



"The appearance of U.S. Department of Defense (DoD) visual information does not imply of constitute DoD endorsement."

Gulf War Illness: An Overview for Healthcare Professionals

Course Director:
Beatrice Alexandra Golomb, MD, PhD
Professor of Medicine
UC San Diego School of Medicine

Presenter:
Danielle J. Dauphars, PhD
UC San Diego School of Medicine

Image in public domain

UC San Diego
SCHOOL OF MEDICINE

Photo Details:

Creator: Department of Defense. American Forces Information Service. Defense Visual Information Center.
Title: U.S. Marines roll into Kuwait International Airport in light armored vehicles after the retreat of Iraqi forces from Kuwait during Operation Desert Storm. At right is a CH-53 Sea Stallion helicopter.

Release Status: Released to Public

Date: 27 February 1991

Permission: Public domain (National Archives Identifier: 6473457)



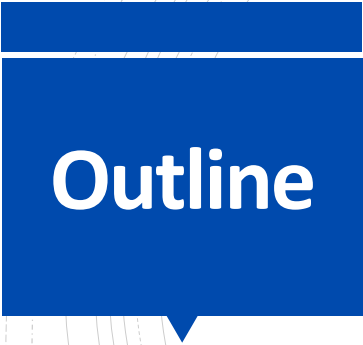
Photo Details:

Creator: US Air Force

Description: A USAF photo, showing F-16 A, F-15C and F-15E planes flying over the burning oil fields of Kuwait during Desert Storm

Permission: Public domain (VIRIN: 120319-D-LN615-001)

Edited to obscure symbols and identifiers, per DoD instruction.



Outline

- I. The First Persian Gulf War
- II. The Exposures
- III. The Symptoms
- IV. Exposures Linked to Illness
- V. Objective Markers and Mechanisms
- VI. Many Comorbidities Increased
- VII. ICD code: The Diagnosis
- VIII. Provider Attitudes Matter
- IX. In Veterans' Words
- X. Recap
- XI. Learn More (Resources)



Photo Details:

Creator: Department of Defense.

Title: Newly arrived Marines are led through an encampment near an airfield during Operation Desert Shield.

Release Status: Released to Public

Date: 11 January 1991

Permission: Public domain (National Archives Identifier: 6461053)

Test Your Knowledge

When were veterans of the First Persian
Gulf War deployed?

- a. 1975-77
- b. 1984-86
- c. 1990-91



01

The First Persian Gulf War

WHAT?

- A military conflict triggered by Iraq's invasion of Kuwait in August 1990.
- In response, a US-led coalition of nations launched a large-scale military operation to force Iraqi troops out of Kuwait.

WHERE?

- Middle East- Primarily Kuwait, Iraq, Saudi Arabia, but also the entire broader Persian Gulf region

WHEN?

- Aug 1990 – Jan 1991: Operation Desert Shield
- Jan 1991 – Feb 1991: Operation Desert Storm
 - Ground war just 4 days: February 24-28, 1991; Many never saw combat
- 28 Feb 1991: Ceasefire declared; troops remained until late 1991

WHO?

- US-led coalition of over 35 countries
- ~697,000 American service members deployed to Gulf theater
 - Americans made up bulk of forces

Test Your Knowledge

When were veterans of the First Persian
Gulf War deployed?

- a. 1975-77
- b. 1984-86
- c. 1990-91



01

Test Your Knowledge

When were veterans of the First Persian
Gulf War deployed?

a. 1975-77

b. 1984-86

c. 1990-91



01



Photo Details:

Creator: Department of Defense.

Title: Oil well fires rage outside Kuwait City in the aftermath of Operation Desert Storm. The wells were set on fire by Iraqi forces before they were ousted from the region by coalition force.

Release Status: Released to Public

Date: 21 March 1991

Permission: Public domain (National Archives Identifier: 6473762)

Test Your Knowledge

List 2-3 chemical exposures Gulf War
veterans experienced

02



Photo Details:

Creator: Department of Defense.

Title: An oil well burns out of control, darkening the sky with smoke, after being set ablaze by retreating Iraqi forces during Operation Desert Storm.

Release Status: Released to Public

Date: 02 March 1991

Permission: Public domain (National Archives Identifier: 6473348)

Unprecedented Exposures

Many new, unique, or excessive exposures^{1,2}:

- Pyridostigmine bromide (PB)^{3,4}: Nerve agent protection pill
- Pesticides and Repellants^{3,5,6}: Prolonged, often excessive exposure to organophosphates, carbamates, pyrethroids, others
- Nerve gas: sarin or cyclosarin (organophosphates)^{3,7,8} (exposure occurred e.g. during demolition of munitions depot containing chemical weapons^{7,8}), limited sulfur mustard^{7,8}
- Oil fires: over 600 burning oil wells Jan-Nov 1991^{9,10}
- Depleted uranium (e.g. to harden tanks, munitions)¹¹⁻¹³
- Large number of vaccines, including uncommon vaccines: Anthrax, Botulinum toxoid^{8,9}
- Many more (e.g.): open-air burning/burn pits^{7,8,14}, solvents and fuels (e.g. jet fuel)^{7,8,15}, chemical agent resistant coating (CARC) paint⁸, fine sand/sandstorms⁸, extremes of heat and cold⁸

Exposure Experiences I

- “..We had a chemical alarm go off and “Holy cow” and you are like, put on your stuff and suit up and wait for the all clear. You never went to the bathroom without your mask.” –IC Lim^a
- “They had the fire trenches lit.. 10,000 meters wide or long fire trench.. of oil was lit.. the flames were burning probably 30 feet high, absolutely no wind. So, from about from the ground level to about 30 feet there were tremendous flames, and then from 30 feet to maybe 10,000 feet there was just a blanket of black smoke going straight up just like a -- just like a curtain.” –PJ Garman^b
- “..when we went through afterwards and detonated equipment that had been left and stores that had been left, there were chemical munitions there.” –PJ Garman^b
- “..oil fires that were so thick it looked like night in the middle of the day. Pyridostigmine bromide tablets we had to take every 8 hours..” –Gulf War veteran^c
- “..we demolished everything that we built, we burn it all in the pits, and I have photos of it. It was not weapons, but debris, human waste, tents, kitchen, shower tower..” –Gulf War veteran^c

Selected quotes from:

- Lim IC. Veterans History Project Collection, American Folklife Center, Library of Congress; oral history recording and transcript (audio). Ingrid C. Lim, AFC/2001/001/65442; collected 2008-10-04.
- Garman PJ. Veterans History Project Collection, American Folklife Center, Library of Congress; oral history interview (video). Patrick J. Garman, AFC/2001/001/23800; collected 2004-02-17.
- *Golomb Research Group survey response

Exposure Experiences II

- “On a nightly basis, we would spray our uniforms with pesticides.. We weren’t supposed to put them on immediately after spraying them. The sand fleas were a problem. We used to put flea collars around the legs of our cots or we would put flea powder on the floor around our cots to try to keep the sand fleas away from us while we were sleeping. We slept with nets over us to keep the flies off. The flies were ungodly.” –SSgt TS^a
- “..we were staying near the oil wells, and your uniform would be completely covered with black, like soot all over you. Your arms were exposed, your food, everything, your water where you took showers. It was constantly dark; there was no such thing as daylight.” –Army Gulf War veteran^a
- “A thermal plume rose into the atmosphere over the largest Iraqi chemical warfare agent research, production, and storage facility at Muthanna after Coalition aircraft and missile bombardment. Seventeen metric tons of Sarin were reportedly destroyed during these attacks, which began on January 17, 1991. These thermal and visual plumes extended directly toward the areas where those same chemical warfare agents were detected and confirmed..” –Jim Tuite, 1997 Congressional Testimony^b
- “We were in a congested area with burning vehicles all around. Suddenly, the tank in front of us caught fire. The ammunition blew, but the blowout panel saved the lives of the crew. We saw DU penetrators flipping end over end over our heads. We immediately rushed to the tank to rescue the guys in it. We were breathing smoke from the burning ammo, but we had no concern about DU and took no protective measures.” –Gulf War veteran^c

Selected quotes included in the 2008 RAC-GWVI Report from:

- a. Johnson A. *Gulf War Syndrome: Legacy of a Perfect War*. Brunswick, ME: MCS Information Exchange; 2001.
- b. U.S. House Committee on Government Reform and Oversight. *Gulf War Veterans' Illnesses: VA, DOD Continue to Resist Strong Evidence Linking Toxic Causes to Chronic Health Effects (Second Report)*. Washington, D.C. Nov 7, 1997. HR 105-338.
- c. Fahey D. *Case Narrative: Depleted Uranium (DU) Exposures*. Swords to Plowshares, Inc., National Gulf War Resource Center, Inc., and Military Toxics Project, Inc.; Sep 20, 1998.

Selected quotes from the 2008 RAC-GWVI Report (and citations from the Report):

There were no less than three days when the smoke ‘hugged’ the ground, and turned the sunlit, bright day into a dark of night. Myself and others traveled the ‘coastal highway’ from Kuwait City down to Saudi Arabia on April 1st, 1991, and the petroleum-thickened air was so impregnated that we choked on oil while breathing through our doubled-up scarves and we were forced to stop and clear the raw petroleum off vehicle windshields and our goggles constantly. At some points on the highway the oil-thickened air was so thick our vehicle headlights could not penetrate the air further than 10-15 feet, and Marine escorts were needed to walk on foot ahead of the vehicles to keep us on the highway.—Marine Corps Captain⁹⁶⁵

It was a Monday, the sky was so dark it was like night. People’s eyes were running with black tears, your saliva was black, you had to have a bandana over your nose to breathe.- Army Sergeant¹⁶⁰⁸

At one point during the war, we were staying near the oil wells, and your uniform would be completely covered with black, like soot all over you. Your arms were exposed, your food, everything, your water where you took showers. It was constantly dark; there was no such thing as daylight.- Army Gulf War veteran⁷¹⁶

We were in a congested area with burning vehicles all around. Suddenly, the tank in front of us caught fire. The ammunition blew, but the blowout panel saved the lives of the crew. We saw DU penetrators flipping end over end over our heads. We immediately rushed to the tank to rescue the guys in it. We were breathing smoke from the burning ammo, but we had no concern about DU and took no protective measures. Afterwards, we stayed around that area for two or three hours but we were buttoned up due to exploding vehicles and ordnance around us.—Gulf War veteran, 24th Infantry Division⁴²⁵

For three months after the fighting stopped, R. and his buddies in the 3rd Armored Division

combat engineer squadron were ordered to crawl around in the black dust left over from successful shots of depleted uranium. He was ordered to live and breathe in it while finishing the job of destroying damaged Iraqi tanks and munitions, to make sure the enemy's equipment couldn't be used again. 'We actually slept underneath destroyed tanks and stuff because we figured they wouldn't fire at their own destroyed vehicles,' R said. For months, the black dust covered many of those vehicles, rubbing off on R's clothing, getting on his skin, and often into his food and water. --Interview with Gulf War veteran, 3rd Armored Division⁴¹⁵

My unit arrived in the Gulf the day before the air war started. We first spent about a month in Dhahran in Saudi Arabia. Our chemical alarms went off several times during that month, and we had to go to MOPP-level four, which meant we had to put on chemical suits, masks, gloves, and boots. While we were still in Dhahran, we started taking pyridostigmine bromide pills, which were supposed to protect us against exposures to nerve gas. About three days after I started taking the pills, my eyes were jittery, my vision was jumping, and I was seeing double, and I was nauseated. By the fourth day, I was vomiting a little blood, so I went to sick-call. They told me to cut the dose in half and said there was nothing to worry about. At least I no longer vomited blood after I reduced the dosage. Many other people in the unit reported having similar vision problems. --SSgt PB, Gulf War veteran⁷¹⁶

On a nightly basis, we would spray our uniforms with pesticides. There was a chemical spray that they gave us to spray our uniforms. We had to hang them outside so that the excess spray would dissipate in the air, I guess. We weren't supposed to put them on immediately after spraying them. The sand fleas were a problem. We used to put flea collars around the legs of our cots or we would put flea powder on the floor around our cots to try to keep the sand fleas away from us while we were sleeping. We slept with nets over us to keep the flies off. The flies were ungodly. --SSgt TS, Gulf War veteran⁷¹⁶

A thermal plume rose into the atmosphere over the largest Iraqi chemical warfare agent research, production, and storage facility at Muthanna after Coalition aircraft and missile bombardment. Seventeen metric tons of Sarin were reportedly destroyed during these attacks, which began on January 17, 1991. These thermal and visual plumes extended directly toward the areas where those same chemical warfare agents were detected and confirmed by Czechoslovak chemical specialists.--Jim Tuite, 1997 Congressional Testimony¹⁶⁸⁴

Citations used in the 2008 RAC-GWVI Report:

- 415.** Evans B. Danger Dismissed: How the Pentagon downplays the risks of depleted uranium weapons - 'Silver Bullet,' Black Dust. *Hampton Roads Daily Press*. Newport News, VA. Dec 12, 2004: A.12.
- 425.** Fahey D. *Case Narrative: Depleted Uranium (DU) Exposures*. Swords to Plowshares, Inc., National Gulf War Resource Center, Inc., and Military Toxics Project, Inc.; Sep 20, 1998.
- 716.** Johnson A. *Gulf War Syndrome: Legacy of a Perfect War*. Brunswick, ME: MCS Information Exchange; 2001.
- 965.** Marine Corps veteran. Subject: Your Gulf War Illness Presentation. [E-mail message to U.S. Department of Defense, Office of the Special Assistant for Gulf War Illnesses]. Jan 21, 1998. Available at: http://www.gulflink.osd.mil/owf_ii/owf_ii_refs/n44en003/8021_E01_0000001.htm.
- 1608.** U.S. Department of Defense, Office of the Special Assistant for Gulf War Illnesses. Interview with Gulf War Army veteran re: Oil Well Fires. [Lead Sheet 8858]. May 15, 1997. Available at: http://www.gulflink.osd.mil/owf_ii/owf_ii_refs/n44en062/5293_008_0000001.htm.
- 1684.** U.S. House Committee on Government Reform and Oversight. *Gulf War Veterans' Illnesses: VA, DOD Continue to Resist Strong Evidence Linking Toxic Causes to Chronic Health Effects (Second Report)*. Washington, D.C. Nov 7, 1997. HR 105-338.

