Unconventional Gas Extraction-Part 1 – Threats to the Environment

By Leslie Walleigh, MD, MPH

Recent technological advances have made feasible the profitable extraction of natural gas from tight geological formations, such as the Marcellus shale, which previously were prohibitively expensive to exploit. The production of natural gas from these formations, referred to as “unconventional gas extraction”, is occurring on a widespread scale from thousands of wells drilled in close proximity to homes, schools, recreational areas, and workplaces.

Unconventional gas extraction (UGE), which includes the process of hydraulic fracturing commonly known as “hydrofracking,” carries the potential for adverse health effects from both chemical and physical exposures, as well as social disruption and stress. Although the primary health concerns raised regarding UGE are those effecting community members in the drilling regions, NIOSH has also identified potential health risks to workers in gas production activities. This article will describe the process of UGE and discuss the potential for environmental contamination of air and water. A future article will discuss the social disruption.

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Aerospace medicine grew out of the military’s experience in World War I since flight is a particularly dangerous and unnatural occupational environment. During that time, 1 out of 50 aircraft that crashed in the area of combat was shot down, 4 of 50 crashed due to some type of mechanical problem, but a staggering 45 out of 50 crashed due to some “human factor” or error. “Flight surgeons” were created to study the aviation environment and make it safer, with the thought that human senses/perceptions and other physiology evolved for the terrestrial environment and were poorly adapted for flight. The term flight surgeon now refers to any physician who practices aerospace medicine on a routine basis, whether or not they actually specialize in aerospace medicine. They are also expected to be personally familiar with the aviation environment; in the military, flight surgeons are aircrew members and are required to fly with their crews on a routine basis. Flight surgeons also perform the following:

- Fitness for duty – aeromedical disposition
- Develop and use medical standards for selection and retention
- Investigate crashes
- Study the hazardous environment; research
- Develop life support equipment
- Study, develop and teach “human factors”
- Patient transport-Clearance; equipment
- Manage public health programs
- Develop plans for medical evacuation
- Human performance enhancement
- Care for families of aviators and astronauts
- Aviator/astronaut training
- Undersea medicine/hyperbarics
- Manage public health programs
- Flight surgeons and their aerospace medicine teams address environment-related issues such as:
  - Pressure effects
    - Barotrauma
    - Decompression sickness
  - Hypoxia
  - Spatial disorientation
  - Vestibular illusions
  - Visual illusions
  - Cosmic radiation
  - Operational environment
  - Weightlessness
  - Fatigue
  - Acceleration effects
    - Sustained
    - Impact
  - Circadian dysrhythmia
  - Cognitive factors
  - Motion sickness
  - Thermal stresses
  - Vibration
  - Noise
  - Toxic exposures
  - Venous stasis

Current “hot topics” in aerospace medicine include long duration commercial aircraft passenger travel of 15 hours of more, communicable disease concerns with commercial passenger travel, human issues related to remotely piloted vehicles (drones), recreational space travel, and interplanetary space flight. Of note, “RAM” refers to a physician who is currently a medical resident in aerospace medicine, formally training in the specialty. Quite confusingly, anyone who has completed a residency in aerospace medicine is also referred to as a RAM. There are currently five aerospace medicine residency programs: US Air Force, US Navy, Wright State University, University of Texas (Galveston), and the Mayo Clinic.

The next speaker was Col (Dr) Hernandez “Joe” Ortega is a RAM and is currently Chief of Aerospace Medicine for the Air Education and Training Command. His last position was as Command Surgeon for the Air Force Intelligence, Surveillance and Reconnaissance Agency, which included drone operations. Dr Ortega’s presentation addressed research regarding military aerial drone operators seeking out mental health assistance at a significantly higher rate than other personnel in military ground units. Drone operators work on the ground, usually at bases within the United States, essentially ‘telecommuting’ to the combat areas, working rotating shifts. Initial findings suggest that drone operators report higher operational stress, occupational burnout and clinical distress than control groups but the source of that stress appears to be shiftwork and similar support issues and not participation in long-distance combat. Rates increase when study subjects work more than 30 hours per week. Rates for post-traumatic stress disorder appear to be much lower than for...
UGE (Continued from page 1)

tion and stress attributable to UGE, as well as the current understanding of occupational exposures.

