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Report to the Chairman, Subcommittee on National Security, Veterans' Affairs, and International Relations, House Committee on Governmental Reform

April 2001

COALITION WARFARE

Gulf War Allies Differed in Chemical and Biological Threats Identified and in Use of Defensive Measures

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United States General Accounting Office
Washington, DC 20548

April 24, 2001

The Honorable Christopher Shays
Chairman
Subcommittee on National Security, Veterans' Affairs, and International Relations
Committee on Government Reform
House of Representatives

Dear Mr. Chairman:

The Persian Gulf War that began in 1990 brought together an international coalition of forces against a single adversary (Iraq) that was suspected of possessing weapons of mass destruction, such as biological, chemical, and radiological arms. The nations belonging to the Gulf War Coalition independently assessed the nature and extent of these threats and took a variety of defensive measures, including storing or administering specific drugs and vaccines. Exposure to weapons of mass destruction and defensive measures against these exposures are being evaluated as possible causes of the illnesses many veterans in the United States (U.S.) and the United Kingdom (U.K.) have reported subsequent to their service in the Gulf War.

To address speculation that, owing to differences in their preparation, French forces had reported fewer illnesses following the war than U.S. or U.K. veterans, you asked us to examine differences among the U.S., U.K., and French forces with regard to (1) their assessment of threats from Iraqi weapons of mass destruction immediately prior to the conflict and the extent to which they shared these assessments and information about associated targets; (2) their approaches to chemical, biological, and radiological defense, including their use of protective gear and specific drugs and vaccines; and (3) the extent of illnesses reported by each country's veterans.

Results in Brief

The United States, United Kingdom, and France differed in their assessments of the types of weapons of mass destruction that Iraq possessed and Iraq's potential for using these weapons during the Gulf War. With respect to biological agents, both the United States and United Kingdom regarded anthrax and botulinum toxin as potential threats, but only the United Kingdom thought it likely that Iraq would use plague. France did not identify any imminent biological warfare threat. All three

countries agreed that the Iraqis might use some form of chemical warfare, but they drew different conclusions about the specific agents that Iraq was most likely to employ. Finally, the United States concluded that Iraq had nuclear weapons production facilities but had limited information on device development; officials from the United Kingdom and France told us that these nations identified no nuclear or radiological threat.

We also found some evidence that threat assessments and target data were not spontaneously shared among Coalition members. For example, U.S. officials told us that French commanders were told of U.S. concerns regarding a biological threat only when the French made inquiries about media reports of U.S. troops receiving anthrax vaccine. Moreover, contemporary U.S. doctrine lacked clear provisions for real-time warning of U.S. ground troops or friendly forces about impending U.S. or Coalition strikes against hazardous targets, such as suspected Iraqi biological warfare, nuclear or chemical industry facilities. In addition, post-war reviews were at odds with some of the Coalition members' pre-war assessments about chemical and radiological hazards, suggesting the original estimates may have been invalid. Since the war, the North Atlantic Treaty Organization has drafted doctrine for members' ratification that incorporates reference to sharing of intelligence regarding such hazards. In addition, U.S. Army doctrine now incorporates some guidance on managing the consequences of damage to civilian chemical targets, though the existence of provisions for warning prior to attack on such targets remains less clear.

The three Coalition members also took different approaches to defense against weapons of mass destruction. The sensitivity of the principal chemical detectors used by the three countries varied widely. In addition, French forces had greater access to collective protection (i.e., protection of groups as well as individuals within a unit). Unlike France, the United States and United Kingdom made widespread use of vaccines specific to particular biological agents that they believed Iraq might have employed.

The three countries varied not only in the extent to which they used drugs and vaccines, but also in the drugs and vaccines they chose and in their policies on consent to administer them. Notably, while U.K. policy prescribed that vaccines be administered on the basis of voluntary informed consent, the United States required some of its military personnel to take certain drugs and vaccines, including some considered investigational for their wartime application, and both U.K. and French forces took a drug, pyridostigmine bromide, on command. To some extent, the variation in the drugs and vaccines employed by the three forces could

be attributed to the variation in these nations' analysis of the threats posed by Iraq. However, there were differences in the selection of medical countermeasures for threats that were mutually recognized and the use of drugs and vaccines varied within the national forces as well as among the three forces. For example, the U.S. inoculated certain troops with a vaccine for botulinum toxin, while the U.K. developed a treatment for use after exposure.

Finally, we found that veterans of the conflict from the United States and United Kingdom reported higher rates of postwar illnesses relative to their compatriots deployed elsewhere. In contrast, approximately 10 years after the war, French veterans have not reported as much war-related illness as veterans from the U.S. and U.K. despite outreach by French veterans' organizations and the existence of veterans' benefits. The disparity in the numbers of illnesses reported by the three countries' veterans does not point unambiguously to any single causative agent; it is accompanied by multiple differences in the veterans' reported experience.

Background

Following the Iraqi invasion of Kuwait on August 2, 1990, the United Nations passed a series of resolutions condemning the action and demanding Iraq's withdrawal, imposing economic sanctions and allowing the use of force to support economic sanctions. Finally, in late November 1990, the United Nations set a deadline of 15 January 1991 for Iraqi withdrawal from Kuwait and authorized military action to enforce this deadline.

These United Nations resolutions formed the legal canopy for the largest international military coalition to be employed in combat since World War II. The Gulf War Coalition included ground forces from 25 countries, naval forces from 23, and air forces from 14. The size of these constituent forces varied greatly as did their locations in the theater, with French ground forces on the western flank, U.S. forces spread across the theater, and U.K. forces concentrated closer to the Saudi-Kuwaiti border. The primary contributors of troops from outside the Gulf area were the United States (697,000), Britain (35,000), Egypt (35,000), France (25,000), Bangladesh (6,000), Pakistan (5,000), and Morocco (1,500). Substantial forces were also provided by countries in the regions surrounding Iraq and Kuwait, including Syria (20,000), Saudi Arabia (45,000), and the Gulf States – Bahrain, Qatar, Oman, and the United Arab Emirates (17,000).

Because of the cultural and political diversity of the Coalition members who were to act in a single campaign, building an acceptable military

structure was a difficult task. On the ground, two different international commands were organized—one integrating the forces from Arab and other Islamic countries and the other combining forces from the Western countries. French forces operated under their own national command and control, maintaining close coordination with both international commands.[1,2]

The Coalition's member nations adopted chemical and biological warfare defensive measures from three basic categories: (1) individual and/or collective protective equipment, (2) equipment for detecting chemical agents in the environment, and (3) specific medical countermeasures (vaccines or drugs) to be used before or after an attack. Detectors are pivotal because they are often used to trigger the use of defensive measures, such as protective masks. The sensitivity of such detectors can vary as well as the set of agents they are capable of detecting. Appendix I lists some of the major chemical warfare agents and their physiological effects and Appendix II lists examples of agents cited as potential biological warfare agents and their effects. Much of the individual and collective protection equipment adopted for chemical and biological environments is also intended to provide some protection against radiological hazards.

After the war, the United Nations Special Commission on Iraq was established to certify Iraq's compliance with postwar agreements regarding cessation of efforts to develop or produce chemical or biological weapons, while the International Atomic Energy Agency was charged with monitoring Iraq's compliance with nuclear and radiological restrictions.[3]

[1] Juan Carlos Neves, "Interoperability in Multinational Coalitions: Lessons from the Persian Gulf War," *Naval War College Review*, vol. XLVIII (1), Winter 1995, 50-62.

[2]The French 6th Light Armored Division was placed under the tactical control of the U.S. Army Central Command, where it operated as a unit of the XVIII Airborne Corps. The French airmobile and anti-armor capabilities were primarily used in the effort to secure the Coalition's western flank ahead of the XVIII Corps. The core of the French ground forces deployed to the Gulf came from a special force called the Force Action Rapide.

[3] See U.N. Resolution S/687 (1991), Section C, April 3, 1991 reprinted in *The United Nations and the Iraq-Kuwait Conflict, 1990-1996*, New York: United Nations Department of Public Information, 1996, pp. 193-198.

Focus and Results of Threat Assessment Differed Among Coalition Nations

As shown in table 1, immediately prior to the start of ground hostilities, the U.S., French, and U.K. forces drew different conclusions about the biological, chemical, and nuclear or radiological threats they faced from Iraq. There is also some evidence that threat assessments and target data were not spontaneously shared among coalition members and post-war reviews suggest that some of the pre-war threat assessments were invalid.

Table 1: Pre-conflict Threat Assessment by Country and Postwar Findings by the United Nations Special Commission on Iraq and the International Atomic Energy Agency

	Determination regarding Iraq's potential use of weapons of mass destruction[a]			
Threat	**United Kingdom**	**France**	**United States**	**Postwar findings of the United Nations Special Commission on Iraq and the International Atomic Energy Agency**
Biological warfare	Yes	No[b]	Yes[c]	Iraq told the Special Commission that it did possess munitions containing anthrax and botulinum toxin, but it continued to deny any work on plague.
Chemical warfare	Yes	Yes	Yes	The Special Commission established that the Iraqi regime had weaponized mustard and nerve agents, including sarin and cyclosarin. Both bulk material and filled munitions relating to these agents were found at the Iraqi facility at Muthanna in Autumn 1991.
Nuclear / radiation	No	No	Limited[d]	The sixth International Atomic Energy Agency inspection team obtained conclusive documentary evidence that the Government of Iraq had a program for developing nuclear weapons. Iraq acknowledged research and studies on nuclear weaponization and the production of very small amounts of plutonium.

[a]This column refers to the assessments made in the months leading into the conflict.

[b]The French assessment that Iraq would not use biological weapons is not necessarily a reflection on the specific biological capabilities Iraq might have had.

[c]DOD's official history of the Gulf War notes that, "In contrast to the reasonably comprehensive appreciation of Iraqi CW capabilities and doctrine, intelligence assessments of the BW threat were much more tenuous." See Conduct of the Persian Gulf War: Final Report to Congress, p Q-3.

[d]DOD reported after the war that, "Information on Iraqi nuclear devices development was limited at the time of the crisis." Since the war, the CIA has reported that it provided DOD with information on the locations of Iraqi nuclear weapons production facilities. A declassified September 1990 intelligence assessment of Iraqi nuclear capability noted that Iraq could construct a radiological dispersal device (nuclear material combined with high explosives), but cited no supporting evidence that Iraq would do so and judged that the probability of this happening was negligible. Later, DOD reported to Congress that, while U.S. intelligence agencies were aware of Iraqi military capabilities, they lacked access to information on the Iraqi leadership's intentions and the scope and exact disposition of nuclear weapons programs.

Sources: GAO interviews, U.N. reports, and national postwar reviews, including, the U.K. Ministry of Defence's, "British Chemical Warfare Defence During the Gulf Conflict," Dec. 1999; and "Iraqi CW capability during the Gulf War" Feb. 1998. Also, the International Atomic Energy Agency's "Nuclear capabilities of Iraq: A chronology of events," April 1992; and DOD, *Conduct of the Persian Gulf War: Final Report to Congress*, April 1992.

Both the United Kingdom and United States considered biological warfare a threat during the Gulf War, but France did not. The United Kingdom and United States mutually concluded that use of anthrax or botulinum toxin was possible, but the United Kingdom alone concluded that plague was a threat. French officials told us they did not identify a biological threat.

The United States, United Kingdom, and France agreed that a chemical warfare threat was present and the U.S. and U.K. made similar assessments of the delivery mechanisms that might be used, such as chemically armed ballistic missiles.[4] For example, the U.S. intelligence community concluded before the war that Iraq had a significant chemical weapons capability. At the time of U.S. deployments to the Persian Gulf, the U.S. intelligence community had reached consensus that Iraq had chemical weapons in its arsenal, had likely deployed them, and was prepared to use them against Coalition forces.

