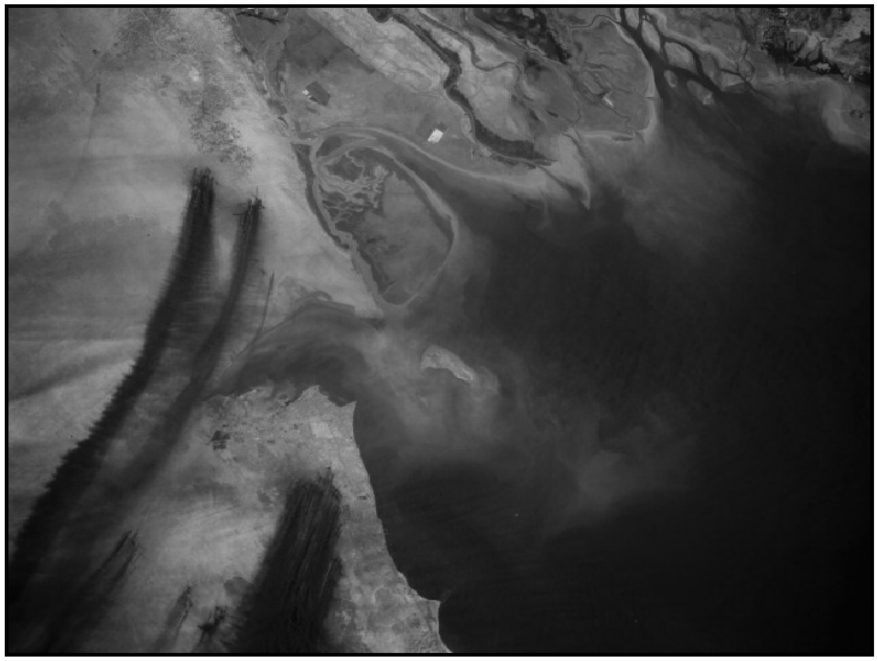
Presentation 3 – Lea Steele

Oil Well Fires, Petroleum Combustion



Hydrocarbon Fuel Combustion Products

Primary Sources of Exposure:

- Oil well fires (partially combusted crude oil)
- Tent heaters, cooking stoves (combusted gasoline, kerosene, diesel, jet fuel)
- Open burning of trash, wastes

Toxicants Associated with Petroleum Combustion

- Ozone (O_3)
- Nitrogen Dioxide (NO_2)
- Sulfur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Hydrogen Sulfide (H_2S)
- VOCs: Volatile organic compounds *(benzene, toluene, etc)*
- PAHs: Polycyclic aromatic hydrocarbons *(anthracene, pyrene,etc)*
- Metals *(cadmium, chromium, lead, nickel, mercury, vanadium)*
- Acidic gases/aerosols *(hydrochloric acid, nitric acid, sulfuric acid)*
- Particulate matter *(PM_{10}, $PM_{2.5}$, ultrafine particles)*

IOM Report on Fuel, Combustion Products, and Propellants (2005)

Sufficient evidence to conclude that there is an association between combustion products and lung cancer

Limited/suggestive evidence of an association between combustion products and cancers of nasal and oral cavities, bladder cancer, and low birthweight/pre-term births

Oil Well Fires, Combustion Products: Information Considered by RAC in 2004-2005

- Projects to estimate levels of exposure to contaminants from oil well fires and tent heaters, expected health risks
- Epidemiologic/human studies to evaluate associations between exposures and health outcomes

Estimates of Exposure/ Modeled Health Risks

Oil Well Fires

Petroleum Combustion Exposures in the Gulf War: How Many Were Exposed?

Study	Population	Findings
Kang, 2000	11,441 US Gulf veterans	65% reported exposure to smoke from oil well fires 80% reported exposure to diesel, kerosene, petro fumes 30% consumed food contaminated w/ oil, smoke
Unwin, 1999	3,284 UK Gulf veterans	72% reported oil well fire smoke exposure 78% reported exposure to exhaust from heaters 84% reported exposure to diesel/petrochem fumes
Cherry, 2001	7,971 UK Gulf veterans	61% reported oil well fire exposure

Emissions from unvented tent heaters

- 2 studies from Lovelace Respiratory Research Institute
  - Zhou Y, Cheng YS. Aerosol Science and Technology 33:510-524 (2000)
  - Cheng YS, Zhou Y, et al. Aerosol Science and Technology 35: 949-957 (2001)
- Experiments simulated and characterized emissions from heaters used inside of Army tent
- Tested 3 types of heaters, 3 types of fuels (kerosene, JA-1, JP-8)

