical monitors and test kits. Additionally, according to DOD training guidelines, soldiers were to be trained prior to deployment regarding procedures for self and buddy aid and individual decontamination. Lastly, there were DOD regulations on the treatment of chemical agent casualties and conventional military chemical injuries. However, as we noted in a report issued just after the Persian

[2]U.S. General Accounting Office, Operation Desert Storm: Army Not Adequately Prepared to Deal With Depleted Uranium Contamination, GAO/NSIAD-93-90 (Washington, D.C.: January 1993), p. 2.

Gulf war, chemical training and equipment were inadequate and significant equipment shortages and deficiencies existed.[3]

## Synergistic Effects of Hazardous Exposure

There was no training and no education on the avoidance of exposure to multiple hazards.

## Potential Reproductive Hazards

We reviewed the possibility of reproductive dysfunction in each of the categories discussed above. We found three where reproductive toxicants were suspected: pesticides, substances from the oil-well fires, and decontaminating agents. As a result, we obtained lists of all pesticides used in the Persian Gulf war, a list of all compounds found in the oil-well fires, and information on decontaminating agents. These substances were matched to a list we developed on reproductive and developmental toxicants as well as information from the toxicology literature.

According to these sources, several substances present in the Persian Gulf war could cause reproductive dysfunction (see the body of the letter for a list of these substances). However, in some cases, it is currently unknown at what concentrations these substances cause adverse reproductive outcomes or what concentrations existed in the gulf. Additionally, other substances and hazards could cause reproductive dysfunction. One possibility is the synergistic effects of pyridostigmine and pesticides; another is the effects of pesticides on host defense mechanisms.[4] To date, DOD, VA, and HHS have no efforts under way to examine these possible synergistic relationships as they relate to exposure found in the Persian Gulf war.

Thus, the training and education afforded the soldiers of Operation Desert Shield and Desert Storm were minimal in regard to reproductive toxicants (except for occupational hazards through the health assessment programs of the services). DOD provided little information or additional training for these potential reproductive toxicants.

[3]U.S. General Accounting Office, Chemical Warfare: Soldiers Inadequately Equipped and Trained to Conduct Chemical Operations, GAO/NSIAD-91-197 (Washington, D.C.: May 1991).

[4]Some studies illustrate marked effects on the immune system from exposure to pesticides. Some of these substances were used in the Persian Gulf war (carbaryl, dichlorvos, lindane, and malathion).

# Monitoring for Reproductive Dysfunction

In this appendix, we provide detail about our fourth evaluation question: To what extent are active duty military personnel and veterans currently monitored for reproductive dysfunction that may have resulted from duty in the Persian Gulf? Several studies and monitoring efforts have been undertaken since the end of the war. For the efforts listed below, we describe concerns regarding whether reproductive issues have been, or will be, addressed.

## VA and DOD Registry and Examinations

### VA Registry and Examination

The VA presently conducts a registry and examination for Persian Gulf veterans who ask to be placed on the registry or want to have a Persian Gulf registry examination. There are now approximately 20,000 soldiers on this registry. The original registry code sheet asked if "there is evidence of birth defects among veteran's children" and categorized children by whether they were conceived before or after deployment to the Persian Gulf.

A revised code sheet is to include additional questions on infertility and miscarriages. Examinations on certain reproductive indexes, such as sperm counts, will be done only if medically indicated. The VA does not yet know whether this revised questionnaire will be provided to the veterans who have already completed the original questionnaire and examination.

### DOD Registry and Examination

A revised DOD registry has recently been established that will allow gulf veterans to place themselves on it; included will be a standardized general physical examination comparable to the VA Persian Gulf registry examination. The DOD registry is a three-phase evaluation process. The purpose of the phase I evaluation is to establish definitive diagnoses for patients' health complaints related to the Persian Gulf. If the health care provider or a patient is not satisfied with the explanation given for the illness, the patient is evaluated at a regional military medical center under the phase II protocol, which consists of supplemental baseline laboratory tests and consultations. Again, if the health care provider or patient is not satisfied with the results of these examinations, the patient can receive a phase III evaluation, which consists of a special individualized evaluation, including questions concerning chemical intolerance. Patients who after

this phase still have unexplained complaints or findings are considered to provisionally have illness related to service in the Persian Gulf. Records of these individuals will be reviewed by a special clinical review committee.

Nonroutine diagnostic studies, including reproductive evaluations such as sperm counts, will be performed "only if medically indicated." Those who are eligible include Persian Gulf veterans who are on active duty or retired, who are on full-time National Guard duty and who are members of the Ready Reserve, and family members of such personnel who are eligible beneficiaries within the Military Health Services System.[1] Veterans of the Persian Gulf war may be part of both the VA and DOD registries.