Although these Coalition members agreed that a chemical warfare threat was present in Iraq, they were not in full consensus with regard to the specific types of chemical agents that might be used. Both the U.S. and U.K. assessed that Iraq had weapons capable of delivering blister and nerve agents. Immediately prior to the conflict, the U.K. assessed Iraq's chemical weapon capability as including nerve agents (definitely tabun and sarin and possibly cyclosarin and VX), blister agents (definitely sulfur mustard and possibly nitrogen mustard) and probably a blood agent, (hydrogen cyanide). Similarly, the U.S. military believed at the time of the war that Iraq had weapons capable of delivering nerve agents (including sarin, soman and VX) and mustard.[5] In November 1990, the U.K. specifically concluded that the Iraqis had dust impregnated with sulfur mustard (H), commonly known as "dusty mustard."[6] We requested but did

[4] For example, the U.K. determined that the range of delivery methods believed to be available included mortar bombs, artillery shells, rockets, and air dropped bombs and concluded that ballistic missiles with chemical warheads were probably available. The U.K. also thought Iraq might have projectiles filled with chemical warfare agents that it could fire from the one or two long-range guns that were thought to be available to them. We were not provided detailed information on French assessments regarding potential delivery mechanisms.

[5] *Final Report*, Presidential Advisory Committee on Gulf War Veterans' Illnesses (Washington, D.C.: Dec. 1996), p. 107.

[6] In addition, U.K. analyses of Gulf War decision making state that it was known that Iraq had been provided information on the nerve agent Soman (GD), the choking agent phosgene (CG) the psychochemical BZ and the vomiting agent Adamsite (DM).

not receive any systematic description from French officials regarding the specific chemical threats they believed Iraq might possess. However, in contrast to the November 1990 U.K. assessment, French officials told us that they did not believe agents in dust form were present before, during, or after the war.

The CIA reports that, prior to the conflict, it provided the Department of Defense with the locations of known Iraqi nuclear weapons production facilities, though an official history of the conflict notes that the U.S. lacked information on Iraqi intentions.[7] U.K. and French officials told us that these nations concluded that Iraq did not pose a nuclear or radiological threat—that it would not use any nuclear or radiological capabilities it might have had.

With regard to sharing information about threats and targets, we found that U.S. doctrine at the time contained no specific provisions for warning friendly forces about impending strikes against hazardous targets. There is evidence that the U.K. anticipated these plans to strike chemical and biological targets, but we found no procedures for real-time warning of their execution, perhaps owing to concerns about operational security.[8] Statements from personnel at the U.S. Army Training and Doctrine Command as well as our review of U.S. doctrine indicate that U.S. doctrine prescribed warnings for U.S. detonation of nuclear devices or chemical attacks, but not for pending U.S. strikes on nuclear, biological, or chemical

[7] See CIA, *CIA Support to the U.S. Military During the Persian Gulf War* (June 16, 1997), p. 6; and DOD, *Conduct of the Persian Gulf War: Final Report to Congress* (April 1992), p. C-18.

[8] See G.B. Carter, *Porton Down: 75 Years of Chemical and Biological Research* (London: HMSO, 1992). In discussing contributions by the U.K. Chemical and Biological Defense Establishment to the U.K.'s efforts in the Gulf War, the author writes that, "The hazard distances which could arise from Allied conventional weapon attacks on Iraqi chemical and biological facilities were assessed, as were those which could arise from PATRIOT interception of SCUD-type missiles with chemical or biological warheads."

sites, or potentially hazardous industrial targets.[9] However, many strikes were made on targets believed at the time to be potentially hazardous, including reactors and chemical industry facilities.[10] Since the war, NATO has drafted doctrine regarding the management of operations following hazardous releases from such targets.[11] In addition, some guidance is incorporated in U.S. Army doctrine with regard to managing the consequences of damage to civilian chemical facilities.[12] Difficulties in ensuring secure communications within the Coalition force might have complicated issuance of real-time warnings, as would gaps in hazard prediction capabilities. In addition, official reports on the war have noted that a sustained need to don full protective gear would have substantially slowed the tempo of the campaign.[13] At DOD's request, the Institute of Medicine (IOM) has recently issued a comprehensive review of force protection. Among other gaps, the IOM report notes that environmental

[9]Since the war, NATO has issued guidance (Allied Command Europe Directive 80-63, August 2, 1996) regarding defensive measures against low-level radiological hazards during military operations. The Institute of Medicine has reviewed the NATO directive and found it to be "a positive step in providing the soldier with protection against potential adverse effects of ionizing radiation," but also found it "incomplete in scope and unclear in certain areas." For additional information, see Institute of Medicine Committee on Battlefield Radiation Exposure Criteria, *An Evaluation of Radiation Exposure Guidance for Military Operations: Interim Report*, Washington, DC: National Academy Press, 1997, or, from the same source in 1999, *Potential Radiation Exposure on the Battlefield: Protecting the Soldier Before, During and After*.

[10] An IAEA report of its first two postwar inspections (United Nations, S/22788, July 15, 1991) notes area contamination in connection with one of the bombed facilities at the Baghdad Nuclear Research Center. The CIA later concluded that bombed Iraqi nuclear facilities caused only local contamination north of the 31st parallel, which defined the northern boundary of the Kuwait Theater of Operations. (See *CIA Report on Intelligence Related to Gulf War Illnesses*, Aug. 2, 1996; reprinted May 30, 1997, pp. iii and 8.) We did not independently assess the methods used to arrive at these conclusions.

[11]See NATO, *Joint Doctrine Ratification Draft*, JP-01(A), 1999 (esp. Chapter 19).

[12] See Headquarters, Department of the Army, *Field Manual 3-3, Chemical and Biological Contamination Avoidance*, Washington, D.C., Nov. 16, 1992 (incorporating provisions of Change 1, Sep. 29, 1994). The final chapter of this manual concerns civilian chemical hazards.

[13] According to the DOD's summary of the campaign, while temperatures during Operation Desert Storm were comparatively cool, the tempo of the campaign could have been hindered had U.S. troops been forced to remain fully protected by masks and suits. See Department of Defense, *Conduct of the Persian Gulf War: Final Report to Congress*, April 1992.

and medical hazards still are not well integrated in the information provided to commanders.[14]

Post-war reviews suggest that some of the prewar assessments about chemical warfare threats and radiological threats were invalid. For example, as we noted earlier, at the time of the U.S. deployments to the Gulf, the U.S. intelligence community had reached consensus that Iraq had chemical weapons in its arsenal, had likely deployed them, and was prepared to use them against Coalition forces. However, following the war, the CIA published an assessment that indicated that Iraq moved chemical weapons out of the theater prior to the war, had never deployed chemical weapons to its frontline units during the war, and never used them against Coalition forces. Since the war, the U.S. intelligence community has reported that it has not uncovered evidence that Iraq employed chemical weapons during the Gulf War.[15] In terms of radiological warfare threats, the International Atomic Energy Agency, which was charged with monitoring Iraq's nuclear program after the war, found that this program involved far more facilities than reflected in coalition target lists.[16] After the war, the Defense Intelligence Agency reportedly concluded that, "prior to Desert Storm, little was known about Iraq's highly compartmented nuclear weapons program."[17] The International Atomic Energy Agency reported on October 4, 1991, that it had obtained conclusive documentary evidence that the Government of Iraq had a program for developing nuclear weapons. Iraq subsequently

[14] Institute of Medicine, *Protecting Those Who Serve: Strategies to Protect the Health of Deployed U.S. Forces*, Washington, D.C.: National Academy Press, 2000, pp. 1-3.

[15] *CIA Support to the U.S. Military During the Persian Gulf War*, CIA Persian Gulf War Illnesses Task Force, p. 6.

[16] As we have previously reported, information compiled by the Special Commission since Desert Storm revealed that the number of suspected nuclear, biological, and chemical targets identified by U.S. planners, both prior to and during the campaign, did not fully encompass all the possible targets of this type in Iraq. See *Operation Desert Storm: Evaluation of the Air Campaign* (GAO/NSIAD-97-134, June 12, 1997).

[17] See Michael R. Gordon and Bernard E. Trainor, *The Generals' War: The Inside Story of the Conflict in the Gulf*, (Boston: Little, Brown & Company, 1995), pp. 181-82, 457; and Robert W. Chandler (with Ronald J. Trees), *Tomorrow's War, Today's Decisions: Iraqi Weapons of Mass Destruction and the Implications of WMD-Armed Adversaries for Future U.S. Military Strategy*, (McLean, VA: American Committee on Development Affairs, 1996), pp. 15-61.

acknowledged that research and studies had been underway in nuclear weaponization and that small amounts of plutonium had been produced.[18]

Coalition Forces Varied in Measures Used to Address Chemical and Biological Threats

The United Kingdom, United States, and France used varied combinations of equipment, drugs, and vaccines for defense against chemical or biological exposures. France made less use of vaccines and relied more on protective gear than did either the United States or the United Kingdom. French detection equipment was more sensitive than U.S. equipment, but this did not distinguish France from the U.K., which used a still more sensitive detector. Similarly, both French and U.K. protective garments were reportedly less cumbersome than those in widespread use by the U.S., presenting reduced barriers to their use. In contrast to France, both the U.S. and U.K. made extensive use of drugs and vaccines. Both took medical countermeasures (i.e., drugs and vaccines) against exposures to biological and chemical warfare agents, whereas French military officials told us that they had not supplied their troops with medical countermeasures against exposure to biological warfare agents.[19] However, they stated that French forces did distribute medical countermeasures against exposures to chemical nerve agent.

Detection and Protective Equipment Varied

The French chemical detector in most widespread use was more sensitive than the principal detector used by the U.S. In addition, French forces used individual devices to record radiation exposure, employed less cumbersome protective gear that presented fewer barriers to use, and reportedly had more access to collective protection than forces of the United States and United Kingdom.

Detection equipment

Protection under any doctrine based on the flexible use of protective equipment depends on the availability of appropriate and functional monitoring for any levels of agent that might produce harmful effects. Timely detection and warning is important to warn adjacent and downwind forces, allow protective measures to be taken to limit exposure,

[18] International Atomic Energy Agency, "Nuclear capabilities of Iraq: A chronology of events," April 1992.

[19] However, in September 2000, following creation of a commission to examine the health of French veterans of the Gulf War, a French defense ministry spokesman stated that French government officials had become convinced that certain French military personnel were vaccinated together with the allied troops with whom they were stationed. See Reuters, "French to Check Liaison Officers for Gulf Syndrome," Sept. 14, 2000.

initiate therapy early, alert the casualty handling system, and allow units to communicate the "all clear" signal. The principal chemical detector employed by French forces was twice as sensitive to nerve agents as the most commonly used U.S. detector and the principal U.K. detector was still more sensitive. In certain cases, U.S. detectors might not have been able to detect or confirm the presence of exposure levels below casualty thresholds.[20] (See Table 2 for the agents detectable by the principal U.S., U.K., and French chemical detectors.) Detection of biological agents was generally recognized as inadequate across the three national forces.[21]

French forces also employed devices worn by individuals to record external radiation. The U.S. made use of similar devices, but U.K. officials told us that such devices were not used by British forces.[22] These devices, known as individual dosimeters, are not alarms or real-time detectors, but can provide information on dosage when read directly or by other equipment.

[20]See DOD/Office of the Special Assistant for Gulf War Illnesses, "Case Narrative: Czech and French Reports of Chemical Agent Detections," July 29, 1998, p. 16. The document states, "Since most U.S. detectors are less senstive than the Czech and possibly less sensitive than the French detectors discussed above, they might be unable, in certain cases, to detect or confirm the presence of low (below casualty thresholds) levels of chemical agents. U.S. equipment was designed to detect concentrations of chemical agents that pose a direct and immediate threat to a soldier's health." French officials noted that the setting of detection levels was an operational rather than a scientific matter. We were told that France had accepted NATO-recommended detection thresholds for organophosphates and sulfur mustard (0.2 milligram-minutes/cubic meter and 50 milligram-minutes/cubic meter, respectively), but had established a separate safety rating.

