APPENDIX I

STAKEHOLDER AND PUBLIC REVIEW DOCUMENTATION

STAKEHOLDER MEETINGS

ABSTRACT FROM NEW MEXICO HEALTH CONFERENCE

MASS MAILING LETTERS

MAILING LISTS

NEWSPAPER ADVERTISEMENTS AND PRESS RELEASES
FOR OPEN HOUSES

POST CARDS

DUST-RELATED HEALTH STUDIES

State of New Mexico
ENVIRONMENT DEPARTMENT
AIR QUALITY BUREAU
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502-6110
Telephone (505) 827-0031
Fax (505) 827-0045

GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

October 27, 2000

Dear Potential Stakeholder for the Natural Events Action Plan:

We are delighted that so many of you were able to take time away from your busy schedules to attend the Natural Events Action Plan (NEAP) - Stakeholder meeting held in Las Cruces on October 17, 2000. We were also very pleased with the input we received from you. I have enclosed a copy of the slides from each of the presentations made at the morning session of the meeting. We have also developed a draft outline of a general stakeholder agreement much like the one developed at the October 17th meeting, should anyone like a copy.

For those of you already working on an agreement, please feel free to call us if you need assistance.

If you happen to be one of the potential stakeholders who were unable to attend the meeting we would be glad to answer any questions you may have regarding this material. We will also be contacting stakeholders individually, who are not already participating in the NEAP, about stakeholder agreements. As always we would like to meet with any of you to discuss the development of stakeholder agreements.

Please remember that we have to submit the Doña Ana County Natural Events Action Plan to EPA-Region 6 by the end of this year for their approval. So, the sooner we can meet with those of you we haven't met with, the better. If you have any questions or need further information please feel free to call us at 1-800-810-7227 and ask for Kim Kirby, Gail Cooke, or Steve Dubyk. Thank you for your support and cooperation on the development of the Doña Ana County NEAP.

Sincerely,

Kimberly D. Kirby

GARY E. JOHNSON
GOVERNOR

State of New Mexico
ENVIRONMENT DEPARTMENT
AIR QUALITY BUREAU
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502-6110
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PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

October 6, 2000

Dear Potential Stakeholder:

We are hosting two gatherings that you are invited to participate in that concern keeping dust down and growth up in Doña Ana County.

1. **We would like to invite you to come and browse an Open House:**

October 11, 2000 Wednesday Hatch Community Center 837 W. Hall 4pm - 8pm	October 12, 2000 Thursday Sunland Park City Council Chambers 3800 McNutt Rd. 9am - 9pm	October 13 and 14, 2000 Friday 9am - 9pm Saturday 8am - Noon Mesilla Park Recreation Center 304 Bell Ave., Mesilla Park

2. Stakeholder Meeting (see attached schedule):

- Presentations by: EPA Representatives, NM Air Quality Bureau, & various dust control vendors.
- Tuesday, Oct. 17, from 8am to 5pm
- Mesilla Park Recreation Center, 304 Bell Ave.

We look forward to meeting with you and discussing what can be done to help. We hope that you are able to attend, and if not, we would be delighted to meet with you at your earliest convenience. If you have any question or need further information please call Kim Kirby at (505) 827-0048. I will be out of the office from October 11 to the 18th, so during that time please call Steve Dubyk at (505) 827-2859.

Sincerely,

Kimberly Kirby

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GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

For Immediate Release
November 1, 2000

Contact: Kim Kirby, Env. Sci., Air Quality Bureau
Phone: (505) 827-0048
Contact: Cathy Tyson, PIO, NMED
Phone: (505) 827-2855

STATE ENVIRONMENT DEPARTMENT HOLDING MEETINGS ON DOÑA ANA COUNTY DUST AND AIR QUALITY

(Santa Fe, NM) – The New Mexico Environment Department's Air Quality Bureau invites the public to attend "open houses" designed to provide information and solicit ideas about a plan for reducing dust, sustaining growth and improving health in the area.

There will be no formal presentations, just a relaxed self-guided tour with staff available to answer questions. NMED is soliciting the public's thoughts, ideas, comments, and concerns in order to tailor the plan to local needs. The open house in Sunland Park will also include a separate section with information about Camino Real Landfill's operating permit and collection and control systems. The meeting times and locations are:

November 8, 2000
Wednesday 9 am –7 pm
Sunland Park
City Council Chambers
3800 McNutt Rd.

November 13 & 14, 2000
Monday 1pm - 7 pm
Tuesday 8 am – 6 pm
Mesilla Park Recreation Center
304 W. Bell Ave., Mesilla Park

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GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

For Immediate Release
October 4, 2000

Contact: Kim Kirby, Env. Sci., Air Quality Bureau
Phone: (505) 827-0048
Contact: Cathy Tyson, PIO, NMED
Phone: (505) 827-2855

STATE ENVIRONMENT DEPARTMENT HOLDING MEETINGS ON DONA ANA DUST AND AIR QUALITY

(Santa Fe, NM) - The New Mexico Environment Department's Air Quality Bureau invites the public to attend "open houses" designed to provide information and solicit ideas about a plan for reducing dust, sustaining growth and improving health in the area.

There will be no formal presentations, just a relaxed self-guided tour with staff available to answer questions. NMED is soliciting the public's thoughts, ideas, comments, and complaints in order to tailor the plan to local needs. The meeting times and locations are:

OCTOBER 11, 2000
WEDNESDAY
HATCH
COMMUNITY CENTER
837 W. HALL
4PM - 8PM

OCTOBER 12, 2000
THURSDAY
SUNLAND PARK
CITY COUNCIL CHAMBERS
3800 MCNUTT RD.
9AM - 9PM

OCTOBER 13 AND 14, 2000
FRIDAY 9AM - 9PM
SATURDAY 8AM - NOON
MESILLA PARK RECREATION CENTER
304 W BELL AVE., MESILLA PARK

###

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GARY E. JOHNSON
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PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

For Immediate Release
October 4, 2000

Contact: Kim Kirby, Env. Sci., Air Quality Bureau
Phone: (505) 827-0048
Contact: Cathy Tyson, PIO, NMED
Phone: (505) 827-2855

STATE ENVIRONMENT DEPARTMENT ASSISTS DONA ANA COUNTY IN DEVELOPING "DUST MANAGEMENT" PLAN

(Santa Fe, NM) - The New Mexico Environment Department (NMED) is assisting Doña Ana County in developing a Natural Events Action Plan (NEAP). This Plan is being required by the U.S. Environmental Protection Agency (EPA) to combat the increase in human-caused dust that has resulted in unhealthful levels of particulate matter (windblown dust).

In the past, particulate matter, or blowing dust, levels such as those observed in Doña Ana County would have resulted in an area being designated "non-attainment" by EPA. With such a non-attainment status comes the stigma of being an unclean and undesirable area to live. Moreover, the stigma could be coupled with expensive requirements, such as more stringent controls on transportation, construction or industry. Current EPA policy provides the opportunity for areas with high dust levels due to natural events (like wind) to develop a NEAP.

The U.S. EPA has requested that local governments and the NMED develop a plan (the NEAP) to reduce adverse health effects from human-caused dust in this area. If this is done, the EPA will not require mitigation techniques, which are often unsuitable for New Mexico's particulate problem. Furthermore, this approach gives more control, along with responsibility, to local government agencies.

more --

The plan must address measures for reducing windblown dust from contributing man-made sources, such as land clearing and dirt roads, when and where possible. The plan is not meant to address naturally occurring, wind-blown dust.

Under the Federal Clean Air Act, the EPA has established maximum standards for six major air pollutants, one of which is particulate matter. These six pollutants are called "criteria" pollutants because the limits were set using health-based criteria. Studies continue to show that breathing small dust particles irritates the lungs and can trigger allergic reactions as well as asthma attacks.

The NMED has been working with local government entities in an effort to complete and submit the NEAP by the end of this year. The City of Las Cruces has taken an active role in developing a regulation that will limit the amount of dust within the city limits. Doña Ana County is also being asked to regulate industries or activities that generate particulate matter. The NMED, in its' quest to help develop a NEAP for the County, is now asking those stakeholders not under City or County jurisdiction to voluntarily take steps to control blowing dust.

