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ROCHESTER INSTITUTE OF TECHNOLOGY

A Thesis Submitted to the Faculty of  
The College of Imaging Arts and Sciences

School of Art

In Candidacy for the Degree of

MASTER OF FINE ARTS

*World Trade Center Health Effects*

by

Erin Neill

Date: 8/8/2012

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## **Abstract**

The author worked with the World Trade Center Medical Monitoring and Treatment Program to create part of a public health education campaign to advertise the existence of the program and to explain World Trade Center health effects. World Trade Center Dust contained particles of many sizes, and it caused irritation to the body's tissues resulting in aerodigestive disorders like World Trade Center Cough, Sinusitis, Bronchitis, Rhinitis and Tracheo-Laryngitis. At the completion of this project, 2 posters, 1 brochure, 4 fact sheets and an interactive web site were created. One of the posters designed was used to promote program awareness amongst Ground Zero volunteers and workers. The second poster created was geared for use in clinics and doctor's offices, especially waiting areas. The author created a series of four patient education fact sheets that explain some of the most frequently seen respiratory diseases amongst World Trade Center volunteers and workers. Also designed was a brochure that included information about the diseases featured in the fact sheets, but in a more condensed form. The educational literature created needed to be simple in design and content, and it had to be presented in a medium that could be easily and cheaply reproduced and distributed to patients by health clinics and the Medical Monitoring and Treatment Program.

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## World Trade Center Health Effects

### Introduction

After the collapse of the World Trade Center Towers (WTC) on September 11, people worked day and night for 9 months as part of recovery and clean-up efforts in the 16-acre area that has become known as Ground Zero. During this period of time, police officers, fire fighters, contractors, ironworkers, construction crews, and volunteers labored around the clock to clear building debris and transport it out of lower Manhattan. People were unaware, as they worked at Ground Zero, that their bodies were being exposed to chemicals, gases, fibers and particles. Respirators were in short supply, so a significant number of those involved in clean-up and recovery efforts developed health problems after the disaster. [1]

Many health organizations related to the World Trade Center disaster formed after the event to assist different groups of survivors. One organization formed just after 9/11 was the WTC Worker and Volunteer Screening Program at Mt. Sinai Medical Center. This program was provided with start-up grants from the National Institute of Occupational Safety and Health (NIOSH). Initially, the WTC Worker and Volunteer Screening Program was only provided funds for monitoring; not treatment. After fundraising efforts by the staff, The Bear Stearns Foundation provided the initial money for the treatment of people in the program. The Center for Occupational and Environmental Medicine (COEM) at Mt. Sinai initiated the program after people noticed a gap in healthcare and necessary medical treatment for volunteers and workers. This program “evaluated more than 300 World Trade Center responders in the months following 9/11 and began to identify a pattern of 9/11-related conditions that suggested the need for a clinical screening program.” [2] In September of 2006, the WTC Health Panel was formed to give recommendations to government officials. The panel rated the World Trade Center Medical Monitoring Program at Mt. Sinai Medical Center as one of three centers of excellence in New York City that deal with WTC related health issues.

At the time research began for this project, all three “Centers of Excellence” were in danger of closing by the end of 2007 because of a lack of

funding [2]. The World Trade Center Medical Monitoring and Treatment Program and other organizations put pressure on the government to procure funding for continuation of World Trade Center disaster related health programs. Diane Stein, from the World Trade Center Medical Monitoring and Treatment Program at Mount Sinai, was solicited by the author to create artwork that would promote the program and bring increased awareness to their current educational materials for patients. Diane Stein felt that additional visibility for the program would be great, and she was excited to hear about student interest in creating artwork for them.

### **The History of World Trade Center Disaster Health Programs**

The citizens that came from all over the country and congregated at Ground Zero to volunteer were often without any type of healthcare coverage, and many of these otherwise healthy people didn't even have a doctor. It has been concluded that "40% of Mt. Sinai program people are uninsured." [2] Many New York City residents exposed to WTC dust are also without healthcare coverage. Those with health insurance or money to pay healthcare costs became frustrated when their health care professional was not knowledgeable about the possible health effects of World Trade Center dust exposure. Many doctors at the time were unaware of the conditions at Ground Zero, where toxic gases, dusts and airborne fibers surrounded people. Doctors had no idea what World Trade Center workers and volunteers were exposed to during the recovery and clean up of Ground Zero and why they became sick. Labor unions also became very concerned about the number of people that fell ill, missed work, or became completely disabled and unable to ever return to work due to the jobs they performed at Ground Zero. Legal problems arose because many people hired to work at Ground Zero wanted to file worker's compensation claims. By 2006, "approximately 6,000 people" had applied for workers compensation [2]. Countless families found that the time their loved ones spent at Ground Zero had become an economic burden because the financial provider for the family was now unable to work. "More than 700 firefighters developed permanent and disabling respiratory illness leading to retirement as firefighters"[2].

With much support from labor unions and survivor organizations like Beyond Ground Zero, the Mt. Sinai program expanded into what is now known as the WTC Medical Monitoring and Treatment Program in 2002 [2]. NYPD employees are part of Mt Sinai's program, and "Approximately 4,000 NYPD officers have participated in the program"[2]. The NYPD secured funds independently and worked hard on its own to organize short term and long term medical studies based on data they collect.

The other two programs in New York City that have also been named "centers of excellence" by the World Trade Center Health Panel are the Fire Department's WTC Program and Bellevue Hospital's World Trade Center Environmental Health Center. The National Institute for Occupational Safety and Health (NIOSH) provided the FDNY with the necessary money to begin the Fire Department's medical program. Just like the other "centers of excellence", Bellevue's funds would not last beyond 2006[2].

Mt. Sinai's Medical Monitoring Program differs from the Bellevue's WTC Environmental Health Center in many regards. One critical difference between the two programs is that Bellevue's WTC Environmental Health Center is funded entirely by the city, while until 2006, Mt. Sinai relied completely on federal and private funding. The Medical Monitoring and Treatment Program is now federally funded through a grant from the National Institute for Occupational Safety and Health. When the Bellevue program was created, it took over a Red Cross program set up in 2005.[2] As a rule, a person can only be eligible for the Bellevue's WTC Environmental Health Center program if they worked or lived in the area and experienced health problems. The requirements for entrance into each program leaves Bellevue's WTC Environmental Health Center program significantly smaller than the Mt. Sinai or FDNY program. Any residents of NYC that have become sick without working or volunteering at Ground Zero the specified number of hours are only eligible for this Bellevue program. By 2006, Bellevue's WTC Environmental Health Center had a waiting list of over 700 people.[2]

An additional organization involved in the study of the health effects of 9/11 is the World Trade Center Health Registry, which collects medical data of its' participants for study [2]. The registry is a combined effort started with

federal funding in 2003 between New York City's Department of Health and Mental Hygiene (DOHAMH), the federal Agency for Toxic Substances and Disease Registry and the Department of Health and Human Services[2]. The registry is a necessity to establish research studies on the health effects of 9/11. "The registry was made up of 55.8% of people from New York City, 26.8% New Jersey and 14.3% New York State" [3]. One of the objectives of the registry is to provide critical statistics and tracking of all changes in the health of World Trade Center building survivors [3]. Registration for the program was optional and stopped in November 2004 so researchers could begin working with the data that had been collected.[2] To calculate correct statistics, the group being examined must stay the same size throughout the study to give the most accurate information.

The World Trade Center Health Registry is currently made up of 71,437 people, and the health of the participants will be monitored for 20 years [3]. 8,418 of those registered are survivors from collapsed and damaged buildings [3]. There were a total of 38 buildings that collapsed or were damaged from the 9/11 terrorist attacks, and all of the published registry statistics come from September 11<sup>th</sup> survivors of these buildings. [3] These statistics show that more than half of the people studied reported worsening respiratory symptoms after the building collapse [3]. In September 2006, the registry published a Morbidity and Mortality Weekly Report with the information it had gathered over the past three years [2]. One important use of the registry and its information was to provide the public with things like cancer statistics and death rates related to the disaster. The goals of the World Trade Center Health Registry are geared toward research, but the goals of programs like the World Trade Center Medical Monitoring and Treatment Program are much different.