Emissions from unvented tent heaters

- **Results:**
  - **Emissions varied with type of fuel, type of heater, and temperature**
  - **Convection heaters emitted more NO and SO_2 then radiant heaters, less CO and particulates**
  - **NO_x, CO, and SO_2 exceeded air quality standards when tent doors were closed; but did not exceed 24-hour exposure standards**
  - **Most particulates were in the fine range (peak ~0.2 - 0.3 microns), with some in the ~10 micron range. Levels exceeded 24-hour standards when door closed, close to standards when door open**

Zhou Y, Cheng YS. Aerosol Science and Technology 33:510-524 (2000)

USACHPPM

Exposure to Smoke from the Kuwait Oil Well Fires

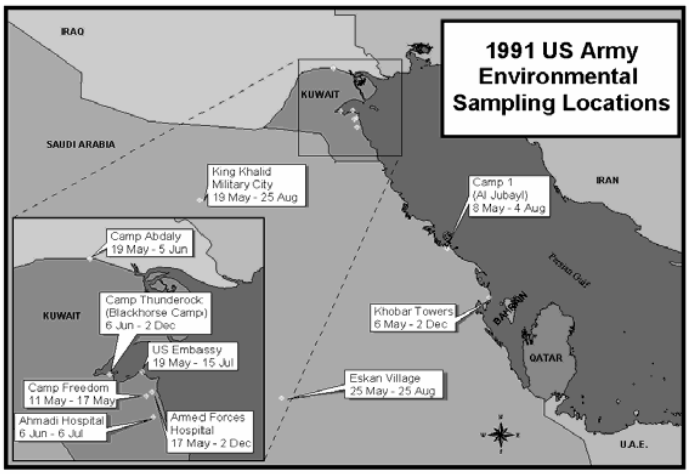
Presentation to

Research Advisory Committee on Gulf War Veterans' Illnesses

Mr. Jeffrey Kirkpatrick
Acting Program Manager
Global Threat Assessment
25 October 2004

Slide adapted from: Kirkpatrick J. Exposure to Smoke from the Kuwait Oil Well Fires. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

1991 Oil Fires Sampling Locations



Slide adapted from: Kirkpatrick J. Exposure to Smoke from the Kuwait Oil Well Fires. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Slide adapted from: Heller JM. Overview of the Assessment of U.S. Forces Exposure to Oil Well Fire Emissions in the Persian Gulf in 1991. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Modeled Exposure Data

- Expands Oil Fires Assessment of:
  - **Time** (from May-Dec '91 to Feb-Nov '91)
  - **Location** (from 10 Specific Sites to Entire KTO)
  - **Population** (from Subset of Exposed Population to Entire Oil Fires Exposed Population)
  - **Sources** (Separates oil fire sources from industrial, vehicular and natural sources)

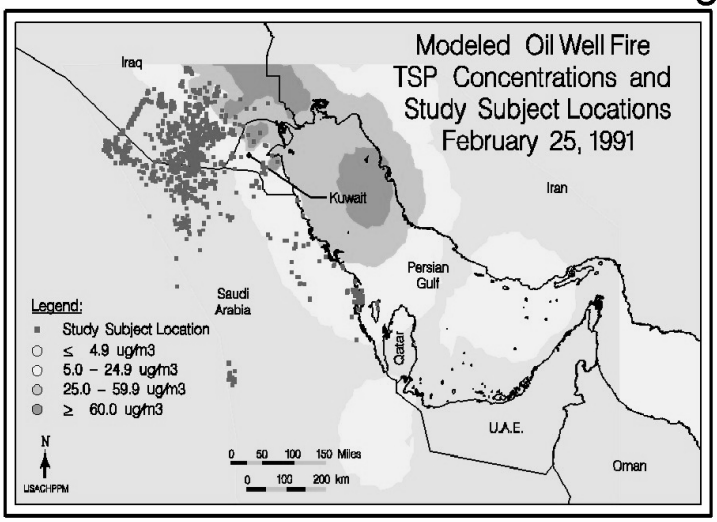
Slide adapted from: Kirkpatrick J. Exposure to Smoke from the Kuwait Oil Well Fires. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Modeled Pollutants of Concern

Volatile Organic Compounds		
Benzene	Toluene	m-Xylene
o-Xylene	p-Xylene	Propylbenzene
Ethylbenzene		
Polycyclic Aromatic Hydrocarbons		
Naphthalene		
Particulates, Metals, Inorganics		
Total Suspended Particulate	Iron	Nickel
Vanadium		