Exposure Experiences III

- “..we had traveled through many of the oil fires that were burning so we had that smoke that we were inhaling, right? ..Gulf War sand particulates are extremely sharp and minute. We were engulfed in numerous sandstorms where it was just a wall. And when it hit ya, you couldn’t see your hand three inches right in front of your face. We had goggles but nothing really for protection for lungs.. they think that our unit was hit with low levels of sarin gas between four and eight times.. And then the last one of the details is either trash burning, the burn pit, along with doing cleaning out the latrine stalls, using diesel and lime to ignite that burn.” –Jeremy
- “And all this time, they were giving us pills, shots, you know, because supposedly he had anthrax and all that other chemical warfare stuff.” –Joseph
- “.. all my alarms started going off.. So the M8 alarms were going off, verifying with the M256 kits. We called that in, and everybody was put in MOPP level four. MOPP level four is where you put on all your protective equipment, gas masks.. At the time, I did not know that there was an ammunitions dump nearby that was blown up and that we were directly downwind from that. So it's my firm belief that all of us that were exposed.” –”Santos”

Quotes from: HealthExperiencesUSA, multiple Gulf War veterans, *Gulf War Illness – Military Exposures*, accessed August 2025.

Test Your Knowledge

List 2-3 chemical exposures Gulf War
veterans experienced

02



Photo Details:

Creator: Department of Defense.

Title: An oil well burns out of control, darkening the sky with smoke, after being set ablaze by retreating Iraqi forces during Operation Desert Storm.

Release Status: Released to Public

Date: 02 March 1991

Permission: Public domain (National Archives Identifier: 6473348)

Test Your Knowledge

List 2-3 chemical exposures Gulf War
veterans experienced

Any combination of:

- Pyridostigmine bromide (PB)
- Pesticides: organophosphates, carbamates, pyrethroids
 - Nerve agents: sulfur mustard, sarin, cyclosarin
- Unusual Vaccines: high multiplicity, anthrax, botulinum
 - Oil fires
- Depleted uranium
- Open-air burning/Burn Pits
- Fuels & solvents, CARC paint, sand, temperature extremes

02





Photo Details:

Creator: Department of Defense.

Title: A hospital corpsman checks a Marine's blood pressure in a field hospital during Operation Desert Storm

Release Status: Released to Public

Date: 27 February 1991

Permission: Public domain (National Archives Identifier: 6465563)

Edited to obscure symbols and identifiers, per DoD instruction.

Test Your Knowledge

Which of these are symptoms of Gulf War Illness?

- a. Pain
- b. Cognitive Problems
- c. Fatigue
- d. Gastrointestinal Problems

03



Veterans Describe Symptoms

- “..I am diagnosed with chronic fatigue.. Fibromyalgia, and IBS, just to name a few” –Veteran from Dallas, TX^a
- “Insomnia, chronic fatigue, skin rash, sleep apnea.” –Veteran from Duncan, OK^a
- “..my body still hurts all the time and have joint and back pain.. still living with headaches almost daily as well and skin rashes with severe psoriasis and memory loss. Believe it or not as I'm writing this I have to stop for a bit to remember names of things that I have known for years..” –Veteran from Geneva, OH^a
- “My symptoms began in the Gulf with severe abdominal cramping and severe diarrhea. I also had terrible headaches and bouts of dizziness and tingling. Once I returned to the base in Germany, the headaches persisted, and I experienced the cramps and diarrhea on a cyclic basis. I also went through periods of night sweats. And there were periods when I would sleep a lot because I was so fatigued. My joints were stiff, and my knees would swell after I ran. It was harder for me to do things without feeling short of breath. These symptoms became worse as time passed...” –SSgt BJ^b

Selected quotes from:

- a. Winnett DK Jr. *Statement for the Record before the U.S. House of Representatives, Committee on Veterans' Affairs, Subcommittee on Oversight and Investigations, for a hearing entitled "Persian Gulf War: An Assessment of Health Outcomes on the 25th Anniversary"*. 2016 Feb 23. Available from: <https://www.congress.gov/114/chrhg/CHRG-114/hrhg99606/CHRG-114/hrhg99606.pdf>
- b. Johnson A. *Gulf War Syndrome: Legacy of a Perfect War*. Brunswick, ME: MCS Information Exchange; 2001. (Included in the 2008 RAC-GWVI Report.)

Selected quotes from the 2008 RAC-GWVI Report (and citations from the Report):

I arrived in Theater on January 6, 1991 ... During official visits to strategic military cities there were frequent SCUD attacks during which I heard chemical alarms sound. When I asked if these alarms meant chemicals had been detected, I was told that the chemical alarms had malfunctioned. I became ill and was treated for nausea, headaches, vomiting, diarrhea, and high temperature. Rashes I had over my body I thought were normal and expected since I spent most days in the sand, wind, and sun with all the attendant fleas, flies, and desert parasites. Headaches I attributed to fatigue and lack of sleep. The symptoms...continued after I returned home and got progressively worse.--COL GR, Gulf War veteran¹⁶⁸⁴

My symptoms began in the Gulf with severe abdominal cramping and severe diarrhea. I also had terrible headaches and bouts of dizziness and tingling. Once I returned to the base in Germany, the headaches persisted, and I experienced the cramps and diarrhea on a cyclic basis. I also went through periods of night sweats. And there were periods when I would sleep a lot because I was so fatigued. My joints were stiff, and my knees would swell after I ran. It was harder for me to do things without feeling short of breath. These symptoms became worse as time passed.. --SSgt BJ, Army Gulf War veteran⁷¹⁶

DG was a Staff Sergeant with the 1165th Military Police Company. He recalled being awakened at 3:30 a.m. The Battalion NBC NCO was announcing that they were under chemical attack. An M-256 kit registered a positive reading for a chemical agent. They went to MOPP level 4 for four hours. Afterward, all of them had runny noses. When asked if people were made sick from the attack, DG responded that most people were already sick from the pyridostigmine bromide pills. He said that they had been taking them for two or three days before the attack and that 'a lot of people got sick and three or four had to be medevaced out.' DG currently suffers from headaches, fatigue, joint and muscle pain, an inability to concentrate, recurring rashes, irritability, night sweats, insomnia, diarrhea, gastrointestinal problems, dizziness, blackouts, excessive photosensitivity, sore gums, swollen lymph nodes,

and a spot on his brain.--1994 Senate Committee report on Gulf War veteran¹⁶⁸⁸

Citations used in the 2008 RAC-GWVI Report:

716. Johnson A. *Gulf War Syndrome: Legacy of a Perfect War*. Brunswick, ME: MCS Information Exchange; 2001.

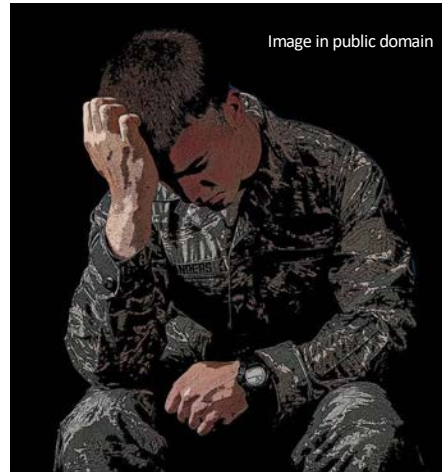
1684. U.S. House Committee on Government Reform and Oversight. *Gulf War Veterans' Illnesses: VA, DOD Continue to Resist Strong Evidence Linking Toxic Causes to Chronic Health Effects (Second Report)*. Washington, D.C. Nov 7, 1997. HR 105-338.

1688. U.S. Senate Committee on Banking Housing and Urban Affairs. *U.S. Chemical and Biological Warfare-Related Dual Use Exports To Iraq and Their Possible Impact on the Health Consequences of the Persian Gulf War*. Washington, D.C. May 25, 1994.

About **25-35%** of those deployed became ill, attributable to deployment^{16*}
Most have remained ill, even decades later^{17,18}

Gulf War Illness (GWI)

- Chronic
- Multi-symptom
- Chemical-induced
 - PB
 - Pesticides
 - Nerve agents
 - Other exposures



*i.e.: the fraction that are ill, over and beyond the percent of non-deployed veterans meeting similar criteria.

Photo Details:

Creator: US Air Force.

Title: PTSD is not just about combat.

Release Status: Released to Public

Date: 17 September 2015

Permission: Public domain (VIRIN: 150917-F-YH552-004)

Gulf War Illness Symptom Domains

"Kansas criteria" are specific for GWI

01. Fatigue/Sleep

04. Gastrointestinal

02. Neurological
Includes Cognitive and Mood

05. Respiratory

03. Pain

06. Skin

Citation #19: Steele L. Prevalence and patterns of Gulf War illness in Kansas veterans: Association of symptoms with characteristics of person, place, and time of military service. Am. J. Epidemiol. 2000;152:992–1002. doi: 10.1093/aje/152.10.992.

Gulf War Symptoms¹⁹

Fatigue/Sleep Domain

- Fatigue
- Problems falling or staying asleep
- Not feeling rested after you sleep
- Feeling unwell after physical exercise or exertion

Neurological/Cognitive/Mood Domain

- Headaches
- Feeling dizzy, lightheaded, or faint
- Eyes very sensitive to light
- Blurred or double vision
- Numbness or tingling in your extremities
- Tremors or shaking
- Low tolerance for heat or cold
- Night sweats
- Having physical or mental symptoms after breathing in certain smells or chemicals
- Difficulty concentrating
- Difficulty remembering recent information
- Trouble finding words when speaking
- Feeling down or depressed
- Feeling irritable or having angry outbursts

Pain Domain

- Pain in your joints
- Pain in your muscles
- Body pain, where you hurt all over

Gastrointestinal Domain

- Diarrhea
- Nausea or upset stomach
- Abdominal pain or cramping

Respiratory Domain

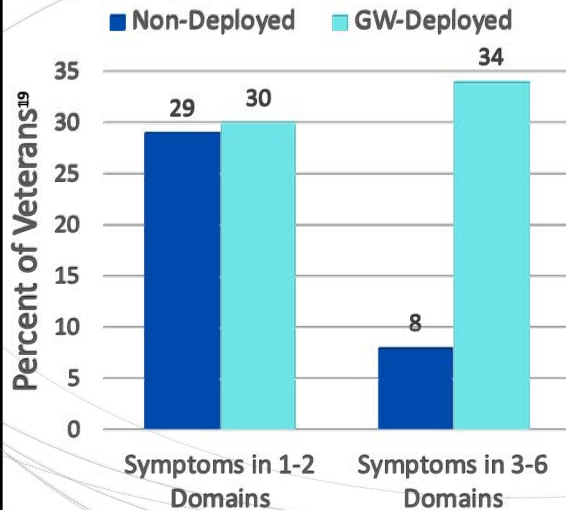
- Difficulty breathing or catching your breath
- Frequent coughing when you don't have a cold
- Wheezing in your chest

Skin Domain

- Skin rashes
- Other skin problems

GWI Defined by Symptoms and Deployment

- Symptoms arising during or after Gulf theater deployment
- Symptom profile consistent across Gulf War veteran populations and studies^{16,19}



Kansas GWI criteria:

Chronic symptoms (present for ≥ 6 months*), either multiple or > mild, in at least 3 of 6 domains:

- Fatigue/Sleep
- Neurological
- Pain
- Gastrointestinal
- Respiratory
- Skin

*Many with GWI have had symptoms persist for >30 years

Early GWI studies excluded conditions later shown to be increased by Gulf service; these exclusions are now mostly dropped by researchers and are not clinically disqualifying.