### **Goals of World Trade Center Medical Monitoring and Treatment Program**

The World Trade Center Medical Monitoring and Treatment Program was created to give World Trade Center disaster relief workers medical screenings at no cost to the individual. Most people that were not employees of the FDNY, federal government, or New York state government were left ineligible for most health care and screening programs. [4] The motto of the program is "Keep

Track. Come Back.”, which is exemplified by the stress the program puts on getting relief workers coming in for an initial screening to return for follow-up exams and appointments. The Medical Monitoring and Treatment Program has clinics in Manhattan, Queens, Long Island, Staten Island and New Jersey, as well as other participating clinics in New York state and nationwide. The Medical Monitoring and Treatment Program can provide referrals for follow up care to patients with World Trade Center health effects, and can also assist participants in understanding what benefits they are eligible to receive. There is a website ([www.wtcexams.org](http://www.wtcexams.org)) and telephone number to allow potential enrollees to gather more information about the program and potential health risks. A first exam and screening usually includes a physical exam, spirometry test, chest x-rays and other tests. Participants are also given questionnaires to fill out about their mental and physical health. It is important for health care workers to catch World Trade Center health effects and illnesses early to prevent patients from getting sicker or acquiring permanent health issues. Patients are encouraged to return every 12 months for check-ups for their own health benefit. A follow-up appointment also allows the program to gather information about World Trade Center workers and volunteers.

It is up to participants to return for follow-up exams so that their state of health can be assessed and recorded. It is essential to the World Trade Center Medical Monitoring and Treatment Program to create a supportive environment filled with people that have had the same experiences as relief workers and also suffer from complex health issues as a result. The program also has staff knowledgeable about the health effects of the World Trade Center disaster.

On March 21, 2007, Mayor Bloomberg spoke to the senate about the need for the federal government to provide continued funding to the three centers of excellence as suggested by the WTC Health Panel in its report. Mayor Bloomberg announced on December 26<sup>th</sup>, 2007 that the Consolidated Appropriations Act of 2008 had been signed and passed by the President and Congress. By passing this act, the federal government began providing the money necessary to keep the World Trade Center health programs alive. Formation of the WTC Health Panel and the conclusions it came to saved all three “Centers of Excellence” from closing their doors for good because of a lack of financial support.

## **Thesis summary and goals**

The artwork created for the World Trade Center Medical Monitoring and Treatment Program will be used as part of a public health education campaign to advertise the existence of the program and to explain World Trade Center health effects. One of the posters designed was used to promote program awareness amongst Ground Zero volunteers and workers. This poster was to be placed in public areas like job and construction sites as well as union halls to encourage people to contact the program and schedule an exam with the Medical Monitoring and Treatment Program. The second poster created is geared for use in clinics and doctor's offices, especially waiting areas where people would be bored and looking around at things. This poster also advertises the World Trade Center Medical Monitoring and Treatment Program, but its additional goal is to make respiratory anatomy understandable to low literacy patients.

The author created a series of four patient education fact sheets that explain some of the most frequently seen respiratory diseases amongst World Trade Center volunteers and workers. Also designed was a brochure that included information about the diseases featured in the fact sheets, but in a more condensed form. The educational literature created needed to be simple in design and content, and it had to be presented in a medium that can be easily and cheaply reproduced and distributed to patients by health clinics and the Medical Monitoring and Treatment Program. The author also created a library of graphic art that could be used by the Medical Monitoring and Treatment Program for conferences and presentations.

## **Who was exposed to World Trade Center Dust?**

It may seem obvious who suffered exposure to dangerous dusts and gases during the WTC disaster and subsequent clean up. The first people the public thinks of are evacuees from the WTC towers and surrounding buildings. Evacuees were present at the very beginning of the disaster, so they suffer from exposures relating to the building collapses and fires as well as the initial fires from the jet fuel filled planes that struck the towers. The next people thought to have suffered exposure to toxins were the first responders; like police,

firefighters, paramedics, EMTs, and other citizen volunteers. Most first responders received heavy exposure to toxins because they rushed to the site immediately after the planes struck. They became trapped in the cloud subsequently created by the buildings' collapse.

As someone truly considers the environment during and after 9/11, they realize that bystanders were also exposed to toxins along with New York City area residents and commuters. People living all over New York City and those commuting for work were covered in the dangerous, far-reaching cloud of dust. Commuters and residents were also exposed early on in the disaster when the dust clouds were the thickest and the fires burned strong. All of those present at the beginning of the disaster received high initial exposures, but it is the people exposed after the first day of the disaster who are so often forgotten.

The construction workers, ironworkers, engineers, and volunteers from the Red Cross, Salvation Army and other labor unions and organizations are often not remembered by the public because they arrived a day or more after the collapse. Those helping recovery and clean-up efforts at Ground Zero were continuously exposed to toxins, even though they were not present on September 11<sup>th</sup>. Often, the public that did not take part in recovery efforts doesn't realize that the fires at Ground Zero burned for months after the initial disaster, continuing to produce noxious gases and smoke. [4]

There are countless smaller categories of people exposed to toxins in New York City and surrounding areas. School children and teachers in Manhattan were subjected to the dusts and gases on September 11<sup>th</sup>; then were exposed daily to hazardous dusts once they returned to their schools. Residents of Chinatown were exposed on a daily basis, just by being at their businesses and homes. New York State and city officials who came to survey the damage and speak to the public are also at risk for developing respiratory problems, along with television and radio reporters who flocked to the scene. Railway tunnel and transportation workers were exposed as they worked to clean up the subway station and restore roads in the damaged areas. Electric and telephone company workers had to spend time at Ground Zero to help restore communication and provide power for recovery efforts. [4]

Hundreds of people from all over the country drove to New York City right after the disaster to offer help in any way they could. These volunteers consisted of police, firefighters, union members and ordinary citizens from many states. All of these individuals selflessly dropped what they were doing to go help those in need in New York City. After being exposed at Ground Zero, volunteers returned home to resume their normal lives. Unfortunately, their location now leaves many responders unable to see the doctors and experts at the World Trade Center health organizations throughout New York City. Returning home left the non-local sick individuals in an even harder place to learn about health care information, benefits and programs related to 9/11 relief efforts.

Ground zero is not the only location where workers came in contact with World Trade Center dust. Hospital employees and other health care workers who treated the injured from Ground Zero inhaled World Trade Center dust and chemicals from patients' clothing. The medical examiner and morgue employees handled the deceased recovered from the scene and worked to identify smaller remains found in rubble. Identification required close examination, and it is likely that some workers inhaled particles of the dust and chemicals still on the remains. Sanitation workers and those transporting and loading steel and building debris from Ground Zero to the Fresh Kills Dump on Staten Island received "repetitive, low level exposures" [4].

The Fresh Kills Dump, otherwise known as the Staten Island Landfill, is not the sole location that Ground Zero contents were brought. Barge workers were exposed to the dangerous materials while hauling building scrap, plane parts and evidence to the Staten Island Recovery World Trade Center Operations Center where professionals could examine it. [3] To this day people are still being exposed to old World Trade Center dust that has settled after the disaster outside and inside of buildings around New York City. If not cleaned up properly, the dust becomes re-suspended in the air during sweeping or turning on heating and cooling vents. Many business, school, and residential buildings in New York City still need vents and other areas professionally cleaned to prevent further World Trade Center dust exposure. [3]

## **What were people exposed to?**

After the collapse of the twin towers, the air in lower Manhattan became a health hazard to anyone close enough to inhale it. The pulverized building contents, burning fuel and smoldering debris released harmful aerosols into the environment. Small and large particles of dust traveled across the city and spread into neighboring regions and cities. The greatest concentrations of dangerous substances were found directly in and around Ground Zero because the air at the center of the disaster was completely dense with particles and emissions. The time period during which people were subjected to the heaviest exposure was the first few days of the disaster when the air was especially dense with visible and invisible toxic substances resulting from the intense building collapses and fires. By September 12<sup>th</sup>, the dangerous dust and smoke plumes had spread east and then south into Brooklyn [1].

Elements that were harmful to the human body were present in large amounts in the initial cloud formed by the World Trade Center towers' collapse. Volatile organic compounds (VOCs) like benzene, metal, and polycyclic aromatic hydrocarbons (PACs) from "unburned or partially burned" jet fuel were in the cloud formed by the collapse of the towers [1]. The contents of the initial cloud were found to be mainly combustion products [1]. Soot, which is made of combustion products, was found in some World Trade Center dust samples [1]. When scientists analyzed World Trade Center dust samples collected throughout the day, the "samples had soot levels peak at night when wind dies down and the plume lowers" [5]. The people present at the building collapse and fire, and those caught in the initial dust cloud are known to have the most severe exposure to toxins. The amount of time spent at Ground Zero and a person's proximity to the fires and gases directly affects the severity of illness and the symptoms present in a person from exposure [6].