Slide adapted from: Kirkpatrick J. Exposure to Smoke from the Kuwait Oil Well Fires. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Oil Fires Particulate Matter Modeling



Slide adapted from: Kirkpatrick J. Exposure to Smoke from the Kuwait Oil Well Fires. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Oil Well Fires Emissions Modeling

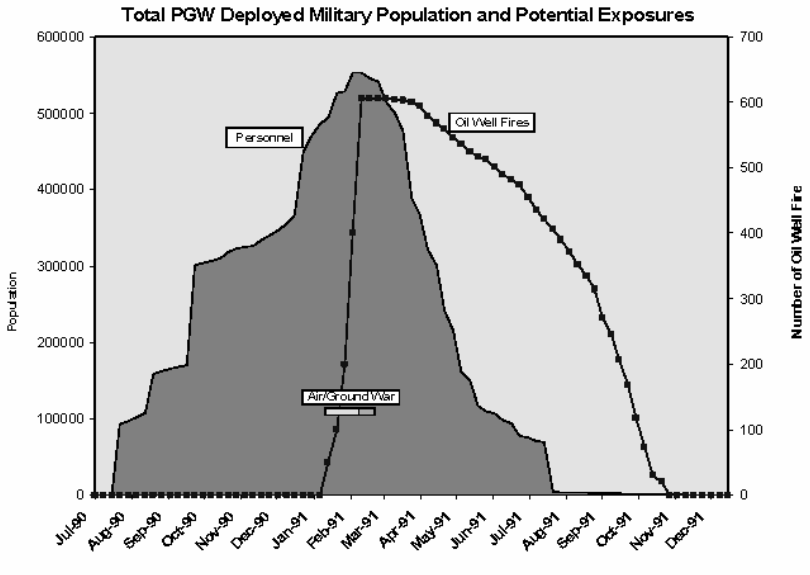
- Dispersion Modeling: NOAA ARL
  - HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory) Model
- Source Term Refinements
  - 24 Hour Unit Emission Concentration – Breathing Zone
  - Extinguishment Chronology
  - Smoke Lofting Feedback
- 15 Km Grid Spacing for Gulf War Theater (over 40,000 points)
- Meteorological Data:
  - National Weather Service; Medium Range Forecast Model
  - European Center for Medium Range Weather Forecasting (ECMWF)
- Air Concentrations Validated – Ground and Aircraft Measurements of SO_2 and Soot

Slide adapted from: Kirkpatrick J. Exposure to Smoke from the Kuwait Oil Well Fires. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Troop Location Information and Database

Unit Movement Data
Persian Gulf War Registry
Oil Well Fires Web Page

Slide adapted from: Wortman W. Troop Location Information and Database. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.



Slide adapted from: Wortman W. Troop Location Information and Database. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

General Health Risk


DEPLOYMENT ENVIRONMENTAL SURVEILLANCE PROGRAM

Gulf War Fires

USACHPPM

Individual Oil Well Fire Smoke Exposure Risk

The U.S. Army Center for Health Promotion and Preventive Medicine located in Aberdeen Proving Ground, Maryland is responsible for assessing the environmental health risk of our deployed forces. We determined your exposure to Oil Well Fire Smoke based on data showing that you were in theater from 1/1/1991 to 4/30/1991 with the 0475 MEDICAL HOSPITAL MASH.
The table below shows your oil fire smoke exposure.

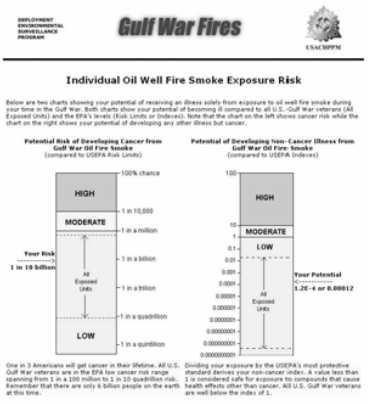
9/13/2004
900-00-0024

Factor	Potential Illness
Extra chance of getting cancer.	Low
Extra chance of getting an illness other than cancer.	Low

Potential Illness Charts

Slide adapted from: Wortman W. Troop Location Information and Database. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Cancer/Non-Cancer Risk


DEPLOYMENT ENVIRONMENTAL SURVEILLANCE PROGRAM

Gulf War Fires

USACHPPM

Individual Oil Well Fire Smoke Exposure Risk

Below are two charts showing your potential of receiving an illness solely from exposure to oil well fire smoke during your time in the Gulf War. Both charts show your potential of becoming ill compared to all U.S.-Gulf War veterans (All Exposed Units) and the EPA's levels (Risk Limits or Indexes). Note that the chart on the left shows cancer risk while the chart on the right shows your potential of developing any other illness but cancer.