Test Your Knowledge

Which of these are symptoms of Gulf War Illness?

- a. Pain
- b. Cognitive Problems
- c. Fatigue
- d. Gastrointestinal Problems

03



Back to our question, which of these are symptoms of gulf war illness?

Test Your Knowledge

Which of these are symptoms of Gulf War Illness?

a. Pain

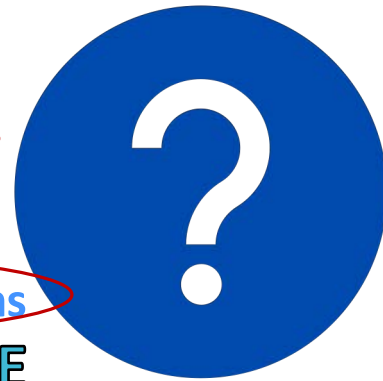
b. Cognitive Problems

c. Fatigue

d. Gastrointestinal Problems

03

AND MANY MORE



All of these: pain, cognitive problems, fatigue, and gastrointestinal problems—and many more are symptoms of gulf war illness.



Photo Details:

Creator: Department of Defense.

Title: Dressed in rain suits, gloves and M-17A1 protective masks, three soldiers from the 82nd Airborne Division walk around their camp to acclimate their bodies to the heat of the Saudi summer during Operation Desert Shield

Release Status: Released to Public

Date: 18 August 1990

Permission: Public domain (National Archives Identifier: 6461892)

Test Your Knowledge

Which (2) of the following factors currently show strong evidence tying them to GWI?

- a. Brucellosis
- b. Pyridostigmine bromide (PB)
- c. Uranium
- d. Pesticides

04



Example Evidence of Exposure Links to GWI

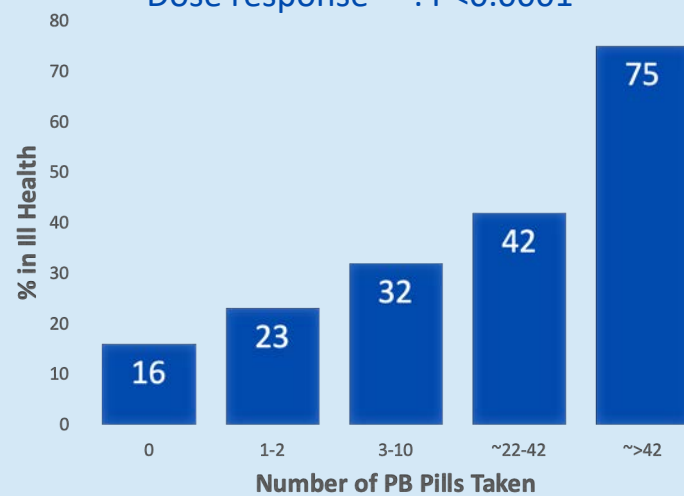
Exposure*	OR for GWI (95% C.I.)†
PB Pills	2.6 (2.2-3.1)
Chemical or nerve agent attack	2.6 (1.9-3.5)
NBC suits (proxy for PB, sarin, heat)	2.7 (2.3-3.3)
Pesticide (personal pesticides)	2.2 (1.9-2.6)
Hear chemical alarms (possible proxy for nerve agent exposure)	2.2 (1.9-2.6)

*Table from PNAS paper exploring evidence of exposures linked strongly to illness from many studies³.

†For those with these exposures relative to unexposed.

PB Pills Show a Dose Relation to GWI

Pyridostigmine bromide (PB) nerve agent protection pill
Dose response^{3,20}: $P < 0.0001$



Test Your Knowledge

Which (2) of the following factors currently show strong evidence tying them to GWI?

- a. Brucellosis
- b. Pyridostigmine bromide (PB)
- c. Uranium
- d. Pesticides

04



Test Your Knowledge

Which (2) of the following factors currently show strong evidence tying them to GWI?

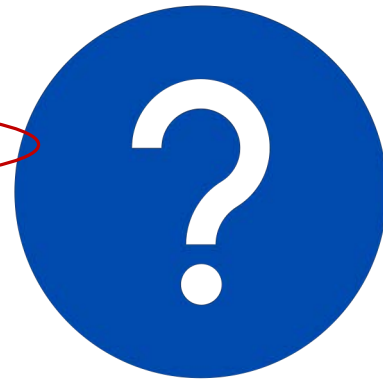
a. Brucellosis

b. Pyridostigmine bromide (PB)

c. Uranium

d. Pesticides

04



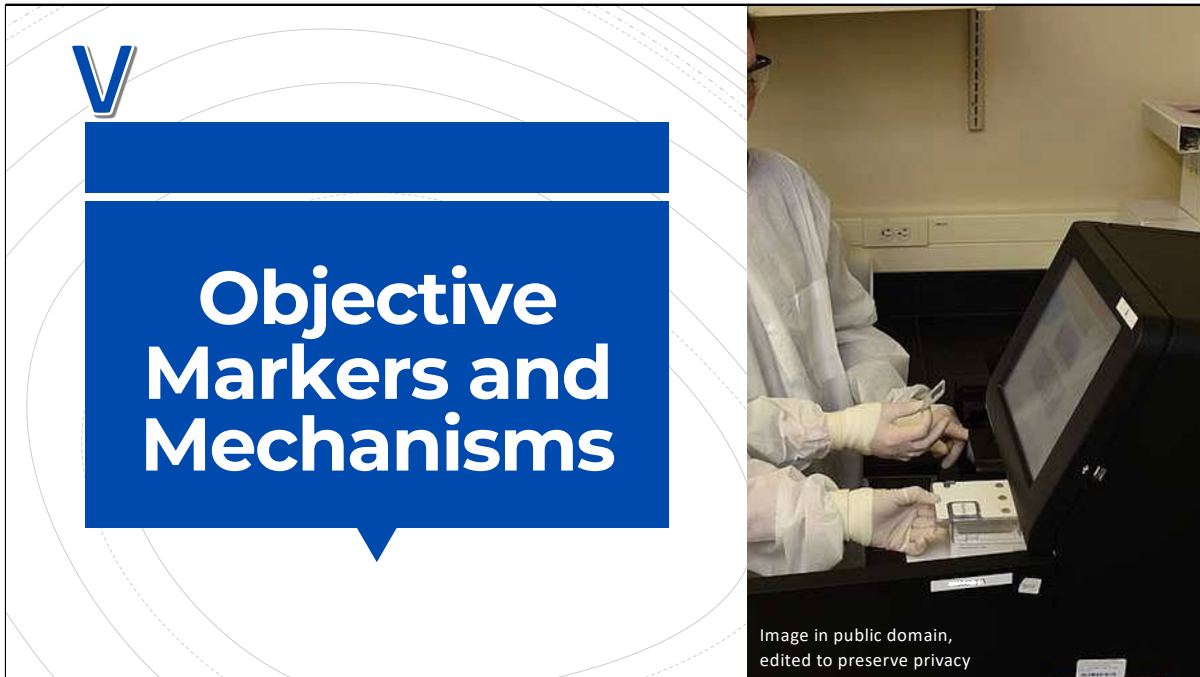


Photo Details:

Creator: US Navy.

Title: Next Generation DNA Sequencing

Release Status: Released to Public

Permission: Public domain (VIRIN: 160308-N-PI709-048)

Edited to obscure symbols and identifiers, per DoD instruction.

GWI: Many Objective Markers are Altered

- ↓ Mitochondrial function/bioenergetics²¹⁻²⁴ (also GWI animal models)^{25,26}
- Δ Lipidomics, lipid products²⁷⁻²⁹ (also GWI animal models)³⁰⁻³²
- ↑ Inflammation (mild), coagulation³³⁻³⁵
- ↑ Neuroinflammation³⁶ (also GWI animal models)^{37,38}
- ↑ Autoantibodies³⁹
- ↑ Autonomic dysfunction⁴⁰⁻⁴²
- Δ Hormones⁴³⁻⁴⁶
- ↓ Natural killer cells (number, activity)^{39,47,48}
- ↓ Brain gray matter/volume; white matter changes⁴⁹⁻⁵¹

PON1 Gene-Environment Interactions

- A variant at position 192 on the PON1 detoxifying enzyme relates to PON1's effectiveness at detoxifying different chemicals, including organophosphates (OPs), such as nerve agents and pesticides
 - The R variant at 192 is worse at detoxifying sarin than the Q variant
 - The Q variant at 192 is worse at detoxifying some pesticides than the R variant
- Those with less effective sarin detox (R at 192) had more GWI, in those exposed to sarin^{*52,53}
- Those with less effective pesticide detox (Q at 192) had more GWI, in those exposed to some pesticides⁵³

*By proxy of hearing chemical alarms

Notes for slide:

Q/R polymorphism at position 192 of the paraoxonase (PON)-1 enzyme produce PON1₁₉₂ variants with different capacities for neutralizing specific chemicals, including certain acetylcholinesterase inhibitors.

Q=glutamine

R=arginine

PB Gene- Environment Interactions

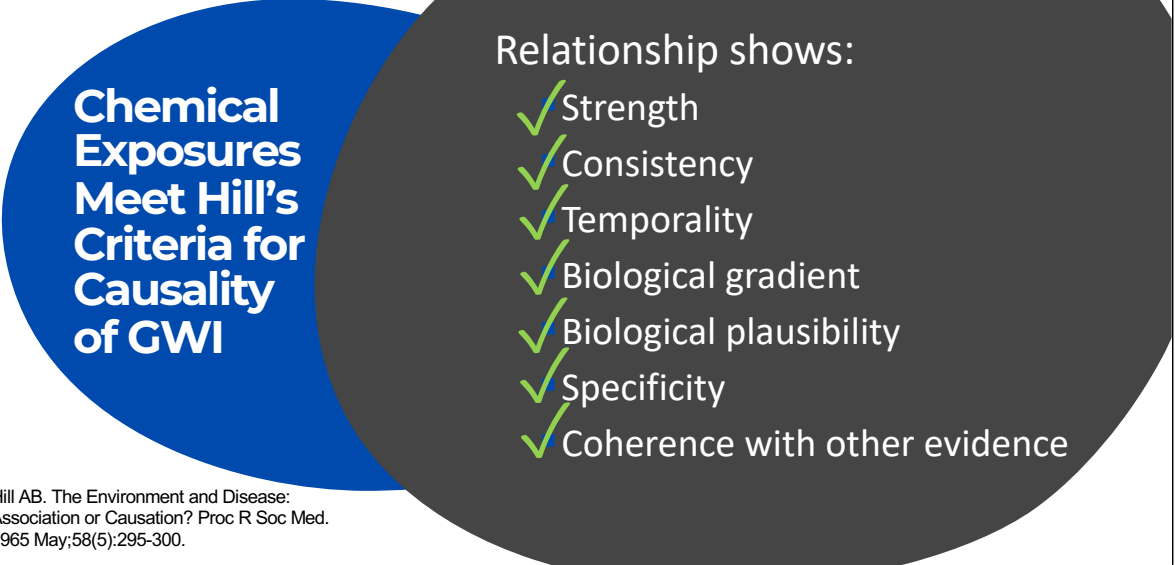
- Butyrylcholinesterase (BChE) enzyme: binds and detoxifies pyridostigmine bromide (PB)
- Among Gulf War veterans with usual BChE genotypes: PB exposure → ~3× higher prevalence of GWI⁵⁴
- Among GW veterans with low activity BChE genotypes: PB exposure → 40× higher prevalence of GWI⁵⁴
- Adverse BChE genotype ≠ illness: in the absence of PB use, BChE genotype was not associated with GWI⁵⁴
- Findings support causal role of PB

Possible Mechanism: Mitochondrial Impairment²⁴

Factors	In Gulf War Illness [^]	In Mitochondrial Impairment
Exposures (e.g.):		
Carbamates (including PB)	✓	✓ ^{55,56}
Organophosphates	✓	✓ ⁵⁶⁻⁶⁰
Pyrethroids	✓	✓ ⁵⁸
Symptoms (e.g.):		
Multiple, vary person to person	✓	✓ ⁶¹⁻⁶³
Brain, fatigue, muscle (organs with high energy demand)	✓	✓ ^{64,65}
Variable latency to onset	✓	✓ ^{66,67}
Comorbidities (e.g.):		
Sleep apnea	✓	✓ ⁶⁸
Hypertension	✓	✓ ⁶⁹
Cardiovascular disease	✓	✓ ⁷⁰
Treatment (early data): cell energy and antioxidant support yields benefit	✓	✓ ^{71,72}

* Additionally: Severity of GWI is tied to severity of mitochondrial impairment, not true (e.g.) for inflammation²⁴

[^] Gulf War Illness-specific citations in previous slides



**Chemical
Exposures
Meet Hill's
Criteria for
Causality
of GWI**

Relationship shows:

- ✓ Strength
- ✓ Consistency
- ✓ Temporality
- ✓ Biological gradient
- ✓ Biological plausibility
- ✓ Specificity
- ✓ Coherence with other evidence

Hill AB. The Environment and Disease:
Association or Causation? Proc R Soc Med.
1965 May;58(5):295-300.