[21] For example, the United States did not have a real-time detection system for biological agents; instead, it relied on time consuming analyses by remote field laboratories, as did the United Kingdom. DOD comments on our report noted that the U.S. did field some experimental biological detectors. These were predecessors of the 38 interim Biological Integrated Detection Systems (BIDS) it fielded in September 1996. The BIDS were designed to be capable of detecting and identifying up to four biological agents at a time within 45 minutes of exposure. Though this level of performance is commonly termed a "detect to treat" capability, early treatment of certain agents can be critical.

[22] See *Potential Radiation Exposure in Military Operations: Protecting the Soldier Before, During, and After*, Institute of Medicine, Committee on Battlefield Radiation Exposure Criteria (National Academy Press, Washington, D.C.: 1999).

Table 2: Capabilities of the Principal Chemical Agent Detectors Used by Three Gulf War Coalition Nations

	Name of Principal Detector[a]		
Chemical Agent	**M8A1 (U.S.)**	**NAIAD (U.K.)**	**Detalac (France)**
Nerve agents			
Tabun	X	X	
Sarin	X	X	X
Soman	X	X	X
Cyclosarin/CMPF		X	
GP		X	
VX	X	X	X
Blister agents			
Sulfur mustard			
Nitrogen mustard			
Lewisite			
Phosgene Oxime			
Blood agents			
Arsine			
Hydrogen cyanide		X	
Cyanogen chloride		X	
Choking agents			
Incapacitants/irritants			
Vomiting agents			

[a]The detectors identified in this table are designed to detect agents in vapor form. Some of these agents are more difficult to maintain in vapor form than others. The methods listed in this table were supplemented by other detection or identification methods that were less widely available or that did not incorporate alarms. For example, the French Detalac was supplemented by a chemical agent identification kit and a prototype detector with enhanced sensitivity and capability to detect additional agents.

Source: Nancy R. Brletich et al., Worldwide Chemical Detection Equipment Handbook, (Chemical and Biological Defense Information and Analysis Center: Aberdeen Proving Ground, MD), 1995; Gulf Veteran's Illnesses Unit, U.K. Ministry of Defence, "British Chemical Warfare Defence During the Gulf Conflict (1990-91)," Dec. 7, 1999, and GAO interviews with officials of GIAT and the French Army.

Protective Equipment

All U.S., U.K., and French forces wore protective gear at certain levels of alert. While U.S. protective gear had the proven potential to substantially degrade performance, French forces employed protective gear (the S3P or NBC Tropical Suit) that was less bulky and they were reported to have used it more often. In addition, French forces had greater access to forms of collective protection, such as specially ventilated truck cabs and shelters. Individual protective equipment consisted of protective masks, boots, gloves, overgarments, and personal decontamination kits. Specialized clothing and equipment can reduce the potential for chemical exposure and casualties and reduce the impact of chemical weapons on

combat operations. Personal protective equipment used against chemical agents is also reported to offer some level of protection against biological agents, although the nature and duration of the protection varies with the threat and the particular equipment.

According to U.S. doctrine during the Gulf War, as the threat level increased, troops would don more parts of the chemical protective ensemble and, by getting this head start, reduce the amount of time it would take them to reach full protection in the event of a chemical attack.[23] However, higher levels of alert required accepting degradation in performance.[24] Therefore, commanders were given the flexibility to adjust the level of response (i.e., what protective equipment to wear) based on the perceived threat of nuclear, biological, or chemical attack and the impact of such response on military operations.

Similarly, instructions issued by U.K. joint headquarters defined different combinations of equipment to be used based on the nuclear, biological, and chemical threat level (low, medium, high, or black) and the wearer's location (in the open, under cover, or under collective protection). Protective gear was not to be worn unless the threat level was at least medium, indicating that there were strong indications that the enemy will use chemical or biological warfare in the immediate future. A U.K. after action report notes that, notwithstanding the instructions, there is evidence that the standard procedure in theater was not to wear any individual protective equipment even at medium-threat levels.

The French Ministry did not provide detailed information about threat levels and corresponding levels of protective gear; however, French forces employed somewhat less cumbersome protective garments, the S3P and NBC Tropical Suit. For example, the NBC Tropical Suit could be worn directly on the skin rather than over the regular uniform, and, according to

[23] There are five levels of mission-oriented protective posture: Level 0, in which none of the protective clothing and equipment is worn, but it is readily available; Level 1, in which the overgarment is worn; Level 2, in which overboots are added; Level 3, in which the chemical protective mask and hood are added; and Level 4, in which butyl rubber gloves are added and at which point personnel are completely encapsulated.

[25] Wearing high levels of U.S. chemical protection equipment could degrade combat performance because of heat buildup and difficulty seeing, hearing, speaking, eating, drinking, moving, and handling equipment or supplies. See G. Weaver and J. D. Glaes, *Inviting Disaster: How Weapons of Mass Destruction Undermine U.S. Strategy for Projecting Military Power*, Mclean, VA: American Committee on Development Affairs, 1997, pp. 41-43.

U.S. officials who served in the war, French forces made more liberal use of this less bulky protective gear. In the event of an actual exposure to CW agent, the more sensitive detection equipment used by French forces would also have triggered use of individual protective equipment at lower concentrations than U.S. alarms.[25]

In addition, French forces had more access to collective protection than U.S. forces. Collective protection systems—such as specially ventilated truck cabs, tanks, field hospitals, or shelters—permit soldiers to rest or operate in a chemical environment without individual masking or protective gear. Although many U.S. vehicles, such as armored personnel carriers, lacked collective protection systems, we were told that French armored personnel carriers, tanks, and trucks had such systems.[26]

Appendix III describes and compares the approaches adopted by the three nations with respect to warning and reporting arrangements, detection capabilities, use of individual protective equipment, collective protection, and decontamination.

U.S. and U.K. Forces Implemented a Variety of Medical Countermeasures

French medical officials have reported they dispensed fewer medical countermeasures than the United States and United Kingdom, which employed a variety of drugs and vaccines directed at specific biological and chemical warfare threats.[27] None of the three countries report using medical countermeasures to protect against radiological threats.

Medical Countermeasures Against Biological Agents

Table 3 summarizes differences in the medical countermeasures taken by the three countries against three agents – anthrax, botulinum toxin, and plague – assessed as biological threats by one or more countries.

[25] The U.S. has since developed a program to procure lighter-weight protective garments using the Joint Service Lightweight Integrated Suit Technology, but older equipment has not yet been fully replaced.

[26] See also C.F. Foss, *Jane's Armour and Artillery, 1990-91,* (11th ed.), U.K.: Jane's Information Group, pp. 328, which reports that an NBC system was standard for French Army versions of the VAB armoured personnel carrier.

[27] Also see U.S. Senate Committee on Veterans' Affairs, *Report of the Special Investigation Unit on Gulf War Illnesses: Appendices*, S-PRT. 105-39, Part II, 1998, p. 692.

Table 3: Medical Countermeasures Used Against Biological Threats by Selected Coalition Forces

		Anthrax	Botulinum toxin	Plague
Countermeasures	U.K.	Anthrax vaccine augmented by pertussis vaccine and an antibiotic, doxycycline	Antitoxin (doses of human and goat antitoxin were retained for use following an exposure)	Plague vaccine and doxycycline
	U.S.	Anthrax vaccine[a]	Botulinum toxoid vaccine for prophylactic use	No medical countermeasures (did not identify as a threat)
	France	No medical countermeasures (did not identify as a threat)	No medical countermeasures (did not identify as a threat)	No medical countermeasures (did not identify as a threat)
Implementation	U.K.	Augmented anthrax vaccine with pertussis in the belief that this would help achieve adequate immunity by the projected onset of conflict. The prescribed dosing schedule involved four doses of vaccine over 32 weeks; the U.K. reduced the immunization schedule to 3 doses over 7 weeks on the presumption that the decision to give the doses in conjunction with pertussis vaccine would help achieve adequate immunity by the projected onset of conflict. Over half of U.K. veterans reported receipt of anthrax vaccine.	Was to be administered post-exposure	After assessing a threat in November 1990, vaccinated troops against plague with vaccine procured from the U.S. and cultured plague for manufacture of additional vaccine. Plague vaccine was administered concurrently with the second anthrax and pertussis doses to take advantage of any boost in immunity that this simultaneous administration might effect. About 26 percent of U.K. veterans report receiving the vaccine (34 percent among those who had reference to records).
	U.S.	Had insufficient time to implement the recommended immunization schedule (six shots over 18 months). The Institute of Medicine reported in 1996 that it was estimated that about 150,000 troops received one or more doses. Of these, most received a maximum of 2 injections 2 weeks apart. About 40 percent of U.S. veterans report receiving the vaccine.	Administered pre-exposure. Approximately 8,000 U.S. troops received at least one dose. The recommended dosage was 3 injections 2 and 12 weeks apart with a booster at one year. Approximately 12 percent of U.S. veterans report having received this vaccine.	Did not identify as a threat. The U.S. did not vaccinate against plague for the Gulf War, but some U.S. troops would have received it for other purposes.[b] About 22 percent of U.S. Gulf War veterans report having received plague vaccine.
	France	No countermeasures (did not identify as a threat)	No countermeasures (did not identify as a threat)	No countermeasures (did not identify as a threat)

		Anthrax	Botulinum toxin	Plague
Type of consent	U.K.	Vaccines were to be administered on the basis of voluntary informed consent. In January 2000, the U.K. published the results of an investigation into whether its informed consent policies were consistently followed in practice. The review found that some U.K. Service personnel had no real understanding of what vaccines were being given to them, some medical officers were uneasy about the lack of information provided, and that commanders were given no advice as to how they were to meet the requirement to ensure that adequate information was made available.[c]		
	U.S.	Administered anthrax vaccine to certain personnel on a mandatory basis. DOD requested and FDA granted a waiver that obviated informed consent even for drugs considered experimental for their wartime application. Nonetheless, owing to limited supplies, personnel were reportedly permitted to decline botulinum toxoid vaccine.		
	France	Did not identify as a threat or administer medical countermeasures.		
Concerns/issues regarding future use	U.K.	U.K. officials have since concluded that the pertussis vaccine was ineffective as a method to speed up the effects of anthrax vaccine.	U.K. officials stated they would have preferred to use a vaccine administered in advance of attack. After action reports noted that the U.K. had no botulinum vaccine in stock and could not have acquired any in time.	U.K. after action reviews have noted that the vaccine had a reputation for inducing adverse reactions. Although licensed by the U.S. Food and Drug Administration, there were no data on the protection the dead cell vaccine offered against the most likely form of a plague threat on the battlefield and it was not licensed in the U.K.
	U.S.	U.S. had insufficient vaccine to inoculate all of its troops and insufficient time to implement the immunization schedule believed necessary to confer immunity (six shots over 18 months), raising questions about how the U.S. will protect forces against biological threats when a specific threat is not identified until conflict is imminent and the medical countermeasure requires substantial time to become effective.	Under a waiver sought by DOD and granted by the U.S. Food and Drug Administration, DOD used a toxoid that had not received full approval and licensure from the FDA.	No medical countermeasures (did not identify as a threat)
	France	No medical countermeasures (did not identify as a threat)	No medical countermeasures (did not identify as a threat)	No medical countermeasures (did not identify as a threat)

[a]According to the U.K. Ministry of Defence, the anthrax vaccine administered to British troops was produced by the Centre for Applied Microbiology and Research and sold under a licence held by the British Secretary of State for Health. The U.K. Ministry of Defence procured the vaccine from Porton Products Limited under this distribution and marketing agreement. We did not examine any differences in manufacture between this vaccine and the U.S. anthrax vaccine.