Potential Risk of Developing Cancer from Gulf War Oil Fire Smoke
(compared to USEPA Risk Limits)

100% chance
HIGH
1 in 10,000
MODERATE
1 in a million
Your Risk
1 in 10 billion
All Exposed Units
1 in a billion
1 in a trillion
1 in a quadrillion
LOW
1 in a quintillion

One in 3 Americans will get cancer in their lifetime. All U.S. Gulf War veterans are in the EPA low cancer risk range spanning from 1 in a 100 million to 1 in 10 quadrillion risk. Remember that there are only 6 billion people on the earth at this time.

Potential of Developing Non-Cancer Illness from Gulf War Oil Fire Smoke
(compared to USEPA Indexes)

100
HIGH
10
MODERATE
1
LOW
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.0000001
0.00000001
0.000000001
All Exposed Units
Your Potential
1.2E-4 or 0.00012

Dividing your exposure by the USEPA's most protective standard derives your non-cancer index. A value less than 1 is considered safe for exposure to compounds that cause health effects other than cancer. All U.S. Gulf War veterans are well below the index of 1.

Slide adapted from: Wortman W. Troop Location Information and Database. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Overview of the Assessment of U.S. Forces Exposure to Oil Well Fire Emissions in the Persian Gulf in 1991

25 October 2004

Jack M. Heller, Ph.D.
Director Health Risk Management

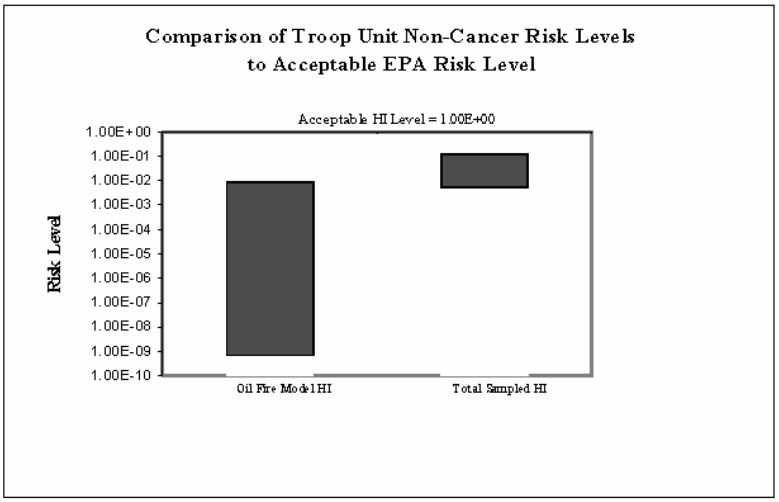
Slide adapted from: Heller JM. Overview of the Assessment of U.S. Forces Exposure to Oil Well Fire Emissions in the Persian Gulf in 1991. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Risk Characterization

- Carcinogenic Risk = Intake X Slope Factor
  - USEPA Acceptable Range (1E-04 to 1E-06)
- Non-Carcinogenic Risk = Intake / Reference Dose (Hazard Quotient)
  - USEPA Acceptable Level (1)
  - Segregate Chemicals by Mechanism of Action / Target Organ
- Total Risk
  - Additive for Chemicals and Pathways

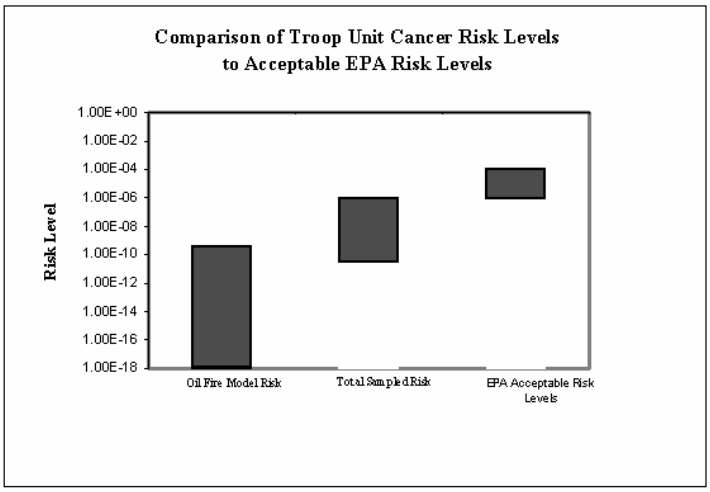
Slide adapted from: Heller JM. Overview of the Assessment of U.S. Forces Exposure to Oil Well Fire Emissions in the Persian Gulf in 1991. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Non-Cancer Comparison