Concerns about the VA and DOD registries include (1) self-selection bias, (2) possible failure of the registries to capture all reproductive problems (infertility, for one), (3) possible failure of the revised VA registry to capture reproductive problems of earlier registrants, and (4) the use of nonroutine diagnostic studies only if medically indicated.

In regard to this latter point, some have noted that it will be impossible to obtain a comprehensive overview of possible reproductive problems being experienced by gulf veterans unless certain studies (such as sperm counts) are performed on all gulf veterans who present themselves to the VA or DOD registries. Questions on the revised VA code sheet for their examination that attempt to ascertain whether veterans or their spouses are having reproductive problems is a first step in overcoming this problem.

Additionally, two other issues have arisen in our discussions with a limited number of veterans. First, some believe that not all gulf veterans know about the DOD and VA registries, and, second, there are reports of active duty personnel being directly or indirectly pressured not to report their illnesses (based on fear among personnel that they may lose their positions during military downsizing if they do report their illnesses). However, the extent of these problems is unknown and, as noted previously, DOD officials have stated that official policy has been to encourage participation in the registries.

[1]By law, the VA can treat spouses or children of veterans only if the veteran has been killed or totally disabled. Some have suggested that this should be changed if it is found that the illnesses being experienced by Persian Gulf veterans are transmittable.

# Reproductive Studies

## DOD Reproductive Study

An epidemiologic study of morbidity among veterans is planned and has been assigned to the Navy Medical Research Center in San Diego, California. The study's protocol proposes three studies. One of these is to examine the effects on any children born to gulf veterans with that of nongulf veteran controls.

The study population will be approximately 350,000 gulf veterans, while the control group will consist of 700,000 military personnel who were not deployed to the Persian Gulf. The hypothesis to be tested is that there is no difference in the incidence of fetal death, premature birth, serious birth defects, and neonatal deaths between the two populations.

Our concern regarding this study is that it will examine records of active duty personnel only from DOD hospitals (the only data that are presently available for this study). Thus, active duty personnel who choose to have a child outside the DOD hospital system will not be included. DOD does not intend to collect indexes on birth outcomes for military personnel who served in the reserves, nor on other reproductive indicators such as infertility and miscarriage rates, because these data do not presently exist. This missing information could be increasingly important to have available to serve as baseline data against reproductive outcomes from military personnel who serve in future conflicts, especially if the reserve components begin to make up a larger portion of the U.S. fighting force.

## Mississippi Cluster Study

The VA, CDC, and Mississippi State Department of Health have studied the birth outcomes of an Army Reserve unit from Waynesboro, Mississippi, that had complained of abnormally high rates of birth defects after the reservists had returned from the Persian Gulf. The study sponsors concluded that initial results of this study indicated a normal rate of birth defects for this group, although the size of the group (N = 51) was rather small.

The study sponsors also indicated that they were unwilling to make a final conclusion until all medical records from the Mississippi group were collected (given the need for parental consent to obtain these records, this may never occur). As noted previously, the sponsors decided not to

perform a before-and-after comparison for this group because of expected difficulties in obtaining adequate medical records.

One of our concerns regarding the methodology used to ascertain whether the Mississippi group had an abnormal rate of birth defects was the comparability of the two groups. While CDC's data from the Atlanta metropolitan area constitute a standard set of data accepted among experts for measuring birth defect rates, it is possible that the Mississippi reservists were a healthier set of individuals than the overall population in this Atlanta data base with the social, economic, and health issues that may arise in a large metropolitan area. Thus, if the rate of serious birth defects of the Mississippi reservists turned out to be no higher than predicted by the Atlanta comparison group, it is very unclear as to whether this would, or would not, indicate a problem among the Mississippi veterans.

Moreover, the sponsors decided not to conduct a before-and-after comparison of birth outcomes for the group in Mississippi (conceptions before and after service members were deployed to the gulf). The sponsors thought that it would have been very difficult to obtain a complete and accurate set of medical records for this group, while a before-and-after study would have had its own complications, it might have shed additional light on the possible effect of the gulf war on this group of veterans.

Finally, the size of the Mississippi group is quite small. A comparison of this small group to any other control group, or even with its own members before the war, cannot conclusively prove that the deployment to the Persian Gulf did or did not cause an abnormally high birth defect rate. Any conclusive determination of whether this group of veterans are experienceing abnormally high reproducive dysfunction or their children are experiencing related problems would require far more extensive research and tesing than has been done or is currently planned.