Aerosols were some of the most harmful gases people were exposed to from burning material at Ground Zero. Aerosols can contain transitional metals, like the Titanium, Zinc, Chromium, Manganese and Copper that were found in the air above Ground Zero and in the dust collected after the disaster [1]. The Titanium levels were high because of the amount of white paint throughout the buildings [1]. Lead, copper, and zinc were also present in WTC dust samples

taken. These elements were found as a result of burning computers and electrical systems [7]. Aerosols were mostly present at the beginning of the disaster in the smoke from building fires and burning plastics. Burning plastic can release acid mists along with toxic and irritating gases. There were two different types of aerosols present in World Trade Center dust; pulverized dust from the buildings' collapse and smoke from the fires in the debris pile. In subsequent months, during the recovery and clean up, the toxic aerosols came from diesel generator emissions [5]. Aerosols from diesel fuel are still a problem today because of the amount of construction equipment at Ground Zero to rebuild the area.

### **Which dust components are the most dangerous?**

The content of the dust from this environmental disaster has been studied by many scientists, and most agree that World Trade Center dust has been found to contain mostly gypsum, soda lime glass, mineral wool and slag wool [1]. The dust contents that have the ability to harm the body are called contaminants of potential concern (COPCs). The COPCs that most people have heard of are asbestos fibers. There are several types of asbestos fibers. One of the fibers, chrysotile, has been found in World Trade Center dust samples. The fact that asbestos fibers exist in the World Trade Center dust alarms many, but it was found that asbestos made up “.8-3% the mass” but less than 1% of the volume of the dust [1]. Asbestos was used in the construction of the North tower during the 1970's. The steel beams of the tower and other areas were coated with asbestos before legislation stopped its use.

Aside from asbestos, other COPCs in World Trade Center dust were “glass fibers, lead and PAHs” [1]. PAHs are polycyclic aromatic hydrocarbons, and they were produced by burning wood and plastics [7]. Glass fibers like mineral wool, glass wool, and fiberglass are an especially dangerous component of World Trade Center dust because they can become coated in harmful substances like formaldehyde. Mineral wool is a glass fiber made by melting slag and spinning it into insulation. Fiberglass is similar to mineral wool and is used in insulation and weather proofing because it doesn't burn. Lots of glass fibers were found in WTC dust samples “due partially to windows, but primarily to ceiling tiles” [5].

Aside from the asbestos in the walls of the north World Trade Center tower, many building contents are forgotten about as sources of potentially harmful particles and gases. The towers had offices, elevators, restaurants, and bathrooms that were built using tons of steel, concrete, and plaster. Inside these towers were people, along with computers, paper, office furniture, carpeting, heaters, boilers, piping, drywall, sewage, windows, paint, wood, and wiring [1].

### **Dust Particle size**

The size of an inhaled particle of World Trade Center dust proved to be a major factor in how much exposure a person got to toxic elements. Particle size is measured by the diameter, and the diameter of the particle is what determines where it lodges in the body [7]. Large particles are less likely to get deep inside the lung because the body uses the nasal and throat passageways to filter out large foreign particles. Hair, cilia, and mucus are just some of the resources the respiratory passages of the body have to help catch and expel particles. Particles with a diameter larger than  $10\mu\text{m}$  usually don't get deeper into the airways than the nose and throat. These particles are "swallowed or expelled by coughing and sneezing" [7]. The nose is lined with hair to filter out the largest particles, while the cilia are used deeper in the respiratory tract as a filter for smaller particles that passed the nose hairs and mucus. "Particles larger than  $5\mu\text{m}$  are effectively filtered out by impaction in upper airways", which prevents the particles from traveling deeper into the respiratory tract [8]. Elimination of the particles occurs when the particles enter the naso-pharynx and get stuck in the mucus that lines the airways.[9] Particles with diameters "between  $2.5$  and  $10\mu\text{m}$  usually only get to upper airways, but less than that can get deep into alveoli in lung"[7]

"Smaller particles, which can penetrate into the deep lung, " are most likely "generated by burning materials" [8]. Fine particulate matter smaller than  $.1\mu\text{m}$  can actually "diffuse into the alveoli" of the lung [9]. These tiny particles are often produced by combustion and are less caustic than other airborne debris [7]. Scientists know that just because fine particulate matter is more pH neutral does not mean that it is not hazardous to the body.

The pH of inspired particles is a concern because the body must keep a neutral pH to continue functioning properly. The dust from 9/11 is extremely basic (PH 10-11) because of the amount of cement dust in it. [1] The pH of a sample on Cortland street was found to be 11.5, which is way above the pH 7 that the human body keeps [1]. Long, thin glass fibers in World Trade Center dust became especially dangerous when smaller particles attached to them. These fibers were inhaled or swallowed and the high pH of the attached particles “caused initial lung irritation reported by residents and workers”[1].

Dust particles larger than 10 um most likely caused WTC Cough because the caustic particles irritated upper passages of the nose and throat [5]. The large size of the very basic particles prevented the particles from getting deep into the lung. Many scientists believe that gastrointestinal problems were also caused by inhalation of World Trade Center dust. It was found that “any large particle inhalation could also lead to ingestion exposure after particles are cleared from the upper airways of the lung by musculocilliary processes” [1] Most of the gastrointestinal health effects seen have symptoms similar to Gastro-esophageal reflux disease (GERD). Symptoms of GERD include upper gastrointestinal tract irritation, heartburn and regurgitation. These are most likely problems from swallowing particles and getting intestinal exposure to irritants and toxins. (Clinicians guide....”, 6 )

### **WTC dust’s effects on the human body**

Airway injury can occur from inhaled particles or gases. There are mucus-secreting cells, called goblet cells, in the lining of the trachea and other portions of the airway. Mucus produced by goblet cells helps remove irritants we breathe in by catching small particles that get into the respiratory tract. When the body coughs, the debris filled mucus moves up the respiratory tract to a location where it can be further expelled by coughing. Pseudostratified columnar epithelial cells line the trachea along with mucus producing goblet cells. The cilia of the pseudostratified columnar epithelial cells work in unison to sweep the mucus upwards towards the mouth. If not caught in mucus, a particle can imbed itself in the cells lining the trachea and cause irritation to the cells in the area. Mucus transportation in the affected area can become stalled by the reaction to

the particle, and the transportation process can become less efficient. Smaller fibers may be inhaled deeper into the respiratory tract and lungs without getting stuck in the blanket of mucus. The small size of the particles allows them to imbed themselves in the alveoli and the lining of the respiratory tract. In the upper airway, pH changes from inhaled particles or gases can cause areas of ciliated cells to die and be replaced in the area by cells without cilia and without the ability to move mucus. [10] Particles can similarly embed themselves in alveoli of the lung, causing lung dysfunction. This is known to have happened to disaster workers because firefighter sputum tests show “irregularly shaped particles” in “epithelial cells and alveolar macrophages”. [8]

Hundreds of people may be sick now, but those who are not currently showing symptoms are still at risk for developing a World Trade Center related health effect later in life. Most people with irritation related illnesses like bronchitis, sinusitis, and tracheo-laryngitis, began showing symptoms within days or weeks of exposure. There are other illnesses that may not cause symptoms immediately upon exposure. Cancers have become one of the largest concern for those exposed to World Trade Center dusts and gases, but other chronic conditions can be just as debilitating. Pulmonary fibrosis causes permanently disabling changes in lung tissue and blood cancers have already begun to appear in people from Ground Zero. Cancers from silica and asbestos take years to appear even after high levels of exposure. The specific cancer caused by silica exposure is called Malignant Mesothelioma. [4]

## Conditions caused by World Trade Center dust/ aerosol exposure

Condition	Symptoms	Caused by
Sinusitis (chronic)	congestion, headache, sinus pain, ear pain	inflammation in the turbinates and other areas of the sinuses
Bronchitis (chronic or acute)	mucus producing cough	irritation and inflammation of the bronchi
Rhinitis	congestion and itchy, runny nose	inflammation of the nasal mucosa from inhaled irritants
Tracheo-laryngitis	hoarse throat with change or loss of voice	inflammation of the mucous membrane of the larynx and trachea
Asthma	dyspnea, wheezing	airway inflammation and hyperreactivity
World Trade Center Cough	a cough that is chronic, chest tightness, feeling short of breath	a combination of upper & lower airway diseases like RADS, RUDS, & GERD
GERD (Gastro-esophageal reflux disease)	heartburn, acid reflux	swallowing & ingestion of particles causing gastrointestinal tract irritation
RADS (Reactive Airway Dysfunction Syndrome) also known as irritant induced asthma	asthma symptoms of bronchial inflammation, chest tightness, cough and wheezing	irritant exposure or injury that makes the airway hyperreactive and become inflamed
RUDS (Reactive Upper Airways Dysfunction Syndrome) also known as chronic rhinosinusitis	sore throat, sinus inflammation & nasal inflammation	irritation to mucus membranes
COPD (Chronic Obstructive Pulmonary Disease)	chronic cough, dyspnea	obstruction of the pulmonary airways because of inflammation or fibrosis of the broncheal wall and excess mucus production
Allergic Conjunctivitis	eye redness, tearing and itching of the eye	inflammation of the conjunctiva of the eye
Pulmonary fibrosis/Sarcoidosis	rapid, shallow breathing	lung volume is reduced because of lung fibrosis, the scarring of lung tissue preventing lung from expanding

### **The choice to focus on respiratory symptoms**

There are many symptoms and illnesses caused by exposure during the WTC disaster; which may be now considered one of the worst environmental disasters in United States history. A substantial number of the exposed populace now suffer from severe mental health problems, like PTSD, depression, and anxiety disorders, stemming directly from the attack. Mental health problems and respiratory problems were by far the most common health effects reported amongst the people studied in the WTC Health Registry [3]. The mental health effects suffered by those present at the disaster site are so numerous and such an expansive field of study that journal articles have been written specifically about those issues. To readers of journal articles about the physical and mental health effects of the World Trade Center disaster, the number of physical symptoms present in so many workers can become overwhelming.

