

*Publication*

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**V**  
**Veterans**  
**at Risk**

**The**  
**Health**  
**Effects of**  
**Mustard**  
**Gas and**  
**Lewisite**

## Executive Summary

### BACKGROUND

World War II (WWII) has been called "the unfought chemical war." Both sides had produced millions of tons of chemical weapons and had made massive preparations for their use, yet the weapons were never used. These preparations included the establishment of secret research programs to develop better weapons and better methods of protecting against these weapons. In the United States, some of this research was focused on the development of protective clothing and skin ointments, which could prevent or lessen the severe blistering effects of mustard agents (sulfur and nitrogen mustard) and Lewisite (an arsenic-containing agent).

By the time the war ended, over 60,000 U.S. servicemen had been used as human subjects in this chemical defense research program. At least 4,000 of these subjects had participated in tests conducted with high concentrations of mustard agents or Lewisite in gas chambers or in field exercises over contaminated ground areas. The human subjects had experienced a wide range of exposures to mustard agents or Lewisite, from mild (a drop of agent on the arm in "patch" tests) to quite severe (repeated gas chamber trials, sometimes without protective clothing). All of the men in the chamber and field tests, and some of the men in the patch tests, were told at the time that they should never reveal the nature of the experiments. Almost to a man, they kept this secret for the next 40 or more years.

Public attention was drawn to these experiments when some of the WWII human subjects began to seek compensation from the Depart-

ment of Veterans Affairs (VA) for health problems that they believed were caused by their exposures to mustard agents or Lewisite. Two factors complicated resolution of these cases. First, there were often no records or documentation available of an individual's participation in the testing programs. Second, there was a great deal of uncertainty about which health problems were in fact the result of mustard agent or Lewisite exposure.

In June 1991 the VA announced guidelines for the handling of these cases. These guidelines included the loosening of normal requirements for documenting the individual's participation in the experiments and the identification of seven diseases that the VA would consider to be caused by mustard agents or Lewisite. These seven are asthma, chronic bronchitis, emphysema, chronic laryngitis, corneal opacities, chronic conjunctivitis, and keratitis (of the eye). In addition, the VA requested that the Institute of Medicine convene a committee to survey the scientific and medical literature in order to assess the strength of association between exposure to these agents and the development of specific diseases. The committee was also charged with identifying the gaps in the literature and making recommendations relevant to closing those gaps. This report details the committee's findings and recommendations.

Between October 1991 and August 1992, almost 2,000 scientific papers, technical reports, and other documents were reviewed by the committee. The experimental protocols used in the WWII testing programs were examined to assess the potential dose levels experienced by the experimental subjects. In addition, the committee consulted with a variety of outside experts and sought information from the affected veterans themselves, through a public hearing process that resulted in written or oral statements from over 260 veterans regarding their exposures to these agents and subsequent health problems.

The committee found large gaps in the literature pertaining to the long-term health effects of exposure to mustard agents and Lewisite. For many diseases, very little or no work had been done in the eight decades following the first use of sulfur mustard in World War I. Almost all of the work in the United States had been conducted or funded by chemical defense sections of the military and was concerned only with the acute effects of these agents and not with their long-term effects. As a result, the committee depended heavily on occupational studies of chemical weapons production workers in other countries, on what could be found on battlefield casualties, and on what was known about the effects of nitrogen mustard derivatives that have been used since WWII as cancer chemotherapy agents. In addition, the committee carefully considered the basic scientific data available regarding the biological mechanisms of tissue damage from mustard agents and Lewisite.

EXECUTIVE SUMMARY

3

Special attention was directed at estimating the dose levels to which the experimental human subjects had been exposed in gas chambers or field exercises. In these experiments, subjects wore varying amounts of the protective clothing being tested, as well as gas masks. In the chamber tests, human subjects were required to enter gas chambers repeatedly for an hour or more per trial, until, after a number of trials, their skin showed evidence of chemical burns (erythema)—an indication that the agents were penetrating the protective clothing. In the field tests, the agents were dropped over large tracts of land, and human subjects, wearing clothing being tested, were sent into those areas for varying amounts of time. Penetration of the agents through the clothing was assessed in these tests in the same manner as in the chamber tests.

### GENERAL CONCLUSIONS

The committee reached the following conclusions on the basis of its analysis of the experimental protocols:

- The lack of follow-up health assessments of the human subjects in the WWII gas chamber and field tests severely diminished the amount and quality of information that could be applied in the assessment of long-term health consequences of exposure to mustard agents and Lewisite.

