Health information for workers that worked around

Diesel Exhaust

Study background

Two government agencies, the National Institute for Occupational Safety and Health (NIOSH) and the National Cancer Institute (NCI) did a study called the Diesel Exhaust in Miners Study. This study was done to find out if there is an association between exposure to diesel exhaust and the risk of lung cancer. The study was completed and published in two articles:
The Diesel Exhaust in Miners Study: A Cohort Mortality Study with Emphasis on Lung Cancer (http://www.ncbi.nlm.nih.gov/pubmed/22393207) and
The Diesel Exhaust in Miners Study: A Nested Case–Control Study of Lung Cancer and Diesel Exhaust (http://www.ncbi.nlm.nih.gov/pubmed/22393209).

How was the study done?

The Diesel Exhaust in Miners Study involved two health studies. The first health study was done by NIOSH. This study included 12,315 men and women workers in 8 non-metal mines located in Ohio, Missouri, New Mexico, and Wyoming. These individuals worked for at least 1 year during the time that diesel equipment was used. Workers that held only administrative or management positions were not included in the study. Records provided by the mines indicated that the first time diesel equipment was used occurred sometime between 1947 and 1967. The NIOSH study began by finding out how many of these workers were living as of December 31, 1997. Death records were looked at to see how many workers died of lung cancer and other diseases. These numbers of deaths were compared with death rates in the population of the states where the mines are located. This comparison allowed the researchers to see if more workers had died of lung cancer and other diseases than what would have been expected in the study group.

The second health study was done by NCI. It focused on 198 workers that had died of lung cancer as of December 31, 1997. These workers were selected from the 12,315 workers that were included in the NIOSH health study. NCI looked at the estimated levels of exposure in the jobs of workers that had died of lung cancer. NCI compared those levels with the levels of exposure in jobs of workers that had not died of lung cancer. Their study was able to adjust for other factors that cause lung cancer, such as smoking.

Both health studies looked at different groups of workers based on whether they worked above or below ground, and also by estimated level of diesel exhaust exposure. This allowed

the researchers to see if the risk of dying from lung cancer was different in workers based on different working conditions or levels of exposure to diesel exhaust.

A key part to each of these two health studies was to estimate the levels of diesel exhaust for each job within each department within each mine for each year between 1947 and 1997. This estimation process used air measurements and mine records on use of diesel equipment. See "How was diesel exhaust exposure estimated?" below for more information about the process.

How were the mines chosen?

Before starting this study, the researchers looked at 24 non-metal mines located throughout the United States to find the best to study. Out of these, 8 mines were chosen. The researchers requested that the mines participate and they agreed. The mines produced one of the following: salt, limestone, potash, or trona/ash. They shared these five things:

1. They had no or minimal levels of radon, silica, and asbestos. These substances in the air can cause lung cancer.
2. They employed a large number of workers for which exposure levels to diesel exhaust varied.
3. Personnel records were available on each worker.
4. Their historical and current records on diesel equipment used, horsepower ratings, and fuel consumption were available.
5. Historical monitoring data from sources such as the Bureau of Mines, Mine Safety and Health Administration (MSHA), and NIOSH were available.

What makes up diesel exhaust?

Exhaust from a diesel engine is a mix of gases, vapors, and small particles (see Figure 1). Measuring "diesel exhaust" directly cannot be done because it is a complex mixture. However, it is possible to measure its components. Elemental carbon is one component of diesel exhaust. It is considered the best index for assessing the level of diesel exhaust. The black smoke that is seen coming from a diesel engine is mostly carbon, and much of it is elemental carbon. The larger solid carbon spheres shown in Figure 1 are respirable elemental carbon particles. These particles are very small. They are capable of being inhaled and can be trapped in the lungs, if the lungs cannot exhale them. Another component of diesel exhaust is carbon monoxide. It is a gas that is commonly found in the exhaust of diesel engines.

How was diesel exhaust exposure estimated?