Slide adapted from: Heller JM. Overview of the Assessment of U.S. Forces Exposure to Oil Well Fire Emissions in the Persian Gulf in 1991. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Excess Cancer Comparison



Slide adapted from: Heller JM. Overview of the Assessment of U.S. Forces Exposure to Oil Well Fire Emissions in the Persian Gulf in 1991. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Human Studies: Associations between Petroleum Combustion Products and Health Outcomes

Oil Well Fires, Petroleum Combustion

Emissions from Tent Heaters: Health Outcomes

Study	Outcome	Exposure	Findings
Proctor, 1998 (220 Army vets)	symptoms (groups)	smoke from tent heaters	Sign. correlated with cardiac, neurological, and pulmonary symptoms ($p<0.001$)
Unwin, 1999 (3,284 UK vets)	CMI	exhaust from heaters	OR = 1.9 (1.6-2.2)
Spencer, 2001 (1,119 OR/WA vets)	CMI	diesel heater kerosene heater potbelly heater cleaned heaters	OR = 1.78 (0.93-3.42) OR = 1.92 (0.93-4.00) OR = 2.31 (1.14-4.66) OR = 2.41 (1.29-4.52)
Gray, 2002 (11,868 Seabees)	GWI	jet fuel burned in tent heaters	OR = 2.12 (1.81-2.49) (unadj) OR = 1.11 (0.88-1.39) (saturated)
Wolfe, 2002 (945 Army vets)	CMI	heater in tent	OR = 1.6 (1.0-2.5)

Exposure to Oil Well Fire Smoke: Symptom Complexes

Study	Exposure	Outcome	Findings
Iowa Study, 1997 (1,886 Iowa vets)	s/r smoke, combustion products	cogn dysf symps FMS symps depression symps	sign prev diff (p<0.001) sign prev diff (p<0.001) sign prev diff (p<0.001)
Haley, 1997 (249 Navy vets)	s/r oil smoke	any of 3 syndromes	ns
	scaled smoke exposure	Syndrome 2	p = 0.02
Nisenbaum, 2000 (1,163 Air Guard vets)	s/r	mild-mod CMI severe CMI	OR = 1.29 (0.92-1.81) OR = 1.62 (0.79-3.35)
Spencer, 2001 (1,119 OR, WA vets)	eye irritation from burning oil wells	CMI	1-5 days: OR = 2.64 (1.34-5.20) 6 + days: OR = 4.47 (2.07-9.63)

Exposure to Oil Well Fire Smoke: Symptom Complexes

Study	Exposure	Outcome	Findings
Unwin, 1999 (3,284 UK vets)	s/r	CMI	OR = 1.8 (1.5-2.1)
Wolfe, 2002 (945 Army vets)	s/r oil fire smoke odor	CMI	OR = 2.1 (1.4-3.2)
Gray, 2002 (11,868 Seabees)	modeled	GWI	bivariate: OR = 1.54 (1.31-1.80) multivar: OR = 0.44 (0.26-0.73)
	self-report		bivariate: OR = 2.22 (1.85-2.66) (s/r) multivar: OR = 1.23 (0.91-1.65) (s/r)
Kang, 2002	consumed food contaminated with oil, smoke	Neuro symp factor	73% cases vs. 21% controls

Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies

David N. Cowan, PhD, MPH

Division of Preventive Medicine
Walter Reed Army Institute of Research
Silver Spring, MD

EPICON Associates, LLC
Silver Spring, MD

Formerly with
DOD Deployment Health Clinical Center
Walter Reed Army Medical Center
Washington, DC

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

A case control study of asthma among U.S. Army Gulf War veterans and modeled exposure to oil well fire smoke