[b]According to DOD's Office of the Special Assistant for Gulf War Illnesses, at the time of the Gulf War, only Marine Corps recruits and selected special operating forces received the plague vaccine. After the Gulf War, routine immunization of Marine Corps recruits was discontinued, so that the vaccine was subsequently given only to high risk occupational groups and persons deploying or traveling to high risk areas. While many Gulf War veterans had received the plague vaccine under the contemporary immunization program for Marine Corps recruits or special forces, the plague vaccine was not recommended for Gulf War deployment by U.S. Central Command.

[c]See U.K. Ministry of Defence, "Implementation of the Immunisation Programme against Biological Warfare Agents for U.K. Forces During the Gulf Conflict 1990/91," Jan. 2000.

Some of the differences in the three countries' use of medical countermeasures against biological threats could be attributed to their having identified different threats, but some differences occurred in the use or selection of countermeasures even when the same threat had been identified. For example, botulinum toxin was identified as a threat by both the United States and the United Kingdom, but the United Kingdom addressed it with antitoxin to be given post-exposure while the United States used the investigational botulinum toxoid vaccine to be administered prior to exposure. The U.K. Ministry of Defence has written that it had no access to any similar immunoprophylaxis and only had limited supplies of antitoxin, so it chose to reserve the antitoxin for therapeutic use (rather than attempting to treat a subset of the force prior to exposure). In contrast, the U.S. had a limited supply of the investigational vaccine and used it to immunize an estimated 8,000 troops, primarily in the First Marine Division and the Army's VII Corps. The relative effectiveness of the two approaches to resource limitations was not tested as there was no report of any attack involving botulinum toxin. The botulinum toxoid vaccine has not received approval from the Food and Drug Administration and therefore is regarded as investigational, although it had been used by high risk laboratory workers for 20 years.[28]

Exposure to particular medical countermeasures for biological threats varied within as well as across national commands. For example, the United States did not administer botulinum toxoid vaccine to all of its troops. Similarly, the U.K. reports it administered the first anthrax injection to over 75% of its deployed forces, with some units fully vaccinated and others less so.

Medical Countermeasures Against Nerve Agent

In addition to the varied countermeasures against biological warfare agents, all three countries issued two medical countermeasures to protect military forces against chemical nerve agent attack. The first was the drug pyridostigmine bromide, that was intended to enhance the effectiveness of post-attack therapies for exposure to the nerve agents soman or tabun.

[28]See Institute of Medicine, *Health Consequences of Service During the Persian Gulf War: Recommendations for Research and Information Systems*, (Washington, D.C.: National Academy Press), 1996, pp. 51-52. The Institute of Medicine reports that all members of the U.S. units were to have had the opportunity to volunteer and give informed consent before receiving the botulinum toxoid vaccine. For further information on the issues surrounding DOD's decision to deploy pyridostigmine bromide and botulinum toxoid, see R. Rettig, *Military Use of Drugs Not Yet Approved by the FDA for CW/BW Defense: Lessons From the Gulf War*, MR-1018/9-OSD (Santa Monica, CA: RAND), 1999.

The second was an injection of a combination of drugs intended to mitigate the effects of nerve agent exposure following an attack. The extent of use of the first drug differed somewhat across the Coalition forces, but its formulation did not (30 milligram tablets). For the second countermeasure, the formulation varied (one combined injection or two separate ones) and the policy for administration varied accordingly. Table 4 provides detail on the nature and employment of these countermeasures across the three Coalition countries.

Table 4: Medical Countermeasures Used Against Nerve Agents by U.K., U.S., and French Forces

	United Kingdom	United States	France
Countermeasures	Pretreatment: Pyridostigmine Bromide in 30 mg. tablets to be taken 8 hours apart without respect to weight or gender		
	Post-attack therapy: Troops were issued injection devices containing atropine and other ingredients to be used in the event of nerve agent exposure. The mix of these ingredients varied across national commands. French and U.K. troops used a single injector that contained both atropine and an anticonvulsant to provide protection to the brain in the event of an exposure. The U.S. incorporated anticonvulsants in a separate injector that was intended for buddy-aid rather than self-injection.		
Implementation	U.K. forces were ordered to take pyridostigmine bromide when Iraqi SCUD launches began. U.K. troops in theater were given permission to stop taking the pills on March 1, 1991, and commands in the U.K. were told that troops about to deploy to the Gulf could cease taking the pills on March 4, 1991. In a survey of U.K. Gulf War veterans, 81.6% reported use of pyridostigmine bromide.	Both pyridostigmine bromide and atropine were issued to soldiers, the former in blister packs of pills to be taken on command. A survey of U.S. Gulf War veterans found that 49.2% reported taking pyridostigmine bromide pills, the majority reporting use for 7 or fewer days and consumption of no more than 20 pills.	Pyridostigmine bromide was distributed to troops, to be administered only on command. The French Minister of Defense has confirmed that 9000 French troops were ordered to take the drug for about 4 days.[a]
Type of consent	Was to be administered on command.	Administered on command. DOD sought and received a waiver from the U.S. Food and Drug Administration relieving it of the ordinary requirement to obtain informed consent prior to administration of drugs, such as pyridostigmine bromide, that were considered investigational for their wartime application.	Drugs were to be administered on command.
Licensure	The U.K. Medicines Control Agency had licensed pyridostigmine bromide to the Ministry of Defence for the pretreatment of service personnel at risk for nerve agent poisoning.	Pyridostigmine bromide is not licensed for this purpose by the U.S. Food and Drug Administration.[b]	The French government had not licensed PB for the purpose of chemical warfare prophylaxis.
Other concerns/issues for future use		U.S. atropine autoinjectors reportedly did not hold up well, breaking or discharging while stored in soldiers' mask carriers.[c] The U.S. has since begun to develop a replacement that incorporates atropine and anticonvulsant in a single injector, like the version fielded by the U.K. and France.	Reports indicate that French military officials state the drug is still stored for CW defense.

[a] E. Inciyan, "Syndrome du Golfe: 9,000 militaires français aurait pris un produit dangereux," [Gulf War Syndrome: 9,000 French military could have taken a dangerous product], *Le Monde*, Nov. 2, 2000, p. 10; and "Syndrome du Golfe: L'armée confirme les propos du général Michel Roquejoffre," [Gulf War Syndrome: The Army Confirms the Statement of General Michel Roquejoffre], *Le Monde*, Nov. 4, 2000, p. 12.

[b] At the time of the Gulf War, the standard medical countermeasure regimen in use by the U.S. Army was pretreatment with pyridostigmine bromide followed by injection of the atropine-based drug mixture post-exposure. Researchers told us that, to address problems with the standard regimen, the Army had provided emergency funding for a project to develop the use of an anticonvulsant drug, diazepam, as a pretreatment. Researchers conducted experiments in which animals pretreated with this anticonvulsant survived several times the dose of soman that would normally kill 50% of the exposed population and were less subject to brain damage. However, this regimen was not adopted.

[c] DOD, *Conduct of the Persian Gulf War: Final Report to Congress*, April 1992, p. Q-9.

Varied Reporting of Illnesses

To date, French veterans of the Gulf War have not reported as much illness since the conflict as their counterparts from the U.S. and U.K., who have reported illnesses since the war at rates that are significantly higher than their compatriots who were not deployed or deployed elsewhere.[29] Across several studies of U.S. and U.K. veterans, the rates of illness reported by those deployed to the Gulf War has consistently been between 25 and 30 percent greater than reported by comparison groups of veterans.

A survey of U.S. veterans found that Gulf War veterans reported significantly higher rates of ill health and medical conditions than did veterans who were deployed elsewhere during the same timeframe. Compared to the non-Gulf veterans, U.S. Gulf War veterans reported a rate of functional impairment twice as high and a 50% higher rate of work or functional limitations due to health problems.[30] Researchers checked medical records for a subsample of survey respondents and found that survey responses were largely accurate with respect to physician contacts and hospitalizations. In addition, a recent study of Kansas veterans found that the probability of reporting a specific set of symptoms that were more common among Gulf veterans was highest among those who served in Iraq

[29] See Iowa Persian Gulf Study Group, "Self-reported Illness and Health Status Among Gulf War Veterans: A Population-Based Study," *Journal of the American Medical Association*, 277 (3), (1997), pp. 238-245. K. Fukuda et al., "Chronic Multisymptom Illness Affecting Air Force Veterans of the Gulf War," *Journal of the American Medical Association*, 280, (Sep. 16, 1998), pp. 981-88; C. Unwin et al., "Health of U.K. Servicemen Who Served in the Persian Gulf War," *Lancet*, 353, (Jan. 16, 1999), pp. 169-178; and P. Pierce, "Physical and Emotional Health of Gulf War Veteran Women," *Aviation, Space and Environmental Medicine*, 68, (Apr. 1997), pp. 317-21.

[30] Han K. Kang et al., "Illnesses Among United States Veterans of the Gulf War: A Population-based Survey of 30,000 Veterans," *Journal of Occupational and Environmental Medicine*, 42 (5), May 2000, 491-501.

or Kuwait, and, among those who served elsewhere in the region, it increased with the length of stay after the war.[31] By late 1997, about 12 percent of the 697,000 U.S. Gulf veterans had enrolled in voluntary health registries organized by the Departments of Defense or Veterans' Affairs. DOD reports that, as of January 31, 2001, about 20 percent of Gulf War veterans (137,862) had signed up with the two registries – 57,048 with the DOD and 80,814 with the VA, but 16,180 of those signed up with DOD declined evaluations.

In the U.K., researchers surveyed U.K. Gulf War veterans, U.K. personnel deployed to Bosnia, and U.K. personnel who were in the service during the Gulf War, but deployed elsewhere. They found that Gulf War veterans reported symptoms and disorders significantly more frequently than the other two groups of veterans, which reported levels of illness similar to one another. Even after adjusting for various factors, perceptions of physical health and ability were significantly worse among Gulf War veterans than among others. In particular, Gulf War veterans were more likely to report substantial fatigue, symptoms of post-traumatic stress and psychological stress, and to report symptoms consistent with a working case definition developed by the Centers for Disease Control.[32] The U.K. Defence Committee notes that no reliable figure can yet be put on the number of people affected by illnesses which may be attributable to their service in the Gulf. However, it also notes that, "one indication of the number who themselves ascribe their ill health to the Gulf War is that to date 2,934 of the 53,462 U.K. forces personnel deployed to the Gulf (5.5 percent) have been examined by the Ministry of Defence's Medical Assessment Programme. " Additional details on the results of U.K. and U.S. surveys of Gulf War veterans are presented in appendices IV and V.

The French government has not completed any survey of Gulf veterans regarding their health status, although plans for an epidemiological study have recently been announced.[33] Despite having contacted medical staff at a military hospital, multiple French veterans' organizations, a French

[31] L. Steele, "Prevalence and Patterns of Gulf War Illness in Kansas Veterans: Association of Symptoms with Characteristics of Person, Place, and Time of Military Service," *American Journal of Epidemiology*, 152 (10), 992-1002, Dec. 2000.

[32] C. Unwin et al., "Health of U.K. Servicemen Who Served in the Persian Gulf War," *The Lancet*, 353 (9148), Jan. 16, 1999.

[33] See "Syndrome de la guerre du Golfe: vers une étude épidémiologique [Gulf War Syndrome: Towards an Epidemiological Study]," *Le Monde*, Sep. 1, 2000, p. 26.

military writer, and many French military officials, we did not find reports of war-related illness among French veterans when we visited in 1998. The leader of a French veterans' organization cited only a few cases of psychological problems and a handful of personnel affected by war-related traffic accidents, accidental atropine injection, and unexplained hair loss (2 cases), whereas veterans from the U.S. and U.K. had long reported a variety of symptoms, including fatigue, weakness, and muscle pain. The relative absence of reports of illness among French veterans could not, even at that time, be attributed to a lack of publicity within France regarding the problems of U.S. and U.K. veterans, which had been discussed in articles and broadcasts in mainstream French media.[34] The apparently low rates of reported illness persisted even in the presence of outreach by French veterans' organizations, and the existence of veterans' benefits. More recently, 140 among the 25,000 French veterans of the Gulf Conflict have come forward with illnesses they link to their roles in the war, a new group (Avigolfe) specifically representing ill Gulf War veterans has been formed, and the French legislature has held hearings to review the matter.[35] However, as recently as June 2000, French military authorities stated that no case of Gulf War syndrome had been identified among the 25,000 French veterans of the war.[36] Officials report that only 300 requests for compensation have been made, of which 120 had been granted based on proof of Gulf War service-connection.