To estimate diesel exhaust exposures for a worker, the researchers chose to measure respirable elemental carbon and carbon monoxide. Air monitoring surveys were

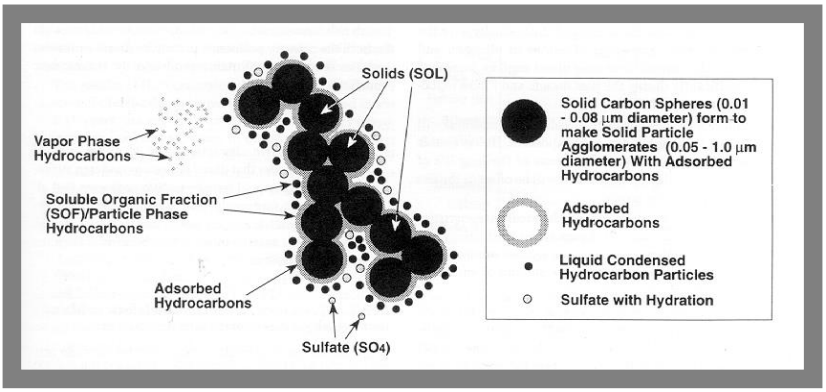

Figure 1. Source: Health Effects Institute. 1995. Diesel Exhaust: A Critical Analysis of Emissions, Exposure, and Health Effects. A Special Report of the Institute's Diesel Working Group. Health Effects Institute, Cambridge, MA.

done between 1998 and 2001 at the study mines. Air measurements for respirable elemental carbon, carbon monoxide and other gases, particles, and dust were taken. A total of 7,759 area and personal measurements were collected. Of this total, 1,156 respirable elemental carbon personal measurements, 216 respirable elemental carbon area measurements, and 208 carbon monoxide area measurements were taken. Prior to 1998, there were very few respirable elemental carbon measurements available. However, there were many carbon monoxide measurements taken regularly between 1976 and 1997. Each mine provided historical records on mine ventilation between 1970 and 1997. In addition, they provided records on type, frequency, and horsepower of diesel engines used between 1947 and 1997. Using all of these data allowed the researchers to estimate the levels of respirable elemental carbon (i.e., diesel exhaust) for each job a worker held from 1947 through 1997. Details of this process have been published in a series of five papers and they can be found at NCI's Web Site (http://dceg.cancer.gov/oeeb/research/exposureassessment/DEMS). These estimates of diesel exhaust levels for each job within a mine were then used in various ways in the two health studies. One way the researchers used these estimates was to calculate an average level of diesel exhaust each worker was exposed to for the total time a worker worked at the mine.

What are the study findings?

The study findings are based on results from both health studies. They are based on pooling data gathered from all eight mines. These findings do not necessarily represent the findings from any specific mine.

- The total number of workers was 12,315: 5,521 worked in trona/ash mining, 4,571 worked in potash mining, 1,676 worked in limestone mining, and 547 worked in salt mining.
- Of the total number of workers, 67% (8,307 out of 12,315) had an underground job and 33% (4,008 out of 12,315) had a surface job.
- Overall, workers had a lower risk of dying from a known cause compared to the population in all four states combined. 2,185 workers died of any cause, compared to 2,342 expected deaths based on rates in the population from all states combined.
- Of those 2,185 workers that died, the leading cause of death was heart disease followed by cancer of any kind. There were 582 workers that died of heart disease. There were 556 workers that died of cancer of any kind.
- Workers had a 26% higher risk of lung cancer compared to the population in all 4 states combined. 203 workers had died of lung cancer, compared to 161 expected deaths based on rates in the population from all states combined.
    - Workers that ever worked an underground job had a 22% higher risk of lung cancer compared to the population in all 4 states combined. 122 workers died of lung cancer, compared to 100 expected deaths based on rates in the population from all states combined.
    - Workers that only worked above ground had a 33% higher risk of lung cancer compared to the population in all 4 states combined. 81 workers died of lung cancer, compared to 61 expected deaths based on rates in the population from all states combined.