After beginning research on physical health effects, the author realized that it would be the most informative to the public if a smaller, more specific group of symptoms was focused on for study and artwork. Respiratory health problems, like WTC cough, were becoming so common amongst exposed responders that they were starting to be discussed on national news sources like NPR. The most detailed study for this project was on WTC Cough, and later it was expanded to include other respiratory issues. As research was done, it was learned that gastrointestinal problems were also common in addition to respiratory symptoms. The passages of the digestive tract were exposed and damaged by WTC dust in the same way as the respiratory passages. When workers breathed in dust, it often was swallowed down into the gastrointestinal system. Eventually the Medical Monitoring and Treatment Program began to call all of the physical symptoms and illnesses related to WTC dust exposure “aerodigestive disorders”, a term which includes eye reactions, respiratory health problems, and gastrointestinal symptoms. It was decided not to include gastrointestinal problems in this project because the author wanted to focus on respiratory health issues.

## Health Literacy

There are many published recommendations to increase the health literacy of a large program/project. Vocabulary is an important part of public health materials, and identifying and changing uncommon words in a project is an important part of the evaluation of the materials. The length of the sentences used in public health materials is also important to consider when trying improving readability.

The “Health Education and Adult Literacy: Breast and Cervical Cancer Project” public health campaign by World Education, seemed similar to the World Trade Center Medical Monitoring and Treatment Program campaign in many aspects, including audience [12]. The “HEAL: Breast and Cervical Cancer”, (The Heal: BBC) campaign, was funded and later evaluated by the CDC, to research the campaign’s effectiveness. Several suggestions made in the book “Advancing Health Literacy” by Zarcadoolas were used to improve this project. The audience in the Heal: BCC campaign was similar to that of the Medical Monitoring and Treatment Program in that both programs were created to work best for a low literacy or low educational level adult audience. Many of the adults in each campaign were non-English speaking and had low income. Having low literacy or a low income level makes a person more likely to struggle with health issues because many are unable to effectively communicate with a health care provider, if they even have one [12]. It was learned that “33% of people in LA and Atlanta hospitals could not understand health information written at a 4<sup>th</sup> grade level” [12]. The Medical Monitoring and Treatment Program audience was not solely low literacy or non-English speaking people, but the purpose of the illustrations and educational materials created was to make the topic of World Trade Center health effects understandable to all individuals. It may be easy to guess that there would be non-English speaking people in the program, but it is still surprising to learn that “More than 14% of interviews” were conducted “in languages other than English” [4].

The Heal: BCC campaign was a program consisting of English language teaching classes introducing health issues to people that were learning to read. The “HEAL: Breast and Cervical Cancer” campaign relates to this project because the audiences of both programs consist of people of many different cultural

backgrounds. There is a possibility that the audience of the Medical Monitoring and Treatment Program could be poor and without health insurance, and have low literacy levels. The graphics in the HEAL: BCC project were very simplified and almost looked like symbols or icons. It was decided that the illustrations of World Trade Center related health conditions could be shown as symbols that a person can see, identify, and relate to. (Figure 1)

### **Initial Project Concept**

The initial concept to introduce World Trade Center health effects information to the public was to have a portable interactive computer station or booth that could be set up in places like hospitals, clinics and conferences. This station would include a computer for the user to view the animations and interactive content created during this project. Original plans were to have a selection of fact sheets for users to take home on one wall of the booth, and a poster that explained the anatomy of the respiratory system on the other walls of the booth. The computer was a tool to allow the user access to the internet, and there was to be a web page of links set up as part of the project's website. The links page would assist the user in navigating the content on the internet, and clicking a link would bring up more online information about WTC health issues from scientific journals and support groups. At the time this was planned, there was no single place on the internet where all of the facts, articles and information about World Trade Center health programs were together to easily explore.

This idea was short lived because the director of Outreach and Education for the Medical Monitoring and Treatment Program and one of the thesis advisors for this project, Diane Stein, informed the author that clinics in New York City have absolutely no extra space available. There would also be security problems keeping the computer safe in any clinic or convention. In addition to the security issue, many of the people coming to the clinic speak different languages, so the interactive content would only help some of the Medical Monitoring and Treatment Program patients. The Medical Monitoring and Treatment Program has its own translator to use to translate printed materials, but even with translations, it would be very time consuming to create an animation that could run using different languages. Another problem found with

the computer booth idea was that technically challenged people may be unable to navigate around well on computers, and could be intimidated by a computer booth. A lack of computer skills could cause someone to skip the information all together. While intimidation by technology is a valid issue, the author believed that the informational booth would be extremely helpful for people that can use computers, but do not have access to the internet at work or in their homes. All of the most up to date World Trade Center health information is contained in reports and journal articles on the internet. Without access to the internet, people still are unable to view any recent scientific reports, news articles, responder websites, and government help sites. It was decided that the internet and interactive content would be an important portion of the thesis project, but a smaller part than had originally been planned.

Spending time on an interactive informational booth would be devoting a great deal of effort to a creation that would only be effective for a portion of the population the thesis project was trying to educate. Ms. Stein and the author had a discussion about what would be the most helpful in the long term to the Medical Monitoring and Treatment Program. She was interested in artwork that could be reused for fact sheets, brochures, posters, and presentations at conferences and websites. The program could use this artwork like clip art over the years to create many different types of educational publications. Ms. Stein stressed that the artwork needed to explain respiratory anatomy and illnesses to people who were not used to being sick or concerned about their health. The art would also need to be completely anatomically correct so that the materials could be sent to doctors to use when educating their patients. If doctors did not have confidence in the illustrations, the physicians would not dispense the information to patients. Physician support is critical to the project, because people trust information from their doctor far more than the information they find on the internet or hear from friends.

### **Creating Thesis Artwork**

As a way to start, the author created multi-use clip art by sketching characters and scenes that could be used in animations and in printed materials like posters and fact sheets. It was decided that many of the illustrations would

first be made in color for use in the animation. The color illustrations produced were flat and line based so they could quickly be changed into black and white illustrations. The goal was to create colorful graphics reminiscent of line art that could easily be turned into black and white images without having to re-draw each piece. One advantage to using vector graphics is that line art files remain consistent when transferred between computer applications. Another advantage to vector art is that art made using Adobe Illustrator remains completely editable as vector art when imported into Flash.

Adobe Illustrator was the best computer program to use to create vector art because the pieces could be copied, pasted, or imported into Flash quickly. Vector artwork could be used for several purposes in the thesis project, and this would save time. The Adobe Illustrator files could easily be used in Flash to create animations and websites, or they could be placed in Adobe InDesign for publication layouts. Once flattened, vector artwork would be the easiest for people at the Medical Monitoring and Treatment Program to use. The edges of vector art remain crisp and clean, and resolution does not degrade as the image gets larger. One of the most important reasons for using Adobe Illustrator is that the vector graphics can be blown up or reduced without concerns about pixilation and resolution values. Doctors, education and development people using this art will not necessarily be familiar with computer graphics programs and the problems that can arise with resolution. People unfamiliar with Adobe applications simply want to be able to drag a file into their Microsoft Word document or PowerPoint presentation. For this reason, a cd with a .jpeg, .tiff, and .ai file of each image will be provided to the Medical Monitoring and Treatment Program so that they will not have to convert files into different formats to use the art.