The apparently lower rate of illnesses reported by French Gulf War veterans does not point unambiguously to any particular cause for Gulf War veterans' illnesses; there were, in fact, several differences in French veterans' experience. For example, apart from the differences in force location and tactics already discussed, French forces did not, unlike

[34] See, for example, Nathalie Mattheiem, "Dix mille soldats américans de la "Tempête du désert" atteints Enquêtes en chaîne sur le "syndrome du Golfe [Ten thousand American soldiers from Desert Storm wait for investigations in process on 'Gulf War Syndrome']," *Le Soir* (May 27, 1994), p. 6; and Naima Lefkir-Laffitte and Roland Laffitte, "Armes radioactives contre l'"ennemi irakien" [Radioactive arms against the "Iraqi Enemy"] *Le Monde Diplomatique* (April 1995), p. 2.

[35] See E. Inciyan, "Une mission d'information sur le 'syndrome de la Guerre du Golfe' envisagée à l'Assemblée [An investigation on 'Gulf War syndrome' envisaged in the National Assembly]," *Le Monde*, June 16, 2000, p. 12; and "Les 140 dossiers d'Avigolfe [The 140 dossiers of the Association of Victims of the Gulf War (Avigolfe)], *Le Télégramme*, Oct. 19, 2000.

[36] "La polémique sur le 'syndrome du Golfe' atteint l'armée française: Aucun cas, selon les autorités militaires" ["The debate on Gulf War syndrome reaches the French Army: Not one case, according to military authorities.], *Le Monde*, June 7, 2000, p. 12.

certain U.S. and U.K. forces, make use of biological warfare vaccines, French officials reported that they also made no use of organophosphorus pesticides, unlike the U.S. and U.K. forces, and relied on bottled water.

Conclusions

We confirmed differences among the U.S., U.K. and France in the rates at which illnesses have been reported among their Gulf War veterans; their assessment of nuclear, biological, and chemical threats in the Gulf; and their preparations to meet them. However, owing to the number of differences in the experience of the three sets of veterans, they do not point unambiguously to any single cause for the reported illnesses.

If multinational allies are to act in a coordinated fashion, they require a similar level of awareness of and (when possible) preparation for the threats to be faced; otherwise, force protection and operational success could be jeopardized and the utility of some forces restricted. Gulf War Coalition members prepared for somewhat different threats and employed different countermeasures. In addition, the U.S. lacked clear doctrine for timely and systematic warning of allied forces and U.S. ground troops about pending strikes on suspected nuclear, biological, and chemical targets.

Agency Comments and Our Evaluation

DOD provided comments on our draft report that are reproduced in Appendix VI. The agency took no issue with our findings that the allies had assessed threats differently and taken varied approaches to chemical and biological defense, that threat assessments were not always voluntarily shared among Coalition members, and that the U.S. had no doctrine to prescribe timely warning of allied forces or U.S. ground troops of planned attacks on hazardous targets. DOD characterized our comparisons of specific equipment as uneven and occasionally misleading and provided additional technical and editorial comments, which we have incorporated as appropriate.

DOD also commented that we might be hasty in concluding that the French had fewer health complaints after the war. We have described the situation 10 years after the war. We cannot preclude the possibility that additional time or more thorough examination could yield additional reports of health problems among French veterans. However, we found that the problems of U.S. and U.K. Gulf War veterans had received publicity in France since at least 1997.

Finally, DOD asserts that health problems among Gulf War veterans are common to veterans of many wars over the past 130 years and the result of multiple factors not unique to the Gulf War. Our report draws no conclusions regarding the cause or causes of health problems reported by veterans of the Gulf War or other conflicts. Nonetheless, we are hesitant to compare clinical data across two centuries or to draw a conclusion by comparing the illnesses of military populations from different historical periods with varied levels of health and nutrition. While identification of common sets of symptoms can be an important starting point for effective research, common symptoms alone do not show that veterans of various wars necessarily had a similar disease process.

Scope and Methodology

To compare threat assessments and the extent to which they were shared by the three countries and to assess use of various countermeasures across the three forces, we conducted structured interviews with officials of the French and U.K. governments, members of their military and veterans' organizations, and their U.S. counterparts. A list of the organizations contacted in the U.K. and France is provided in appendix VII. These interviews addressed both the threats assessed prior to or during the conflict and the countermeasures adopted in response. We supplemented these interviews with reviews of published information, including U.S. and NATO nuclear, biological and chemical doctrine, and reviews of the Gulf War campaign produced by DOD, the U.K. Ministry of Defence, and campaign participants.

To supplement the aforementioned work and to assess the extent of illnesses reported by the three sets of veterans, we complemented our interviews of officials and veterans' representatives with review of official documents, scientific literature, and reports of various veterans' organizations, publications of the Office of the Special Assistant for Gulf War Illnesses, the Gulf War Veteran's Illnesses Unit of the U.K. Ministry of Defence, reports of the U.K. Defence Committee, the U.S. Department of Defense, RAND, the Institute of Medicine, and various U.S. congressional and executive advisory committees. We reviewed key findings with the U.K. Gulf War Liaison officer and with staff of the French Embassy. Finally, we collected and reviewed media reports regarding the extent and nature of illness reported in the three countries and the progress of official investigations into these complaints.

Our work was limited primarily to describing the assessment and sharing of information on chemical, biological, and nuclear/radiological threats and the use of medical countermeasures against them. Thus, we did not

systematically examine the extent of exposure to many of the other potential challenges that could have been encountered by the three sets of veterans, such as oil fire smoke, pesticides, depleted uranium, or any hazards that may have emerged from air strikes on military targets. In addition, many of the broad-based surveys of illness across Coalition nations rely on health information reported by veterans. While such self-reporting can be biased by media influence, a large national survey of Gulf War era veterans found that their reports of doctor and hospital visits were in good agreement with medical records.

We conducted initial data collection and site visits between August 1997 and January 1998. At your request, we suspended this work to carry out a higher priority engagement for you. In April 1999, we resumed our work and conducted additional data collection and updated our findings. We completed our work in January 2001. All work was conducted in accordance with generally accepted government auditing standards.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we will send copies of this report to other interested congressional committees and members.

If you have any questions or would like additional information, please contact those listed in appendix VIII.

Sincerely yours,

Nancy Kingsbury
Director, Applied Research and Methods

Appendix I: Major Chemical Warfare Agents and Their Physiological Effects

Chemical Agent Class	Name	Mechanism of Action
Nerve Agents	Tabun Sarin Soman GF VX	Anticholinesterase agents that interfere with normal transmission of nerve impulses
Vesicants or Blister Agents	Sulfur mustard Nitrogen mustard	Blistering agents, bone marrow depressants, and alkylating agents that damage DNA
	Lewisite	Blistering agent, arsenical poison
	Mustard/lewisite mixture	Like lewisite and mustard (see above)
	Phosgene oxime	Causes rapid irritation of the respiratory tract, later pulmonary edema; very irritating to mucous membranes
Pulmonary Agents	Phosgene	Causes coughing, choking, chest tightness and pulmonary edema
Blood Agents	Hydrogen cyanide	Interferes with oxygen utilization at cellular level
	Cyanogen chloride	Like hydrogen cyanide, but also causes respiratory tract irritation, cough, choking, tightness in chest
Vomiting Agents	Adamsite Diphenylchlorarsine Diphenylcyanarsine	Local irritant, induces vomiting
Irritants (Tear agents)	Chloroacetophenone Bromobenzylcyanide	Local irritants that cause eye redness, irritation, pain and tearing
	O-Chlorobenzylidene Malononitrile Dibenzoxazepine	Local irritants that cause intense eye irritation, pain, tearing, and photophobia
Incapacitating Agents	3-quinuclidinyl benzilate	Causes headache, disorientation, hallucinations, and lack of coordination
	LSD	Induces hallucinations, poor concentration

Appendix II: Examples of Potential Biological Warfare Agents

Disease	Causative agent	Incubation time (days)	Fatalities (percent)
Anthrax	Bacillus anthracis	1 to 6	80
Plague	Yersinia pestis	1 to 5	90
Tularemia	Francisella tularensis	14 to 10	5 to 20
Cholera	Vibrio cholerae	2 to 5	25 to 50
Venezuelan equine encephalitis	VEE virus	2 to 5	< 1
Q fever	Coxiella burnetti	12 to 21	< 1
Botulism	Clostridium botulinum toxin	1 to 3	30
Staphylococcal enterotoxemia (food poisoning)	Staphylococcus enterotoxin type B	1 to 6	< 1
Multiple organ toxicity	Trichothecene mycotoxin	Dose dependent	

Source: *The Biological and Chemical Warfare Threat*, Revised Edition, Washington, D.C.: Superintendent of Documents, 1999; and U.S. Army Medical Research Institute of Infectious Disease, *Medical Management of Biological Casualties Handbook* (2nd ed.), Fort Detrick, MD: USAMRIID, August 1996.

Appendix III: Nonmedical Chemical and Biological Defense

This appendix describes non-medical countermeasures, including procedures and protective equipment, employed by the U.S., U.K. and France along with some of the countries' assessments of how well they worked. Protective equipment included detection, identification, and warning systems; protective clothing and decontamination kits; vehicles and shelters; and other decontamination equipment.

Approach Used By U.S. Forces

U.S. commanders' determination of threat levels (for purposes of donning the chemical protection ensemble) hinged to some extent on alarm systems intended to provide early warning. In addition to the chemical alarms, certain Iraqi attacks were regarded as sufficient cause for increased use of chemical protective clothing. During Iraqi SCUD missile attacks against Coalition bases, U.S. forces donned some chemical protective clothing in response to attack warnings or sirens.

Warning and Reporting

Provisions for reporting NBC detections and warning other U.S. Army units are described in Army Field Manual 3-3. Under doctrine developed by the Army, which is lead agent in this area, information about detections is processed through the Automated Nuclear, Biological, and Chemical Information System. A hierarchy of standard message formats is used for transmitting information about NBC detections and meterological information useful in hazard estimation. Two additional message formats, CHEMWARN and STRIKWARN would have been used to warn other U.S. forces of a pending U.S. attack using chemical or nuclear weapons, respectively. According to a postwar review by the U.K. Ministry of Defence, at least some U.S. forces in the Gulf War did not comply with NATO Allied Tactical Pamphlet 45 with respect to warning and reporting, which was the procedure in use by U.K. forces. Thus, different warning and reporting practices were in use across the Coalition's member forces.

Detection, Identification, and Alarm Systems

Detectors and alarms were used at the unit level to provide detection and warning of the presence of chemical and/or biological agents. Most units deployed to Southwest Asia with standard detection equipment, including the M256A1 chemical detector kit and the M8A1 Chemical Alarm System. According to the official history of the conflict, a few newly developed detection systems were fielded for Operations Desert Shield and Desert Storm without benefit of previous field experience. In many cases, this equipment provided unique capabilities never before available in the field, but also presented difficulties since the systems were unfamiliar, were not

in final military configurations, or were serviced by special civilian support personnel.[1]

The M8A1 Chemical Alarm System, developed in the mid 1980s, was the U.S. military's primary means of detecting nerve agent vapors and its primary early warning system during the Gulf War. The M8A1 is a continuous air sampling alarm that detects nerve agent vapors and warns personnel with both audible and visual signals. U.S. forces used over 12,000 of these M8A1 Chemical Alarm Systems in the Kuwaiti Theater of Operations. However, this system was designed to detect only a narrow spectrum of chemical nerve agent vapor or inhalable aerosol (specifically, G and V series nerve agents, such as tabun, sarin, soman and VX); it would not have detected tear gas, blister agents (e.g., mustard), blood agents, or agents not in inhalable form. It could take up to 2 minutes for detectors to alarm in the presence of agent, so they were to be placed far away and upwind to allow enough time for personnel to take appropriate protective measures. Up to five alarm units could be connected to one detector to enable more personnel to hear or see the alarm.