- Few other causes of death were more than expected. These are pneumoconiosis (for example, coal workers' pneumoconiosis), esophageal cancer, explosions, electrocutions, and drowning. None of these causes appeared to be related to how much diesel exhaust workers breathed.
- Workers that only worked above ground and reported that they were current smokers of at least 2 packs of cigarettes a day were 27 times more likely to die of lung cancer than never smokers.
- Workers that worked below ground and reported that they were current smokers of at least 2 packs of cigarettes a day were about 8 times more likely to die of lung cancer than never smokers.
- Workers exposed to higher estimated levels of diesel exhaust were about 3 to 5 times more likely to die of lung cancer than workers exposed to the lowest level of diesel exhaust.
    - Workers exposed to higher estimated levels of diesel exhaust and reported that they were never smokers were 7 times more likely to die of lung cancer than never smokers exposed to the lowest level of diesel exhaust.
    - Workers exposed to higher estimated levels of diesel exhaust and reported that they were current smokers of at least 2 packs of cigarettes a day were 17 times more likely to die of lung cancer than never smokers exposed to the lowest level of diesel exhaust.

What are the limits of this study?

All studies, no matter how carefully they are done, have limitations. There are two main limitations in this study. First, both health studies relied on estimates of a worker's exposure to diesel exhaust (i.e., respirable elemental carbon) while working at one of the study mines between 1947 and 1997. As described earlier, the estimation process relied on a variety of records and different sampling methods. This involved assumptions that were based on the researchers understanding of accepted scientific practice. The study's estimate of a worker's exposure to diesel engine exhaust will have a certain amount of error despite any level of effort to minimize this error. For more information about the evaluation of the exposure estimation process see "The Diesel Exhaust in Miners Study: V. Evaluation of the Exposure Assessment Methods" at NCI's Web Site (http://dceg.cancer.gov/oeeb/research/exposureassessment/DEMS).

Second, information on other risk factors associated with lung cancer was not available for the first health study. Smoking and risks found at other jobs held by workers before or after working in the study mines are examples of other risk factors. The second health study was able to collect and use data on smoking and other potential risk factors. A limitation of the second health study was that these data were obtained from interviews with the next-of-kin for those workers that died.

What does this study mean to you?

While this study is like others in the past that have suggested a possible association between exposure to diesel exhaust and cancer, this does not mean you will get lung cancer if you work near diesel equipment. Nor are these studies saying that working near diesel

equipment will cause you to die if you were diagnosed with lung cancer in the past. The study findings presented above are based on the combined results from eight mines. These findings may not necessarily represent the findings at any specific mine at which you worked.

There are many factors that can work together to contribute to any potential risk of getting lung cancer. If you work near diesel equipment that is operating, the nature of your job could affect your risk. For example, if part of your job requires you to exert more while doing a specific task then this may cause you to increase your breathing rate which may affect your risk. How often you work near diesel equipment, how long you are exposed to the exhaust from the diesel engines, the size of the diesel equipment, the age of the diesel equipment, how well the diesel engines are maintained, and the type of fuels used are important additional factors.

Your risk of getting lung cancer also depends on other factors outside of work conditions. Smoking raises your risk of getting lung cancer. You might be at more risk if cancer or other ailments, like chronic obstructive pulmonary disease (COPD) run in your family. To learn more about risk factors for lung cancer see the Centers for Disease Control and Prevention's Lung Cancer Risk Factors Web Site (http://www.cdc.gov/cancer/lung/basic_info/risk_factors.htm).

If you are still working at one of the mines in the study, your employer may already have taken a number of steps to reduce diesel exhaust levels at your mine. This study began in the late 1990's and the findings are based on diesel equipment used between 1947 and 1997. After 1990, advancements in equipment, fuels, and technology were being made. Old engines were being replaced with newer, cleaner engines. Mines began to improve their ventilation when diesel equipment began to increase in the mines. In addition, the MSHA Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners Standard (http://www.msha.gov/REGS/FEDREG/FINAL/2005finl/05-10681.pdf) requires mines to follow regulations and requirements for the use of diesel equipment and exposures from diesel equipment. All of these factors have contributed to the decreasing levels of diesel exhaust. However, exposure to exhaust from diesel equipment may still be a problem today. For example, some mines may still be using the older diesel engines. Ask your employer for information regarding its compliance with MSHA's standard on Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners.