## Army Surgeon General's Office Data Collection Efforts

The Army Surgeon General's Office has collected data that highlight major and minor birth defect rates for live births of active duty personnel at all Army hospitals. Data were collected for all live births from 1985 to 1993 (N = 346,322). The rate for major and minor birth defects for this period ranged from 5.8 percent to 9.6 percent, which is within the range of 8 to

17 percent that is expected.[2] This was also the case for the 2 years 1992 and 1993 immediately following the gulf war. Thus, birth defects rates for those years fell within the range that was expected. However, these results cannot be generalized to either the DOD population as a whole or gulf veterans, since they include only active duty Army personnel who had their babies in Army hospitals during 1985 to 1993.

# Cross-Cutting Efforts

## NIH Technology Assessment Workshop

A recent NIH technology assessment workshop was convened to examine the evidence for an increased incidence of unexpected illnesses attributable to service in the Persian Gulf war and the plausible etiologies and biological explanations for these unexpected illnesses. The expert panel concluded that the biological, chemical, physical, and psychological complexity of the Persian Gulf environment appears to have resulted in complex health effects on the military personnel who served in the gulf. It also noted that "congenital malformations have been reported in the offspring of people who served in the Gulf area. The currently available data are not sufficient to determine whether the incidence is increased."[3]

## Defense Science Board

The Defense Science Board task force on gulf war health effects reviewed available intelligence and reports of chemical and biological detections. It was also to examine the scientific and medical evidence relating to exposure to nerve agents at low levels and the long-term health effects of such exposures. Finally, it was to review other possible causes of the so-called "Persian Gulf syndrome."

A report on these efforts was released in June 1994 and noted that DOD needed "substantial improvements in pre- and post-deployment medical assessments and data handling." It also outlined cases of birth defects that had been self-reported in the VA registry. The report concluded that the nature of the birth defects was not defined or verified and the occurrences of these birth outcomes were based on self-reports. No other information in the report specifically addressed reproductive issues.

[2]Expected rates are commonly excepted levels based on data from the Metropolitan Atlanta Birth Defects Monitoring Program and scientific literature in the field of pediatrics. There was no breakdown of major versus minor defect rates in the DOD data.

[3]National Institutes of Health, workshop statement from NIH Technology Assessment Workshop on the Persian Gulf Experience and Health, Washington, D.C., April 27-29, 1994, p. 5.

## Institute of Medicine

The Institute of Medicine, National Academy of Sciences, is reviewing existing scientific, medical, and other information on the consequences to health of military service in the Persian Gulf theater of operations. The committee examining this issue will conduct a 3-year study and prepare a final report. The committee has not yet made a decision as to whether it will examine reproductive issues and determine if future research is needed in this area.

## Kuwait-Persian Gulf Registry

The Kuwait-Persian Gulf registry at the Armed Forces Institute of Pathology (AFIP) is to be a central repository for tissue, body fluids, and clinical and laboratory data related to personnel who served in the Kuwait theater of operations. This material is to be collected, catalogued, and stored from over 230 military hospitals. AFIP has analyzed biopsies and some blood specimens from Persian Gulf veterans for metal content and, to date, there is no evidence of unique or new diseases or statistically significant increases in the incidence of well-known diseases. It is also anticipated that autopsy material from Persian Gulf veterans will be forwarded from VA and military hospitals to AFIP for review and inclusion in the registry. AFIP also plans to collect genito-urinary organs of both sexes in its usual sampling and study during autopsies to be performed in the future on gulf veterans.

AFIP also conducted autopsies on 302 military personnel who died in the Persian Gulf war. Histopathologic examinations were conducted in 60 cases. To date, according to AFIP, no pathologic lesions could be clearly related or attributable to an environmental exposure.

## Navy Construction Battalion Study

The Navy Environmental and Medicine Unit conducted a study of symptomologies of the 24th Construction Battalion, which had a high incidence (N = 155) of soldiers complaining of illnesses after their return from the gulf. However, this study included only a breakdown of symptoms reported by the reservists from answers to a questionnaire survey and did not perform any examinations. Additionally, no information was collected on birth outcomes from these soldiers and their spouses or other reproductive issues such as infertility or miscarriage rates.

# Infectious Diseases

Studies have been conducted by the Walter Reed Army Institute of Research on visceral infection caused by leishmaniasis in veterans of the

Gulf war.[4] The findings of one study concluded that "there is no diagnostic test to detect infection or early manifestations of systemic disease. The use of the classic diagnostic criterion of visualization of parasites detects only cases of disease in which the parasite burden is high."[5] The study also concludes that diagnosis still requires procedures such as bone-marrow aspiration or lymph-node biopsy. However, no such tests are routinely performed by any of the examinations conducted by the VA or DOD (discussed above). This is also problematic because incubation periods of up to 10 years have been reported for Leishmania donovani, one variant of leishmaniasis. It is yet unknown whether Leishmania tropica (the form of leishmaniasis present in the Persian Gulf war) has similar incubation periods or can produce reproductive dysfunction.