If an adequate NEAP is *not* developed for Doña Ana County by December 2000, the U.S. EPA may designate this area as "non-attainment" for particulate matter. This could trigger a number of federal requirements and generally impact on the ability of Las Cruces and Doña Ana County to develop. These requirements could restrict the influx of new businesses into the area, area construction and development, and may affect road and highway construction and maintenance.

For more information, please contact Kim Kirby or Gail Cooke at 1-800-810-7227.

###

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GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

November 17, 2000

Mr. Donnie Quintana
Assistant Director
New Mexico Economic Development Department
Economic Development Division
Joseph Montoya Building
1100 St. Francis Drive
Santa Fe, New Mexico 87505

Dear Mr. Quintana:

I feel it is important to inform you that Doña Ana County is currently faced with a situation that could be detrimental to economic growth, tourism, and public health. The situation is caused by windblown dust generated during high winds from man-made sources. Local government staff from Doña Ana County and the City of Las Cruces, assisted by the state's Environment Department, have been working on this windblown dust issue for the last few years. Both Las Cruces and Doña Ana County either have or are currently developing local dust control ordinances. However, additional support is now needed from all stakeholders.

The Air Quality Bureau of the New Mexico Environment Department has arranged a meeting with the U.S. Environmental Protection Agency Region VI personnel in Santa Fe on November 20, 2000, to discuss this important issue. Economic Development Department management and staff members are encouraged to attend. The meeting agenda is enclosed with this letter. The meeting will be held at the State Highway and Transportation Department building, 1120 Cerrillos Road, in Santa Fe, in Training Rooms 1 and 2, at 10:30 a.m. Other state agency personnel may also be attending this meeting.

I'm asking all stakeholders for your full support of Doña Ana County's local governments in doing what is needed to prevent the area from being designated non-attainment by the U.S. EPA. Your support is crucial to the success of this project.

I have included a briefing package so that you may be fully informed on this serious and immediate economic and environmental issue. Please call Kim Kirby at 827-0048, or Steve Dubyk at 827-2859 if you have any questions or require additional information. I thank you for your time and consideration on this matter, and I look forward to your support.

Sincerely,

Peter Maggiore
Cabinet Secretary

Attachments: Briefing Document
Dust Storms and Health brochure
Natural Events Fact Sheet
November 20, 2000 Meeting Agenda

GARY E. JOHNSON
GOVERNOR

State of New Mexico
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PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

November 17, 2000

Dr. Kathleen Forrer
Chief Financial Officer
New Mexico Department of Education
300 Don Gaspar
Santa Fe, New Mexico 87501-2786

Dear Dr. Forrer:

I feel it is important to inform you that Doña Ana County is currently faced with a situation that could be detrimental to economic growth and public health. The situation is caused by windblown dust generated during high winds from man-made sources. Local government staff from Doña Ana County and the City of Las Cruces, assisted by the state's Environment Department, have been working on this windblown dust issue for the last few years. Both Las Cruces and Doña Ana County either have or are currently developing local dust control ordinances. However, additional support is now needed from all stakeholders, including public schools.

The Air Quality Bureau of the New Mexico Environment Department has arranged a meeting with the U.S. Environmental Protection Agency Region VI personnel in Santa Fe on November 20, 2000, to discuss this important issue. Department of Education management and staff members are encouraged to attend. The meeting agenda is enclosed with this letter. The meeting will be held at the State Highway and Transportation Department building, 1120 Cerrillos Road, in Santa Fe, in Training Rooms 1 and 2, at 10:30 a.m. Other state agency personnel may also be attending this meeting.

I'm asking all stakeholders for your full support of Doña Ana County's local governments in doing what is needed to prevent the area from being designated non-attainment by the U.S. EPA. Your support is crucial to the success of this project.

I have included a briefing package so that you may be fully informed on this serious and immediate economic and environmental issue. Please call Kim Kirby at 827-0048, or Steve Dubyk at 827-2859 if you have any questions or require additional information. I thank you for your time and consideration on this matter, and I look forward to your support.

Sincerely,

Peter Maggiore
Cabinet Secretary

Attachments: Briefing Document
Dust Storms and Health brochure
Natural Events Fact Sheet
November 20, 2000 Meeting Agenda

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GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

November 17, 2000

Mr. Peter Rahn
Cabinet Secretary
New Mexico State Highway and Transportation Department
1120 Cerrillos Road
P.O. Box 1149
Santa Fe, New Mexico 87504-5100

Dear Secretary Rahn:

I feel it is important to inform you that Doña Ana County is currently faced with a situation that could be detrimental to economic growth, tourism, and public health. The situation is caused by windblown dust generated during high winds from man-made sources. Local government staff from Doña Ana County and the City of Las Cruces, assisted by the state's Environment Department, have been working on this windblown dust issue for the last few years. Both Las Cruces and Doña Ana County either have or are currently developing local dust control ordinances. However, additional support is now needed from all stakeholders.

The Air Quality Bureau of the New Mexico Environment Department has arranged a meeting with the U.S. Environmental Protection Agency Region VI personnel in Santa Fe on November 20, 2000, to discuss this important issue. New Mexico State Highway and Transportation Department management and staff members are encouraged to attend. The meeting agenda is enclosed with this letter. The meeting will be held at the State Highway and Transportation Department building, 1120 Cerrillos Road, in Santa Fe, in Training Rooms 1 and 2, at 10:30 a.m. Other state agency personnel may also be attending this meeting.

I'm asking all stakeholders for your full support of Doña Ana County's local governments in doing what is needed to prevent the area from being designated non-attainment by the U.S. EPA. Your support is crucial to the success of this project.

I have included a briefing package so that you may be fully informed on this serious and immediate economic and environmental issue. Please call Kim Kirby at 827-0048, or Steve Dubyk at 827-2859 if you have any questions or require additional information. I thank you for your time and consideration on this matter, and I look forward to your support.

Sincerely,

Peter Maggiore

Peter Maggiore
Cabinet Secretary

Cc: Judith James, Environmental Program Manager, NMSHTD

Attachments: Briefing Document
Dust Storms and Health brochure
Natural Events Fact Sheet
November 20, 2000 Meeting Agenda

New Mexico Environmental Health Conference

NMEHC-2000

October 23-25, 2000

Albuquerque Convention Center • Albuquerque, New Mexico, USA

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With a focus on Global, National, Regional, Community and Border Issues

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The WERC Conference on the Environment

ABSTRACTS

(Alphabetical by Presenter)

KIRBY-O'NEIL, Kimberly, New Mexico Environment Department, Air Quality Bureau, Environmental Scientist

Track Air Quality

Topic/Title Grappling with Dust Storms and Health in New Mexico

Authors Kimberly Kirby-O'Neil, Environmental Scientist, New Mexico Environment Dept., Air Quality Bureau; Michael D. Smith, Albuquerque Environmental Health Dept., Air Quality Division

Abstract Dust storms generated by high winds have caused unhealthful levels of airborne particulate matter within the state of New Mexico. Two of the state's largest and fastest growing economic areas find themselves required to implement measures addressing this problem. How the issue is dealt with will impact New Mexico's industries and public, however, to what extent depends on the avenue of implementation.

Particulate matter of 10 microns or less (PM10) is an air pollutant that is regulated by the federal Environmental Protection Agency (EPA) under the National Ambient Air Quality Standards. Studies show that elevated levels of PM10 may aggravate asthma and other respiratory problems.

To protect public health, EPA designates areas where PM10 levels exceed federal standards as "nonattainment areas." State and local governments must then adopt plans to reduce air pollution in these areas in order to protect public health. Federal requirements for these areas are focused on reducing air pollution from industries and motor vehicles. However, we know that the traditional approach of controlling factories and tailpipe emissions won't fix a PM10 problem due to natural events such as blowing dust raised by high winds.