Unconventional Gas Extraction in the Marcellus Shale

The Marcellus shale is a narrow (100-200 feet high) geologic formation lying approximately 6-7,000 feet below the earth’s surface. The formation extends through parts of West Virginia, Ohio, Pennsylvania, and New York. Although shale is relatively impermeable, over thousands of years natural gas has migrated into naturally occurring minute fractures throughout the formation.

Extracting this gas in an economically feasible manner was made possible by four recently developed technologies:

Directional drilling - Conventional vertical drilling, as to a defined collection of gas or oil, would not be productive in shale or other tight formations. Directional drilling allows for vertical drilling until the shale is reached, followed by horizontal drilling for thousands of feet through the narrow shale formation.

High-volume, high-pressure hydraulic fracturing - Hydraulic fracturing is the process of injecting fluid into fissures in rock formation to increase the outflow of gas. Conventional hydraulic fracturing uses 20,000-80,000 gallons of fluid at 2,000-3,500 psi per episode of fracturing. In contrast, high-volume, high-pressure hydraulic fracturing typically uses 4-5,000,000 gallons of fluid at 10,000-11,000 psi per episode of fracturing. High-volume, high pressure fracturing was first used in the Marcellus shale in 2003.

“Slickwater” - Overcoming the friction produced while injecting millions of gallons of fluid over long distances at high pressure, required the addition of additives to form “slickwater.” Although 90% of the fluid injected into wells during the different stages of hydraulic fracturing is water, a variety of chemicals (Table one) are added at different stages of the process. The largest volume of additives is made up of the “proppant”, typically sand, used to “prop” open the fissures.

Multi-well pads - The drilling of multiple parallel vertical and horizontal well bores from the same well pad allows for extraction of gas from large areas of shale from one site.

Understanding the stages and processes involved in unconventional gas extraction is critical to understanding the potential for adverse health effects. The stages include:

Seismic testing - Dynamite charges are placed in 20 foot holes. As the charges are exploded, seismic equipment measures the shock waves generated. The resulting information is used to determine the geologic characteristics of a site before drilling begins.

Pad construction - Typically, 4-6 acres of land are cleared and flattened, with the construction of access roads, as well as plastic lined impoundments for the storage of water and drilling waste. Buried pipelines are also placed to transport produced gas to more centralized processing facilities.

Drilling - Drilling occurs in two stages: vertical then horizontal. After the vertical drilling has progressed through an aquifer, steel casing is inserted into the well bore to protect the aquifer from further contamination from drilling, hydraulic fracturing, and gas production activities. Cement is injected to fill the space between the steel casing and the well bore. As the remainder of the drilling process proceeds, successive stages of casing and cementing occur. The rig work for a single horizontal well, including drilling, casing and cementing, generally lasts about four to five weeks.

Hydraulic fracturing - The hydraulic fracturing process occurs segmentally. Beginning at the far end of the horizontal well, a segment of the casing is perforated using directional explosives. The hydraulic fracturing process proceeds, successive stages of perforating, hydraulic fracturing and casing.