- The levels of exposure to mustard agents or Lewisite experienced by the human subjects may have been much higher than inferred in the summaries of the gas chamber and field tests.

The lack of follow-up of these subjects particularly dismayed the committee for a number of reasons. For example, the end point of the chamber and field tests was tissue injury, but it was already known by 1933 that certain long-term health problems resulted from sulfur mustard exposure. Further, it was documented that numerous subjects suffered severe injuries that required up to a month of treatment. Finally, the exposure levels were sufficiently high that even the most efficient gas mask would have leaked enough mustard agent or Lewisite to cause inhalation and eye injuries.

- The committee was additionally dismayed that there were no epidemiological studies done of mustard agent-exposed, U.S. chemical weapons production workers, war gas handlers and trainers, or combat casualties from WWII.

Tens of thousands of people (military and civilian) worked in U.S. arsenals that produced mustard agents, Lewisite, and other chemicals. Exposure levels in these facilities were often quite high, as evidenced by the number of injuries reported and by the poor safety record of the

Chemical Warfare Service during the peak years of production. Many other servicemen were trained to handle the gases or were assigned to jobs that put them in contact with mustard agents or Lewisite. A German bombing attack on the harbor of Bari, Italy, released sulfur mustard from a damaged American ship into the water and atmosphere, resulting in thousands of injuries and hundreds of deaths. Yet no follow-up studies were done with any of these groups; the committee had to rely instead on occupational studies from Japan and Great Britain for data on World War II production workers and their long-term health problems.

### SPECIFIC FINDINGS

The following is a summary of the major conclusions reached by the committee regarding the association of exposure to mustard agents or Lewisite and the development of specific diseases in different organ systems. Much more is known about mustard agents than is known about Lewisite. Thus, the following summary pertains to mustard agents, except when Lewisite is indicated.

The findings generally fall into one of three categories. In some cases, the data examined were found to indicate a *causal* relationship between exposure and a particular disease. For a few diseases, the data were *suggestive* but not completely clear. Finally, there were many diseases for which very little or no data existed regarding the possible contributions of exposure to mustard agents or Lewisite. This means that many diseases in this category may (or may not) be caused by mustard agents or Lewisite, but no study has been done. It is important to emphasize that *no condition evaluated could be removed from consideration as a health consequence of exposure to these agents*. Thus, for many diseases there remains significant doubt.

The evidence found indicated a causal relationship between exposure and the following health conditions:

- Respiratory cancers
  - Nasopharyngeal
  - Laryngeal
  - Lung
- Skin cancer
- Pigmentation abnormalities of the skin
- Chronic skin ulceration and scar formation
- Leukemia (typically acute nonlymphocytic type, nitrogen mustard)
- Chronic respiratory diseases (also Lewisite)
  - Asthma

EXECUTIVE SUMMARY

5

- Chronic bronchitis
- Emphysema
- Chronic obstructive pulmonary disease
- Chronic laryngitis
- Recurrent corneal ulcerative disease (Includes corneal opacities; acute severe injuries to eye from Lewisite will also persist.)
- Delayed recurrent keratitis of the eye
- Chronic conjunctivitis
- Bone marrow depression and (resulting) immunosuppression (An acute effect that may result in greater susceptibility to serious infections with secondary permanent damage to vital organ systems.)
- Psychological disorders
  - Mood disorders
  - Anxiety disorders (including post-traumatic stress disorder)
  - Other traumatic stress disorder responses (These may result from traumatic or stressful features of the exposure experience, not a toxic effect of the agents themselves.)
- Sexual dysfunction (Scrotal and penile scarring may prevent or inhibit normal sexual performance or activity.)

The evidence found suggested a causal relationship between exposure and the following health conditions:

- Leukemia (acute nonlymphocytic type, sulfur mustard)
- Reproductive dysfunction (genotoxicity, mutagenicity, etc.; mustard agents)

There was insufficient evidence found to demonstrate a causal relationship between exposure and the following health conditions:

- Gastrointestinal diseases
- Hematologic diseases
- Neurological diseases
- Reproductive dysfunction (Lewisite)
- Cardiovascular diseases (Except for those that may result from serious infections shortly following exposure—heart disease resulting from rheumatic fever, for example.)

## RECOMMENDATIONS

There are large gaps in all areas of the knowledge base about the long-term health risks associated with exposure to mustard agents and Lewisite. For example, very little is known about the long-term effects on specific organ systems from studies in animals. The data from human studies lack precise information about the exposure levels in occupational settings. After consideration of these gaps in light of the commit-

tee's findings regarding the probable long-term health effects of exposure to these agents, as well as the likely exposure levels to the human subjects involved, the committee formulated the following recommendations.