Photo Details:

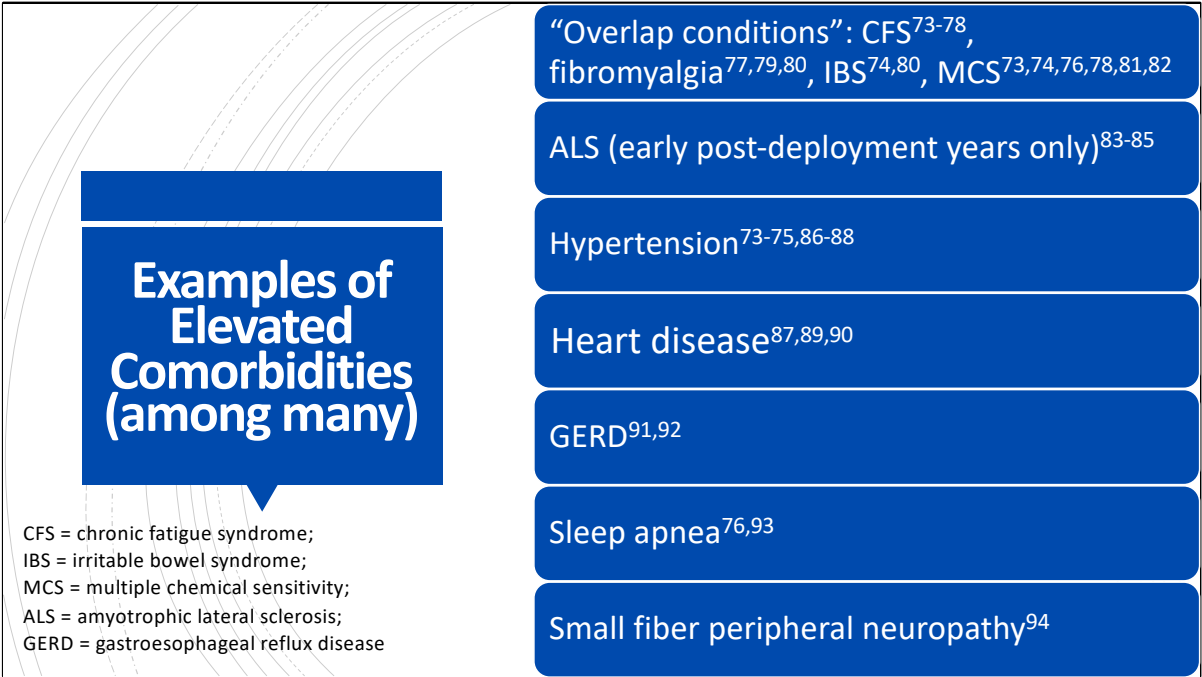
Creator: Department of Defense.

Title: The sleepy and the restless [Image 4 of 5]

Release Status: Released to Public

Date: 30 October 2015

Permission: Public domain (VIRIN: 151030-F-WT808-061)



Examples of Elevated Comorbidities (among many)

CFS = chronic fatigue syndrome;
IBS = irritable bowel syndrome;
MCS = multiple chemical sensitivity;
ALS = amyotrophic lateral sclerosis;
GERD = gastroesophageal reflux disease

“Overlap conditions”: CFS⁷³⁻⁷⁸,
fibromyalgia^{77,79,80}, IBS^{74,80}, MCS^{73,74,76,78,81,82}

ALS (early post-deployment years only)⁸³⁻⁸⁵

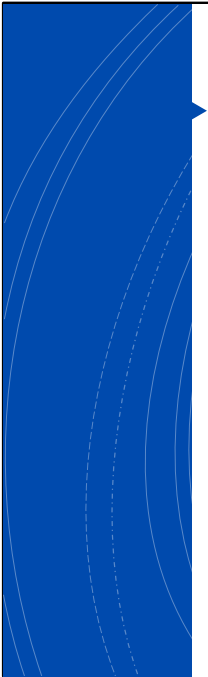
Hypertension^{73-75,86-88}

Heart disease^{87,89,90}

GERD^{91,92}

Sleep apnea^{76,93}

Small fiber peripheral neuropathy⁹⁴

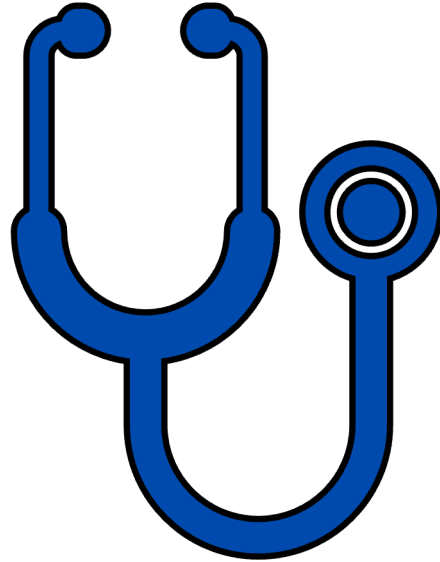


Sleep Apnea

- A vicious cycle: Sleep apnea is prevalent among those with mitochondrial diseases⁷¹, and intermittent hypoxia, in turn, causes mitochondrial damage and oxidative stress⁶⁸
- Veterans with GWI have more frequent Sleep Disordered Breathing than control veterans($p<0.0001$)⁹³
- Sleep apnea magnifies GWI symptoms due to its impact on cell energy
- SDB treatment with CPAP lessens GWI symptoms like pain, fatigue, cognitive dysfunction, and more, supporting its contributory role⁷⁶

VII

**ICD-10-CM
Code: The
Diagnosis**



Test Your Knowledge

We have discussed causes & symptoms; list
2-3 considerations for diagnosis?

05



Photo Details:

Creator: Department of Defense.

Title: [Redacted for privacy]

Release Status: Released to Public

Date: 01 April 1992

Permission: Public domain (National Archives

Identifier: 6472939)

Edited to obscure symbols and identifiers, per DoD instruction.

Test Your Knowledge

Which (1) of these patients meets Gulf War Illness diagnostic (Kansas) criteria?

- a. 42-year-old veteran presenting with muscle pain, irritability, and emphysema who developed symptoms in the years after deploying to Iraq in 2003
- b. 53-year-old veteran, who served in Kuwait in 1990, presenting with diarrhea, dry skin, nausea, headaches, mild confusion, and fatigue who reports that he has suffered from headaches since childhood, but did not notice other symptoms until he started chemotherapy for small cell lung cancer
- c. 62-year-old veteran presenting with severe diarrhea, hypertension, muscle pain, severe fatigue, and recurrent unexplained rashes, symptoms emerging gradually starting around 6 months after he returned from June 1991 service in Iraq
- d. 75-year-old veteran, who served in Saudi Arabia during Operation Desert Shield, presenting with muscle pain and joint pain that have been increasing in the last five years, but are well-controlled with occasional acetaminophen use, on review of symptoms, there are no other persistent complaints

06



Diagnosing Gulf War Illness

"Kansas criteria"

- Deployment to the Gulf War theatre of operations 01 Aug 1990 - 31 Jul 1991
- Chronic Symptoms (≥ 6 months), with either multiple symptoms per domain or ≥ 1 symptom considered moderate or severe in ≥ 3 of 6 domains:
 - Neurological, Fatigue/Sleep, Respiratory, Pain, GI, Skin
- Symptom onset during or after Gulf deployment
- Symptoms present over the previous 6 months
- In research, we exclude some veterans with conditions that those with GWI are at increased risk for, but these should not be clinically disqualifying
 - Consider timing of symptoms, deployment, and other conditions

ICD-10-CM Codes:

T75.830 = Gulf War Illness

**Z77.31 = Contact with and
[suspected] exposure to
Gulf War theater**

Why is an ICD-10-CM code important? In their words...

"The single most important thing for me about this new code is validation of an illness that has impacted me for 34 years." —Ronald E. Brown, Gulf War Veteran, Toxic Wounds Consultant for Vietnam Veterans of America

"With use of this diagnostic code over time, there is real potential for better monitoring continued health problems, tracking treatments tried successfully and not, and identifying co-occurring conditions potentially related to Gulf War Illness. All that will help our veterans suffering from this debilitating and currently incurable disease." —Anthony Hardie, National Chair & Director, Veterans for Common Sense

"It is my sincere hope that with the creation of ICD-10 codes for Gulf War Illness, I will be able to spend more of my time and energy focused on doing what I need to improve my symptoms, and less time educating and advocating for my care.. The creation of these codes will help people within the VA better understand us and our illness. This better understanding will relieve veterans who suffer from Gulf War Illness of some of the burden of having to constantly re-explain ourselves and the medical background of our illness.. I look forward to the improved care and collaboration that the creation of these codes promises for me and veterans like me." —Veteran Jason Carrick

Supportive Care

- Test and Treat Sleep Apnea!
- “Clean” nutrient-dense low processed food diet⁹⁵
 - Avoid additional chemicals to which many veterans are intolerant⁹⁶
 - Such diets are beneficial across many populations⁹⁷
- Exercise: “Start low, go slow”
 - Many veterans experience post-exertion fatigue, severe pain, cognitive, and/or muscle problems⁴²
- Rethink Pharmacological Approaches
 - “Avoiding certain drugs is often more beneficial than application of established, apparently indicated drugs”⁹⁸ in patients with mitochondrial problems, since many drugs compound mitochondrial impairment⁹⁶
- Keep your eyes open for new studies; many small studies show apparent benefit.
 - Monitor clinicaltrials.gov/search?cond=Gulf%20War%20Illness

Test Your Knowledge

We have discussed causes & symptoms; list
2-3 considerations for diagnosis?

05



Photo Details:

Creator: Department of Defense.

Title: [Redacted for privacy]

Release Status: Released to Public

Date: 01 April 1992

Permission: Public domain (National Archives

Identifier: 6472939)

Edited to obscure symbols and identifiers, per DoD instruction.

Test Your Knowledge

We have discussed causes & symptoms; list

2-3 considerations for diagnosis?

Any combination of:

- Deployment to Gulf region 1990-91
- Gulf exposures, if known by veteran
 - Symptoms: Kansas criteria
- Health problems prior to Gulf deployment
- Timing of symptom onset relative to deployment and other candidate causes
- High risk of comorbidities

05



Test Your Knowledge

Which (1) of these patients meets Gulf War Illness diagnostic (Kansas) criteria?

- a. 42-year-old veteran presenting with muscle pain, irritability, and emphysema who developed symptoms in the years after deploying to Iraq in 2003
- b. 53-year-old veteran, who served in Kuwait in 1990, presenting with diarrhea, dry skin, nausea, headaches, mild confusion, and fatigue who reports that he has suffered from headaches since childhood, but did not notice other symptoms until he started chemotherapy for small cell lung cancer
- c. 62-year-old veteran presenting with severe diarrhea, hypertension, muscle pain, severe fatigue, and recurrent unexplained rashes, symptoms emerging gradually starting around 6 months after he returned from June 1991 service in Iraq
- d. 75-year-old veteran, who served in Saudi Arabia during Operation Desert Shield, presenting with muscle pain and joint pain that have been increasing in the last five years, but are well-controlled with occasional acetaminophen use, on review of symptoms, there are no other persistent complaints

06



Test Your Knowledge

Which (1) of these patients meets Gulf War Illness diagnostic (Kansas) criteria?