<table>
<thead>
<tr>
<th>Additive</th>
<th>Purpose</th>
<th>Chemical Example</th>
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<tbody>
<tr>
<td>Proppant</td>
<td>“Props” open fractures</td>
<td>Sand</td>
</tr>
<tr>
<td>Acid</td>
<td>Removes cement and drilling mud from casing perforations</td>
<td>HCL</td>
</tr>
<tr>
<td>Solvent</td>
<td>Additive soluble in oil, water, and acid based fluids</td>
<td>Various aromatic hydrocarbons</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Reduces fracturing fluid surface tension, aiding recovery</td>
<td>Methanol, ethoxylated alcohol</td>
</tr>
<tr>
<td>Breaker</td>
<td>Reduces fluid viscosity</td>
<td>Peroxydisulfates</td>
</tr>
<tr>
<td>Biocide</td>
<td>Reduces growth of organisms</td>
<td>Glutaraldehyde</td>
</tr>
<tr>
<td>Gelling Agent</td>
<td>Increases fluid viscosity</td>
<td>Guar gum, petroleum distillates</td>
</tr>
<tr>
<td>Iron control</td>
<td>Prevents precipitation iron oxides</td>
<td>Citric acid</td>
</tr>
<tr>
<td>Scale inhibitor</td>
<td>Prevents precipitation of carbonates and sulfates</td>
<td>Ammonium chloride, ethyleneglycol</td>
</tr>
<tr>
<td>Buffer</td>
<td>Adjusts pH</td>
<td>Sodium Carbonate, Acetic acid</td>
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<tr>
<td>Clay stabilizer</td>
<td>Prevents migration of clays</td>
<td>Potassium Chloride</td>
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<tr>
<td>Corrosion inhibitor</td>
<td>Reduces rust formation</td>
<td>Methanol</td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Increase viscosity</td>
<td>Borate salts</td>
</tr>
<tr>
<td>Friction reducer</td>
<td>Minimizes friction of injected fluids</td>
<td>Polyaerylamide, petroleum distillates</td>
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Table One: Classes of Chemicals Added to Hydraulic Fracturing Fluid
in this segment then proceeds in four general stages. The first stage is an acid treatment, which cleans the area adjacent to the well bore, accessed through the perforations in the casing. The second stage is a high pressure, high volume "slickwater" phase in which existing fractures in the shale are widened and propagated, and new fractures are formed. In the third phase, proppant, usually sand, is injected into the fractures to "prop" them open. The final stage is a water or brine flush to clean out the wellbore. The initial segment is then temporarily plugged. Moving backwards toward the vertical wellbore, successive segments are perforated, hydraulically fractured, and then plugged. Numerous classes of chemicals are used in the different stages. (Table one). After the entire horizontal well is hydraulically fractured, the temporary plugs are drilled out. Hydraulic fracturing typically is completed in 3-5 days.

Waste water management – Following hydraulic fracturing, a variable amount (3-80%) of the millions of gallons of fluid from the fracturing process returns to the surface as "flowback" or "produced water". The returned fluid not only contains the chemicals used in the fracturing process, but also chemicals naturally occurring in the shale, including salts, heavy metals, hydrocarbons and naturally occurring radioactive materials (NORMs). This waste water is often stored onsite for periods of time in lined impoundment pits. It is sometimes recycled for use in hydraulic fracturing elsewhere. Other management options have included trucking for processing at municipal sewage treatment facilities or for disposal in deep injection wells, or spreading on roads for ice and dust control.

Flaring – During the period following hydraulic fracturing, the initial gas production is often vented or flared until of sufficient quality to capture for production, which may take several weeks. These practices will be prohibited in new wells by EPA regulations which go into effect in 2014 requiring the capture and processing of the initial gas production.

Gas production and processing – During production at natural gas wells, the fluids brought to the surface are differing mixtures of natural gas, other gases, water, and hydrocarbon liquids (known as condensate). A variable amount of processing occurs on the well pad. For example, some well pads include condensers, which separate the gas from water and condensate, storing the materials onsite in condensate tanks. Other sites include glycol dehydrators, which remove water. The glycol is regenerated through a heating process, venting the resulting steam, which also contains hydrocarbon vapors. Gas is usually piped from the well pad to a local compressor station for further processing.

Potential Sources of Environmental Contamination

Unconventional gas extraction potentially exposes community residents to harmful chemical exposures through both air and water contamination.

Air Contamination

The primary sources of air contamination from unconventional gas extraction include fugitive hydrocarbon emissions, diesel exhaust, flaring, and impoundment pit vaporization. In addition, ground level ozone is generated by sunlight acting on the combination of volatile organic chemical and NOx emissions. Fugitive hydrocarbon emissions, including benzene, ethylbenzene, toluene, and xylene (BTEX) occur from the well-head in addition to gas processors such as dehydrators, condensers, and compressor stations. Diesel exhaust is emitted both from engines powering the on-site processes and from the diesel powered trucks transporting over 2,000 truckloads of water and sand to the average well.