### **Interactive Artwork**

An animation was not one of the pieces requested by the Medical Monitoring and Treatment Program, but the author wanted to have an interactive component to the thesis project. Once work began on the animatic and the Medical Monitoring and Treatment Program saw the learning potential an animation created, they became interested in this aspect of the thesis. Several

interactive pieces on the subject of World Trade Center related health effects were created, and then the people met with in New York City from the Medical Monitoring and Treatment Program were left to decide which pieces would be the most helpful. After much consideration and evaluation, the decision was made to have the animations and the posters' images focus on one main character; a male construction worker. Statistics about the Medical Monitoring and Treatment Program's participants state that 87% of the people in Mt. Sinai's study are male [2]. Also, construction workers were the largest occupational group in the Medical Monitoring and Treatment Program study, and law enforcement was the second most popular job reported [2].

Hundreds of women worked and volunteered at the WTC site, but the majority of the population seeking treatment was male. The author felt having a male construction worker as the main character would be a fair representation when the Medical Monitoring and Treatment Program's statistics are considered. Using one male and one female character would be unnecessary and time consuming because there are no big differences in respiratory anatomy between the two genders. Focusing the animation on one character allowed more room for close up views of respiratory anatomy.

One interactive element developed was a computer based quiz for people potentially exposed to toxins that can help an individual determine if they should get a Medical Monitoring and Treatment Program exam. A web page that showed part of a micrograph image magnified to show properties of the cells of the respiratory tract was also created. The micrograph showed the cells of the trachea, and focused on a few pseudo-stratified cells, and a few goblet cells. The author also created another educational interactive element similar to a simple jigsaw puzzle. The small four-piece puzzle shows a 3d electron-micrograph image of ciliated cells and goblet cells that have a blanket of mucus on top of them. This image is useful in explaining how mucus sits on top of the respiratory tract cells, and how it is possible for the cilia to move mucus. The puzzle pieces can be dragged together on the screen to form a full image of the cells. Diane Stein felt that this was definitely not patient geared material, and that it probably wouldn't be usable for the Medical Monitoring and Treatment Program website or presentations. She felt it could be included it as part of the

webpage created for the thesis opening and project website, but the material covered by the puzzle, quiz and micrograph was too scientific for the public.

The next task was to create an animation that would be appropriate for all participants of the Medical Monitoring and Treatment Program. The author began the creative process in traditional media, by drawing and sketching. Once a decision was made about which sketches looked best, the sketches were used to create a storyboard for the animation in colored pencil. During the storyboard creation, the author was able to explore different color schemes for the project. Research was done on the particles that were found in WTC dust, and it was felt that a graphical representation of these could help people visualize what damaged their respiratory passages. Hearing words like “benzene”, “soda lime glass”, “asbestos”, and “slag wool” doesn’t help actually explain the particles contained in the dust. The first scene of the first animation showed enlarged illustrations of particles in a cloud of brown dust. (Figure 2) The color scheme decided on included yellow, Mt. Sinai blue, and brown. The blue and yellow are the same colors used by the Medical Monitoring and Treatment Program, so the pieces could be integrated well in their website. The exact Pantone number of the colors from the Medical Monitoring and Treatment Program weren’t given to the author, but a PDF of the program’s brochure was downloaded, it was possible to use the eyedropper tool in Adobe Illustrator to find out what exact colors were used.

The author planned to have the particles swirling around at the beginning of the animation, and then shrinking and becoming more transparent as they blended in with the rest of the WTC dust. A male figure slowly became visible through the dust, and his respiratory anatomy became visible on top of his body. The field of vision zooms in, and the male construction worker moves to the side so that a cross-sectional view of his respiratory anatomy can be seen. Glen Hintz and the author both felt that people may be able to understand the placement of the lungs and airways from a frontal view, but that the connections between the nasal passages and the mouth to the trachea were best explained with a cross-sectional view. The sinuses of the construction worker slowly turned from transparent to opaque on top of the character’s face as the camera zoomed in closer to his face. The view became so close up to the worker that eventually

only his facial features took up the screen. The sinuses can clearly be seen at this point, and the construction worker's eyes begin to turn red from dust particle irritation.

This animation began with very rough versions of all the symbols to get the timing and flow correct. As the artwork progressed, many changes to the body and face of the main character were made. The character began with blue skin to try and stay with a definite color scheme. (Figure 3) When Glen Hintz and the author discussed the animation, it became clear that the blue skin made the worker look cyanotic and sick, not aesthetically pleasing, as was hoped. The author hoped to avoid the issue of choosing an ethnicity or skin color for the character by making the skin less natural and more artistic. Instead, the author now had to decide what skin color would be best. The character's skin was made a dark Caucasian color because a majority of the participants in the World Trade Center Medical Monitoring and Treatment Program were Caucasian. Latinos were the second largest ethnic group participating in the program. [2]

On the trip to NYC, the author showed a rough version of this animation to Ms. Stein and her colleagues, since they agreed to critique this material even though it was not the matter they wanted to use in their clinics. They were impressed, but felt that there needed to be some changes in the character used. They did not want the character to wear a construction hat because not all of the workers in their program wore one, or were construction workers. (Figure 4) They didn't want to exclude any type of worker or volunteer, and felt that a character with a non-specific occupation would be best. The group reviewing the work also wanted a female worker in the animation so that the artwork wouldn't be exclusively oriented to men. It was explained that the idea of including both genders was a good idea, but that the time involved in designing and animating another character was immense, and that the author would have needed to know this at the beginning of the animation to plan the space in the animation accordingly. They were also informed that the details of the character's respiratory anatomy would have to be much smaller to fit two characters within a 450 x 450 pixel area. It would be harder to concentrate on one body part or health issue at a time if it was necessary to show it in both characters. Unfortunately, when the author began this portion of the thesis

project, the Medical Monitoring and Treatment Program had not decided what type of animation would be most useful, so decisions on what would be best were left up to the author.

Through class critiques and speaking with Ms. Stein and her colleagues, it was learned that the particles section of the animation was too lengthy. Classmates of the author felt that it shouldn't be used to begin the animation because it seems like a separate idea from the "symptoms" animation that followed. It was suggested that two separate animations from the current long running animation be created. When the animation was shown as two different pieces, Glen Hintz and the other students reviewing the piece felt that the movie clips in the "symptoms" animation were too complex; even as a separate animation. The symbols that created dust and smoke in the background took too long to load because there were numerous alpha/transparency changes going on in the background. The students that viewed the animation felt that the dust and smoke moved too much and was distracting. The detailed movement was a problem because the dust was not the focus of the entire piece. The dust was meant to be the background and should not have distracted the viewer. Another piece of feedback received was that using only shades and tints of blue and yellow didn't succeed in informing anyone about the particles because they didn't look realistic. (Figure 5) The particle movie clips had become too graphical in the efforts to symbolize and simplify them.

### **Lung Artwork**

A great deal of time was spent illustrating the lungs for this project. Making voluminous lungs was a challenge because only one color could be used. One anatomic detail that was struggled with was the decision to show the individual lobes of the lungs. The author felt that the anatomically correct, asymmetrical lobes of the lungs could confuse people who were used to seeing the lungs represented as two symmetrical solid masses. In most simplified lung drawings, the lungs are made to look identical without the use of lobes or a cardiac notch.

The same basic lung illustration was to be used throughout the thesis, which would include the logo, animation, fact sheets, and posters. The author began to design the logo with the lungs as the main focus. The lungs were placed inside of many different shapes with lots of different text to try to find the best graphical representation of the thesis. The first versions of the WTC Health Effects logo included a trachea branching into bronchi and the left and right lungs. All of the first logo designs showed these anatomical structures inside a circle. In the first logos, the lungs were simplified, anatomically correct outlines of the overall lung shape, but lobes were not included. To imply a difference in the number of lobes, two left bronchi and three right bronchi were shown.

Around the same time, the author discussed the lung designs with Glen Hintz and Diane Stein. Ms. Stein and the author decided that if the lungs were made symmetrical, clinic doctors might not feel that the information is anatomically correct enough to show their patients. Mr. Hintz felt that the lungs should have lobes to help show volume. After many tries, a new line drawing of the lungs with lobes was created. (Figure 6a) Mr. Hintz and the author critiqued the line drawing of the lungs, and decided that the back portion of the left lung should be shown in gray to emphasize the fact that we were seeing a more posterior part of the lung. Mr. Hintz also pointed out that the rounded pieces of cartilage in the trachea portion of the illustration (shown in figure 6b) were too extreme. The cartilage appeared way too thick, and the illustration didn't have the feel of a tube containing many layers of tissues around the cartilage rings.

An anatomical issue that was struggled with was the fact that cartilage rings making up the trachea do not form complete circles; they are actually more horseshoe shaped. The illustration didn't show how flat the back portion of the tracheal passage really is. It was difficult to create a monochromatic trachea with depth that could be used in the logo and print artwork.