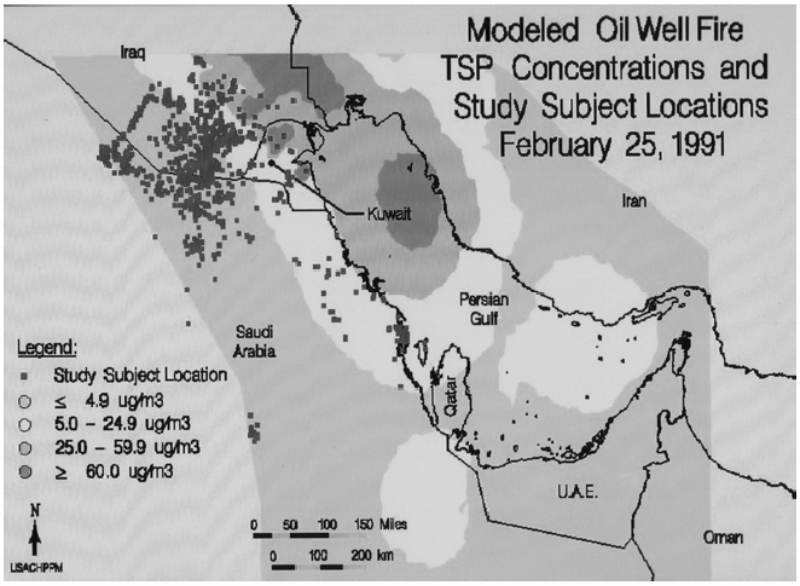
David N. Cowan, Jeffrey L. Lange, Jack Heller,
Jeff Kirkpatrick, Samar DeBakey
Mil Med 2002 Sep;167(9):777-82

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Two 2002 Studies of Asthma and Exposure to Oil Well Fire Smoke

- **Smith TC, Heller JM, Hooper TI, Gackstetter GD, Gray GC. Are Gulf War veterans experiencing illness due to exposure to smoke from Kuwait oil well fires? Examination of Department of Defense hospitalization data. Am J Epidemiol 2002 May 15;155(10):908-17**
- **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. Environ Health Perspect 2002 Nov;110(11):1141-6**

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.



Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Comparison of exposures

- **Poor agreement between self-reported and modeled exposures (kappas of 0.13 and 0.12)**
- **High correlation between modeled cumulative exposure and days exposed to high (r_s=0.84)**

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Table 4. Adjusted* Odds Ratios for Associations with Measures of Smoke Exposure

Cumulative exposure mg/m^3-days	
Categories	Adjusted Odds Ratio (95% CI)
< 0.1	1.00 (referent)
>= 0.1 – < 1.0	1.24 (1.00 – 1.55)
>= 1.0	1.40 (1.11 – 1.75)
Continuous	1.08 (1.01 – 1.15)

**Adjusted for sex, age, race/ethnicity, rank, smoking history, and self-reported exposure.*

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Table 4. (Cont) Adjusted* Odds Ratios for Associations with Measures of Smoke Exposure

Days with Exposure >= 65 ug/m^3	
Categories	**Adjusted Odds Ratio (95% CI)**
0	1.00 (referent)
1-5	1.22 (0.99 – 1.51)
6-30	1.41 (1.12 – 1.77)
Continuous	1.03 (1.01 – 1.05)
**Adjusted for sex, age, race/ethnicity, rank, smoking history, and self-reported exposure.*	

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Discussion

- We found significant associations between modeled smoke exposure and physician-diagnosed asthma for both cumulative exposure measures defined *a priori*
- We found dose-responses for both when considered as categorical measures and as continuous measures

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

What did they find?

- Smith, et al. No association between modeled smoke exposure (MSE) and hospitalization for asthma (and other diseases)
- Lange, et al. No association between MSE and self-reported asthma symptoms

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Diagnostic specificity and sensitivity

- Smith, et al., used only hospitalized cases, likely missed 90% of all cases (high PPV, not sensitive)
- Lange, et al., used self-report, likely included many non-cases (low PPV, not specific)
- Classification error for both
- Cowan, et al., used physician dx, sensitivity and specificity unknown.

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

More comments on non-differential misclassification

- "...the attenuation (of the odds ratio) can be appreciable even with a high sensitivity and specificity." Armstrong, et al. *Principles of Exposure Measurement in Epidemiology*
- "Random misclassification always results in an underestimation of the true relative risk..." Hennekins and Buring, *Epidemiology in Medicine*

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Conclusions

- When the observed odds ratios from the Cowan, et al., study are considered in the light of the substantial opportunity for misclassification, the findings are suggestive of an association between objective estimates of exposure to oil well fire smoke and risk of asthma diagnosis among CCEP participants
- Smith, et al., and Lange, et al., are likely to have even higher levels of misclassification, and that may account for the findings of no association
- More studies needed...

Slide adapted from: Cowan DN. Did Exposure to Oil Well Fire Smoke During the Gulf War Increase the Risk of Asthma among Veterans? A Review of Three Studies. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Oct 25, 2004; Washington, DC.