At the urging of western states, EPA agreed to try a more common sense approach to the problem. In June 1996, EPA adopted a new policy for natural events. The Natural Events Policy offers states flexibility in meeting the PM10 standard, while still providing for public health protection. This policy outlines requirements in general terms and urges local stakeholder involvement in developing the actual plan. These general requirements include public health education, public notification, and control of human-caused sources of windblown dust where feasible and effective. If a state develops and implements a plan that responds to public health effects impacted by natural events, EPA will not designate the area as nonattainment.

Biography Kimberly Kirby-O'Neil is an Environmental Scientist in the Control Strategy Section of the New Mexico Environment Department's Air Quality Bureau. She is currently concentrating on the development and implementation of a Natural Events Action Plan for Doña Ana County. She also deals with other dust issues and agriculture burning, as well as with the Small Business Assistance Program. Ms. Kirby-O'Neil holds a Masters of Science degree in Animal Science and a Bachelor of Science degree in Agriculture Economics and Animal Science, both from New Mexico State University. Previous work experience includes working as a Production Team Advisor, QA/QC Specialist for environmental remediation projects, and Agriculture Consultant for a bioremediation firm.

Contact
Kimberly Kirby-O'Neil
NM Environment Department
PO Box 26110
Santa Fe NM 87502

KNOWLTON, Robert G., Mission Research Corporation and HydroTechnics, Inc.

Track Technology Deployment

Topic/Title Innovative Groundwater Flow Sensors and Groundwater Modeling Applied to the Fruit Avenue Plume Superfund Site

Authors Robert G. Knowlton, PhD, P.E. and Martha Moses, Mission Research Corporation and HydroTechnics, Inc.

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GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

September 6, 2000

Dear Interested Party:

The New Mexico Environment Department (NMED) is asking for your assistance with the Dona Ana County **N**atural **E**vents **A**ction **P**lan (NEAP). This Plan is being required by the US Environmental Protection Agency (EPA) to combat the increase in man-made dust that has caused exceedances in the levels of particulate matter (windblown dust) since 1996. I have included for your information a factsheet and brochure so that you may better understand the option of a NEAP.

The Federal Clean Air Act of 1970 established maximum standards for six major air pollutants, one of which is particulate matter. These six pollutants are called “criteria” pollutants because the limits were set using health-based criteria. Studies continue to show that breathing small dust particles irritates the lungs and can trigger allergic reactions as well as asthma attacks. Please refer to the “Dust Storms and Health” brochure included.

In the past, exceedances such as those observed in Doña Ana County would have resulted in an area being designated non-attainment. With such a non-attainment status comes the stigma of being an unclean and undesirable area to live. Moreover, the stigma would be coupled with burdensome and expensive requirements, shouldered by both local and state governments, as well as local businesses.

The US EPA has requested that the NMED develop a plan (the NEAP) to reduce adverse health effects from dust in this area. This means that if we do what we reasonably can to inform the public and protect health, the EPA will not require mitigation techniques that may be unsuitable for New Mexico’s situation. Furthermore, this approach gives more control, along with responsibility, to local government agencies. The plan must include measures for reducing windblown dust from contributing man-made sources when and where possible.

The NMED has historically viewed development of the NEAP by both state and local affected entities as the key to a successful submittal of this document. The NMED has been working with local governmental entities in an effort to complete and submit the NEAP by the end of this year. The City of Las Cruces has taken an active role in developing regulation that will limit the amount of dust within the city limits. Dona Ana County is also being asked to regulated industries or activities that generate particulate matter. The NMED, in its' quest to help develop a NEAP for the County, is now asking those stakeholders not under City or County jurisdiction to voluntarily take steps to control PM10 from property and facilities that they control.

If an adequate NEAP is *not* developed for Dona Ana County by December 2000, the US EPA will designate this area as "non-attainment" for PM10. This will trigger a number of onerous federal requirements and generally have a negative impact on the ability of Las Cruces and Dona Ana County to develop economically and regulate their own resources. These requirements may restrict the influx of new businesses into the area, area construction and development, and may affect road and highway construction and maintenance.

If you would like to receive more information or be actively involved in the NEAP development, please contact Kim Kirby or Gail Cooke at 1-800-810-7227. We look forward to hearing from you.

Sincerely,

Sandra Ely
Bureau Chief
Air Quality Bureau

Enc.: Dust Strom and Health Brochure
Particulate Air Pollution Factsheet

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GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

Addressee
Title/business
Street Address
Town, NM zip

September 1, 2000

Dear Political Official:

I feel it is important to inform you that Doña Ana County is currently faced with a situation that could be detrimental to economic growth, tourism, and public health. The situation is caused by windblown dust generated during high winds from man-made sources. Local government staffs from Doña Ana County and the City of Las Cruces, assisted by the state's Environment Department, have been working on this windblown dust issue for the last few years. However, additional support is now needed.

I have included a briefing package so that you may be fully informed on this serious and immediate economic and environmental issue. In short, due to high readings of particulate matter (PM10, otherwise know as airborne dust) in Doña Ana County's air, US EPA has informed us that we have only two options regarding the air quality status for this area:

- Non-attainment status for particulate matter (dust). Becoming a non-attainment area can be detrimental to economic development, requiring more stringent controls for existing industry and new businesses. Furthermore, non-attainment status bears with it a stigma of an area being dirty and polluted, which could affect tourism and retirement community growth. It also means more complex air quality permitting requirements for new and expanding businesses, as well as more burdensome requirements for city, county and state road development and maintenance.

- Attainment status, with an adequate Natural Events Action Plan (NEAP) in place by the end of this year. The attached briefing package contains information regarding what must be accomplished within the next few months in order for the area to have an adequate NEAP (refer to page 5).

I'm asking for your full support of Doña Ana County's local governments in doing what is needed to prevent the area from being designated non-attainment by the US EPA. Your support is crucial to the success of this project.

Should you require further information on this issue, my staff and I would be delighted to provide you with further information or a presentation. Please call Jim Najima, Environmental Protection Division Director at (505) 827-2932. I thank you for your time and consideration on this matter, and look forward to your support.

Sincerely,

Peter Maggiore
Cabinet Secretary
New Mexico Environment Department

Enc.: Briefing Package
Dust Storms and Health brochure

State of New Mexico
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PETER MAGGIORE
SECRETARY

PAUL R. RITZMA
DEPUTY SECRETARY

«FirstName» «LastName»
«JobTitle»
«Company»
«Address1»
«City», «State» «PostalCode»

September 5, 2000

Dear Stakeholder:

The New Mexico Environment Department (NMED) has identified you as a potential stakeholder that may have a vested interest in developing and implementing the **N**atural **E**vents **A**ction **P**lan (NEAP) for Doña Ana County. We are seeking your assistance for this process. This Plan is being required by the US Environmental Protection Agency (EPA) to combat the increase in man-made dust that has caused exceedances in the levels of particulate matter (windblown dust) since 1996. I have included a briefing package so that you may be fully informed on this serious and immediate economic and environmental issue.

The NMED has historically viewed development of the NEAP by both state and local affected entities as the key to a successful submittal of this document. The NMED has been working with local governmental entities in an effort to complete and submit the NEAP by the end of this year. The City of Las Cruces has taken an active role in developing regulation that will limit the amount of dust within the city limits. Doña Ana County is also being asked to regulated industries or activities that generate particulate matter. The NMED, in its' quest to help develop a NEAP for the County, is now asking those stakeholders not under City or County jurisdiction to voluntarily take steps to control PM10 from property and facilities that they control.

The sources of windblown dust in this area include unpaved roads and parking lots, construction sites, unpaved industrial and storage areas, laydown yards, bladed undeveloped area, and shoulders of paved roads. The NMED has identified several stakeholders within Doña Ana County who can make a significant contribution in reducing windblown dust. The NMED is requesting that stakeholders help develop a list of **B**est **A**vailable **C**ontrol **M**easures (BACMs) for dust controls at these sites, which can include:

- Revegetating bladed undeveloped areas.
- Landscaping, including the use of low-water use vegetation.
- Covering areas with geotextiles.
- Using of chemical dust suppressants on unpaved high traffic areas.
- Using organic stabilizers and mulches on cleared undeveloped areas.
- Staging site construction to reduce dust from bladed areas.
- Planning construction or other land-use projects to include dust control and suppression.
- Conducting educational programs to show citizens of the community what they can do to reduce windblown dust from their properties.