Substances that form ionized products similar to those of nerve agents could cause the M8A1 to false alarm.[2] Many chemical compounds used in either a normal or a military operational environment can cause the M8A1 to false alarm. Examples of such known interferents include heavy concentrations of screening smoke, signaling smoke, rocket propellant smoke, nuclear blasts, and diesel and gasoline exhausts. Other potential interferents include jet fuel vapor; smoke from burning jet fuel, oil, or kerosene; insecticides (e.g., Diazinon and Malathion); paint fumes; floor wax; perfumes; cologne; aftershave; and cigarette smoke. DOD's Office of the Special Assistant for Gulf War Illnesses has reported that, during the Gulf War, the M8A1 Chemical Alarm System encountered many of the interferents that would cause it to false alarm and that its alarms sounded so frequently that some soldiers lost confidence in the alarm or turned it off. In addition, this detector cannot be operated while on the move.

[1] See *Conduct of the Persian Gulf War: Final Report to Congress*, Appendix Q, April 1992.

[2] The unit operates through a process of ionization. As a pump draws air and any contaminants through the cell module, the air and contaminant molecules pass over a radioactive source and break up into charged pieces called ions. These ions then travel into the baffle section where the lighter and less stable air ions filter out. The collector then senses the current given off by the heavier ions formed from any nerve agent vapor. An electronic module, which monitors the collector, triggers the alarm when it senses a current change that matches the critical concentration of nerve agent.

During the Gulf War, the M8A1 was supplemented by 60 Fox Nuclear Biological and Chemical Reconnaissance Vehicles. These had an initial alerting mechanism to warn personnel of the possible presence of dangerous chemicals, and a detailed confirmation capability by means of a mass spectrometer to aid chemical identification.[3] However, tactics involving rapid movement often restricted the operation of the Fox vehicle to less than its full capability to detect chemical agents and its vapor detection capabilities were regarded as poor. Thus, the M43A1 detector was added to the Fox to raise its vapor detection ability to the same level as the M8A1.

In addition to the M8A1, the U.S. sent more than 1300 Chemical Agent Monitors to the theater, although this supply was not adequate to support unit requirements down to the company level. Army and Marine Corps after action reports cited good results with Chemical Agent Monitors when they were used properly to check personnel and equipment for contamination. (The system often was used improperly as a continuous monitor and alarm). However, it could not detect both nerve and blister agents simultaneously. False alarms reportedly were caused from exposure to certain petroleum products and red fuming nitric acid (a Scud missile fuel oxidizer).

Ten developmental XM-21 remote sensing chemical agent alarms were fielded by the end of December 1990. To supplement on-site ("point") detectors, which would not have sounded until troops had entered a contaminated area, the XM-21 was intended to alarm upon detecting chemical agents at a distance. While the Fox vehicle was intended to mark contaminated areas, as noted above, its vapor detection capability was poor and tactics involving rapid movement restricted it to less than its full capability to detect agents.

Finally, to improve chemical and biological warfare agent warning and reporting, the Defense Nuclear Agency developed the Automated NBC Information System, which linked computer support in the United States to forces in the field. This system provided greater identification of potential hazard areas by drawing map overlay contours of different dosage intensity according to specific attack data from the field, giving the

[3] Other detection equipment aboard the Fox included the M43A1 detector that formed the basis of the M8A1, an M256 Series Chemical Agent Detector Kit, the AN/VDR2 radiation detector, and the ASG1 radiation detector.

combat commander a more definitive prediction of the probable extent of serious contamination. This system was used by U.S. forces in more than 600 tests and exercises.

Individual Protective Equipment

Individual protective clothing consisted of protective masks, boots, gloves, battle dress overgarments, and personal decontamination kits. Protective clothing was worn in various combinations according to the alert level. During Operation Desert Shield, training was conducted in an attempt to acclimatize personnel to the stress the protective gear would impose. Many units donned chemical protective clothing at the start of Operation Desert Storm and continued to wear some items throughout the ground offensive.

Protective mask shortcomings were reported in availability, durability, and suitability. With respect to availability, DOD reported after the war that overgarments for chemical and biological defense were initially in short supply among U.S. forces, especially in the desert camouflage pattern. Consumption of chemical protective clothing exceeded expectations, causing a reduction of reserve stock available for other contingencies as the Army transferred overgarments to southwest Asia. Production of new overgarments was accelerated in an attempt to compensate. However, the industrial base for consumable chemical defense items was pressed to keep pace with the reduction of war reserve stocks. As a result of experience in southwest Asia, DOD reported that stock levels and resupply procedures would be reconsidered for chemical defense items in high demand. The capacity to test the functionality of available equipment was also stretched. The Marine Corps had only one U.S. test site for chemical masks with a peak testing capacity of 450 masks a day, thus a need was established for additional test sites. The Marines also reported that testing of the M17 protective masks showed high failure rates and that the masks' prepositioned replacement filters had exceeded their shelf life. The problems in mask fit included poor joints around the voicemitter, bent drinking tube levers, and outlet valve deterioration. Separately, the Army deployed specialized teams equipped with mask leakage detection devices to ensure adequate fits. Individuals with hard-to-fit faces received new M40 protective masks to ensure adequate protection. Army surveys subsequently cited the mask as uncomfortable for prolonged wear and reported that the mask carriers deteriorated because of the abrasive effects of sand. In general, all masks received some criticism for limiting or distorting vision, and the inability to change filters or eat while in a potentially contaminated environment.

The battle dress overgarment, designed primarily for use in a European environment, is described as providing 24 hours of protection in a contaminated environment, and being more durable than other types of suits.[4] However, this durability and protection was achieved at the expense of greater heat stress. During Operations Desert Shield and Storm, personnel criticized boots and gloves because of difficulty in performing detailed tasks and because of excessive perspiration. The Marines also reported some overgarments drawn from prepositioned supplies were damaged by heat or petroleum while in storage.

As a consequence of dissatisfaction with the battle dress overgarments available during the operation, the Air Force and Marine Corps procured lightweight aircrew and ground personnel chemical protective overgarments made of a German-designed material, but these were not fielded before the cessation of hostilities. The Marines also used the British Mark IV protective suit. The Army began shortly after the war to assess options to field lighter protective clothing for certain missions. The Air Force fielded a multi-man intermittent cooling system for use by ground crews on flight lines. This system included standard flight line air conditioners with an air distribution system hooked up to air cooled vests, to help keep body temperatures down.

Collective Protection Systems (Vehicles and Shelters)

The Department of Defense reported after the war that its collective protection systems for chemical and biological warfare were insufficient. Occupants of armored vehicles with no collective protection or cooling systems were particularly susceptible in a contaminated environment in hot climates. The Army's newer M1A1 tanks, which have specially ventilated interiors and cooling systems, can operate in such an environment with less crew stress. However, during the conflict, significant numbers of combat vehicles had only mask-based chemical protection with no cooling or specially ventilated interior that would allow unmasked use. In addition, the harsh desert environment made it necessary to change filters frequently on air intakes of chemical alarms and monitors as well as on collective protection systems of combat vehicles, vans, and shelters.

[4] Another type of individual protection, known as the Chemical Protective Overgarment, was rated for 6 hours of protection in a contaminated environment.

Decontamination Equipment

Decontamination equipment was issued to U.S. forces at both the personal and unit level, and included M258A1 individual decontamination kits for removing contamination from clothing and skin; small sprayers, such as the M11 or M13 decontamination apparatus, for decontamination of vehicles and weapons, and the M12A1 power driven decontamination apparatus mounted on a 5-ton truck (available at the chemical defense unit level). According to DOD, the lighter and more transportable M17 lightweight decontamination system also supported the Army, Air Force, and Marines.

DOD reported that decontamination equipment was not used during combat operations, but received extensive training use. An adequate supply of water for decontamination operations was reported as a major problem in the desert. In both the older M12A1 decontamination system and the newer M17 system, U.S. operating forces noted poor reliability, insufficient water pressure, and inadequate availability of spare parts. In particular, high failure rates were reported during extended use of the newer M17 system. These water-based decontamination systems, designed for the European theater, were subsequently judged inadequate for desert operations. To resist chemical agents, U.S. vechicles were painted with a substance known as chemical agent resistant coating.

Approach Used By United Kingdom Forces

The procedures the U.K. established with respect to use of chemical protective gear were largely similar to those adopted by the U.S. However, the chemical detectors available to trigger the use of protective clothing were somewhat different as were warning and reporting mechanisms.

Warning and Reporting Mechanisms

U.K. warning and reporting of NBC attacks was based upon standard NATO practice and the guidelines set out in the *Manual of Nuclear Biological and Chemical Defence Training on Land*, which prescribe the establishment of NBC data gathering cells at different levels of command to receive, log, plot, evaluate, and disseminate NBC reports, passing warnings to those concerned. During the Gulf War, it was established that these NBC cells would adhere to procedures documented in NATO Allied Tactical Pamphlet 45, "Reporting Nuclear Detonations, Biological and Chemical Attacks, and Predicting and Warning of Associated Hazards and Hazard Areas."

In practice, according to the U.K. Ministry of Defence, the warning and reporting organization was less straightforward owing to the gradual arrival of U.K. troops in theater. Eventually, the NBC cell in the British

Headquarters in Riyadh became responsible for liaison with Coalition NBC organizations, development of NBC defense plans, organizing NBC warning and reporting in the theater, and controlling the process for sampling and identification of biological and chemical agents along with other theater assets.[5] This cell was under operational control of the chemical and biological defense cell at British Joint Headquarters in High Wycombe. Above this was the Joint Operations Center led by the Chief of the Defence Staff and its chemical and biological defense cell. In addition to these arrangements, to ensure that warning and reporting of any Iraqi use of chemical and biological weapons covered a wider area, NATO's Supreme Allied Commander Europe requested that NATO's Southern Flank Warning and Reporting System be activated and it remained so from January 21 through 3 March 1991.

The primary means of reporting and warning was a British air force electronic system, known as the Air Staff Management Aid. Because this was not universally available, other methods were needed to provide a complete reporting and warning chain for British forces. Thus, radio and telephone were used and authorization was given for use of the British Forces Broadcasting Service. To predict the extent of a hazard, U.K. forces used the Danish Bruhn Data NBC-Analysis software and software developed by its own Chemical and Biological Defence Establishment. Local warnings of attack were to be provided in accordance with NATO guidance by radio, land-line, audible alarms and, where practical, visual signs. From the outset of the operation, British analysis notes that there was consensus that a new NBC alarm system was required, particularly because alarms in the Gulf needed to be transmitted over large distances. Confusion resulted when U.K. troops were based alongside American troops who did not use NATO Allied Technical Procedure 45 and British reports note that, "There were criticisms that there was not sufficient,

[5] U.K. documents note that it was recognized that the first use of CBW agents during the operation would have been a matter of strategic importance, necessitating proof beyond reasonable doubt to inform the military, political, and medical response. Since observations on the battleground would constitute only circumstantial proof, there was a need to take samples from the area of any alleged attack and to return these to a lab for analysis while maintaining an irrefutable audit trail. Prior to the Gulf Conflict the U.K. had developed a process to satisfy this need in accordance with NATO STANAG 4359, NATO Handbook for the Sampling and Identification of Chemical Warfare Agents (SIBCA). SIBCA kits and instructions were sent to U.K. forces in the theater and the process was tested in November 1990 when samples were sent from Royal Air Force bases in Dhahran and Muharraq. U.K. after action reports note that evidence suggests the SIBCA kits were issued to Army Headquarters and Royal Air Force detachments, but not to individual units.

formal in-theater liaison on NBC matters between Coalition forces of different nations, and there is evidence that, on a number of occasions, U.K. troops entered a state of chemical alert just as neighboring U.S. troops were beginning to relax." Similarly, the U.K. reports indicate that there is evidence that soldiers could not distinguish between the hand-held alarm provided for local nuclear, biological and chemical warning and the alarm from the Nerve Agent Immobilized Enzyme Alarm and Detector, the temperature alarm on the blood banks at a field hospital, and the sound of the warning tone to indicate reverse movement of a motor vehicle. Over time, this could have contributed, at worst, to alarms being disregarded or, at best, to unnecessary confusion.