The committee recommends that the Department of Veterans Affairs (VA) institute a program to identify each human subject in the WWII testing programs (chamber and field tests, and to the degree possible, patch tests), so that these individuals can be notified of their exposures and the likely health risks associated with those exposures. Further, all subjects so identified, if still living, should be medically evaluated and followed by the VA as to their health status in the future. These individuals should also, if they request it, be treated by the VA for any exposure-related health problems discovered. Morbidity and mortality studies should be performed by the VA, comparing chamber, field, and patch test cohorts to appropriate control groups, in order to resolve some of the remaining questions about the health risks associated with exposure to these agents.

The only way to answer some of the key remaining questions is to establish a base of knowledge based on human exposures. There is precedent in the later identification and follow-up of veterans exposed to chemicals, including hallucinogenic drugs, in other military testing programs.

The committee is well aware that a half century has now passed and that many of those who might have benefited from a broader understanding of the toxicity and carcinogenicity of mustard agents and Lewisite are already dead. Nevertheless, their surviving family members deserve to know about the testing programs, the exposures, and the potential results of those exposures. For those veterans still living, diseases such as skin and lung cancer may still appear, and full knowledge of their likely cause might well save their lives.

In the case of the human subjects of the WWII testing programs, it is reasonable to assume that secrecy, uncertainty, and fear may have resulted in adverse psychological effects for the veterans and their families.

The committee recommends that careful attention be paid by health care providers to the special problems and concerns of the affected veterans and their families. This attention may include the convening of a special task force of experts in stress disorders and risk perception to aid the VA, further than this

EXECUTIVE SUMMARY

7

committee is able, in the establishment of comprehensive guidelines for handling of these cases.

These recommendations are not meant to ignore the fact that thousands, probably tens of thousands, of other military and civilian personnel were exposed to mustard agents and Lewisite in occupational and training settings, and in combat in the Bari harbor disaster. Some of these exposures will have resulted in one or more of the exposure-related health problems identified in this report; and, in fact, some military personnel who served in the Chemical Warfare Service have qualified for service-connected disability as a result of such exposures. However, many more military personnel were exposed to significant levels of mustard agents or Lewisite than is obvious from service records.

The committee additionally recommends that the Department of Defense (DoD) should use all means at its disposal, including public channels, to identify former chemical warfare production workers (military or civilian) and individuals exposed to mustard agents or Lewisite from gas handling, training, the Bari harbor disaster, or other circumstances. Records of former military personnel could be turned over to the VA for notification, inclusion in morbidity and mortality studies, and health status evaluation. Records of the civilian personnel should be used by the DoD to advise former workers as to their health risks and options for seeking appropriate compensation for any illnesses that resulted from their exposures.

This committee discovered that an atmosphere of secrecy still exists to some extent regarding the WWII testing programs. Although many documents pertaining to the WWII testing programs were declassified shortly after the war ended, others were not. Of those declassified, many remained "restricted" to the present day and, therefore, not released to the public. As a result, the committee often had great difficulty obtaining information. For example, only one of the three major chamber test locations, the Naval Research Laboratory, freely shared technical reports and detailed summaries with the committee from the beginning of the study. For other locations, such information arrived only as the study was in its final stages, despite months of requests and inquiries to a variety of offices. The committee is certain that other relevant information exists that was never obtained. It is also clear that there may be many exposed veterans and workers who took an oath of secrecy during WWII and remain true to that oath even today. Even as this report was going to press, veterans were still contacting the committee for information, having just heard about the study and

thinking it might now be permissible to reveal their experiences. This continuing secrecy, in the committee's view, has impeded well-informed health care for thousands of people.

The committee recommends that the VA and DoD publicly announce and widely advertise that personnel exposed to mustard agents or Lewisite during their service are released from any oath of secrecy taken at the time. In addition, professional educational materials should be prepared by the VA or DoD, or both, and made available for physicians who may be treating affected individuals. These materials should incorporate the latest information regarding the long-term health effects of exposure to mustard agents and Lewisite.

There is no doubt that the long-term health consequences of exposure to mustard agents or Lewisite can be serious and, in some cases, devastating. This report has demonstrated that complete knowledge of these long-term consequences has been and still is sorely lacking, resulting in great costs to some of those exposed in WWII. The lack of knowledge, however, has ongoing ramifications as nations will probably continue to use these chemical weapons in battle or begin to grapple with their disposal. Thus, accidental and deliberate human exposures to mustard agents and Lewisite can only be expected to continue in the foreseeable future.