The NMED feels that Doña Ana County stakeholders have much to offer by developing BACMs for their sites, since site conditions are variable throughout the County, and vary according to land use. Therefore, we request that stakeholders identify the areas and the methods that they are willing to include for the development of a satisfactory and successful NEAP.

I look forward to working with you on this important issue of controlling man-made sources of dust in Doña Ana County. If you require additional information about this program and BACMs, please call Kimberly Kirby at the New Mexico Air Quality Bureau at 1-800-810-7227, or (505) 827-0048.

Sincerely,

Jim Najima
Division Director
Environmental Protection Division
New Mexico Environment Department

Enc.: Briefing Package
Dust Storms and Health brochure

State of New Mexico
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GOVERNOR

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STATE ENVIRONMENT DEPARTMENT HEALTH ADVISORY

DOÑA ANA COUNTY DUST AND AIR QUALITY

(Santa Fe, NM) – The New Mexico Environment Department's (NMED) Air Quality Bureau along with the City of Las Cruces and Doña Ana County would like to alert all citizens of Doña Ana County of the risks associated with dust storms.

A combination of weather conditions, features of the natural environment, and human activity can cause dust storms. High winds can raise large amounts of dust from areas of dry, loose, exposed soil. In the Doña Ana County area, high winds are most common during January through April.

Dust storms can cause a number of serious health problems and can make some health problems worse. It can irritate the lungs and trigger allergic reactions, as well as asthma attacks. For people who already suffer from these conditions dust can cause serious breathing problems. Dust can also cause coughing, wheezing and runny noses. Breathing large amounts of dust for prolonged periods can result in chronic breathing and lung problems.

Breathing too much dust can potentially harm anyone. However, the following groups run the highest risk of potentially being adversely affected by a dust storm.

- Infants, children, and teens
- Elderly

- Peoples with asthma, bronchitis, emphysema, or other respiratory conditions
- People with heart disease
- Pregnant women
- Healthy adults working or exercising vigorously outdoors

There are several different ways to protect yourself from a dust storm. The best precaution is simply to avoid going outside during severe dust storms. If you must go outside, spend as little time outside as possible and avoid hard exercise. Wearing some type of covering over your nose and mouth can provide some protection from large particles.

For more information on the risks associated with dust storms please see the NMED's website at www. nmenv.state.nm.us, click on " Air Quality Bureau" or contact Helly Diaz-Marcano at (505)524-6300.

AIR QUALITY BUREAU

Our Mission: To protect the inhabitants and natural beauty of New Mexico by preventing the deterioration of air quality

New Mexico
Environment Dept.

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P.O. Box 26110
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OPEN HOUSES
Keeping Dust Down and Growth Up in Doña Ana County
(Natural Events Action Plan)

The State Air Quality Bureau and local governments and stakeholders are developing a plan for reducing dust, sustaining growth and improving health in Doña Ana Co. The open houses are designed to provide you with information and solicit your comments. **We are very interested in your thoughts, ideas, comments, and concerns. We look forward to visiting with you. So, join us at:**

Sunland Park City Council Chambers

3800 McNutt Rd, Sunland Park

November 8th, 9 am to 7 pm

OR

Mesilla Valley Recreation Center

304 W. Bell Ave., Mesilla Park

November 13th, 1 pm to 7 pm

November 14th, 8 am to 6 pm

OPEN HOUSE
Keeping Dust Down and Growth Up in Doña Ana County

New Mexico Environment Department
Air Quality Bureau

The State Air Quality Bureau and local governments and stakeholders, are developing a plan for reducing dust, sustaining growth and improving health in Doña Ana County. We encourage your participation at this open house to develop Doña Ana County's Natural Events Action Plan. The open house is designed to provide you with information and encourage your input. **We are very interested in your thoughts, ideas, comments, and concerns. We look forward to visiting with you.**

This open house will also include a separate section with information about Camino Real Landfill's operating permit and collection and control systems.

Join us at: **Sunland Park City Council Chambers**
3800 McNutt Rd., Sunland Park
November 8, 2000
9 am to 7 pm

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Our Mission: To protect the inhabitants and natural beauty of New Mexico by preventing the deterioration of air quality

Survei lance for Dust Storms and Respiratory Diseases n Washington State, 1991

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ABSTRACT. Southeast Washington State, which has a long history of seasonal dust storms, experienced 2 d of dust storms in October 1991, during which PM_{10} levels exceeded 1 000 $\mu g/m^3$ (i.e., six times greater than the Environmental Protection Agency's 24-h PM_{10} standard). Three community hospitals in southeast Washington were visited for the purpose of assessing the possible effects of dust storms on respiratory health. During these visits, the number of emergency room visits for respiratory disorders for each day of 1991 were abstracted. These numbers were compared with daily PM_{10} levels for 1991. Also determined were the observed/expected ratios for the number of emergency room visits for each respiratory disorder category during October 1991. The maximum observed/expected ratio for the respiratory disorders was 1. 2. For 1991, we found a 3.5% increase in the number of daily emergency room visits for bronchitis for each 100 $\mu g/m^3$ increase in PM_{10}. In addition, 2 d subsequent to those days on which the PM_{10} levels exceeded 150 $\mu g/m^3$, there was a 4.5% increase in the number of emergency room visits for sinusitis for each 100 $\mu g/m^3$ increase in PM_{10}. Our results indicate that the naturally occurring PM_{10} in this setting has a small effect on the respiratory health of the population in general.

SOUTHEAST WASHINGTON STATE has a long history of seasonal dust storms. Reportedly, the dust-storm phenomenon takes place a number of times each spring and fall and occurs when high-velocity gales from the Columbia River basin reach the arid plains of eastern Washington, during which particulate matter is dispersed into the atmosphere. Notations in the Lewis and Clark diaries of October 1805 concerning the Columbia River basin in southwest Washington and Oregon record the high wind velocities the explorers encountered in the area. Later, a historian described "a miserable country" in which "westerly winds came inland from the sea to send stinging clouds of dust and sand whirling in every direction."[1]

Modern cultivation of the region, which denudes some of the land, and a regional 5-y drought have been accused of making the dust storms more severe. The purpose of this investigation was to determine what effects these dust storms, particularly thoracic particulate matter less than 10 μ in diameter (PM_{10}), may have had on respiratory health in 1991. We were specifically interested in examining the effect that very high PM_{10} levels (> 1 000 $\mu g/m^3$) during October 1991 (October 16 and

21) had on the number of visits to emergency rooms for respiratory disorders. The Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards for PM_{10} that include a maximum level of 150 μg/m³ over a 24-h period and a maximum average level of 50 μg/m³ over a 1-y period.[2]

Materials and methods

In an effort to investigate the possible effects of dust storms on respiratory health, in April 1991 we visited three community hospitals in Richland, Pasco, and Kennewick, the three cities that constitute the Tri-Cities area of Washington State. Data collection involved the review of emergency room logs at each of the hospitals to abstract the total number of emergency room visits and the number of emergency room visits for respiratory disorders. The respiratory disorders categorized were otitis media, bronchitis, upper respiratory tract infections (including rhinitis and viral syndromes), pharyngitis (also included tonsillitis and laryngitis), sinusitis, croup, pneumonia (all types), asthma, influenza, bronchiolitis, and chronic obstructive pulmonary disease (COPD). The total number of emergency room visits and the number of emergency room visits for each of the disorders were determined for each day during October 1990 and for all months of 1991. Information from October 1990 was collected and compared with data from October 1991.

A dust storm day was defined as a day with blowing dust that resulted in visibility of 5/8 of a mile or less (which is the definition of a dust storm day used by Batelle, Pacific Northwest Laboratories) or as a day with blowing dust and a peak windspeed of 20 miles per hour (mph) or greater.

Daily PM_{10} data for the Tri-Cities area was obtained from the Washington Department of Ecology. The PM_{10} samples were collected on top of a building in Kennewick, Washington, on microquartz fiber filters with a high-volume PM_{10} sampler for 24 h; gravimetric analysis was performed on all samples after collection.[3] Other environmental pollutants are not measured in the Tri-Cities area. Meteorological data were obtained for the area (daily mean temperature, humidity, windspeed, and visibility) from Batelle, Pacific Northwest Laboratories, Richland, Washington.