Exposure to Oil Well Fire Smoke: Diagnosed Conditions

Study	Exposure	Outcome	Findings
Gray, 2002 (11,868 Seabees)	CHPPM models	self-reported medical diagnoses	Asthma OR = 1.82 (1.23-2.69) Bronchitis OR = 1.49 (1.18-1.87)
Cowan, 2002 (873 cases, 2464 controls from CCEP)	s/r and CHPPM models	clinically diagnosed	Asthma OR = 1.4 (1.1 – 1.8)
Lange, 2002 (1,560 Iowa veterans)	s/r CHPPM models	symptoms of asthma, bronchitis	Asthma ORs = 1.77-2.83 (s/r) Bronchitis ORs = 2.14-4.78 (s/r) Asthma, Bronchitis: ORs= 0.77-1.26
Kelsall, 2004 (1,456 Australian vets)	s/r exposure to "SMOIL"	self-reported medical diagnoses	Asthma OR = 1.82 (1.23-2.69) Bronchitis OR = 1.49 (1.18-1.87)

Gulf Veterans vs. Not Deployed: Diagnosed Conditions

Study	Exposure	Outcome	Findings
Unwin, 1999 (3,284 UK vets)	PGW vs. nondeployed	self-reported medical dx	Asthma OR = 1.8 (1.4-2.4) Bronchitis OR = 1.7 (1.2-2.3)
Iowa Study, 1997 (1,886 Iowa vets)	PGW vs. nondeployed	symptoms suggesting dx	Asthma sign. prev difference Bronchitis sign. prev difference
Steele, 2001 (2,031 Kansas vets)	PGW vs. nondeployed	self-reported medical dx	Asthma OR = 2.08 (1.02-4.26) Bronchitis OR = 2.61 (1.53-4.47)
Gray, 2002 (11,868 Seabees)	PGW vs. nondeployed	self-reported medical dx	Asthma OR = 1.82 (1.23-2.69)
Goss-Gilroy, 1997 (Canadian vets)	PGW vs. nondeployed	symptoms suggesting dx	Asthma OR = 2.64 (1.97-3.55) Bronchitis OR = 2.81 (2.22-3.55)
Kelsall, 2004 (1,456 Australian vets)	PGW vs. nondeployed	self-reported medical dx	Asthma OR = 1.2 (0.8-1.8) Bronchitis OR = 1.1 (0.9-1.5)

Summary of Epidemiologic Findings: Oil Well Fire Smoke

- Among veterans who served in the Gulf War, exposure to oil fire smoke associated with:
  - Diagnosed and self-reported asthma (ORs~1.4 - 2.8)
  - Chronic multisymptom conditions (ORs~1.5 - 4.5) (possible dose-response effect—proximity and duration)

Tours of Duty

- **Late February 1991 through 11-8-91**
- **Work day 10 – 12 hours**
- **Tour 28 – 40 days alternated with 28 day leave**

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Tours of Duty

- Adair – 39 men - avg. 98 days
- Wild Well – 38 men avg. 98 days
- Boots and Coots – 30 men avg 112 days
- Average – 105 days

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Texas Based Oil Well Fighters

- Extinguished the majority of the wells
- The largest oil fields
- High pressure wells with the largest flow of gas and oil and the largest plumes
- Longest exposure times

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

LIVING CONDITIONS

Lived within 2 miles of the burning fields in an abandoned complex between Burqan and Ahmadi Oil fields

Initially no running water (trucked in)

Smoke filled building

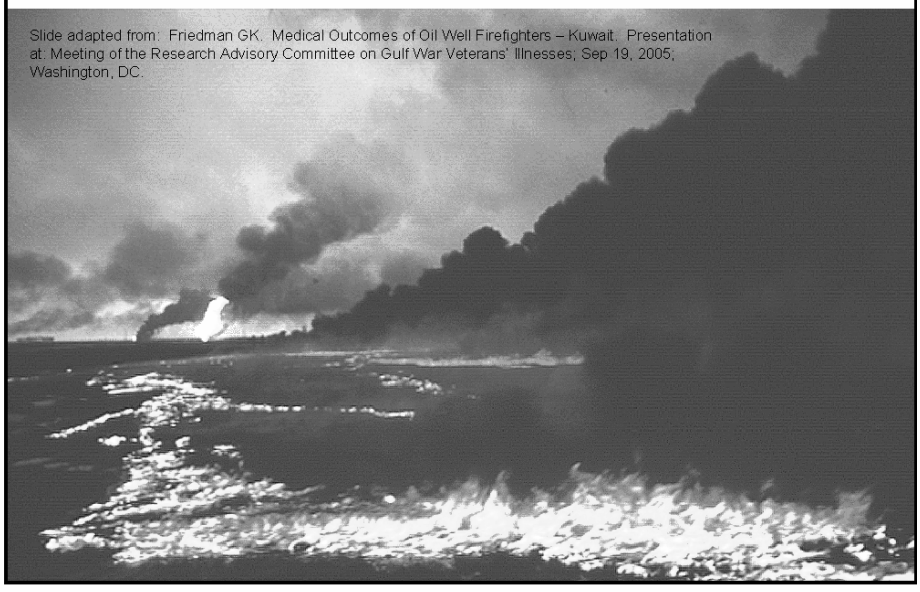
Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