Although there are no large scale epidemiological studies investigating potential adverse health effects of exposure to air pollution generated by unconventional gas extraction, a recent study from Colorado measured ambient hydrocarbon emissions from unconventional gas extraction well pads and used EPA methodology to estimate non-cancer and cancer health risks to residents living greater than a ½-mile to those living less than a ½-mile from wells. The study included both 163 measurements from a fixed monitoring station located “in the midst of rural homes and ranches” and “4 miles upwind of other potential emission

### Table 2: Air Contamination from Unconventional Gas Extraction

<table>
<thead>
<tr>
<th></th>
<th>Fugitive Emissions</th>
<th>Vehicles and Engine Exhaust</th>
<th>Flaring</th>
<th>Wastewater Impoundment Pits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Hydrogen Sulfide</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Ozone</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>CO</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>NOx</td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>SO2</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>VOC’s</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>BTEX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Methane</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>NORM’s</td>
<td>X</td>
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</table>
When I told family, friends and colleagues I was headed to Paraguay for my Air Guard mission last June, I was routinely met with blank looks. A few people responded, “Is that next to Uruguay?” Everyone asked, “Why does the Guard go there?” No one seemed to know anything in particular about Paraguay. Despite this, I was soon to learn that the work of our reserve unit is greatly appreciated by the people of Paraguay, and that in a small way our unit makes a difference in the health and well being of the hundreds of people seen each year.

Before my unit left for Paraguay (a three-day odyssey from Boston via Houston, Miami, Panama, and Brazil) we were briefed in the history, geography and culture of the country. Paraguay has a history ranging from the totally bizarre to the tragic: a brief look at this nation’s past explains why the people of Paraguay desperately need assistance from the international community. Believe it or not, Paraguay (not Germany, the Soviet Union, Cambodia, Rwanda or other countries which might spring to mind) suffered the bloodiest war in the history of the world, when dictator Francisco Lopez declared war on the much larger and more powerful neighboring countries of Argentina, Brazil, and Uruguay simultaneously in 1865. Within 5 years, 90% of the male population of Paraguay over the age of 12 was killed in combat or died in the field from disease, exposure or thirst. Paraguay never fully recovered from the effects of the war, and over the next 150 years, 44 different men attempted to rule the country—half of whom were forcibly thrown out of office.

From 1932 to 1935, nearly 100,000 people died in the Chaco War between Bolivia and Paraguay. Having learned briefly about the Chaco War, I was amazed when I actually laid eyes on the Chaco after three bleary days of traveling. Adding to my disorientation was the fact that we had spent one night in the capital city, Asuncion—it seemed to be a modern city with a nice Marriott and great churrascaria—making us wonder, how bad could the rest of Paraguay be? But when we told one cabdriver we were going to the Chaco on a medical mission in the wake of devastating floods, he said merely: “Don’t go.” Others we met noted that in Paraguay, there was Asuncion—a city with a varied European Colonial history (not to mention the influx of infamous Germans after WWII, including Josef Mengele)—and then there was the rest of Paraguay—which was a whole different story.

Why anyone would fight a war over the Chaco is a mystery to anyone seeing it for the first time: farming is nearly impossible, there are no valuable resources of any kind, and while the region is close to the geographic center of South America, it is virtually cut off by mountains, jungle, desert and some of the deepest rivers in the world. Various writers and explorers have referred to it as “the great dismal swamp” or the “back of hell.” Yet, thousands of human beings have made their home here for generations, developing ingenious methods for surviving in the endless flat, barren swamp. The many tribes and groups that make up the indigenous population of Paraguay have suffered unimaginably over the years, having been conscripted in all of Paraguay’s wars, subjected to disease and displacement, colonized and then abandoned by various religious organizations, massacred, and enslaved.

My unit arrived at a flooded village site in the Chaco at dusk after a long, bumpy convoy across truly stunning wasteland (and I say that as a native of the flattest part of North Dakota). Standing water was everywhere—making us all grateful for anti-malarial drugs. We soon realized that we would not be able to stay in the village as our Paraguayan colleagues had planned, since the villagers who had traveled (most by foot!) for days to attend our clinic had moved into the school where we had been planning to sleep. The standing water engulfing nearly the entire village meant nowhere to camp, let alone any sanitary facilities. After seeing the total lack of facilities and the hundreds of people crammed in every inch of the already decrepit buildings, our team had no objections to trucking an hour further north across the swamp to the end of a day to stay in a hotel. Although by “hotel,” I mean “place with a roof

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run by German speaking men where we could sleep and be somewhat dry but possibly get bedbugs and definitely wake up with small frogs that live in the toilet bowl sitting on you,” as opposed to “the Asuncion Marriot.” Turns out it was a German “touring” hotel.