The SAS statistical package was used, and the daily respiratory disorders, PM_{10} levels, and meteorological data were entered and analyzed. The annual, monthly, and daily totals for each respiratory disorder were calculated and correlations were made between the respiratory disorders, PM_{10} levels, and meteorological data. We calculated the observed/expected ratios for each respiratory disorder in October 1991, using the first 15 d as a reference period and the next 15 d as the period of exposure.[4]

We performed multivariable analysis using generalized estimating equations to predict the number of daily emergency room visits for each disorder (dependent variable). A log link function was used, and daily visits were assumed to have a poisson distribution. Each month of 1991 was treated independently, allowing for correlation from day to day. An exchangeable correlation structure was used. The predictors (independent variables) in the logistic models included daily PM_{10} values (all values, values > 150 μg/m³ only, and values with a 1- and 2-d lag period, each analyzed separately); seasons of the year; relative humidity; and the previous day's emergency room visit total for each disorder. With respect to the independent variables, Robust z values were obtained and 95% confidence intervals (CIs) were calculated. As to the log linear function, each incremental change of 100 in an independent variable results in a multiplicative change ($e^{100\beta}$) in the dependent variable.[5]

Results

In 1990, the population of the Tri-Cities area of Washington State was 101 623 persons (Pasco, 27 153; Richland, 32 315; Kennewick, 42 155).[6] In 1991, the total number of emergency room visits for the three hospitals of the Tri-Cities area was 73 749 (Pasco, 20 231; Richland, 22 150; Kennewick, 31 368). The total number of emergency room visits for all respiratory disorders was 23 349. Total emergency room visits for each respiratory disorder and daily averages are given in Table 1.

The percentages of total monthly emergency room visits that were the result of respiratory disorders for each month of 1991 are as follows: January, 34%; February, 43%; March, 40%; April, 34%; May, 30%; June, 26%; July, 22%; August, 24%; September, 26%; October, 34%; November, 33%; December, 35%.

The total number of emergency room visits for all respiratory disorders was significantly higher for October 1991 (2 001 visits) than for October 1990 (1 656 visits) ($p < .001$). During each month, from February through May 1991, however, there were higher emergency room visit totals for respiratory disorders than for October 1991 (Fig. 1).

The days on which there were the highest emergency room visit totals for most of the respiratory disorders occurred during the winter months of 1991. None of the highest daily emergency room visit totals for respiratory disorders occurred during October 1991.

A greater number of emergency room visits for pneumonia, influenza, otitis media, pharyngitis, upper respi-

Table 1.—Annual Total of Emergency Room Visits to Three Tri-City Hospitals and Daily Averages for Each Respiratory Disorder, 1991

Respiratory disorder	Total ER visits	Daily average visits
Otitis media	5 775	15.8
Bronchitis	4 992	13.7
URI	4 586	12.6
Pharyngitis	4 253	11.6
Sinusitis	1 111	3.0
Asthma	850	2.3
Pneumonia	767	2.1
Influenza	397	1.1
COPD	303	< 1.0
Croup	248	< 1.0
Bronchiolitis	42	< 1.0
Respiratory allergy	25	

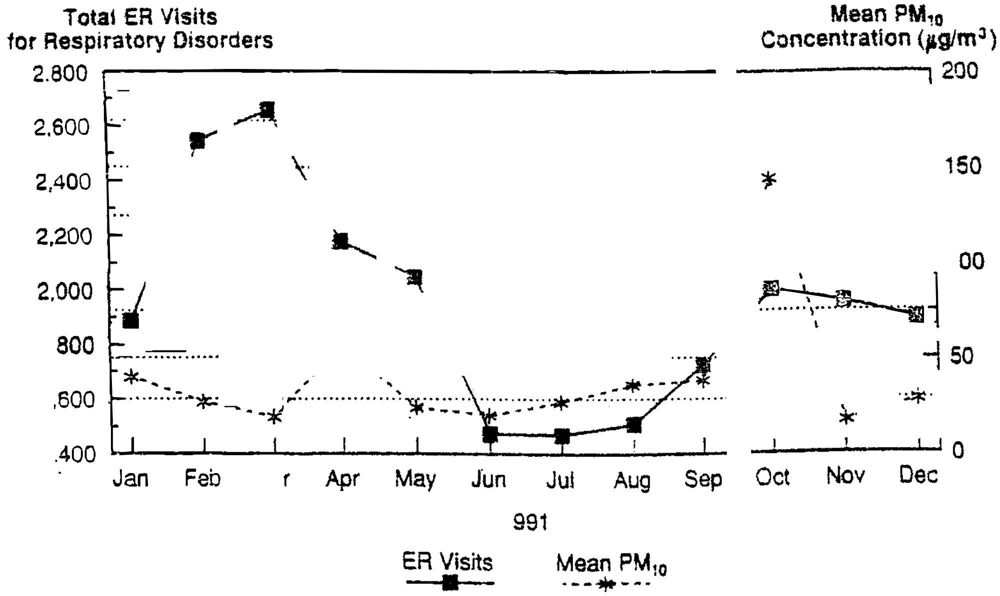

Fig. Total emergency room visits for respiratory disorders and mean PM_{10} levels, by month (1991)

ratory tract infections, and bronchitis were made during the second half of October 1991 than during the first half: however, even during this month the observed/expected ratios for these disorders did not exceed 1.2 (Table 2).

A total of 278 daily PM_{10} samples was obtained for 1991; most of the samples were obtained on Tuesday through Saturday for each week of the year. Daily levels of PM_{10} correlated with daily 1:00 P.M. windspeed (Pearson $r = 0.4$; $p < .001$). The annual mean PM_{10} value was 40 µg/m³, with a daily range of 3–1 689 µg/m³. As shown in Figure 1, October had the highest mean PM_{10} value (144 µg/m³) and November had the lowest (17 µg/m³). During October 1990, the mean PM_{10} value was 32 µg/m³. There were 7 d in 1991 when PM_{10} values exceeded 150 µg/m³ (the EPA standard for a 24-h period), including October 16 and 21 when PM_{10} values reached 1 689 and 1 035 µg/m³, respectively. In accordance with our definition, we identified these two dates as the only 2 d in 1991 during which dust storms occurred. In Figure 2 is shown the comparison of daily total emergency room visits for respiratory disorders with daily PM_{10} levels for October 1991.

Daily PM_{10} levels and emergency room visit totals for each day of 1991 showed a statistically significant correlation for bronchitis only (Pearson $r = 0.13$; $p = .03$). Correlations between daily PM_{10} levels, restricted to days on which levels exceeded 150 µg/m³, and the number of emergency room visits were statistically significant for sinusitis (Pearson $r = 0.80$; $p = .03$). Correlations between daily PM_{10} levels greater than 150 µg/m³ and the number of emergency room visits 2 d later were statistically significant for sinusitis (Pearson $r = 0.94$; $p = .002$) and upper respiratory tract infections (Pearson $r = 0.74$; $p = .05$).

The daily emergency room totals for each disorder, except respiratory allergy, had statistically significant inverse correlations with mean daily temperature. Statistically significant correlations were found between daily relative humidity and bronchitis, COPD, croup, pneumonia, and upper respiratory tract infections (Table 3). On a given day, for each disorder, the number of emergency room visits was significantly related to the number of daily emergency room visits on the preceding day ($p < .01$), except in the cases of bronchiolitis and pneumonia.

Table 2.—Observed and Expected Numbers of Emergency Room Visits for Respiratory Disorders in Three Tri-City Hospitals, October 1–30, 1991

Respiratory disorder*	Observed visits (Oct. 16–30)	Expected visits (Oct. 1–15)	Observed/expected	p
Otitis media	246	210	1.2	.1
Bronchitis	235	210	1.1	.2
URI	222	184	1.2	.06
Pharyngitis	176	163	1.1	.5
Sinusitis	44	56	0.8	.2
Asthma	28	36	0.8	.3
Pneumonia	33	32	1.0	.9
Influenza	18	16	1.1	.7
COPD	8	11	0.7	.5
Croup	17	25	0.7	.2
Bronchiolitis	2	2	1.0	1.0

*We observed no respiratory allergy diagnoses for October 1991.