## Prophylactic Agents

DOD performed four retrospective surveys to determine the adverse effects of pretreatment with pyridostigmine for nerve agent exposure. These studies indicated that there were several types of reaction to taking the pill including headaches, nausea, diarrhea, abdominal cramps, and other stomach problems. Furthermore, in two of these studies, between one quarter and one third of the individuals taking the pills reported having these types of side effects.

Additionally, as one study noted, the side effects appeared to be most severe in individuals of smaller size. This has raised concerns regarding differences in effects between men and women, since the dosage was the same for all personnel. The studies noted above excluded women and those who might be hypersensitive to pyridostigmine as well as the potentiality that these pills might cause adverse reproductive effects. There have also been no further studies on the safety of the botulinum toxoid or anthrax vaccines and their potential effects on reproductive outcomes. (See appendix I for studies that have been performed on these prophylactic agents.)

[4]Leishmaniasis is a condition transmitted by sand flies in which skin lesions commonly evolve into painful nonhealing ulcers. According to DOD, the disease is not acutely debilitating, but its presence can be psychologically disturbing and inpatient treatment can be prolonged.

[5]Alan Magill et al., "Visceral Infection Caused by Leishmania Tropica in Veterans of Operation Desert Storm," New England Journal of Medicine, 328:19 (May 1993), 1386.

# Oil-Well Fires and Petrochemicals

## CDC Study

Studies have been initiated to examine the possible effects of the oil-well fires and illnesses reported by gulf veterans. A CDC study examined volatile organic compounds in the blood of military personnel (N = 54) in Kuwait during the oil-well fires and compared these to levels found in oil-well firefighters.

That study found elevated concentrations of volatile organic compounds (VOCs) among oil-well firefighters compared to the group in Kuwait. However, the study examined only 14 U.S. personnel in Kuwait in May 1991 and 40 oil-well firefighters in October 1991 (both well after the oil fires had begun). Also, many of the VOCs evaluated have a half life of less than 4 hours. Thus, it would be difficult to discern any comparability between results found in the CDC study and exposure rates among servicemen and servicewomen during the war. In fact, the study concludes that "these results cannot be used to assess the health effects from exposure to VOCs in Kuwait. We know of no studies that have evaluated the potential adverse health effects of VOC levels similar to those found in this study."[6]

The study did not examine reproductive outcomes. However, the results that showed higher concentrations of VOCs in the blood of the firefighters might be relevant for this issue, given that several compounds noted in our list of potential reproductive toxicants were from the oil fires.

## AFIP Study

A study by AFIP's department of environmental and toxicologic pathology performed three examinations of metal concentrations in the blood and urine from approximately 200 members of the 11th Armored Cavalry Regiment as part of a larger biological surveillance initiative. The report found that metal concentrations were within acceptable reference ranges.

The main concerns regarding this study, from a methodological point of view, are that the samples may have been taken well after direct exposure to the oil-well fires and that the exposures experienced by this group may be dissimilar to those experienced by troops deployed during the Persian

[6]Ruth A. Etzel and David Ashley, Volatile Organic Compounds in the Blood of Persons in Kuwait During the Oil Fires (Atlanta, Ga.: Centers for Disease Control and Prevention, National Center for Environmental Health, 1991), p. 12.

Gulf war, since these samples were collected in June, August, and October 1991. Again, reproductive issues are relevant in that our list of reproductive toxicants denotes several compounds from the oil-well fires that are metal compounds (cadmium, lead, mercury, and nickel).

The initiative noted above may also be relevant in assessing potential reproductive effects from service in the war. It is part of a large report by the Army Environmental Health Agency on environmental hazards in the Persian Gulf war that was expected to be completed in June 1994. However, the study is mainly concerned with possible carcinogenic effects and has not specifically examined possible reproductive effects from exposure to oil-well fires.

## Depleted Uranium

The Armed Forces Radiobiology Research Institute released three reports on depleted uranium in March 1993 assessing the risks from exposure to embedded fragments of depleted uranium, a protocol for monitoring gulf war veterans with embedded fragments of depleted uranium, and a question-and-answer format regarding concerns about depleted uranium.