- a. 42-year-old veteran presenting with muscle pain, irritability, and emphysema who developed symptoms in the years after deploying to Iraq in 2003
- b. 53-year-old veteran, who served in Kuwait in 1990, presenting with diarrhea, dry skin, nausea, headaches, mild confusion, and fatigue who reports that he has suffered from headaches since childhood, but did not notice other symptoms until he started chemotherapy for small cell lung cancer
- ☒ c. 62-year-old veteran presenting with severe diarrhea, hypertension, muscle pain, severe fatigue, and recurrent unexplained rashes, symptoms emerging gradually starting around 6 months after he returned from June 1991 service in Iraq
- d. 75-year-old veteran, who served in Saudi Arabia during Operation Desert Shield, presenting with muscle pain and joint pain that have been increasing in the last five years, but are well-controlled with occasional acetaminophen use, on review of symptoms, there are no other persistent complaints

06



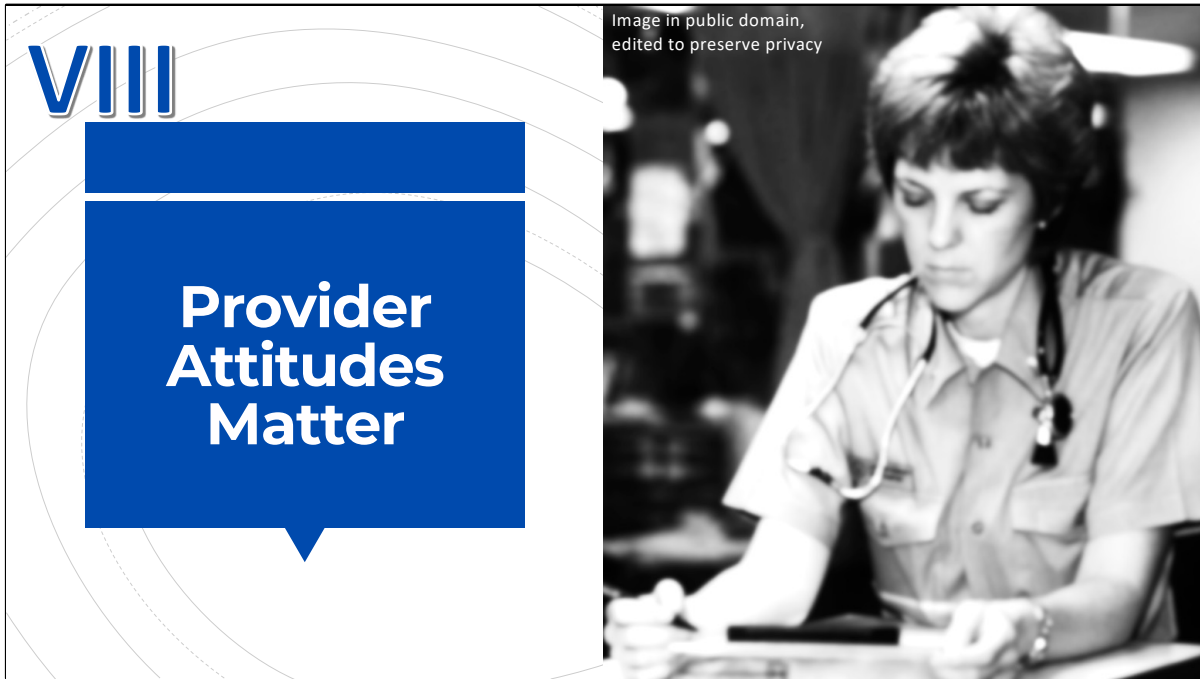


Photo Details:

Creator: Department of Defense.

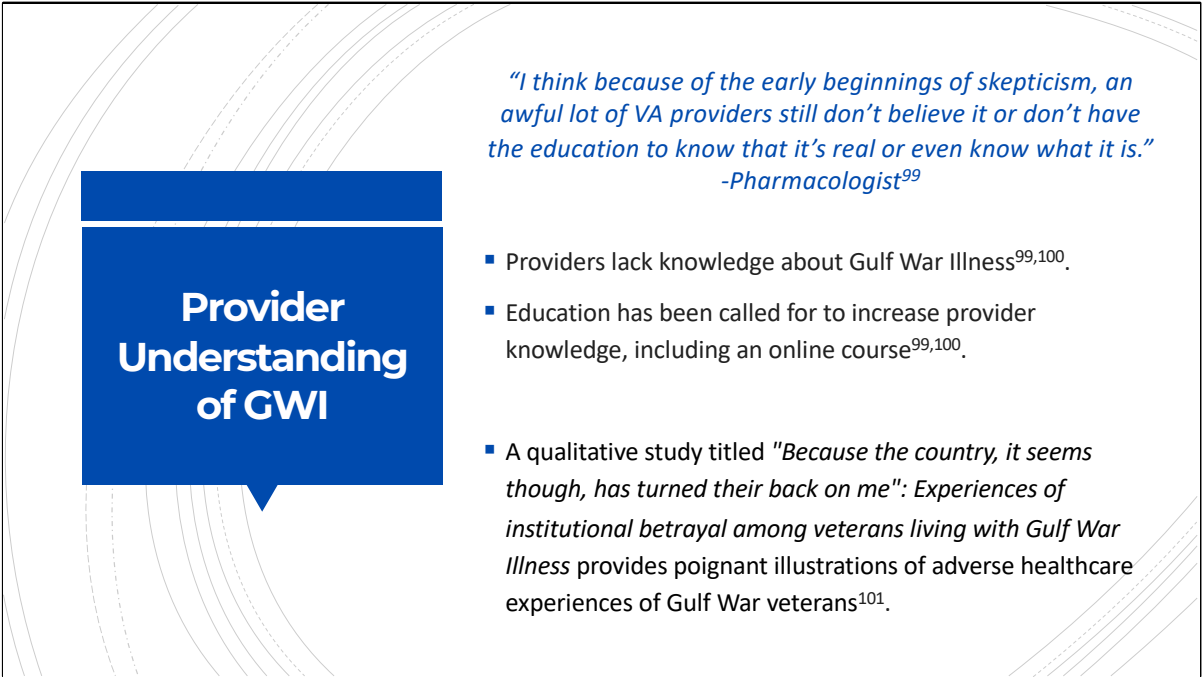
Title: [Redacted for privacy]

Release Status: Released to Public

Date: 01 February 1991

Permission: Public domain (National Archives Identifier: 6468796)

Edited to obscure symbols and identifiers, per DoD instruction.



Provider Understanding of GWI

"I think because of the early beginnings of skepticism, an awful lot of VA providers still don't believe it or don't have the education to know that it's real or even know what it is."
-Pharmacologist⁹⁹

- Providers lack knowledge about Gulf War Illness^{99,100}.
- Education has been called for to increase provider knowledge, including an online course^{99,100}.
- A qualitative study titled *"Because the country, it seems though, has turned their back on me": Experiences of institutional betrayal among veterans living with Gulf War Illness* provides poignant illustrations of adverse healthcare experiences of Gulf War veterans¹⁰¹.

In BEST encounters, veterans:

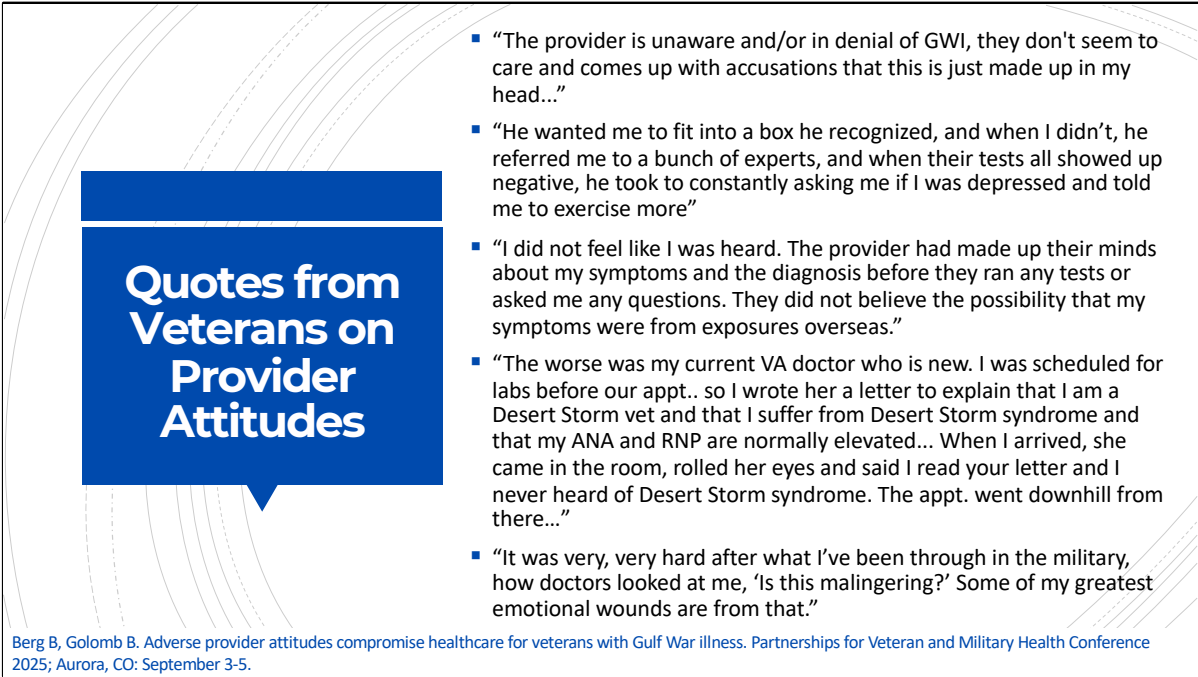
- Feel honored and validated
- Perceive providers as empathetic
- Think providers are knowledgeable
- See providers as trying to help

In WORST encounters, providers:

- Don't believe veterans
- Suggest veterans are malingering
- Suggest symptoms are in their head
- Suggest symptoms are due to stress or age
(even when veterans were in their 20s)

Veteran Survey: Best and Worst Healthcare Visits

Berg B, Golomb B. Adverse provider attitudes compromise healthcare for veterans with Gulf War illness. Partnerships for Veteran and Military Health Conference 2025; Aurora, CO: September 3-5.



Quotes from Veterans on Provider Attitudes

- “The provider is unaware and/or in denial of GWI, they don't seem to care and comes up with accusations that this is just made up in my head...”
- “He wanted me to fit into a box he recognized, and when I didn't, he referred me to a bunch of experts, and when their tests all showed up negative, he took to constantly asking me if I was depressed and told me to exercise more”
- “I did not feel like I was heard. The provider had made up their minds about my symptoms and the diagnosis before they ran any tests or asked me any questions. They did not believe the possibility that my symptoms were from exposures overseas.”
- “The worse was my current VA doctor who is new. I was scheduled for labs before our appt.. so I wrote her a letter to explain that I am a Desert Storm vet and that I suffer from Desert Storm syndrome and that my ANA and RNP are normally elevated... When I arrived, she came in the room, rolled her eyes and said I read your letter and I never heard of Desert Storm syndrome. The appt. went downhill from there...”
- “It was very, very hard after what I've been through in the military, how doctors looked at me, 'Is this malingering?' Some of my greatest emotional wounds are from that.”

Berg B, Golomb B. Adverse provider attitudes compromise healthcare for veterans with Gulf War illness. [Partnerships for Veteran and Military Health Conference 2025](#); Aurora, CO: September 3-5.

Provider Attitudes Cause Harm

Veterans Mistrust Providers Who:

- Suggest GWI is malingering ($p < 0.0001$)
- Suggest GWI is in their heads ($p < 0.0001$)
- Suggest GWI is not tied to Gulf exposures ($p < 0.0001$)



In Turn, Mistrust Predicts:

- Nonadherence to recommendations ($p < 0.0001$)
- Nonreturn for care ($p < 0.0001$)

Berg B, Golomb B. Adverse provider attitudes compromise healthcare for veterans with Gulf War illness. Partnerships for Veteran and Military Health Conference 2025; Aurora, CO: September 3-5.