### **Logo and Lung Development**

In the days preceding the author's trip to New York City in March of 2007, she realized the World Trade Center Medical Monitoring and Treatment Program was not going to be able to choose a logo or poster in time for the thesis gallery opening in May 2007. Upper level people directing the World Trade

Center Medical Monitoring and Treatment Program had not made any decisions about the look of the website and other promotional material. The main focus of the program had begun to shift to securing funds to allow the program to stay in operation. Ms. Stein was able to provide guidance as to which images and animations would be most helpful for patient education, but she could not commit to the images, layout, or text. The author made changes to the project and began to design a website and project with its own name and written information. She decided to title the printed and web materials “World Trade Center Health Effects”. This title replaced the areas in the work that previously contained “Medical Monitoring Program”.

To create a new identity for this project, it was necessary to create a logo that fit the subject matter. The project’s logo needed to be readable and high contrast when used in black and white as well as color media. Any essential part of the logo, like the text, could not be made using a lighter color, like yellow. When transferred to black and white, a light color may not make a gray tone that could be reproduced several times with copiers. The author needed to combine the concepts of respiratory system health, and the World Trade Center disaster into one logo that was simple and iconic. She also had to consider the subject matter and avoid making the logo tacky or offensive to the victims or family members of victims involved in the tragedy. A geometric representation of the World Trade Center towers was wanted, but the author didn’t want the towers to be the first thing that someone would notice about the logo.

The thesis project on World Trade Center Health Effects stemmed from the author’s original focus on the notorious “World Trade Center Cough”. The trachea needed to be included in the logo because when someone coughs, a person may picture the path air takes as it travels out of the lungs. They may visualize air going from the bronchi to the trachea, then being forced out of the body. It was extremely difficult to create a trachea that showed the outline of cartilage rings without the drawing becoming very complicated. The average person has 17-20 cartilage rings in their trachea, so there is a lot of information to fit in a small area.

All of the initial logos that the author designed were respiratory system drawings inside a circle, square, or rounded square. (Figure 7) The length of the

trachea made it difficult to include it with the lungs inside any geometrical shape without creating a large amount of negative space. The author tried including only a short portion of the trachea, but the logo didn't look correctly proportioned.

Some World Trade Center related logos showed the towers at the same height while other logos had one tower slightly taller. When people were asked if they believed one tower was taller than the other, just as many thought the towers were the same height as thought one was taller than the other. The North Tower, otherwise known as 1 World Trade Center, was, in fact, taller than the South Tower. The author wanted this slight difference in height to come through in the project's logo because it created a more interesting and dynamic shape than two equal sized rectangles. She didn't want there to be any details to the logo's towers, like windows, or floors, because it would become too complicated. It was also felt that specific details could upset people and remind them too much about the disaster. Leaving the buildings as simple shapes seemed the best way to represent them anonymously.

Mr. Hintz proposed that the author look at the logo and try to design it so that the trachea uses the negative space all ready in the logo. When the two towers were placed side by side, a gap between the buildings could be used to create a simple trachea. Using the negative space between the towers rid the author of the problem of incorporating anatomical details into the trachea. A logo encapsulated in a circle was no longer needed because everything in the logo was held together by the relationship between the towers and the trachea. Mr. Hintz also suggested that a sans serif font be used for the text in the logo. Once the font was changed, the logo appeared much more simplified and subtle, yet still understandable.

The logo did a great job of relating all the educational materials to each other. It became an important part of all of the project pieces because the interesting shape drew the viewer's eye to the top of the piece where it was positioned with the title. The top of the "Symptoms" poster was greatly improved because it didn't just have text for the top of the poster. Now the poster had a dynamic image that related the poster title and content. The logo gave the thesis the look of an entire project, or a "corporate identity". (Figure 8)

## **Reproduction of Artwork**

When the author began to consider using gray for the posterior lobe of the left lung, it started a query into the possible complications of photocopying. Any print publication made would most likely be photocopied several times. The Medical Monitoring Program, doctors, clinics and patients would probably duplicate fact sheets and brochures numerous times without concern about losing image quality. Each time the artwork was reproduced, the gray tone would degrade and become less and less like the tone on the original piece. A copier places a certain number of black dots on the page to create the look of gray in the viewer's mind. When a copier is used for reproduction, the machine often doesn't reproduce all of the dots on the previous piece. When a copy is reproduced, that photocopy, and each duplication diminishes information. When a copy is underexposed and comes out of the machine too light, the gray tone becomes poorly represented by scattered black dots that don't give the visual impression of gray at all. The opposite can also occur; creating a copy that is too dark. On the World Trade Center Health Effects logo, the back portion of the lungs would not survive being copied more than once without the area looking speckled and odd.

Glen Hintz and the author met again to look at the lung changes and new logo designs. At this point in time, the author had finalized the design of the logo, so she was able to begin experimenting with color. When the World Trade Center logo was created using color, she tried photocopying different colored logos to see how the colors transferred into grayscale on the RIT copier. The yellow logo created was barely even visible when copied, and the blue logo looked like spotty, speckled TV noise. The author started doing photocopying experiments, where she tested how a 15%, 25%, 35%, 45%, 55%, 60%, 75%, 85%, and 95% grey would look when photocopied at RIT. She decided that the 60% gray looked the best in images after copying. Anything above 75% gray looked like black when photocopied because the copier couldn't distinguish a difference between the darker grays. The author used the commercial copier at RIT because it was assumed that the clinics and the hospital and Medical Monitoring

Program staff would have a large, similar copier. She also tried reproduction with her home tabletop printer/copier.

The author knew there wasn't a way to have the logos look similar every time, because they were going to be produced on different copiers. She didn't want the photocopies between one clinic and another to differ just because of the copier. That meant that she would have to stick to mostly black and white shapes in the brochures and fact sheets to guarantee that they would all look the same. The one graphic gray was used on was the posterior lobe of the left lung. If it was made light gray, when the image was copied, the worst that could happen is that the gray wouldn't be picked up. If the copier ignored the gray used, the image would simply be black and white like the rest of the artwork.

The strictly black and white format chosen for the fact sheets and brochures is best for frequent copying. Added grays may become indistinguishable from each other, and if a photocopy is made of a photocopy, no matter what type of printer was used originally, even more information is lost. Clinics unaware of this could easily mix up a photocopied page from an original, or think that it doesn't make a difference. Black and white line art provided the best way to cheaply distribute the information in the longest lasting form, despite frequent recopying.

### **Symptom Symbols Development**

When the author traveled to New York City to meet with Diane Stein, she brought all of the artwork that she had been working on. After creating a series of symbols to be used throughout the project, she wanted some feedback from the group at the World Trade Center Medical Monitoring Program. The author showed Ms. Stein's team the side view of the character and discussed the various options available. There was one image that included a spine and one that did not. The group unanimously decided that the spine should be included in the piece to orient the viewer. (Figure 9) It was much more complicated to decide if a brain should be included in the symbols. The doctor in the group wanted the head to include a brain, and she wanted a more rendered version than had been made. She believed the brain was necessary to orient the viewer and to make the graphic appear more anatomically correct to doctors. Lots of different

arrangements were tried to include the brain without distracting from the actual symptoms that the graphic focused on. The two doctors at the meeting also mentioned their desire for an ear and an eye to be placed in the illustration. The author explained that the presence of any more features or structures could cause the illustration to appear too busy to actually help orient someone.

Many methods were tried to direct the viewer's eye to the area of focus on the symptoms symbols. The author tried just about everything she could think of, including gradients, line weight and colors in back of the structures. The author created patterns in Illustrator that were made of many small black shapes. Patterns based on circles and squares were made, but the best patterns were made of organic shapes. The author wanted to fill the important anatomical structures with a pattern to differentiate them from the rest of the body. She also looked for a pattern that could fill the respiratory passages to show that they had depth, and were rounded. After many failed attempts with patterns, it was decided to use the glow effect in Adobe Illustrator. When printed in red, the glow effect made structures look very inflamed. In black and white, it also attracted attention to the area. The glow effect was one of the only ones that stood up fairly well when repeatedly photocopied.

The glow effect worked well to direct attention to the anatomical structures in the symptoms symbols, but it was still difficult to create the concavity of the respiratory tract and sinuses with a pattern. Several methods were tried to create realistic tracheal cartilage in the hopes that they would add depth to the tract. (Figure 10) The tracheal rings did help, but in the end the glow effect worked best for creating volume. The glow effect is darkest in the center of the shape that has the effect applied, then becomes lighter and fades out.