We could see that our patients had been waiting a long time—perhaps for days (truly giving new meaning to the word)—for our team to arrive. We were eager to start work in the school which had been cleared out for us to set up makeshift clinic space for internal medicine, pediatrics, women’s health, dental, optometry, and even general surgery. Our team of 6 included two physicians, one Physician Assistant, one dentist, one dental technician, and one public health technician who served as our Spanish interpreter. (Interestingly, most of the people in this area speak Guarani, so we had to have two interpreters with each patient—one to translate English/Spanish, and the second to translate Spanish/Guarani.) We were each assigned our own bodyguard as a security detail, as there had been pre-mission intel suggesting threats of hostile action during the week. Besides our team and heavily armed security detail, we were working with the local version of the Paraguayan military medical system, including several dozen physicians, nurses, dentists and medical techs. I smiled at the first patient to enter the clinic, a man of indeterminate age who seemed to have been waiting a long time—perhaps for days. He responded with a quick scratch to the hairline. I instantly remembered a similar gesture among rural tribes people I had worked on in Iraq, and thought immediately of scabies.

Motioning for the patient to sit down, I took a step back and called for our public health technician to find the permethrin. She responded that we hadn’t had time to unpack it yet, since our mission had been re-routed (more on this later) at the last minute interfering with our plan to go over our pharmacy stock, and that it would have to wait. Then, following my eyes to the patients crowding in the door and observing them more closely, all scratching at the hair, she hurried to the pharmacy supply tent and hacked open an entire case of it as fast as humanly possible. As it turned out, an entire village had been infected and would have to be treated before we risked contaminating those patients who did not have it yet but were staying in the overcrowded swamp of a community “campsite”, not to mention our team of providers. Aside from the physical discomfort one close-up look at these parasitic creatures under a microscope could just about cure, if not kill your appetite for the next 3 days, and most definitely prevented anything resembling a normal sleep pattern. (For the remainder of the trip during regular sleeping hours someone would perk up every 15-30 minutes and say things like “What was that? Did you hear anything?”, and “Are you itchy?”).

Once that protocol was established—with two members of the team in full PPE treating each entering patient with Sca-B-Gone (our term for the stuff)—the team dentist and I could assess and attend to the patient’s primary concerns (scabies, sadly, not being among their greatest) which had brought them to the clinic. It soon became apparent that our dentist was going to do the really heavy lifting on this mission: One patient after another presented with hideously swollen and infected gums, swollen mouth tissue, and rotting teeth. Many patients could barely speak and I could not imagine how they could eat with their mouths full of pus and abscesses. The pain these people must have been living in is incomprehensible. (The team lost all desire to eat for several reasons). For the next six hours I injected patients with Novocain while the dentist extracted literally hundreds of teeth—in many cases, every single one of the patient’s teeth had to go. The pile of teeth collecting in the bin on the table next to us bore zero resemblance to the shiny, white whole teeth my healthy, fluoridated sons still leave for the Tooth Fairy—they were broken, cracked, rotting, disintegrating and often wholly unrecognizable as teeth.

At nearly midnight, our Paraguayan colleagues urged us to head back to the dubious comforts of the “Hotel Germany”, where we would spend a completely sleepless night imaging bedbugs creeping up our spines and visions of rotten teeth danced in our heads. After seeing the extent of the suffering in this population, all we wanted to do was get back to work as soon as possible the next day. Anyway, no amount of double strength coffee could overcome the effects of the past 54 hours. Shortly after dawn, we all piled onto the bus and headed back down the “highway”, which bore striking resemblance to the deserted, cracked, and crumbling road in the movie Mad Max, to the flooded village. In fact, the road was in such disrepair we spent more time driving on the wrong side in order to avoid the giant sinkholes along the entire route.