Veteran Quotes: Disbelief Builds Distrust

- “When I originally went for the Gulf War Registry exam the Dr. dismissed all my concerns & although not said out loud, he intimidated.. that I was just a hysterical female & everything was just in my head.”
- “..Did not want to hear about the Persian Gulf. Actually put a comment in my VA record ‘Patient trying to pin condition on the Desert Storm’ [After this dermatologist’s proposed treatments all failed.] ‘I told him of the [CoQ10] study my wife found & how it was helping, he looked at me & basically escorted me out the door. I have not been back to the VA Dermatologist since”
- “During a visit with the VA Dr. they had no time no compassion & put no credence on the fact my symptoms could be related to my time in the gulf. I had no faith in them as they completely discounted my gulf service”

Berg B, Golomb B. Adverse provider attitudes compromise healthcare for veterans with Gulf War illness. Partnerships for Veteran and Military Health Conference 2025; Aurora, CO: September 3-5.

You Can Make a Difference!

Honor and respect your veterans. They served their country, and their Gulf War Illness is a legacy of their noble service.

Believe your veterans' symptoms and their suffering and validate their experience with empathy.

Acknowledge the tie between GWI and Gulf deployment exposures.

Become educated about GWI. (This CME is a great start!)

Be a partner in your veteran patients' search for solutions. Try multiple approaches and listen to their input.

Veteran Quotes: Good Providers

"I have restored part of my soul."

- "I would pass out brochures for [the provider] in the rain, sleet, and snow."
- "I follow [the provider's] advice, every time he gives it."
- [About a treatment] "True game changer in my life."

Berg B, Golomb B. Adverse provider attitudes compromise healthcare for veterans with Gulf War illness. Partnerships for Veteran and Military Health Conference 2025; Aurora, CO: September 3-5.

IX

**In
Veterans'
Words**



In Their Own Words..

"Pain all over the place. I've been tested, poked, and probed, and diagnosed with post-traumatic stress disorder, which I don't buy. And [they] told me there has been no real connection between the individuals [exposures], like Pyridostigmine and gulf war, or anthrax vaccine and the gulf war, or this and the gulf war. "

"In general worst experiences deal with medical physicians not looking for causation to any conditions complained about; fatigue, muscle aches, lack of sleep, GI. Any complaints regarding these conditions have/had no follow through to discover root causation leading to treatment."

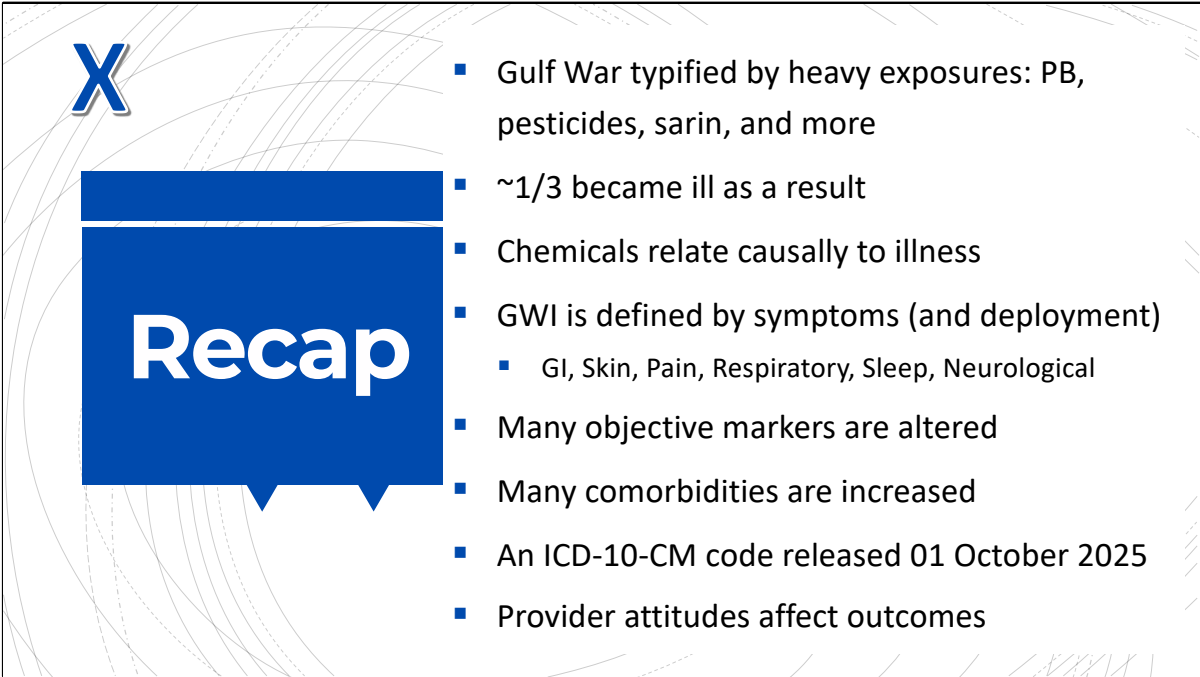
"I have been shot at age 13, Had a Motorcycle wreck, and had broken bones. None of these have caused the levels of pain I feel now every day. The above listed injuries were severe but I healed from them. I don't feel there is a healing for GWI."

"I felt [they] were abandoning the very principle of leave no soldier behind. My rank and career were taken away. My life as I knew it had ended and I was ashamed of who I was and I no longer felt worthy of wearing the uniform, being a person."

All In Your Head

Mercifully delivered, away from death we rode,
Traveling down highways paved with gold,
Arms stretched skyward in victory,
None could ever have imagined what lay in store,
Soon our health would be gone forevermore,
Our vision back then was crystal clear,
yet we were too blind to see,
Young & naive, bold & cool,
that magical day - the day the world we ruled,
Coming home to crowds & cheers & ice cold beers,
Nothing could stop us, there was nothing we feared,
Humbly taking it all in stride,
for a time it seemed, what a rush, what a ride,
Then suddenly things began to fall apart,
the symptoms began, but that was only the start,
Why? was the question, What is it? we asked,
What is wrong with our bodies, failing so fast?,
The answer is simple, our government said,
There is no Gulf War Illness,
It's all in your head.

-Captain David K. Winnett Jr.



X

Recap

- Gulf War typified by heavy exposures: PB, pesticides, sarin, and more
- ~1/3 became ill as a result
- Chemicals relate causally to illness
- GWI is defined by symptoms (and deployment)
 - GI, Skin, Pain, Respiratory, Sleep, Neurological
- Many objective markers are altered
- Many comorbidities are increased
- An ICD-10-CM code released 01 October 2025
- Provider attitudes affect outcomes

Acknowledgements:

Brinton Berg

Beatrice Bruno

Anthony Hardie

Lea Steele, PhD

Veteran Participants & Advocates

This activity was funded by the Department of
Defense Congressionally Directed Medical Research
Programs Gulf War Illness Research Program (Award #
W81XWH-19-1-0797)

UC San Diego
SCHOOL OF MEDICINE

Thank You
For tuning in

Get in touch:



Web: golombresearchgroup.org
Email: golombresearch@health.ucsd.edu

XI

Learn More



Helpful Links For Providers

- Gulf War Illness Info Sheet & Kansas Diagnostic Criteria
 - Quick reference guide to GWI & diagnosis scoring sheet:
<https://www.golombresearchgroup.org/resources>
- Gulf War Illness Research Program Report (2020)
 - https://cdmrip.health.mil/gwirp/pdfs/GWIRP_Landscape_2020.pdf
- War Related Illness and Injury Study Center (WRIISC):
 - Has information about exposure-informed care with resources for providers and veterans, screening information, and education materials:
<https://www.warrelatedillness.va.gov/WARRELATEDILLNESS/EIC/Veterans.asp>
 - VA Providers can refer complex cases of GWI and other service-related conditions to WRIISC for evaluation:
<https://www.warrelatedillness.va.gov/WARRELATEDILLNESS/clinical/va-referrals.asp>

Veteran-Centered Groups and Resources

- Veterans for Common Sense: Offers information, education, and advocacy
 - <https://veteransforcommonsense.org>
- Wounded Warrior Project: Veterans organization involved in information, service, advocacy, and support programs
 - www.woundedwarriorproject.org
- VA Adaptive Sports and Arts: Offers health and healing through sport, art, and therapy
 - <https://department.va.gov/veteran-sports/>
- Boulder Crest Foundation: Holistic healing and posttraumatic growth for veterans, including family programs
 - www.bouldercrest.org
- Outward Bound for Veterans: Adventure-based healing experiences using teamwork in nature
 - www.outwardbound.org/veterans

Citations

Most images in this presentation are in the Public Domain due to being captured as part of the official duties of US military personnel. Many are included in the US National Archives. We thank the creators and curators. "The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement." Descriptions available in Notes.

1. Cherry N, Creed F, Silman A, Kanaan M, Hotopf M, Palmer I, Unwin C, David A, Macfarlane G, Coggon D. Health and exposures of United Kingdom Gulf war veterans. Part II: The relation of health to exposure. *Occup Environ Med.* 2001;58(5):299–306. doi:10.1136/oem.58.5.299.
2. Gray GC, Reed RJ, Kaiser KS, Smith TC, Gastañaga VM. Self-reported symptoms and medical conditions among 11,868 Gulf War-era veterans: the Seabee Health Study. *Am J Epidemiol.* 2002;155(11):1033–44. doi:10.1093/aje/155.11.1033.
3. Golomb BA. Acetylcholinesterase inhibitors and Gulf War illnesses. *Proc Natl Acad Sci U S A.* 2008;105(11):4295–300. doi:10.1073/pnas.0711986105.
4. Golomb BA. A review of the scientific literature as it pertains to Gulf War illnesses. Vol. 2: Pyridostigmine bromide. Washington, DC: RAND; 1999.
5. Cecchine G, Golomb BA, Hilborne LH, Spektor DM, Anthony RA. A review of the scientific literature as it pertains to Gulf War illnesses. Vol. 8: Pesticides. Santa Monica, CA: RAND; 2000.
6. Fricker RD Jr, Reardon E, Spektor DM, Anthony RA, Hilborne LH, Cecchine G. Pesticide use during the Gulf War: a survey of Gulf War veterans. Santa Monica, CA: RAND; 2000. Report No.: MR-1018/12-OSD.
7. U.S. House of Representatives, Committee on Government Reform and Oversight. Gulf War veterans' illnesses: VA, DOD continue to resist strong evidence linking toxic causes to chronic health effects. Second Report. House Report 105-388. 105th Congress, 1st Session. Washington, DC: U.S. Government Publishing Office; 1997. Available from: [https://www.gpo.gov/congressional-records/publications/documents/105-388.pdf](#)
8. U.S. Senate Committee on Veterans' Affairs. Report of the Special Investigation Unit on Gulf War Illnesses. S. Prt. 105-39, Part I. 105th Congress, 2nd Session. Washington, DC: U.S. Government Printing Office; 1998. Available from: [https://www.gpo.gov/congressional-records/publications/documents/105-39.pdf](#)
9. Lange JL, Schwartz DA, Doebbeling BN, Heller JM, Thorne PS. Exposures to the Kuwait oil fires and their association with asthma and bronchitis among gulf war veterans. *Environmental health perspectives.* 2002 Nov;110(11):1141-6.
10. Smith TC, Heller JM, Hooper TI, Gackstetter GD, Gray GC. Are Gulf War veterans experiencing illness due to exposure to smoke from Kuwaiti oil well fires? Examination of Department of Defense hospitalization data. *American journal of epidemiology.* 2002 May 15;155(10):908-17.
11. Institute of Medicine, Committee on Health Effects Associated with Exposures During the Gulf War. Gulf War and Health: Volume 1: Depleted Uranium, Sarin, Pyridostigmine Bromide, and Vaccines. Washington, DC: The National Academies Press; 2000.
12. Harley N, Foulkes EC, Hilborne LH, Hudson A, Anthony CR. A review of the scientific literature as it pertains to Gulf War illnesses, Volume 7: Depleted uranium. *Santa Monica, CA: RAND Corporation; 1999. Report No.: MR-1018/7-OSD.*
13. McDiarmid MA, Keogh JP, Hooper FJ, McPhaul K, Squibb K, Kane R, DiPino R, Kabat M, Kaup B, Anderson L, Hoover D, Brown L, Hamilton M, Jacobson-Kram D, Burrows B, Walsh M. Health effects of depleted uranium on exposed Gulf War veterans. *Environ Res.* 2000 Feb;82(2):168-80. doi: 10.1006/enrs.1999.4012. PMID: 10662531.
14. Penuelas VL, Lo DD. Burn pit exposure in military personnel and the potential resulting lung and neurological pathologies. *Frontiers in Environmental Health.* 2024 Jun 21;3:1364812.
15. Board on Health Promotion and Disease Prevention, Committee on Gulf War and Health: Literature Review of Selected Environmental Particulates, Pollutants, and Synthetic Chemical Compounds. Gulf War and Health: Volume 3: Fuels, Combustion Products, and Propellants. Washington, DC: National Academies Press; 2005 Oct 28. Available from: [https://www.nationalacademies.org/~/media/Files/Reports/2005/GulfWarandHealthVolume3.pdf](#)
16. Research Advisory Committee on Gulf War Veterans' Illnesses. Scientific progress in understanding Gulf War Veterans' illnesses: Report and recommendations. Washington, DC: U.S. Department of Veterans Affairs; 2004. p. 1–141. Available from: [https://www.va.gov/pubs/docs/2004/040104.pdf](#)