### **Fact sheets**

The author wanted doctors, clinics and patients all over the world to be able to download or print out the fact sheets created. A doctor could simply need to distribute the information to one person, but a public clinic may want the PDF to print a large number of fact sheets at different times. A downloadable PDF seemed the most reasonable way to cheaply distribute the information and make it available to people across the globe. A patient may print the PDF out for

themselves on their home computer, while another person may print the information to give to a friend or family member that participated in the recovery efforts.

One of the first things the Medical Monitoring Program mentioned was the lack of money among all of the World Trade Center programs. Most likely, a clinic could only afford to make black and white copies of anything created. The Medical Monitoring Program also doubted that they could afford 4-color or even 2-color printing of the information. The fact sheets would most likely need to be created in grayscale, or the color document would need to translate well to a grayscale document when copied. Creating a full color document that was consistent and readable when reproduced proved to be a challenge. If the document was going to be viewed in grayscale by most of the intended audience, maybe a grayscale document should be created to ensure that all of the details would come across to the reader. (Figure 11) Four different fact sheets were designed for the four most common aerodigestive disorders experienced by those exposed to WTC dust. The author created Sinusitis, Rhinitis, Tracheo-laryngitis and Bronchitis fact sheets; each of which listed common symptoms of the disorder, along with when those symptoms were likely to appear. Each fact sheet also features a question that a patient may ask about the disorder, like “What are the sinuses?”.

### **Blue Symptoms Poster**

After getting a good start on the “World Trade Center Health Effects” animation, focus turned to designs for posters. At the beginning, Ms. Stein and the author decided there would be two different posters. One poster would advertise the World Trade Center Medical Monitoring Program at union halls, construction sites and other blue-collar jobsites throughout the city. The advertising poster is geared towards lower literacy individuals, just like the fact sheets. The author started off with very complicated ideas for the poster. She envisioned a poster showing many types of volunteers and workers on top of a pile of rubble, working together to clean up the site. She also wanted to draw two workers passing pieces of rubble to each other to show people working together towards a common goal. She planned to show male and female police

officers, firefighters and construction workers forming a chain of people handing pieces of steel and rubble down the line. At the end of the line would be a medical professional offering their hand to a construction worker. This image would serve as an analogy for how the World Trade Center Medical Monitoring Program wants to join hands with the Ground Zero workers to create a medical program to help them, just as the workers had helped at the disaster site. The first advertising poster made was meant to show appreciation for the job that the workers and volunteers did at Ground Zero, as well as to inform the workers that people are willing to do their part in helping them get well.

The first poster design idea immediately became difficult because the author wasn't sure how to draw or paint the rubble at Ground Zero accurately without offending anyone. This area was a graveyard for many families, and she didn't want to upset anyone by showing people standing on huge pieces of metal and rock. In reality, remains laid below the volunteers as cleanup efforts went on above. There are numerous photos of the wreckage, but the idea of how to represent it visually to these workers was still troubling. The author consulted with Ms. Stein, and she told the author that the program actually wanted a clear, more simplified poster to advertise the program to workers at job sites and union halls. The original sketches were left behind and brainstorming began on new ideas for the poster. The trip to New York City to meet with Ms. Stein, several doctors, and other members of the Medical Monitoring Program staff was coming up shortly. The author needed to have several mock-ups done by the time she went to NYC so she could press for decisions to be made in person about the direction of the artwork and the necessary text.

As a new proposal for the Medical Monitoring Program posters, three posters with text were designed to show Ms. Stein and her other team members in New York City. The first of the three new posters illustrated and explained the particles found in the World Trade Center dust that people were exposed to. It was thought that by showing images or illustrations of the tiny things making people sick, viewers would get a better understanding of their illness, and why damage could be done to the lungs. This poster also advertised the Medical Monitoring Program and mentioned the upcoming cut off date for benefit enrollment. (Figure 12)

The second advertising poster design showed some of the most common symptoms of World Trade Center related illnesses. The focus was on the symptoms of sinusitis, rhinitis, and tracheo-laryngitis. These diagnostic terms are pretty unfamiliar to the group of people being diagnosed. It was known from research that these three medical issues were extremely common amongst workers. To fully educate people about these conditions, it was important to show where the affected structures are located in comparison to the rest of the respiratory anatomy. This poster also advertised the program's name and contact information, as well as important dates regarding benefits registration.

A third poster with the same format and colors as the other two posters was also designed. This poster was meant to get the viewer to question whether or not they may have suffered exposure to World Trade Center dust. The poster informed viewers that anyone exposed to World Trade Center dust, whether they worked at Ground Zero or not, needed an exam to check for the symptoms of World Trade Center related illnesses. In March, the author brought printed and digital versions of the posters and other artwork up to New York City for her visit to the Medical Monitoring Program. On March 16, she met with a large group of people affiliated with the program, including her thesis advisor Diane Stein, who was the Director of Outreach and Education. The author also met several communications specialists, designers and physicians. She received a great deal of feedback, including suggestions for an additional poster that they wanted created.

The advertising poster and the clinical poster are the two posters the author planned to create from the beginning of the project. The poster focusing on who was exposed to World Trade Center dust was simply an idea that was being proposed to the group. The people from the World Trade Center Medical Monitoring Program were not interested in the poster about World Trade Center dust particles or the poster about who may have been exposed. It was decided that concentration should focus on creating the clinical poster, the advertising poster and a third poster proposed by the group. After discussing ideas for poster content at the meeting, the advertising poster became an ad for the program that showed the symptoms of World Trade Center dust exposure. Ms. Stein and her colleagues decided that the poster should include symptoms

illustrations because that would be eye-catching at job sites they were hung. The second poster worked on was created to hang on the walls of city clinics. The third poster proposed by people at the meeting was to show reasons that people kept coming back to the Medical Monitoring Program for checkups.

Healthcare follow through was seen as a big obstacle for the program, especially if the patient was feeling better. To encourage patients to return for an exam every six months, this poster would show real people and their reasons for returning. (Figure 13a) The quotes would mention an obligation to their family, the need to continue keeping respiratory ailments like asthma under control, and the fact that the healthcare was free. Since many of the people in the program were not insured at all, mentioning the cost effectiveness of the program seemed extremely important. In the end, a final version of this poster was never created. Several drafts of this poster were designed, but finishing the clinical poster, symptoms poster and the fact sheets became a priority for the Medical Monitoring Program.

The final version of the advertising poster (Figure 13d) included three symptoms symbols for tracheo-laryngitis, rhinitis and sinusitis. Next to each symbol was a description of the illness, for example; “Facial pain and inflammation of the sinuses” for sinusitis. The World Trade Center Health Effects logo is in the upper left hand corner next to the very prominent “World Trade Center Medical Monitoring Program” title in blue. The telephone number for the WTC Medical Monitoring Program is quite large underneath the symptoms symbols, and under it in smaller type is the program’s website address. There is no mention on the poster of a date you must register by to receive benefits.

### **Red Clinic Poster**

The clinical poster is intended for a doctor’s office or in a clinic where a doctor could help explain the complex anatomy to a patient. The viewer may only have minimal literacy skills, but their comprehension would be enhanced by the physician’s explanation. The same male character was shown in the clinical poster that was used in the symptoms poster, fact sheets and animation. Keeping the character the same as well as putting the same logo near the title

would help connect this poster to the rest of the body of work created. It was decided to have only one large figure shown from the waist up on this poster so that all of the respiratory structures could be shown as large as possible. A frontal, or coronal, view of the character was used instead of a sagittal view because this orientation would be most useful for the viewer to compare to their own anatomy. It would be difficult to show the digestive tract from the front because the respiratory tract is in front, blocking the view of it. A sagittal view left the author unable to represent the sinuses well. The sinuses are one of the more difficult structures to understand and imagine, so showing them correctly was more important than including the digestive tract. Only one color was used in the poster; a nice deep red to make the viewer associate the image with inflammation and tissue irritation. The blues used in the other poster wouldn't create enough contrast in the clinical poster. The main illustration of the male was created using only black line art, and red was just used to accent labeling and the title. (Figure 14)

## **Brochure**

After creating icon like graphics for the posters and fact sheets, the author prepared to work on the design of a brochure. She thought about the fact that not everybody is going to want to go home with 4 full sheets of paper to see if they have some of the symptoms listed. One compact, but still simple, informational piece was needed that included all of the symptoms focused on in the fact sheets. Most people are more likely to take a compact brochure home to see if they have any symptoms instead of taking four separate pieces of paper for themselves. People who have a friend or family member that is ill with a World Trade Center disaster related disease would probably prefer a small, compact way of presenting this information to their friend. It is not overbearing to say "oh, here, I thought of you when I saw this brochure. I thought you might want to take a look at it". Handing someone four full size sheets of paper may overwhelm them, because they could feel like people in their lives are pushing or persuading them into getting treatment.