Possible routes of exposure to depleted uranium during the war would have been through external exposure, inhalation of aerosol, or embedded fragments. As noted earlier, we concluded in a recent report that "the Army has not effectively educated its personnel in the hazards of DU [depleted uranium] contamination and in proper safety measures appropriate to the degree of hazard."[7]

Furthermore, that report also concluded that "troops externally exposed to DU [depleted uranium] radiation . . . were unlikely to have been exposed to levels that exceeded the Nuclear Regulatory Commission's (NRC) annual regulatory limits for radiation exposure for the general public."[8] However, we reported that Army and NRC officials stated that the relationship between radiation dosage and health risks at low levels of exposure are not clearly understood, and compliance with NRC limits did not eliminate the risk of future health problems. DOD has no plans to medically evaluate the personnel who might have been externally exposed to depleted uranium (that is, those involved in recovering damaged or destroyed vehicles).

[7]U.S. General Accounting Office, Operation Desert Storm: Army Not Adequately Prepared to Deal With Depleted Uranium Contamination, GAO/NSIAD-93-90 (Washington, D.C.: January 1993), p. 2.

[8]U.S. General Accounting Office, Operation Desert Storm, pp. 2-3.

Uranium studies have shown that inhalation of uranium can cause irreparable damage to the kidneys. However, according to studies performed by DOD and the National Materials Advisory Board, no soldier was exposed to levels high enough to meet NRC's minimum exposure rates. With regard to embedded fragments, "the radiological and toxicological hazards associated with long-term exposure to embedded fragments are uncertain and there are no known studies involving the long term implantation of uranium in tissues."[9] A protocol has been developed to track long-term health effects in soldiers who have embedded fragments of depleted uranium, although the protocol does not outline any work to be performed on possible reproductive dysfunction among these soldiers.

## Pesticides

Since EPA has found during its regulatory review that pesticides used in the war are safe and effective, DOD has not performed any additional studies. However, as noted previously, several pesticides in use contained compounds that could result in reduced reproductive capacity, but it is not yet known at what concentrations service personnel were exposed to pesticides during their deployment to the gulf, whether any of those exposures were high enough to be problematic, or whether the EPA reviews for safety and efficacy were performed for similar conditions of use found in the gulf war.

## Chemical and Biological Agents

The Defense Intelligence Agency (DIA) assessed the potential use of chemical agents or fallout from bombed facilities that may have reached U.S. forces. According to DIA representatives, there was no clear evidence of either agents or fallout. However, DOD termed "credible" a Czechoslovakian report of a chemical agent detection. The DIA position on this detection was that it could not have been caused by fallout from a bombed Iraqi facility or through a direct attack. The most logical explanation, according to DIA, was that the detection was a result of live agent testing of the Czechoslovakian equipment or a possible accident involving chemical agents among coalition forces. Regardless of the explanation, the VA and DOD have not entirely ruled out possible exposure of Persian Gulf war veterans to chemical agents. However, as noted previously, a Defense Science Board report concluded that no U.S. service members were exposed to chemical agents or fallout from bombed chemical facilities.

[9]Eric Kearsley and Eric Daxon, Depleted Uranium: Questions and Answers (Bethesda, Md.: Armed Forces Radiobiology Research Institute, March 1993), p. 4.

## Synergistic Effects of Hazardous Exposure

There have been no studies since the end of the Persian Gulf war on the synergistic effects of the multiple chemical and biological hazards encountered during deployment and possible adverse reproductive outcomes. As noted previously, some work on combined exposure to pyridostigmine and DEET has been performed that indicates a tenfold increase in the toxicity of the DEET compound.[10] However, these are tentative conclusions that were based on research performed on cockroaches, and the research work has not yet been replicated by other scientists. Also, in regard to possible synergistic effects, the National Institutes of Health workshop concluded that future research is needed on "well-designed case-control studies that include detailed exposure information for those reporting symptoms and for appropriately selected controls" and that simulations should be conducted on other exposure scenarios involving such substances as petroleum and insecticides.[11]

## Summary

Current monitoring efforts for reproductive dysfunction are mainly being examined through the VA and DOD registries. However, these registries have methodological problems in terms of coverage and do not ascertain certain key indicators such as rates of infertility and miscarriage and other forms of reproductive dysfunction. Most other work performed after the end of the gulf war on the different hazards present in the war have not been directed at ascertaining if exposure to these hazards could result in reproductive dysfunction.

[10]Preliminary work performed by James Moss, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida.

[11]National Institutes of Health, draft of workshop statement from NIH Technology Assessment Workshop on the Persian Gulf Experience and Health, Washington, D.C., April 27-29, 1994, pp. 16-17.

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