FIREFIGHTER PROTECTIVE GEAR

Nomex underwear
Gloves
Hard hat
Leather boots
Work coveralls
No respirators

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Burning Oil Lake



MEDICAL SURVEILLANCE

- Complete history and physical – physician Board Certified in Occupational Medicine and Internal Medicine
- CBC
- SMA-20 (glucose, BUN, Creatinine, Liver enzymes, etc.)
- Urinalysis

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

MEDICAL SURVEILLANCE

- Pulmonary function testing (spirometry)
- Chest x-ray
- EKG
- Stool for O&P (as available or indicated)

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

MEDICAL SURVEILLANCE

- Firefighters were re-evaluated during leaves between their tours of duty
- A follow up in 1994 with each of the 3 Houston based companies revealed no claims for medical problems arising from service in Kuwait.

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

SUMMARY

No significant illnesses have been reported from this cohort. Specifically no complaints resembling "Gulf War Syndrome"

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Current Status 9-14-05

Telephone conference with both Boots and Coots and Wild Well Control reveals no reports of Gulf War Syndrome-type illness or other chronic illness or injury arising from the Kuwait experience. Firefighters have been sent to Iraq during the current conflict without incidence.

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Refinery Fire

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

During the past 25 years evaluation of thousands of Texas refinery and chemical plant workers exposed to crude oil, and its products of combustion have failed to reveal a pattern similar to "Gulf War Syndrome" in a civilian population.

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Raw or burning crude oil should be dismissed as a cause for Gulf War Syndrome

Slide adapted from: Friedman GK. Medical Outcomes of Oil Well Firefighters – Kuwait. Presentation at: Meeting of the Research Advisory Committee on Gulf War Veterans' Illnesses; Sep 19, 2005; Washington, DC.

Petroleum Combustion Products: Information Considered by RAC in 2004-2005

- Oil fire, petroleum combustion exposures, modeled health risks
- Human studies

Oil Well Fires, Combustion Products

Measured/Modeled Exposures

- Modeled exposure assessments consistently suggest no oil fire-related exposures that exceed air quality standards except particulates; no expected increases in cancer, other health problems
- Measured exposures did not provide information on oil fire emissions close to the burning well, or in the weeks and months when exposures were highest
- Modeled tent heater emissions exceed standards for particulates, also high for NO_x, CO_x, SO_2

Oil Well Fires, Combustion Products

Human Studies

- Clinical study indicates modeled oil well fire smoke exposure associated with sign. increased rate of physician-dx asthma
- Epidemiologic studies suggest self-reported oil fire exposure associated with:
  - dx and self-reported asthma (ORs~1.4 - 2.8)
  - Chronic multisymptom illness (ORs~1.5 - 4.5)
    (possible dose-response effect—proximity and duration)
- Epidemiologic studies suggest self-reported tent heater exposure associated with:
  - Chronic multisymptom illness (ORs~2.0), other symptom groups

Oil Well Fires, Combustion Products and the Health of Gulf War Veterans: Remaining Questions

- Is Gulf War-related multisymptom illness linked to exposure to smoke from oil well fires?
  - *As a cofactor with other exposures? (no animal studies or epidemiologic analyses have evaluated oil fires in combination with other exposures)*
  - *Identified associations between oil fires and GWI accurate or due to effects of confounding? bias?*
- Are increased rates of asthma or other diagnosed conditions associated with exposure to oil well fire smoke?
- Associations between tent heater emissions and GWI?

Oil Well Fires, Combustion Products and the Health of Gulf War Veterans: Remaining Questions

- Additional health concerns for military personnel located very close to burning wells for an extended period?
  - This concern s/w diminished by reports on civilian firefighters
- Additional health concerns for veterans who may have been more vulnerable to effects of combustion emissions, particulates?

Discussion of Recommendations

Animal/Toxicological Research:

Epidemiologic Studies:

- Determine whether asthma, chronic respiratory dx associated with Gulf War service generally, and with oil fire exposure
- Clarify possible association of GWI with oil well fire smoke and tent heaters in existing epi studies
  - Increased GWI risk in combination with other exposures?
  - Does association diminish when controlling for other exposures?
- ? Epi study to evaluate health effects on subgroup of Gulf veterans with most intense exposure to oil well fires?