Citations

17. Mawson AR, Croft AM. Gulf War Illness: Unifying Hypothesis for a Continuing Health Problem. *Int J Environ Res Public Health*. 2019;16(1):111. doi:10.3390/ijerph16010111.
18. Steele L, Quaden R, Ahmed ST, Harrington KM, Duong LM, Ko J, Gifford EJ, Polimanti R, Gaziano JM, Aslan M, Helmer DA. Association of deployment characteristics and exposures with persistent ill health among 1990-1991 Gulf War veterans in the VA Million Veteran Program. *Environmental Health*. 2024 Oct 25;23(1):92.
19. Steele L. Prevalence and patterns of Gulf War illness in Kansas veterans: Association of symptoms with characteristics of person, place, and time of military service. *Am. J. Epidemiol*. 2000;152:992-1002. doi: 10.1093/aje/152.10.992.
20. Schumm WR, Reppert EJ, Jurich AP, et al. Pyridostigmine bromide and the long-term subjective health status of a sample of over 700 male Reserve Component Gulf War era veterans. *Psychol Rep* 2002;90(3 Pt 1):707-21. DOI: 10.2466/pr0.2002.90.3.707.
21. Koslik HJ, Hamilton G, Golomb BA. Mitochondrial dysfunction in Gulf War illness revealed by 31Phosphorus Magnetic Resonance Spectroscopy: a case-control study. *PLoS One* 2014;9(3):e92887. DOI: 10.1371/journal.pone.0092887.
22. Fung A, Koslik H, Ritchie J, Dinkeloo E, Golomb BA. Bioenergetics in veterans with Gulf War illness versus healthy controls: Replication and expansion. Presented at: Gulf War Illness State of the Science Virtual Conference; 2020 Sep; Washington, DC.
23. Bui L, Nguyen E, Dinkeloo E, Ritchie J, Golomb BA. Nuclear and mitochondrial genetics together determine Gulf War illness severity and symptom profile. Presented at: Gulf War Illness State of the Science Virtual Conference; 2020 Sep; Washington, DC.
24. Golomb BA, Sanchez Baez R, Schilling JM, Dhanani M, Fannon MJ, Berg BK, et al. Mitochondrial impairment but not peripheral inflammation predicts greater Gulf War illness severity. *Sci Rep*. 2023;13:10739.
25. Shetty GA, Hattiangady B, Upadhy D, et al. Chronic oxidative stress, mitochondrial dysfunction, Nrf2 activation and inflammation in the hippocampus accompany heightened systemic inflammation and oxidative stress in an animal model of Gulf War illness. *Front Mol Neurosci*. 2017;10:182. doi: 10.3389/fnmol.2017.00182.
26. Zakirova Z, Reed J, Crynen G, et al. Complementary proteomic approaches reveal mitochondrial dysfunction, immune and inflammatory dysregulation in a mouse model of Gulf War illness. *Proteomics Clin Appl*. 2017;11(9-10):e1600190. doi: 10.1002/prca.201600190.
27. Naviaux RK, Naviaux JC, Li K, et al. Metabolic features of Gulf War illness. *PLoS One* 2019;14(7):e0219531. DOI: 10.1371/journal.pone.0219531.
28. Golomb BA, Koslik HJ, Christians U, et al. Depressed prostaglandins and leukotrienes in veterans with Gulf War illness. *J Environ Sci Health B* 2019;54(8):623-639. DOI: 10.1080/03601234.2019.1596001.
29. Oberlin S, Nkiliza A, Parks M, Evans JE, Klimas N, Keegan AP, et al. Sex-specific differences in plasma lipid profiles are associated with Gulf War Illness. *J Transl Med*. 2022;20(1):73.
30. Abdullah L, Evans JE, Bishop A, et al. Lipidomic profiling of phosphocholine-containing brain lipids in mice with sensorimotor deficits and anxiety-like features after exposure to Gulf War agents. *Neuromolecular Med* 2012;14(4):349-61. DOI: 10.1007/s12017-012-8192-z.
31. Abdullah L, Evans JE, Montague H, et al. Chronic elevation of phosphocholine containing lipids in mice exposed to Gulf War agents pyridostigmine bromide and permethrin. *Neurotoxicol Teratol* 2013;40:74-84. DOI: 10.1016/j.ntt.2013.10.002.
32. Abdullah L, Evans JE, Joshi U, et al. Translational potential of long-term decreases in mitochondrial lipids in a mouse model of Gulf War Illness. *Toxicology* 2016;372:22-33. DOI: 10.1016/j.tox.2016.10.012.
33. Johnson GJ, Slater BC, Leis LA, Rector TS, Bach RR. Blood Biomarkers of Chronic Inflammation in Gulf War Illness. *PLoS One* 2016;11(6):e0157855. DOI: 10.1371/journal.pone.0157855.
34. Johnson GJ, Leis LA, Slater BC, Bach RR. Elevated platelet count, C-reactive protein and thromboxane analog-induced platelet aggregation in patients with Gulf War veterans' illnesses: evidence of a chronic inflammatory state? *Blood Coagul Fibrinolysis* 2013;24(7):736-41. DOI: 10.1097/MBC.0b013e328362627f.

Citations

35. Butterick TA, Trembley JH, Hocom Stone LL, Muller CJ, Rudquist RR, Bach RR. Gulf War Illness-associated increases in blood levels of interleukin 6 and C-reactive protein: biomarker evidence of inflammation. *BMC Res Notes* 2019;12(1):816. DOI: 10.1186/s13104-019-4855-2.
36. Alshelh Z, Albrecht DS, Bergan C, et al. In-vivo imaging of neuroinflammation in veterans with Gulf War Illness. *Brain Behav Immun*. 2020;87:498-507. doi:10.1016/j.bbi.2020.01.020.
37. Carpenter JM, Gordon HE, Ludwig HD, Wagner JJ, Harn DA, Norberg T, et al. Neurochemical and neuroinflammatory perturbations in two Gulf War Illness models: Modulation by the immunotherapeutic LNFPIII. *Neurotoxicology*. 2019;77:40-50.
38. Madhu LN, Attaluri S, Kodali M, Shuai B, Upadhyay R, Gitai D, et al. Neuroinflammation in Gulf War Illness is linked with HMGB1 and complement activation, which can be discerned from brain-derived extracellular vesicles in the blood. *Brain Behav Immun*. 2019;81:430-43.
39. Vojdani A, Thrasher JD. Cellular and humoral immune abnormalities in Gulf War veterans. *Environ Health Perspect* 2004;112(8):840-6. DOI: 10.1289/ehp.6881.
40. Haley RW, Vongpatanasin W, Wolfe GI, Bryan WW, Armitage R, Hoffmann RF, et al. Blunted circadian variation in autonomic regulation of sinus node function in veterans with Gulf War syndrome. *American Journal of Medicine*. 2004;117(7):469-78.
41. Haley RW, Charuvastra E, Shell WE, Buhner DM, Marshall WW, Biggs MM, et al. Cholinergic autonomic dysfunction in veterans with Gulf War illness: confirmation in a population-based sample. *JAMA Neurol*. 2013;70(2):191-200.
42. Rayhan RU, Stevens BW, Rakshit MP, Ripple JA, Timbol CR, Adewuyi O, VanMeter JW, Baraniuk JN. Exercise challenge in Gulf War Illness reveals two subgroups with altered brain structure and function. *PLoS One*. 2013 Jun 14;8(6):e63903.
43. Golier JA, Schmeidler J, Legge J, Yehuda R. Enhanced cortisol suppression to dexamethasone associated with Gulf War deployment. *Psychoneuroendocrinology*. 2006;31(10):1181-9.
44. Golier JA, Schmeidler J, Legge J, Yehuda R. Twenty-four hour plasma cortisol and adrenocorticotrophic hormone in Gulf War veterans: relationships to posttraumatic stress disorder and health symptoms. *Biol Psychiatry*. 2007;62(10):1175-8.
45. Golier JA, Schmeidler J, Yehuda R. Pituitary response to metyrapone in Gulf War veterans: relationship to deployment, PTSD and unexplained health symptoms. *Psychoneuroendocrinology*. 2009;34(9):1338-45.
46. Bhatti G, Villalon A, Li R, Elammari M, Price A, Steele L, Garcia JM, Marcelli M, Jorge R. Hormonal changes in veterans with Gulf War Illness. *Life Sci*. 2023 Jul 3;328:121908. doi:10.1016/j.ifs.2023.121908.
47. Zhang Q, Zhou XD, Denny T, et al. Changes in immune parameters seen in Gulf War veterans but not in civilians with chronic fatigue syndrome. *Clin Diagn Lab Immunol* 1999;6(1):6-13. DOI: 10.1128/cdli.6.1.6-13.1999.
48. Whistler T, Fletcher MA, Loneragan W, et al. Impaired immune function in Gulf War Illness. *BMC Med Genomics* 2009;2:12.DOI: 10.1186/1755-8794-2-12.
49. Heaton KJ, Palumbo CL, Proctor SP, Killiany RJ, Yurgelun-Todd DA, White RF. Quantitative magnetic resonance brain imaging in US army veterans of the 1991 Gulf War potentially exposed to sarin and cyclosarin. *Neurotoxicology* 2007;28(4):761-9. DOI: 10.1016/j.neuro.2007.03.006.
50. Chao LL, Abadjian L, Hlavin J, Meyerhoff DJ, Weiner MW. Effects of low-level sarin and cyclosarin exposure and Gulf War Illness on brain structure and function: a study at 4T. *Neurotoxicology*. 2011;32(6):814-22.
51. Van Riper SM, Alexander AL, Koltyn KF, Stegner AJ, Ellingson LD, Destiche DJ, et al. Cerebral white matter structure is disrupted in Gulf War Veterans with chronic musculoskeletal pain. *Pain*. 2017;158(12):2364-75.
52. Haley RW, Kramer G, Xiao J, Dever JA, Teiber JF. Evaluation of a gene-environment interaction of PON1 and low-level nerve agent exposure with Gulf War illness: a prevalence case-control study drawn from the US Military Health Survey's national population sample. *Environmental health perspectives*. 2022 May 11;130(5):057001.
53. Steele L, Furlong CE, Richter RJ, Marsillach J, Janulewicz PA, Kregel MH, Klimas NG, Sullivan K, Chao LL. PON1 Status in Relation to Gulf War Illness: Evidence of Gene-Exposure Interactions from a Multisite Case-Control Study of 1990-1991 Gulf War Veterans. *Int J Environ Res Public Health*. 2024 Jul 24;21(8):964. doi: 10.3390/ijerph21080964. PMID: 39200575; PMCID: PMC11353671.