For the rest of the week, my team and I pulled teeth, treated scabies, handed out antibiotics, removed insects from ears, scraped maggots from abscesses, stitched wounds, and saw countless old injuries for which we could do little but give Motrin. We realized quickly that everyone who entered the clinic was expecting something to take home and in fact, many refused to leave without some kind of pill. We handed out vitamins, tylenol and ibuprofen in cases where there was little we could do but pacify the patient. At
Obesity and Work: a MassCOSH Report

When Maria first came to the Massachusetts Coalition for Occupational Safety and Health (MassCOSH), a non-profit safety organization, she could barely move. Like most of the housekeepers at the Boston hotel where Maria worked, her arms, legs and shoulders ached from cleaning 30 rooms in an eight hour shift. But while MassCOSH organizer Mirna Montano was used to seeing injured housekeepers, what surprised her was Maria’s comments about her weight. Despite working laboriously day in and day out, Maria noted that her weight had gone up as her workload increased.

“Maria’s concerns about her weight were so different from the mainstream messages I was hearing about sedentary work causing weight gain,” said Montano, who predominately works with low wage, Latino workers. “Yet as I spoke to other low wage workers in physically demanding jobs, I heard a similar sentiment. Equally jarring to me was[...]”

MassCOSH partnered with The Center for the Promotion of Health in the New England Workplace (CPH NEW) at the University of Massachusetts Lowell, an academic research center that examines the overlap of occupational health and safety with personal health. Both organizations found themselves facing parallel research questions, including how the work environment might affect diet and exercise, and how common such issues are among lower income workers. They recruited Boston Workers Alliance, which serves low wage African American residents, to join them in a participatory research project to look at low wage workers’ perceptions of the link between their working conditions and their weight.

On November 13, the community-university research team will release its findings to an audience of local, state and federal officials, eager to find solutions to what many would call an obesity epidemic. “We held focus groups with 63 low wage Latino and African American residents,” said Suzanne Bruce, a Boston Workers’ Alliance Board Member involved with the study. “Though the type of work they did differed greatly - from janitorial to human service to construction - their experiences were surprisingly similar. The exhaustion and injuries, time pressure, stress and lack of access to healthy food - sometimes even access to a place to eat - were problems that most of the workers felt had a big impact on their weight.”

Some focus groups described work-related injuries that prevented workers from moving, much less exercising. “A friend of mine in construction [had] a cinder block [fall] from the ceiling on her foot, and she said it hurt,” one focus group participant said. “She was very active. Now she can’t do the jobs that she would normally do [and] depression set in.”

“Primary care clinicians already play an important role in identifying risk factors that contribute to obesity, weight gain and related health concerns such as diabetes.” said Rose Goldman, an occupational clinician at Cambridge Health Alliance and Associate Professor of Medicine at Harvard Medical School and School of Public Health. “Given the exposures and amount of time that low wage, vulnerable populations spend at work, and the type of food that is available at the work place, naturally we should be looking at work factors that may contribute to weight gain as well.”

To learn more about the study and/or attend the report release and convening on obesity and work, email marcy.gelb@masscosh.org.
the very least, patients left with some hope and awareness that someone had come to help; at the most, they had been relieved of pain or other symptoms of disease. In four days, my team treated several hundred men, women, and children. Most of their ages were impossible to guess, as even young adults were weathered, wrinkled, and thin from malnutrition and exposure, along with showing effects of frequent infections, untreated gastrointestinal problems, and various effects of a complete lack of hygiene. At the end of the week, after seeing every single patient who had camped patiently in the swamp for the week, we packed up and headed back to Asuncion, where Argentinean beef, Cuban cigars, Spanish wine and (hopefully) bedbug-free sleeping accommodations awaited. Even with the wine and the clean beds, I, for one, still found it impossible to sleep—all those thin, pained faces haunted me. That and we learned the gruesome details of a deadly attack days earlier on a cadre of national police in the western region where we were supposed to have gone, which left 6 national police and 22 people dead. The citizens were rioting, and shortly after we left, the president and several high level members of the government had been removed from office. Thankfully, none of this was covered in the American media, so none of our family or friends who knew where we were had any knowledge of the perilous situation we had been in for the week.

The experience of treating the indigenous people of the Chaco region of Paraguay was stunning, humbling, and profoundly sad—they are one of the world’s most isolated people, nearly forgotten about even in their own nation, in a country few Americans can find on a map. Less than 24 hours after boarding the plane in Asuncion to return home, I was sitting in a restaurant in Keene, NH, with my family; while back in the Chaco, children were sleeping in the mud, crawling with the scabies that probably re-infected them the second they got home. At least now I could answer the question “why do we go to Paraguay” —and feel humble and honored to be returning the following year.