In our final logistic models, the variables associated significantly with the number of daily emergency room visits for bronchitis were daily PM_{10} values (z-Robust = 8.4, $\hat{\beta}$ = 0.000353, CI = 0.00027, 0.00043); and seasons of the year (z-Robust = 4.1, $\hat{\beta}$ = 0.1855789, CI = 0.09607, 0.27509). The variables associated significantly with the number of daily emergency room visits

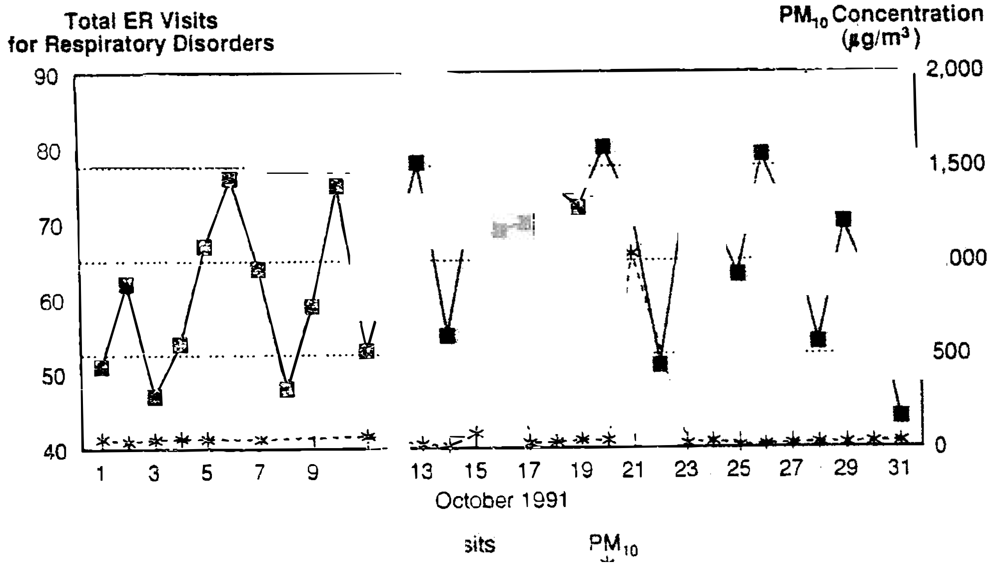

Fig. 2. Daily total emergency room visits for respiratory disorders and daily PM_{10} levels for October, 1991.

for sinusitis were daily PM_{10} values greater than 150 µg/m³ accompanied by a 2-d lag period (z-Robust = 7.6, $\hat{\beta}$ = 0.0004525, CI = 0.00033, 0.00057); and seasons of the year (z-Robust = 3.0, $\hat{\beta}$ = 0.10474, CI = 0.03619, 0.17329). The only variable associated significantly with the number of daily emergency room visits for upper respiratory tract infections was seasons of the year (z-Robust = 3.8, $\hat{\beta}$ = 0.1848814, CI = 0.08966, 0.28010).

Discussion

In this investigation, a relationship was found between PM_{10} levels and the number of emergency room visits during 1991 for bronchitis and sinusitis. These disorders had statistically significant correlations with what we believe is PM_{10} from mostly natural sources. Other air pollutants are not measured in the Tri-Cities area because the region is relatively free of industrial development.

Previous investigations have shown that PM_{10} contributes to respiratory disorders, especially to asthma and acute bronchitis, but in those investigations the source of the particulate matter was primarily industrial.[7–9] Particulates from an industrial source are a complex mixture of smoke, sulfates, nitrates, and gases, such as oxides of sulfur and nitrogen.[7] These differ from the particulates of rural eastern Washington, which are volcanic in origin, are mostly PM_{10}, and belong to the plagioclase (glass) mineral class of aluminum silicates and other oxides.[10] The source of particulates may be important because some investigators report that an increase in respiratory disorders, especially asthma, is usually associated with increased levels of particulate matter and a concurrent increase in other pollutants, such as sulfur dioxide.[11,12]

Furthermore, some studies indicate that the greatest impact of PM_{10} is on certain population subgroups, specifically people with pre-existing pulmonary disease, the very young, and the elderly.[7,13,14] This conclusion is supported by the results of the investigations of people's exposure to naturally occurring particulates following the eruption of Washington State's Mount St. Helens in 1980.[10] Several studies concluded that no new ash-related asthma was observed but that there were increases in adverse respiratory effects among those with pre-existing asthma and chronic bronchitis. They also considered it unlikely that the adult general population exposed to volcanic ash would be at risk, as a result of that exposure, for developing respiratory disease.[10]

An investigation of the effect of smoke from California forest fires on respiratory health revealed a relatively modest overall health impact. Investigators found a significant increase in emergency room admissions for asthma and COPD (observed/expected ratios 1.4 and 1.3, respectively), and they concluded that people with pre-existing respiratory disease should be targeted for in-

Table 3.—Correlation of Each Respiratory Disorder with Mean Daily Temperature and Daily Relative Humidity in the Tri-City Area, 1991

Respiratory disorder	Mean daily temp.		Daily rel. humidity	
	Pearson r	p value	Pearson r	p value
Otitis media	0.2	.0001	0.05	
Bronchitis	0.4	.0001	0.19	.0003
URI	0.3	.0001	0.12	
Pharyngitis	0.2	.006	0.01	
Sinusitis	0.1		0.07	[illegible]
Asthma		04	0.04	.4
Pneumonia		001	0.12	.02
Influenza	0.1	02	0.04	.4
COPD	0.1	04	0.13	.01
Croup	0.2	.0001	0.16	.002
Bronchiolitis	0.2	.000	0.10	.06
Respiratory allergy	0.2	.001	0.08	

ərventioı if potential exposure to smoke orest fires occurs.[4]

The health effects induced by particulates result from an inflammatory response caused by the penetration and deposition of particles into the respiratory tract. This response affects pulmonary function, mucociliary clearance, and other host defense mechanisms and is a plausible explanation for the respiratory disorders we found to be associated significantly with PM_{10} (bronchitis and sinusitis).[7] However, it is surprising that we not only found no significant association between PM_{10} and asthma, but we found relatively few emergency room admissions for asthma in a community that would be expected to have 4 800 persons with asthma (asthma prevalence, 47.7/1 000 persons × Tri-Cities' population).[15]

There are at least four reasons for the fewer than expected emergency room admissions for asthma. People with asthma may premedicate themselves if they anticipate exposure to an asthma-inducing event or they may visit a private physician for an asthma attack, thereby reducing the number of people seeking treatment at emergency rooms. Another possibility is that emergency room cases of asthma may have been misclassified as bronchitis. Bronchitis appeared to be a generic diagnosis (sometimes labeled as tracheobronchitis, laryngotracheobronchitis, or sinobronchitis). Finally, we must consider the possibility that thoracic particulates from a natural source do not exacerbate asthma.

The relatively high numbers of emergency room visits for respiratory disorders in most of the winter and spring months of 1991 (Fig. 1) were probably the result of expected seasonal effects, such as prevalent viral infections. In addition, given the statistically insignificant relationship between the number of emergency room visits for most of the respiratory disorders and PM_{10} levels, the higher number of visits for October 1991, compared with October 1990, was unlikely to be due solely to the higher mean PM_{10} level for October 1991. An outbreak of viral illness may have occurred in October 1991, which could explain the difference in the number of emergency room visits.

We determined that the maximum observed/expected ratio for respiratory disorders resulting from the dust storms on October 16 and 21 (which produced the highest PM_{10} levels of 1991) was 1.2. This relatively low ratio indicates that the high PM_{10} levels probably had a minimal public health impact. We demonstrated a statistically significant relationship between a year of daily PM_{10} levels and two respiratory disorders (bronchitis and sinusitis), although $\hat{\beta}$ values from our longitudinal regression analysis indicate a small effect, i. e., an increase of 100 $\mu g/m^3$ of PM_{10} results in a 3.5% increase in number of emergency room visits for bronchitis. Further investigation is necessary to determine if the increase in the number of emergency room visits for these disorders represents sensitive groups, so that appropriate steps for intervention can be taken when PM_{10} levels are high.