Citations

54. Steele L, Lockridge O, Gerkovich MM, Cook MR, Sastre A. Butyrylcholinesterase genotype and enzyme activity in relation to Gulf War illness: preliminary evidence of gene-exposure interaction from a case-control study of 1991 Gulf War veterans. *Environ Health*. 2015 Jan 9;14:4. doi: 10.1186/1476-069X-14-4.
55. Azzolin VF, Barbisan F, da Cruz Jung IE, Teixeira CF, Ribeiro EE, de Souza Praia R, da Cruz IB. Interaction between Pyridostigmine Bromide and Oxidative Stress. In *Medical Toxicology* 2019 Nov 25. IntechOpen.
56. Leung MC, Meyer JN. Mitochondria as a target of organophosphate and carbamate pesticides: Revisiting common mechanisms of action with new approach methodologies. *Reproductive toxicology*. 2019 Oct 1;89:83-92.
57. Karami-Mohajeri S, Abdollahi M. Mitochondrial dysfunction and organophosphorus compounds. *Toxicol Appl Pharmacol*. 2013 Jul 1;270(1):39-44. doi: 10.1016/j.taap.2013.04.001. Epub 2013 Apr 8. PMID: 23578477
58. Gassner B, Wüthrich A, Scholtysik G, Solioz M. The pyrethroids permethrin and cyhalothrin are potent inhibitors of the mitochondrial complex I. *The Journal of pharmacology and experimental therapeutics*. 1997 May 1;281(2):855-60.
59. Arima Y, Shiraishi H, Saito A, Yoshimoto K, Namera A, Makita R, Murata K, Imaizumi K, Nagao M. The sarin-like organophosphorus agent bis (isopropyl methyl) phosphonate induces ER stress in human astrocytoma cells. *The Journal of Toxicological Sciences*. 2016 Oct 1;41(5):617-25.
60. Pearson JN, Patel M. The role of oxidative stress in organophosphate and nerve agent toxicity. *Annals of the New York Academy of Sciences*. 2016 Aug;1378(1):17-24.
61. Di Donato S. Multisystem manifestations of mitochondrial disorders. *J Neurol*. 2009 May;256(5):693-710. doi: 10.1007/s00415-009-5028-3. Epub 2009 Mar 1. PMID: 19252802.
62. Mancuso M. Complex neurological and multisystem presentations in mitochondrial disease. *Handb Clin Neurol*. 2023;194:117-124. doi: 10.1016/B978-0-12-821751-1.00003-8. PMID: 36813308.
63. Muraresku CC, McCormick EM, Falk MJ. Mitochondrial Disease: Advances in clinical diagnosis, management, therapeutic development, and preventative strategies. *Curr Genet Med Rep*. 2018 Jun;6(2):62-72. doi: 10.1007/s40142-018-0138-9. Epub 2018 May 2. PMID: 30393588; PMCID: PMC6208355.
64. Filler K, Lyon D, Bennett J, McCain N, Elswick R, Lukkahatali N, Saligan LN. Association of Mitochondrial Dysfunction and Fatigue: A Review of the Literature. *BBA Clin*. 2014 Jun 1;1:12-23. doi: 10.1016/j.bbacli.2014.04.001. PMID: 25147756; PMCID: PMC4136529.
65. Klopstock T, Priglinger C, Yilmaz A, Kornblum C, Distelmaier F, Prokisch H. Mitochondrial Disorders. *Dtsch Arztebl Int*. 2021 Nov 5;118(44):741-748. doi: 10.3238/arztebl.m2021.0251. PMID: 34158150; PMCID: PMC8830351.
66. Crimmins D, Morris JG, Walker GL, Sue CM, Byrne E, Stevens S, Jean-François B, Yiannikas C, Pamphlett R. Mitochondrial encephalomyopathy: variable clinical expression within a single kindred. *Journal of Neurology, Neurosurgery & Psychiatry*. 1993 Aug 1;56(8):900-5.
67. Kroenke K, Koslowe P, Roy M. Symptoms in 18,495 Persian Gulf War veterans. Latency of onset and lack of association with self-reported exposures. *J Occup Environ Med*. 1998 Jun;40(6):520-8. doi: 10.1097/00043764-199806000-00004. PMID: 9636932.
68. Lacedonia D, Carpagnano GE, Crisetti E, Cotugno G, Palladino GP, Patricelli G, Sabato R, Foschino Barbaro MP. Mitochondrial DNA alteration in obstructive sleep apnea. *Respiratory research*. 2015 Apr 7;16(1):47.
69. Marshall JD, Bazan J, Zhang Y, Fares WH, Lee PJ. Mitochondrial dysfunction and pulmonary hypertension: cause, effect, or both. *American Journal of Physiology-Lung Cellular and Molecular Physiology*. 2018 May 1;314(5):L782-96.
70. Chistiakov DA, Shkurat TP, Melnichenko AA, Grechko AV, Orekhov AN. The role of mitochondrial dysfunction in cardiovascular disease: a brief review. *Annals of medicine*. 2018 Feb 17;50(2):121-7.
71. Primiano G, Brunetti V, Vollono C, Losurdo A, Moroni R, Della Marca G, Servidei S. Sleep-Disordered Breathing in Adult Patients With Mitochondrial Diseases: A Cohort Study. *Neurology*. 2021;96(2):e241-e49. Epub 20201006. doi: 10.1212/WNL.0000000000011005. PMID: 33024021.
72. Golomb BA, Allison M, Koperski S, Koslik HJ, Devaraj S, Ritchie JB. Coenzyme Q10 benefits symptoms in Gulf War veterans: results of a randomized double-blind study. *Neural Comput*. 2014 Nov;26(11):2594-651. doi: 10.1162/NECO_a_00659. Epub 2014 Aug 22. PMID: 25149705.

Citations

73. Unwin C, Blatchley N, Coker W, et al. Health of UK servicemen who served in Persian Gulf War. *Lancet* 1999;353(9148):169-78. DOI: 10.1016/S0140-6736(98)11338-7.
74. Gray GC, Reed RJ, Kaiser KS, Smith TC, Gastañaga VM. Self-reported symptoms and medical conditions among 11,868 Gulf War-era veterans: the Seabee Health Study. *Am J Epidemiol* 2002;155(11):1033-44. DOI: 10.1093/aje/155.11.1033.
75. Ismail K, Kent K, Sherwood R, et al. Chronic fatigue syndrome and related disorders in UK veterans of the Gulf War 1990-1991: results from a two-phase cohort study. *Psychol Med* 2008;38(7):953-61. DOI: 10.1017/S0033291707001560.
76. Amin MM, Gold MS, Broderick JE, Gold AR. The effect of nasal continuous positive airway pressure on the symptoms of Gulf War illness. *Sleep Breath*. 2011 Sep;15(3):579-87. doi: 10.1007/s11325-010-0406-8.
77. Eisen SA, Kang HK, Murphy FM, et al. Gulf War veterans' health: medical evaluation of a U.S. cohort. *Ann Intern Med* 2005;142(11):881-90. DOI: 10.7326/0003-4819-142-11-200506070-00005.
78. Thomas HV, Stimpson NJ, Weightman AL, Dunstan F, Lewis G. Systematic review of multi-symptom conditions in Gulf War veterans. *Psychol Med* 2006;36(6):735-47. DOI: 10.1017/S0033291705006975.
79. The Iowa Persian Gulf Study Group. Self-reported illness and health status among Gulf War veterans: a population-based study. *JAMA*. 1997;277(3):238-45.
80. Blanchard M, Molina-Vicenty HD, Stein PK, et al. Medical Correlates of Chronic Multisymptom Illness in Gulf War Veterans. *Am J Med* 2019;132(4):510-518. DOI: 10.1016/j.amjmed.2018.11.045.
81. Bell IR, Warg-Damiani L, Baldwin CM, Walsh ME, Schwartz GE. Self-reported chemical sensitivity and wartime chemical exposures in Gulf War veterans with and without decreased global health ratings. *Mil Med*. 1998;163(11):725-32.
82. Reid S, Hotopf M, Hull L, Ismail K, Unwin C, Wessely S. Multiple chemical sensitivity and chronic fatigue syndrome in British Gulf War veterans. *Am J Epidemiol* 2001;153(6):604-9. DOI: 10.1093/aje/153.6.604.
83. Coffman CJ, Horner RD, Grambow SC, Lindquist J. Estimating the occurrence of amyotrophic lateral sclerosis among Gulf War (1990-1991) veterans using capture-recapture methods. *Neuroepidemiology* 2005;24(3):141-50. DOI: 10.1159/000083297.
84. Horner RD, Kamins KG, Feussner JR, et al. Occurrence of amyotrophic lateral sclerosis among Gulf War veterans. *Neurology* 2003;61(6):742-9. DOI: 10.1212/01.wnl.0000069922.32557.ca.
85. Haley RW. Excess incidence of ALS in young Gulf War veterans. *Neurology* 2003;61(6):750-6. DOI: 10.1212/wnl.61.6.750.
86. Kang HK, Mahan CM, Lee KY, Magee CA, Murphy FM. Illnesses among United States veterans of the Gulf War: a population-based survey of 30,000 veterans. *J Occup Environ Med* 2000;42(5):491-501. DOI: 10.1097/00043764-200005000-00006.
87. McCauley LA, Lasarev M, Sticker D, Rischitelli DG, Spencer PS. Illness experience of Gulf War veterans possibly exposed to chemical warfare agents. *Am J Prev Med* 2002;23(3):200-6. DOI: 10.1016/S0749-3797(02)00497-x.
88. Steele L, Klimas N, Krengel M, et al. Brain-immune Interactions as the Basis of Gulf War Illness: Clinical Assessment and Deployment Profile of 1990-1991 Gulf War Veterans in the Gulf War Illness Consortium (GWIC) Multisite Case-Control Study. *Brain Sci* 2021;11(9) DOI: 10.3390/brainsci11091132.
89. Simmons R, Maconochie N, Doyle P. Self-reported ill health in male UK Gulf War veterans: a retrospective cohort study. *BMC Public Health* 2004;4:27. DOI: 10.1186/1471-2458-4-27.
90. Zundel CG, Krengel MH, Heeren T, et al. Rates of Chronic Medical Conditions in 1991 Gulf War Veterans Compared to the General Population. *Int J Environ Res Public Health* 2019;16(6) DOI: 10.3390/ijerph16060949.
91. Malhotra D, Boyle SH, Gifford EJ, Yousef A, Ahmed ST, Wenker THN, Nono-Djotsa ABS, Chandler H, Bandi S, Helmer DA. Self-reported gastrointestinal disorders among veterans with Gulf War illness with and without posttraumatic stress disorder. *Neurogastroenterol Motil*. 2023;35(5):e14548. doi:10.1111/nmo.14548.
92. Yousef A, Ahmed ST, Wenker THN, Nono-Djotsa ABS, Boyle SH, Gifford EJ, Malhotra D, Chandler H, Bandi S, Helmer DA. Upper gastrointestinal symptoms and Gulf War illness in a clinical cohort of US veterans: a retrospective, cross-sectional study. *BMJ Open Gastroenterol*. 2025;12(1):e001859. doi:10.1136/bmjgast-2025-001859.



Citations

93. Amin MM, Belisova Z, Hossain S, Gold MS, Broderick JE, Gold AR. Inspiratory airflow dynamics during sleep in veterans with Gulf War illness: a controlled study. *Sleep Breath* 2011;15(3):333-9. DOI: 10.1007/s11325-010-0386-8.
94. Shadiack EC 3rd, Osinubi O, Gruber-Fox A, Bhate C, Patrick-DeLuca L, Cohen P, Helmer DA. Small Fiber Neuropathy in Veterans With Gulf War Illness. *Fed Pract*. 2024 May;41(5):136-141. doi: 10.12788/fp.0470.
95. Kirkland AE, Baron M, VanMeter JW, Baraniuk JN, Holton KF. The low glutamate diet improves cognitive functioning in veterans with Gulf War Illness and resting-state EEG potentially predicts response. *Nutr Neurosci*. 2022 Nov;25(11):2247-2258. doi: 10.1080/1028415X.2021.1954292.
96. Golomb BA, Han JH. Adverse effect propensity: A new feature of Gulf War illness predicted by environmental exposures. *Iscience*. 2023 Aug 18;26(8).
97. Dinu M, Pagliai G, Casini A, Sofi F. Mediterranean diet and multiple health outcomes: an umbrella review of meta-analyses of observational studies and randomised trials. *Eur J Clin Nutr*. 2018 Jan;72(1):30-43. doi: 10.1038/ejcn.2017.58. Epub 2017 May 10. PMID: 28488692.
98. Finsterer J. Central nervous system manifestations of mitochondrial disorders. *Acta Neurol Scand*. 2006 Oct;114(4):217-38. doi: 10.1111/j.1600-0404.2006.00671.x.
99. Kaimal G, Dieterich-Hartwell R. Grappling with Gulf War Illness: Perspectives of Gulf War Providers. *Int J Environ Res Public Health*. 2020 Nov 19;17(22):8574. doi: 10.3390/ijerph17228574.
100. Baldwin N, Rudquist RR, Lava-Parmeles S, Trembley JH, Butterick TA, Bach RR. Improving Health Care for Veterans With Gulf War Illness. *Fed Pract*. 2019 May;36(5):212-219. PMID: 31138975; PMCID: PMC6530665.
101. Bloeser K, McCarron KK, Merker VL, et al. "Because the country, it seems though, has turned their back on me": Experiences of institutional betrayal among veterans living with Gulf War Illness. *Soc Sci Med* 2021;284:114211. DOI: 10.1016/j.socscimed.2021.114211.