The brochure is designed to look very similar to the fact sheets. It uses the same logo, font, and bullets as the fact sheets and contains the same icon like

graphics, only smaller. The author chose to simplify some of the information that is given in the fact sheet, and focus was put on the things that a person would need to know to tell if their symptoms match. It isn't redundant to have a brochure with information similar to that on the fact sheets, because the fact sheets and the brochure focus on two different kinds of viewers. A person with the fact sheet is more likely to pick up that handout because they have been diagnosed with the condition, and they want further information about it. A brochure is a summary of the fact sheets for those that feel that they are unsure about which specific condition they may have. (Figure 15)

The back panel of the brochure is used to place contact information, and some information that the fact sheets don't include. The back panel informs the reader that there are even more conditions than those illustrated in the brochure. It mentions that eye problems, digestive tract problems and mental health issues may also be affecting survivors. The back of the brochure is more crowded than the rest of the pages because it must fit a large amount of secondary information in a small space. This leaves a majority of the brochure dedicated to the most common symptoms. If the person reading the brochure has actually gotten to the last page, they must really be interested in learning about the illnesses shown inside the brochure. The text inside the brochure is large and minimal to make sure that someone doesn't glance at the complicated medical topics and put it back down. The reader should not feel that the information is too complicated to be understood by them at that point in time. Only the essential symptoms and information about the illness are mentioned in the brochure. The accompanying illustration visually represents the message to help illiterate or non-English speaking people.

## **Conclusion**

The four fact sheets, along with the brochure, were used as handouts at the thesis opening. Visitors walking by were able to pick up and bring home a portion of the thesis project. The author wanted people at the opening to be able to walk away with a sample of her artwork. Originally she created postcards for the thesis opening, but after thinking about it, she felt they were unnecessary. Artists generally use postcards to advertise their work, but they are not usually a

part of a public health campaign. It was better to only have the public health information available at a display table without the details of an art exhibit.

The two posters were hung up for people to see, and next to the table was a computer for people to view the WTC Health Effects animation. The two posters for the exhibit were printed at the RIT Print Center and were mounted on foam core to give them stability. An additional copy of each poster was printed and left un-mounted in case something happened to the original. The second copies of the posters were left rolled up, which would make them easier to ship than the large foam core versions when the people at Mt. Sinai wanted to see them. All of the posters were printed on a matte finish paper to keep them consistent with the rest of the materials printed. The fact sheets and brochures were printed on the author's home ink jet printer on matte white high-resolution inkjet paper. This high resolution paper gave the graphics and text crisp, clear lines without some of the bleeding that can occur in inkjet printing. Printing the items directly from the PDF and not photocopying them also insured that the fact sheets and brochures appeared high quality and consistent.

Not very many of the brochures were produced because it involved printing on one side of the high-resolution paper, then lining up the paper and putting it back into the printer so that the other side would be printed with the folds in the same place. This became very time consuming, so only a small number of brochures were printed for the gallery opening. More brochures were printed at a later time to keep at the display table throughout the exhibit period in the gallery. The printing of the fact sheets was uncomplicated, so plenty of each of the fact sheets were available at the thesis opening and throughout the gallery time. The author stopped by the thesis gallery every few days to make sure there were still enough copies of the brochure and fact sheets available to those viewing the exhibit after the opening.

The posters, brochures and fact sheets were only distributed at the thesis gallery location. They were never printed, used or distributed by the WTC Medical Monitoring Program. During the time the thesis was being created, funds became completely unavailable for production of educational materials by the WTC Medical Monitoring Program. They explained that once they received funding, they would be able to further discuss the content they wanted in the

posters and other artwork. Unfortunately, the author's thesis advisor, Diane Stein, left the WTC Medical Monitoring Program before those content decisions could be made.

The public health materials created may not have been used by the WTC Medical Monitoring Program in the end, but the author created her own public health campaign that is still available to view on the internet. The website (<http://www.erinneill.com/WTCHealth.com>) made all of the artwork available in one place after the thesis opening so that those unable to attend the opening would still have access to all of the artwork online. The four fact sheets and the brochure are still available for all to view, download and printout.

Individuals still suffer from WTC related illnesses today. This thesis may have only discussed in detail the conditions that occurred soon after the WTC collapse, but now in 2012, more conditions have been added to the list of WTC Related Health Conditions. A process has been developed to officially add a condition to the list and a survivor or responder can download a petition to send to the WTC Program Administrator from a new government website set up by the CDC. Many cancers have now been added to the list of WTC-Related Health Conditions for which a patient can receive coverage and treatment. There are now over fifty types of cancer that can be certified as WTC related health conditions. Cancers of the trachea, larynx, nasopharynx and esophagus have been listed along with mesothelioma, thyroid cancer and leukemia.

Almost a decade after the disaster, the James Zadroga 9/11 Health and Compensation Act of 2010 was passed by Congress. It combined all three Centers of Excellence into one federal government run program called The World Trade Center Health Program (WTC Health Program). Luckily, survivors and responders who were enrolled in the three programs created by the Centers of Excellence do not need to re-enroll in the new government program. New responders and survivors are still able to enroll, go through an exam, and receive treatment for any conditions a doctor certifies are WTC related. Newly enrolled survivors now go to the Bellevue Hospital Center for their initial exam and receive treatment at Bellevue Hospital, Elmhurst Hospital or Gouverneur Hospital. FDNY employees or retirees go to the Bureau of Health Services office in Brooklyn for their exam and have the option to choose from clinics in

Brooklyn, Staten Island, Queens, Bayside, Middletown or Manhattan. Mt. Sinai School of Medicine's Irving J. Selikoff Center for Occupational and Environmental Medicine is one of the ten official clinic locations a patient can go for treatment if they were enrolled in the WTC Health Program before January 2, 2011. Mt. Sinai's original website for World Trade Center Exams has been taken down and now a link to the site [www.cdc.gov/wtc](http://www.cdc.gov/wtc) is the replacement.

The new federal government website answers FAQs, has an option to apply for the program, search for a clinic, and also offers resources to responders and survivors. Unfortunately, none of the resources available are patient education or interactive materials on the medical conditions associated with the World Trade Center collapse. Right now, the WTC Health Program is only helping those in NY, but enrollment will begin for those at the Pentagon and the crash site near Shanksville, PA at the end of 2012.

1. Liroy, P.J., et al., Characterization of the dust/smoke aerosol that settled east of the World Trade Center (WTC) in lower Manhattan after the collapse of the WTC 11 September 2001. *Environ Health Perspect*, 2002. 110(7): p. 703-14.
2. Addressing the health impacts of 9-11 : report and recommendations to Mayor Michael R. Bloomberg. 2006, New York: [World Trade Center Health Panel. 83 p.
3. Brackbill, R.M., et al., Surveillance for World Trade Center disaster health effects among survivors of collapsed and damaged buildings. *MMWR Surveill Summ*, 2006. 55(2): p. 1-18.
4. Herbert, R., et al., The World Trade Center disaster and the health of workers: five-year assessment of a unique medical screening program. *Environ Health Perspect*, 2006. 114(12): p. 1853-8.
5. McGee, J.K., et al., Chemical analysis of World Trade Center fine particulate matter for use in toxicologic assessment. *Environ Health Perspect*, 2003. 111(7): p. 972-80.

6. Skloot, G., et al., Respiratory symptoms and physiologic assessment of ironworkers at the World Trade Center disaster site. *Chest*, 2004. 125(4): p. 1248-55.
7. Dalton, L., Chemical Analysis of a Disaster, in *Chemical and Engineering News*. 2003: Washington. p. 26-30.
8. Samet, J.M., A.S. Geyh, and M.J. Utell, The legacy of World Trade Center dust. *N Engl J Med*, 2007. 356(22): p. 2233-6.
9. West, J.B., *Pulmonary pathophysiology : the essentials*. 6th ed. 2003, Baltimore: Lippincott Williams & Wilkins. ix, 205 p.
10. O'Brien, D.W., et al., A mechanism of airway injury in an epithelial model of mucociliary clearance. *Respir Res*, 2004. 5: p. 10.
11. Prezant, D.J., World Trade Center Cough Syndrome and its treatment. *Lung*, 2008. 186 Suppl 1: p. S94-102.
12. Zarcadoolas, C., A.F. Pleasant, and D.S. Greer, *Advancing health literacy : a framework for understanding and action*. 1st ed. 2006, San Francisco, CA: Jossey-Bass. xxv, 368 p.
13. Webber, M.P., et al., Trends in respiratory symptoms of firefighters exposed to the world trade center disaster: 2001-2005. *Environ Health Perspect*, 2009. 117(6): p. 975-80.