Detection, Identification and Alarm Systems

Prior to the start of the Gulf War, different chemical agent detectors and monitors were available to U.K. forces, each of which performed a unique role in the provision of chemical defense. These included the Nerve Agent Immobilised Enzyme Alarm and Detector, the Residual Vapor Detector (which samples the air to test for the presence of nerve and mustard agent), two types of detector paper (which were intended to test for the presence of liquid chemical warfare agent), and the Chemical Agent Alarm (a hand-held point monitor designed for use after an attack to search for and locate nerve and blister agents on personnel, equipment or the ground). Additional detectors were used in very limited distribution.

Although 6000 Residual Vapor Detection kits were deployed with British troops, the NAIAD was the only real detector that was available to British troops. (Other devices, such as the Residual Vapor Detector, required a human operator and/or had no audible alarm to alert forces to the presence of chemical agent.) Just over 2000 NAIADs were deployed with the U.K. Army and at least 300 with the Royal Air Force, with an average of two fitted to deployed ships. However, the NAIAD could not respond to some of the chemical warfare agents that were thought to be at Iraq's disposal. There was no U.K. detector capable of warning of the presence of sulphur mustard, nitrogen mustard, phosgene, adamsite, CS, and BZ. Although the Chemical Agent Monitor would respond to the presence of sulphur mustard and nitrogen mustard, it was not designed for continuous and unattended operation and was not fitted with an alarm to provide warning of a hazard. The U.K.'s Chemical Defence Establishment advised in the early days of the operation that modifications to the software running the Chemical Agent Monitor would give it the ability to respond to all of the potential Iraqi threat elements and that other "add-ons" would allow it to be used as a warning detector. While this software was developed, modifications did not proceed as planned in the months up

until January 1991 and fewer than 290 modified Chemical Agent Monitors were actually used in the Gulf (versus over 2000 Nerve Agent Immobilized Enzyme Alarms and Detectors and 6000 Residual Vapor Detectors). Additionally, Army advisers did not consider it operationally viable to retrain operators at such a late stage in the deployment, when offensive land operations were about to begin.

Individual Protective Equipment

It was recommended that U.K. soldiers deploying to the Gulf be issued with one S10 respirator to protect the eyes, nose, throat, lungs and face from chemical and biological warfare agents and radioactive dust, 3 filter canisters for the respirator, three suits for protection in nuclear, biological and/or chemical environments, six pairs of inner cotton and outer neoprene gloves, and three pairs of overboots made of impermeable butyl rubber. The suit for nuclear, biological and chemical protection included a jacket and trousers made of a lightweight non-woven fabric treated for resistance to chemical warfare agents. This fabric was covered with a more durable, woven material and lined with a layer of fine charcoal to counteract vapor hazards. This suit was to be worn over regular clothing and undergarments. Instructions called for use of the respirator only when there was warning of imminent arrival or presence of chemical or biological agents or radiological hazards.

Because the individual protective equipment given to British troops had been designed for use in Central Europe, it was not well suited to the hot climate of the Gulf, where it could lead to heat stress, psychological casualties, and degraded individual performance. This was particularly difficult when it was worn in combination with Combat Body Armor, which was being worn in combat for the first time. Instructions were provided on the very limited rate of heavy work that should be expected of persons wearing individual protective equipment under these circumstances. The U.K. Ministry of Defence's Gulf Veterans' Illnesses Unit wrote that the final decision as to the level of individual protective equipment to be worn was placed on appropriate field commanders to allow them to balance risk against the requirement to achieve operational tasks.

Collective Protection Systems

Collective protection is protection provided to a group of individuals in a nuclear, biological or chemical environment which permits relaxation of individual protection. It can be hardened or semi-hardened to give protection against ballistic and NBC attack. Unhardened collective protection provides no protection against blast, heat, or fragmentation and

only short term protection from direct liquid attack and limited protection against alpha radiation. Collective protection systems are sometimes fitted to vehicles for mobility.

The United Kingdom provided its troops with two types of unhardened collective protection from the beginning of the Gulf conflict: (1) a transportable facility used by aircrew and ground support staff that could hold about 8 people and could be erected either indoors or outdoors; and (2) a lightweight transportable liner with a capacity to hold about 25 people that was often used inside empty containers that provided some protection against ballistic weapons. A number of air conditioning units were deployed when concerns were voiced about heat and degraded performance by personnel such as medics, who worked in collective protection shelters for extended periods of time. U.K. after action reports note that units generally preferred to carry water, rations or other equipment and did not draw upon some of the collective protection equipment sent to the Gulf. However, it was used by personnel treating casualties, because many of them could not have donned individual protective equipment.

Decontamination Equipment and Procedures

U.K. policy called for a combination of contamination avoidance and decontamination in the event of a chemical attack. Avoidance measures included the use of overhead cover, marking contaminated areas for avoidance and careful route planning to avoid picking up contamination in transit. Chemical Agent Resistant Material was also sent to the Gulf for use as overhead cover to protect from liquid chemical warfare agents.

Where contamination cannot be avoided, British doctrine was based around operational decontamination, where equipment would be decontaminated only to the extent that was necessary to allow the operation to carry on, with troops continuing to wear individual protective equipment and fight 'dirty.' Thorough decontamination was to take place only when it was absolutely essential that troops should be able to unmask quickly. According to a British Ministry of Defence report, It was recommended that it was only worth decontaminating the surfaces of equipment if liquid was still present because the high temperatures of the Gulf meant that chemical warfare agents would be absorbed into surfaces more quickly and that the residual vapor hazard would also fall more rapidly.

Decontamination equipment issued to troops included the Karcher Multipurpose Decontamination System, provided to Army and Air Force

units. This provided dry steam, hot water and blasted fullers earth (a highly absorbent claylike substance) for thorough decontamination. Unlike U.S. forces, U.K. forces did not coat vehicles with chemical agent resistant paint. They concluded that the difficulties of doing this outweighed the benefits and vehicles were therefore deployed with alkyd paint, which would readily have absorbed chemical warfare agents had they been present. In addition, two personal decontamination kits based on fullers earth were issued to individuals to absorb chemical warfare agents from the skin and personal equipment.

Approach Used By French Forces

French doctrine was to take the "most appropriate" individual or collective protection measures after remote or local detection of chemical or biological agents and then to confirm the detection. Next, French forces were to follow decontamination procedures for vehicles and equipment. French officials told us that French troops were ordered to regard each SCUD alert as a chemical attack. Although they stated there were no reports of chemical scuds, we were told that French troops often slept wearing their masks after Iraq began launching scuds.

Warning and Reporting

We received no specific information on French command and control structure for warning and reporting about detection of chemical or biological agents. However, we were told that written reports would have been filed in the event of a detection and that standard NATO reporting procedures would have been followed.

Detection, Identification and Alarm Systems

French and U.S. approaches to chemical defense differed, in part, because of the differences between U.S. and French detection equipment. The detectors used by the U.S. (principally the M8A1) were less sensitive than detectors used by the French (principally the Detalac) and might have been unable, in certain cases, to detect or confirm the presence of levels of chemical agents below casualty thresholds.[6] French equipment used during the Gulf War could detect concentrations of certain chemical agents that were roughly 2 to 20 times smaller than the concentrations

[6] French officials noted that the setting of detection levels was an operational rather than a scientific matter. We were told that the "NATO values" for organophosphates and sulfur mustard were 0.2 milligram-minutes/cubic meter and 50 milligram-minutes/cubic meter, respectively. We were told that France has accepted NATO values but has established a separate safety rating.

detectable with the most widely used U.S. detector; however, like U.S. and U.K. equipment, French detectors were insensitive to some agents. For example, French detection capabilities did not cover cyanic acid (a volatile agent not believed to be effective in hot countries), lewisite, or nitrogen mustard.

French personnel used two major types of chemical detectors—15 prototype detectors, known as the AP2C, and the much more broadly employed Detalac.[7] At that time, the AP2C indicated detections through a two-part light display, not audible alarms. The first light would illuminate on the basis of very low levels of detectable agent (10 to 20 micrograms per cubic meter). The AP2C is used to detect nerve agents (organophosphorus compounds) and Mustard agents (sulfur compounds) in the atmosphere. The AP2C was superior to the U.S. M8A1 in its capability to detect sulfur mustard, which the M8A1 detector was not designed to do. In addition, French officials stated that the AP2C could pick up dusty agents (by rubbing on a surface that contained them) or liquid agents (by using a special sampling tip to collect the sample and then heating it to turn any contamination into vapor form).[8] The AP2C can also measure cumulative doses if they are on the ground. Following the war, the AP2C was used in the United Nations Special Commission's investigations of Iraq's chemical programs.

French officials told us that, based on testing conducted apart from the Gulf War, the AP2C's performance with respect to false alarms was much improved over the Detalac. The technology used in the detectors relies on detection of sulfur, which is a component of mustard, and phosphorous agents, which are components of organophosphates. While volatile substances containing phosphorous agents are rare, sulfur is in most diesel fumes.

As a supplement to the AP2C, French forces used detection papers from a chemical kit to identify liquid contamination and vapors. A hand pump

[7] We were told that the technology for the AP2C is similar to the Detalac. The Detalac also detects 10 micrograms per cubic meter, but the alarm is set at 10 milligrams per cubic meter.

[8] French officials told us that detections never passed 10 micrograms per cubic meter in the areas where the 15 prototypes were deployed. They concluded that the risk of intoxication was very low. There were, however, many alarms with the Detalac, which they characterized as false. We were told that had detections occurred, there would have been written reports and a special procedure would have been invoked for verification.

would draw a constant volume of ambient air through an absorbent paper disc mounted on the pump and toxic agents adhering to the paper would be identified after exposure to one or more of eight reagents from the kit. The reagents would produce a color change that is specific to each type of chemical agent. This kit contained reagents allowing identification of G and V series nerve agents, cyanic acid, mustard, phosgene, and cyanic chloride.

Individual Protective Equipment

French soldiers employed protective suits, known as the NBC tropical suit or S3P. The NBC tropical suit included a jacket with an integrated hood. The entire ensemble weighed 1.8 kg. and the heat stress induced by this gear was described as being no more than classic battledress. The suit could be worn directly on the skin and was subsequently employed by the U.N. Special Commission's chemical destruction group. Technical information supplied by the French Army indicates that the full suit can be worn in a tropical climate for 4 hours during a non-intensive physical activity and that it offers more than 24 hours of protection against liquid agent.

French forces in 1990 also adopted an NBC mask incorporating a toxic-proof face shield known as the ANP VP F1, weighing half a kilogram.

Decontamination

French decontamination efforts were supported by a system consisting of a pressurized hot water generator mounted aboard a 12 ton truck carrying a water tank of 3 cubic meters. A ramp was mounted on the truck for crew to reach the higher parts of equipment to be decontaminated. These decontamination assets were made available to the U.S. during the war. The decontamination apparatus could be dismounted from the truck in order to free it for water runs and the system, though heavy, was reportedly highly mobile with a large range (over 875 miles, or 1,400 kilometers). However, water-based systems, while perhaps efficient on mustard and nerve agents, have obvious limitations in locations where water is not readily available. French officials noted that fielding of enzymatic decontaminants was a NATO priority. They stated that next generation decontaminants would use non-corrosive agents that could be more readily employed with sophisticated electronic equipment.