We express our appreciation to the following people who gave us valuable assistance: Mark W. Oberle, M.D., M.P.H., School of Public Health, University of Washington; Patricia Lacy, Director, Medical Record Department, Kristy LeVeau, Director, Information Systems, Kadlec Medical Center; Loretta J. Wingard, Supervisor, Medical Record Department, Kennewick General Hospital: Anita M. Kongslie, Medical Records, Our Lady of Lourdes Hospital; Ora P. Gifford, Atmospheric Sciences Department, Batelle, Pacific Northwest Laboratories; Tami Laplante, Programmer/Analyst, David Olsen, Ph.D., Theresa Fearrington, Program Assistant, National Center for Environmental Health, Centers for Disease Control; J. Phillip Cooke, Control Officer, William S. Statler, Benton-Franklin-Walla Walla Counties Air Pollution Control Authority; A. G. Corrado, M.D; W. S. Klipper, M. D., P.S.; Greg Van Doren, Benton County Agricultural Extension.

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Particulate Air Pollution and Respiratory Disease in Anchorage, Alaska

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This paper examines the associations between average daily particulate matter less than 10 µm in diameter (PM_{10}) and temperature with daily outpatient visits for respiratory disease including asthma, bronchitis, and upper respiratory illness in Anchorage, Alaska, where there are few industrial sources of air pollution. In Anchorage, PM_{10} is composed primarily of earth crustal material and volcanic ash. Carbon monoxide is measured only during the winter months. The number of outpatients visits for respiratory diagnoses during the period 1 May 1992 to 1 March 1994 were derived from medical insurance claims for state and municipal employees and their dependents covered by Aetna insurance. The data were filtered to reduce seasonal trends and serial autocorrelation and adjusted for day of the week. The results show that an increase of 10 µg/m³ in PM_{10} resulted in a 3–6% increase in visits for asthma and a 1–3% increase in visits for upper respiratory diseases. Winter CO concentrations were significantly associated with bronchitis and upper respiratory illness, but not with asthma. Winter CO was highly correlated with automobile exhaust emissions. These findings are consistent with the results of previous studies of particulate pollution in other urban areas and provide evidence that the coarse fraction of PM_{10} may affect the health of working people. *Key words*: asthma, carbon monoxide, morbidity, outpatient visits, particulate pollution, PM_{10}. *Environ Health Perspect* 104:290–297 (1996)

Recent studies have reported that particulate pollution in ambient air is associated with increased mortality (*1–3*) and morbidity (*4,5*). Studies have been done in cities where the primary source of particulate pollution is combustion products. Studies of areas with high industrial particulate pollution show increases in asthma symptoms and hospital admissions. The present study examined the association between particulate pollution and the incidence of acute respiratory diseases as measured by outpatient visits for specific respiratory diagnoses in an area without significant industrial pollution, Anchorage, Alaska. Anchorage is a city of 240,000 people located in a "bowl" surrounded by mountains and sea coast. Wood smoke is not a major contributor to particulate pollution in this area because wood is not commonly used as fuel due to its high cost. Electric power plants are fueled by natural gas. The main sources of particulate pollution are unpaved roads, road sanding, vehicular traffic, and ashfall from volcanic eruptions.

On 18 August 1992, during the period of this study, Mt. Spurr, 60 miles west of Anchorage, erupted and rained ash on the city. Hourly measurements of particulate matter with aerodynamic diameter less than 10 µm (PM_{10}) reached a maximum level of 3000 µg/m^3. The 24-hr average concentration was 565 µg/m^3 on the day after the eruption. Computer-controlled scanning electron microscopy (CCSEM) was used to determine the composition of particles from 10 random samples taken before and after the volcano erupted (*6*). Over 80% of the particle mass was between 2.5 and 10 µm. The composition was mainly silica and silica–aluminum. CCSEM showed that less than 5% by weight of the filter mass was carbonaceous particles. This is consistent with source apportionment studies by chemical mass balance done 7 years previously (*7*), which concluded that more than 85% of the total suspended particulates (TSP) in Anchorage was earth crustal material. Size-fractionated mass measurements below 15 µm were made in Anchorage by the U.S. EPA in the early 1980s using dichotomous samplers. Historic data collected by EPA during 1983 also suggest a high coarse-particle mass fraction. Average fine [aerodynamic diameter (d_a) < 2.5 µm] to coarse (2.5 µm < d_a < 15 µm) particle mass ratios in the summer of 1983 were 0.14 ± 0.05. The overall median ratio of fine to coarse PM_{15} was calculated to be 0.26. This is in distinct contrast with the 0.4 to 0.7 $PM_{2.5}$/ PM_{15} ratios reported for 6 communities in the lower 48 states by Spengler and Thurston in 1983 (*8*). We investigated the relationship between respiratory illness treated on an outpatient basis and ambient particulate PM_{10} pollution using a health insurance database. Working people and their dependents, generally considered a healthy group, are the sample population used in this analysis. The sample size was approximately 6% of the population of the city of Anchorage.

Methods

Database

Particulates are measured daily as 24-hr PM_{10} samples using an Anderson head sampler at a central location in Anchorage, the Gambell site. Measurements are made intermittently at two other sites within the city. The Pearson correlation coefficient between sites ranges from 0.76 to 0.81. The Gambell site is located close to a major highway, and PM_{10} concentrations are 43–76% higher than concentrations measured at other sites. Other than PM_{10}, few pollutants are routinely monitored in Anchorage. Carbon monoxide monitoring is conducted hourly and daily between October and March. CO is routinely monitored at five locations in the Anchorage area. Only two sites exceeded the 9 ppm CO standard during the period of this study: the Seward Highway site, located four blocks from the Gambell PM_{10} monitoring site, and the Garden site, a residential area about 2 miles from the Gambell PM_{10} monitoring site. Measurement of criteria pollutants, sulfur dioxide, nitrogen dioxide, and ozone are only done occasionally as they remain quite low.

Available 8-hr maximum CO concentrations measured at each of the five CO monitoring sites in Anchorage between 1 October 1992 and 31 March 1993 and between 1 October 1993 and 31 March 1994 were obtained from the Municipality of Anchorage Environmental Services Division. These data were processed to generate the average 8-hr maximum CO concentration for each day, which was then used in the analysis.

Daily claims made for outpatient visits for respiratory illness were obtained from

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Aetna Insurance Company, which processes the health insurance claims for both employees of the State of Alaska and employees of the Municipality of Anchorage. Both groups have comprehensive health insurance with low deductibles for employees and dependents. We analyzed data from a 22-month period from 1 May 1992 to 1 March 1994. All outpatient visits that were submitted to insurance, whether they occurred in doctors' offices or in emergency rooms, were captured by this method. The diagnosis code recorded for the visit was based on the International Classification of Diseases 9th Revision (ICD–9) coding. ICD–9 codes were grouped to identify upper respiratory problems such as sore throat, earaches, sinusitis, rhinitis, and other nonspecific upper airway problems. This whole group of illnesses is referred to as upper respiratory illness (URI). The second group, referred to as bronchitis, includes lower airway diseases such as bronchitis, tracheitis, and nonspecific cough. Pneumonia was not included, as it is frequently treated on an inpatient basis. The third respiratory category, referred to as asthma, included all reactive airway disease, bronchospasm, and asthma ICD–9 codes. Diarrhea, a common diagnosis presumably unrelated to air pollution, was recorded as a control diagnosis. The ICD–9 codes used were: for asthma, 519.1, 493.9, 493.0, 495; for bronchitis, 466.0, 490, 490.0, 491.0, 491.1, 786.2; for chronic obstructive pulmonary disease (COPD), 491.2, 491.9, 492.0, 492.8, 496, 506.4; for congestive heart failure (CHF), 428.0, 428.1, 402.01, 402.11, 402.91, 440.9, 398.91, 429.1, 429.4, 429.9; for diarrhea, 558.9; and for upper respiratory illness (URI), 077.2, 460, 461, 461.0, 461.1, 461.2, 461.3, 461.8, 461.9, 462, 465, 465.0, 465.9, 472, 472.0, 472.1, 472.2, 473.0, 473.1, 473.2, 473.3, 477, 477.1, 477.9, 478.2, 478.8.