On the job, the best way to reduce your risk of getting lung cancer and other health problems is not to smoke and to limit your excessive exposure to diesel exhaust. One way to limit your exposure to diesel exhaust is to use an air purifying respirator with filters certified by NIOSH for diesel particulate matter while working around diesel equipment. Especially, if your employer is not able to use venting or equipment to control the exhaust levels that are above the limits set by MSHA. Check with your health and safety manager at your worksite to learn about your employer's Respiratory Protection Program.

If your employer has a program to check your health, you should take part in it. If you currently smoke and your employer offers a smoking cessation program, you should take

advantage of the opportunity to participate in it. Recent studies show that a low radiation dose computerized tomography (LDCT) test can help detect lung cancer earlier in individuals at high risk of getting lung cancer. If you are or have been a heavy smoker, you should talk with your doctor about this test.

You should get medical help if you have trouble breathing, chest pain, cough a lot, or if you feel very tired without good reason. These could be signs of an illness that involves your breathing. Take a copy of this fact sheet to your doctor and talk about any possible risks you may face where you work.

Will this study matter?

This study adds to what is known about diesel exhaust and human health. The study findings were used in a June 2012 review by the International Agency for Research on Cancer that categorized diesel engine exhaust particles as a known human carcinogen. The study results were given to the Occupational Safety and Health Administration (OSHA) and MSHA. These agencies will use the results from this study when they decide whether to issue further regulations and guidance to control the level of diesel exhaust in the work place. In November 2012, OSHA and MSHA published a Hazard Alert for Diesel Exhaust/Diesel Particulate Matter (http://www.msha.gov/alerts/012013DPMAlert.pdf). These actions help protect the health of men and women that are around diesel equipment on the job.

Where can I learn more?

The following resources available on the Internet provide additional information for you on lung cancer, diesel exposure and health, MSHA's standard on diesel exposure, and respirator use. Your employer or former employer may have additional information for you. To request more information about the Diesel Exhaust in Miners Study send an email to NIOSHDEMS@CDC.gov.

Further questions about the Diesel Exhaust in Miners Study?

- Diesel Exhaust in Miners Study: Questions & Answers
  http://www.cancer.gov/newscenter/newsfromnci/2012/DieselMinersQandA

Questions about cancer?

- American Lung Association
  1-800-LUNGUSA (1-800-586-4872) http://www.lung.org/
- National Cancer Institute (NCI)
  1-800-4-CANCER (1-800-422-6237) http://www.cancer.gov/cancertopics/types/lung
- National Institute for Occupational Safety and Health (NIOSH)
  Science Blog on Cancer http://blogs.cdc.gov/niosh-science-blog/category/cancer/
- U.S. Preventive Services Task Force
  http://www.uspreventiveservicestaskforce.org/3rduspstf/lungcancer/lungcanrs.htm

Questions about diesel exposure and health?

- Environmental Protection Agency, Health Assessment Document for Diesel Engine Exhaust http://www.epa.gov/ttn/atw/dieselfinal.pdf
- International Agency for Research on Cancer (IARC) http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf
- Mine Safety and Health Administration (MSHA), Practical Ways To Reduce Exposure To Diesel Exhaust In Mining http://www.msha.gov/S&HINFO/TOOLBOX/DTBFINAL.htm

Questions about MSHA's Diesel Particulate Matter Standard?

- Mine Safety and Health Administration (MSHA), Part 11: Diesel Particulate Final Rules Single Source Page, Metal/Nonmetal Mines http://www.msha.gov/01-995/Dieselpartmnm.htm

Questions about respirators?

- National Institute for Occupational Safety and Health (NIOSH) http://www.cdc.gov/niosh/topics/respirators/
- Occupational Safety and Health Administration (OSHA) http://www.osha.gov/SLTC/respiratoryprotection/index.html