Appendix IV: Receipt of Other Drugs and Immunizations as Reported in Surveys of U.S. and U.K. Gulf War Veterans

Drug/vaccine[a]	Percent of Gulf War veterans reporting use[b]	
	U.S.[c]	U.K.
"Malaria pills"	41.2	NR[d]
Ciprofloxacin	15.1	NR[d]
Gamma globulin	60.1[e]	6.3 (7.8)
Meningococcus	13.7[f]	NR[g]
Typhoid vaccine	58.8	12.5 (25.4)
Hepatitis B	NR[d,e]	7.2 (10.6)
Yellow fever	NR[d,e]	14.0 (15.8)
Poliomyelitis	NR[d]	13.7 (15.9)
Cholera	NR[d,e]	13.7 (31.5)
Tetanus	NR[d,f]	33.8 (34.3)

Note: Based on responses from 11,441 U.S. and 2,961 U.K. veterans of the Gulf War. Figures in parentheses report the percentage of U.K. respondents with access to vaccine records (n=940) that reported receipt of the vaccine.

Source: Data for U.S. veterans are taken from H. Kang, et al., "Illnesses Among United States Veterans of the Gulf War: A Population-Based Survey of 30,000 Veterans," *Journal of Occupational and Environmental Medicine*, 42(5), May 2000. Data for U.K. veterans are taken from C. Unwin, et al., "Health of U.K. Servicemen Who Served in Persian Gulf War," *Lancet*, 353 (9148), (Jan. 16, 1999), p. 169-178.

[a]The list of drugs in this table consists of drugs and immunizations incorporated in surveys of U.S. and/or U.K. veterans, but excludes drugs and vaccines discussed earlier as having been used as countermeasures for chemical or biological warfare.

[b]No comparable survey of French veterans was available. When we inquired about use of vaccines by French forces, French military health officials told us that they would have been immunized for Hepatitis A., meningococcus, typhoid, and influenza. Certain French troops who had already deployed overseas might have had yellow fever immunization and routine use was made of tetanus toxoid. Other vaccines (diphtheria, measles-rubella, polio) might have been received in infancy, but were not part of basic training. They reported no use of cholera or rabies vaccines.

[c]In addition to the vaccines listed here, U.S. forces had exposure to adenovirus, diphtheria, measles-rubella, and influenza vaccines, which are given during basic training, and to rabies and/or japanese encephalitis vaccines, which are given to U.S. troops deployed to high-risk areas, to alert forces as required by a host country, or as directed by the surgeon general.

[d]Many of the items listed were addressed in one survey, but not the other; "NR" appears where a survey incorporated no report regarding use of a particular drug or immunization.

[e]Immunoprophylaxis for hepatitis A, hepatitis B, cholera, japanese encephalitis, rabies and yellow fever is given to U.S. troops deployed to high-risk areas, to alert forces as required by a host country, or as directed by the surgeon general.

[f]This vaccine is given to U.S. troops as part of basic training.

[g]U.K. officials reported the meningococcus (A and C) vaccine was given to people working as liaisons in the local economy during the war, but not to the whole force.

Appendix V: Gulf War Veterans' Self-Reported Operational Exposures

	Percent of Gulf War veterans reporting the exposure	
Environmental exposure[a]	**U.S.**	**U.K.**
Wore chemical protective gear (other than training) or heard chemical alarms sounding	65.5%	81.7% (NBC suits) 70.7% (sound of chemical alarms)
Diesel or petrochemical fumes	80.4[b]	84.0
Exhaust from heaters or generators	NR[c]	78.2
Smoke from oil well fires	65.1	72.4
Personal pesticides[d]	48.4	69.2
Local food	74.9	69.1
Burning trash or feces	60.0	66.7
Skin exposure to diesel or other petrochemical fuel	56.6	66.6
Dismembered bodies	NR[c]	66.3
Other paints or solvents	29.7[e]	63.9
Dead animals	32.2	56.6
Handled prisoners of war	32.8	53.6
Maimed soldiers	NR[c]	48.0
SCUD missile explosion within 1 mile	43.2	NR[c]
Food contaminated with smoke, oil, or other chemicals	30.2	NR[c]
Bathing or drinking of water contaminated with smoke, oil, or other chemicals	28.1	NR[c]
Direct combat duty	27.2	NR[c]
Witnessed deaths	26.4	NR[c]
Microwaves	23.7	NR[c]
Bathed or swam in local pond, river, or Persian Gulf	23.3	NR[c]
Chemical Agent Resistant Compound paint	21.7	NR[c]
Nerve gas	9.6	NR[c]
Mustard gas or other blistering agents	4.8	NR[c]
Depleted uranium	9.5	NR[c]
Experienced sexual harrassment	5.1	NR[c]
Forced sexual relations or sexual assault	0.8	NR[c]
Pesticides on clothing or bedding	NR[c]	38.4

Note: Based on responses from 11,441 U.S. and 2,961 U.K. veterans of the Gulf War.

Source: Data for U.S. veterans are taken from H. Kang, et al., "Illnesses Among United States Veterans of the Gulf War: A Population-Based Survey of 30,000 Veterans," *Journal of Occupational and Environmental Medicine*, 42(5), May 2000. Data for U.K. veterans are taken from C. Unwin, et al., "Health of U.K. Servicemen Who Served in Persian Gulf War," *Lancet*, 353 (9148), (Jan. 16, 1999), p. 169-178.

[a]This list of environmental exposures incorporates items addressed in major surveys of U.S. and/or U.K. veterans. "NR" appears in cases in which one of the surveys did not report on a particular exposure.

[b]Figure includes tent heater or vehicle exhaust.

[c]NR means that no figure for the exposure was available from the national survey.

[d]This category would include DEET-based skin creams, but not pesticides sprayed for control of the general environment.

[e]Figure includes "and/or other petrochemical substances."

Appendix VI: Organizations Contacted in France and the United Kingdom

France

Conseiller Pour la Santé et les Actions Humanitaires, Cabinet du Ministre, Ministère de la Défense (Counselor for Health and Humanitarian Missions, Office of the Minister of Defense)

Groupement Défense Nucléaire Biologique et Chimique, Facteurs Humains – Ergonomie, Section Technique de L'Armée de Terre (Human Factors, NBC Defense Group, Army Technical Section)

Business Development Directorate, GIAT Industries

Centre d'Études du Bouchet, Ministère de la Défense, Direction Générale des Armées

Direction centrale, Service de Santé des Armées (Headquarters, Army Health Service)

Division Maîtrise des Armements, État-Major des Armées (Arms Control Division, Dept. of the Army)

Bureau Recherche, Sous-Direction Action Scientifique et Technique, Direction Centrale, Service de Santé des Armées (Office of Research, Scientific and Technical Division, Headquarters, Army Health Service)

l'Union Française des Associations de Combattants et de Victimes de Guerre (Coalition of French Associations of Soldiers, Veterans, and Victims of War)

La Fédération des Anciens des Missions Extérieures (Federation of Veterans of Foreign Wars)

Fédération Mondiale des Anciens Combattants (World Veterans Federation)

Hôpital Val de Grace (Military Hospital)

United Kingdom

Gulf Veterans' Illnesses Unit, Ministry of Defence

British Medical Association

Royal Society of Medicine

National Gulf Veterans and Families Association

Royal British Legion

Gulf Veterans Association

Defence Committee, House of Commons

Institute of Occupational Medicine

London School of Hygiene and Tropical Medicine

University of Manchester, School of Epidemiology and Health Sciences

Institute of Neurological Sciences, Southern General Hospital

Appendix VII: Comments From the Department of Defense

OFFICE OF THE SECRETARY OF DEFENSE
1000 DEFENSE PENTAGON
WASHINGTON, DC 20301-1000

SPECIAL ASSISTANT
TO THE SECRETARY OF DEFENSE
FOR GULF WAR ILLNESSES,
MEDICAL READINESS, AND
MILITARY DEPLOYMENTS

MAR 0 2 2001

Mr. Kwai-Cheung Chan
Director, Applied Research and Methods
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Chan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "COALITION WARFARE: Gulf War Allies Differed in Threat Assessment and Took Varied Approaches to Chemical and Biological Defense," dated February 2, 2001, (GAO 713012/OSD Case 3035).

The Department acknowledges receipt of the subject report and appreciates the opportunity to review it. As you pointed out in your report, the cultural and political diversity of the Coalition members created a complex military structure, so it is commendable that you attempt to explain some of the different approaches of these allies in their preparation and prosecution of the Gulf War. However, we find the equipment comparisons to be uneven and occasionally misleading. We have offered comments separately to assist your effort to clarify and correct some inaccuracies.

In addition, because of the importance and sensitivity of the self-reported postwar illnesses, we think the GAO may be hasty in concluding that the French had fewer health complaints after the war. There can be no support for this conclusion until an epidemiological study is conducted among French Gulf War veterans. Since the possibility of a unique cause of illnesses among French Gulf War veterans has just (over the last 6 months) become a major media issue in France, an epidemiological study may well show similar rates of self-reported illnesses and symptoms as in other Gulf War veteran populations.

Finally, we note that similar poorly explained symptoms have been observed among veterans after all major wars in the last 130 years and that the British, Australians, Canadians, and Americans have found similar symptoms among Gulf War veterans despite different exposures. These observations argue strongly that health problems among Gulf War veterans are the result of multiple factors that are not unique to the Gulf War.

Sincerely,

Dale A. Vesser
Acting Special Assistant

Enclosure

Appendix VIII: GAO Contacts and Staff Acknowledgments

GAO Contacts

Sushil K. Sharma (202) 512-3460
Betty Ward-Zukerman (202) 512-2732

Acknowledgments

In addition to those named above, Susan Woodward, Teia Harper, and Jonathan Tumin made key contributions to this report.

Related GAO Products

Anthrax Vaccine: Safety and Efficacy Issues (GAO/T-NSIAD-00-48, Oct. 12, 1999).

Chemical and Biological Defense: Program Planning and Evaluation Should Follow Results Act Framework (GAO/NSIAD-99-159, Aug. 16, 1999).

Chemical and Biological Defense: Coordination of Nonmedical Chemical and Biological R&D Programs (GAO/NSIAD-99-160, Aug. 16, 1999).

Medical Readiness: Issues Concerning the Anthrax Vaccine (GAO/T-NSIAD-99-226, July 21, 1999).

Medical Readiness: Safety and Efficacy of the Anthrax Vaccine (GAO/T-NSIAD-99-148, Apr. 29, 1999).

Chemical and Biological Defense: Observations on DOD's Plans to Protect U.S. Forces (GAO/T-NSIAD-98-83, Mar. 17, 1998).

Chemical Weapons: DOD Does Not Have a Strategy to Address Low Level Exposures (GAO/NSIAD-98-228, Sept. 23, 1998).

Operation Desert Storm: Evaluation of the Air Campaign (GAO/NSIAD-97-134, June 12, 1997).

Defense Health Care: Medical Surveillance Has Improved Since the Gulf War, but Mixed Results in Bosnia (GAO/NSIAD-97-136, May 13, 1997).

Chemical and Biological Defense: Emphasis Remains Insufficient to Resolve Continuing Problems (GAO/NSIAD-96-103, Mar. 29, 1996).

Operation Desert Storm: DOD Met Need for Chemical Suits and Masks, but Longer Term Actions Needed (GAO/NSIAD-92-116, Apr. 7, 1992).

Chemical Warfare: Soldiers Inadequately Equipped and Trained to Conduct Chemical Operations (GAO/NSIAD-91-197, May 29, 1991).

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