Major Abe Timmons is the Chair for the Department of Occupational & Environmental Medicine at Dartmouth-Hitchcock Clinic in Nashua, NH, and is the chief of Aerospace medicine at the 104th Fighter Wing at Barnes Air National Guard Base in Westfield, MA.
chemicals that oil and gas service companies identified as present in products used in hydraulic fracturing between 2005 and 2009. Fourteen of the chemicals were recognized carcinogens. Others were hazardous chemicals regulated under the Safe Drinking Water Act or identified as hazardous air pollutants. Many are suspected endocrine disruptors. The companies were unable to identify some of the chemicals contained in the products, as they were identified as “proprietary” by the manufacturers. As discussed above, UGE wastewater contains not only the chemicals used in hydraulic fracturing, but also the salts, heavy metals, hydrocarbons and NORM’s that accompany the hydraulic fracturing fluid back to the surface.

UGE-related activities can potentially contaminate both surface and groundwater. Surface water and shallow groundwater are at risk for contamination from overflowing or leaking wastewater impoundment pits, accidental onsite or transport related spills, and inadequate processing of UGE wastewater at municipal wastewater treatment plants not designed to remove the chemicals and radioactive materials. Deeper groundwater is more likely to be contaminated due to well-casing failures. The extent to which chemicals can migrate upwards from fractured shale to overlying aquifers remains uncertain.

There have been no large studies investigating the extent of water contamination from UGE, although an EPA study is underway. The EPA did investigate groundwater contamination related to UGE in Pavillion, Wyoming. EPA found contamination of wells drawing both from shallow and deep areas within the aquifer. Shallow sources of contamination were thought to be related to leakage from surface pits used for storage and disposal of drilling wastes as well as produced and flowback water. Deeper sources were thought to be related to gas production, including drilling and hydraulic fracturing. Extrapolating to the different geologic and drilling conditions in the Marcellus shale, they concluded that contamination from surface sources was more likely, while contamination from deeper sources was less likely.

Conclusion
Unconventional gas extraction, made possible by recently developed technologies, carries the risk of widespread air and water contamination with chemicals recognized as hazardous to human health. To date, there have been no comprehensive studies of the effects on air and water quality of this largely unregulated activity. In addition, the assessment of the current human health impacts awaits epidemiological studies.

Photo credits to Robert Donnan.

2 “Chemicals Used in Hydraulic Fracturing” United States House of Representatives Committee on Energy and Commerce Minority Staff, April
4 "Investigation of Groundwater Contamination near Pavillion, Wyoming", Environmental Protection Agency, December 2011

Leslie A. Walleigh, MD, MPH, has been a member of NECOEM for 20 years. She currently works part-time as a Public Health Physician with the Environmental and Occupational Health programs of the Maine CDC and also serves as a medical consultant to the South West Pennsylvania Environmental Health Project.
For more information on aerospace medicine, review the website for the Aerospace Medical Association at [www.AsMA.org](http://www.AsMA.org). Additionally, the slide sets for all three presentations at this conference are available on the NECOEM website. A podcast of this conference will be available on the website soon.

**Aerospace (Continued from page 2)**

soldiers returning from Afghanistan and Iraq, and appear lower than rates for the general civilian population.

Col (Dr) Joann Richardson is a RAM and currently the Headquarters Air Force Public Health Emergency Officer and Chief of Medical Readiness. Among her multiple certifications and distinctions, Dr Richardson is a Fellow of the Infectious Disease Society of America. Her presentation addressed how cabin air is managed on board commercial aircraft, describing various modes of disease transmission, presenting some case studies and describing possible management methods. Dr Richardson concluded with a discussion of the inherent difficulty of performing contact tracing for disease transmission potentially occurring on commercial aircraft, and the challenges of various mitigation strategies which have been attempted.

**Thomas Luna, MD, MPH** is board certified in occupational medicine and aerospace medicine. He recently retired from active duty in the US Air Force and settled in Portland, ME, where he will be a federal contractor supporting the US Dept of Homeland Security.

*Tom has graciously accepted the role of editor of the 2013 NECOEM Reporter*