Reiterations of the insurance data collection were done until we were confident of a stable claims report. Only visits where both patient and provider had an Anchorage zip code were included in the analysis. There were approximately 11,000 State of Alaska and 3000 municipal employees and dependents eligible for health insurance in Anchorage during the time of the study.

Analytical Methods

Daily outpatient visits, temperature, and PM_{10} series exhibit seasonal cycles, some of which are common. Unless adjusted for long-term cycles, shared seasonal or monthly cycles among outpatient visits and environmental variables could confound results. Adopting the technique used in Kinney and Özkaynak (*8*), a weighted 19-day moving average filter developed by Shumway (*9*) was used to detrend the pollution and meteorological series. The method involves subtracting the weighted moving average of each variable (X) from itself on each observation. In other words, the X_t on day $t = i$ is filtered as:

$$X\_F_i = X_i - \sum_{i=-9}^{9} X_i w_i$$

where w_i is the filter weights shown in Shumway (*9*). This process of filtering removes the long-term cycles but not the short-term cycles (i.e., high frequencies). When a linear filter such as this is applied to both the predictor and predicted variables before regression analysis, linear regression relationships among variables are preserved and can be estimated without bias. In addition, this filter efficiently removes the autocorrelation in the pollution and the outpatient visit series. Autocorrelation functions were examined to detect any remaining temporal structure in the filtered data, and none was found.

We computed descriptive statistics for all the filtered and unfiltered data. We used a generalized linear model procedure to test statistical differences in the daily outpatient visits by day of the week. Cross-correlations between filtered outpatient visits (e.g., for asthma) and filtered PM_{10} were calculated to determine the importance of the relationship between doctors visits and same-day (or lag 0), previous-day (or lag 1) and 2-days prior (or lag 2) PM_{10} measurements. We analyzed the daily outpatient visit (OV) counts and pollution data using time–series and regression modeling techniques implemented with SAS software (SAS Institute Inc., Cary, North Carolina).

Because of low daily counts for some categories of doctors visits (e.g., asthma, bronchitis), we examined two different methods of modeling the pollution–health effect relationships. Both ordinary and Poisson regression models were fitted to filtered outpatient visit, temperature, and pollution data. Consistency of results and normality of model residuals were examined. In all cases, results from Poisson and multiple regression models were almost identical. Moreover, residuals from the multiple regression models were very nearly normally distributed. Consequently, for technical and practical reasons, we chose multiple regression modeling framework in the analysis. Basic analysis involved fitting multiple regression models to four filtered morbidity variables (i.e., doctors visits diagnosed as asthma, bronchitis, diarrhea, and upper respiratory infections) using filtered same-day or previous day PM_{10} and temperature as explanatory variables. The diarrhea category was selected for analysis as a control category. The form of the basic regression model (model I) was:

$$OV\_F = \beta_o + \sum \beta_i X\_F_i + E \qquad (2)$$

where OV_F is the filtered daily outpatient visits, X_F_i is the filtered same-day or previous-day daily temperature and PM_{10} measurements, and E is the error term. Other models were also done. Model 2 added a weekend/weekday indicator variable (W_D) as an additional explanatory variable to Equation 2. Model 3 was a regression specification using as the dependent variable outpatient visits that were both filtered and weekend/weekday adjusted. Specifically, model 3 was written as:

$$OV\_R = \sum \beta_o + \sum \beta_i X\_F_i + E \qquad (3)$$

where:

$$OV\_R = OV\_F - (\alpha_o + \alpha_i W\_D) \qquad (4)$$

In models 1–3, same-day temperature and same-day PM_{10} were included. We also ran models with different lags of temperature and PM_{10}. We present results from one of these, Model 4, where previous day's PM_{10} (or lag 1 PM_{10}) instead of same-day PM_{10} is included in the specification. The models were run for all ages combined and separately for three age groups (<10 years, 11–45 years, and 46+). Due to sample size limitations, male and female outpatient visits were combined.

Finally, we also examined potential statistical confounding of results due to other pollutants of health concern and the influence of variations in the PM_{10} composition over time. We included the available wintertime CO measurements independently, as well as jointly with PM_{10} data, in the regression models tested. Potential changes in the seasonal composition of PM_{10} and the influence of the volcanic eruption that occurred on 18 August 1992 were also modeled using nested regression modeling methods. In this case, we estimated separate PM_{10} slopes for winter versus summer seasons and periods strongly influenced by volcanic eruption (18 August 1992–31 December 1992) versus the remaining period less influenced by volcano ash (i.e., 1 May 1992–17 August 17 1992; 1 January 1993–1 March 1994).

Results

Figure 1 displays the daily PM_{10} measurements collected at the Gambell site in Anchorage. Both the original and filtered series are shown. The influence of volcanic eruptions on PM_{10} levels during the fall of 1992 are clear. After detrending, long-term cycles and seasonal patterns are no longer apparent. Daily counts for outpatient visits for asthma, bronchitis, and URI are shown in Figures 2–4. Again, the 19-day moving average filter detrends the observations for respiratory illness visits. Because of the relatively young age of the sample population, CHF and COPD visits were infrequent, and no analysis of these was done. Table 1 presents the summary statistics for the analysis variables: temperature, PM_{10}, CO, visits for illnesses of asthma, bronchitis, diarrhea, and URI. Correlation of 8-hr maximum CO measurements among the five different sites was quite high ($\rho \approx 0.8$). Consequently, using the data from all monitors, we calculated the 8-hr maximum CO value in the Anchorage area for each day data were collected. The correlation between daily PM_{10} and daily average maximum CO was found to be small ($\rho \approx 0.15$). Table 1 also provides a breakdown of the statistics by different age categories. Clearly, most of the visits are recorded in the largest age category, 11–45 year olds. Because only active employee insurance records were analyzed, most of the population at risk were under 65 years of age.

Ordinary regression models were run for all outpatient visit categories. Table 2 presents the results for the basic model (model 1) for the three respiratory illness categories: asthma, bronchitis, and URI. All of the estimated PM_{10} regression coefficients were significant for these illness categories. However, a generalized linear model analysis indicated substantial weekend/ weekday differences in the recorded outpatient visits. Because most doctors' offices are closed on the weekends, typical weekend visit counts for all causes of illness were five times lower than during the weekdays. Moreover, there was also a slight difference, though not statistically significant, in the PM_{10} concentrations during weekdays versus weekends. Average PM_{10} concentration on Saturdays and Sundays was about 37 $\mu g/m^3$, whereas during weekdays it was around 48 $\mu g/m^3$. We suspected that less traffic over the weekend results in slightly lower PM_{10} levels in the city. Consequently, we attempted to control for the differences in the outpatient visits during weekends in two different ways. One way was to add a weekend-versus-weekday dummy or indicator variable to the basic regression model (Eq. 2), which we called model 2. The other way was to adjust for day-of-the-week effect on outpatient visits first, and then run the regression on the residuals with either same-day PM_{10} (model 3) or previous-day PM_{10} value (model 4). The results from these alternative model fits are shown in Table 2. Model 2 results with the weekend/weekday dummy variable do not indicate a significant association between PM_{10} and doctors visits. The reason for nonsignificant findings under model 2 is the induced statistical collinearity between the estimated PM_{10} coefficients and the weekend/weekday (*W_D*) coefficients. Because the underlying reason for reduced outpatient visits over weekend days are different and much more pronounced than those affecting the differences in weekend/weekday PM_{10} concentrations, a separate adjustment of outpatient visits was considered more appropriate. Therefore, a two-stage regression analysis was considered to be the most reliable method with this data set. Models 3 and 4 were both developed as two-stage regression analyses using filtered weekday/weekend adjusted outpatient visits as the dependent variable.

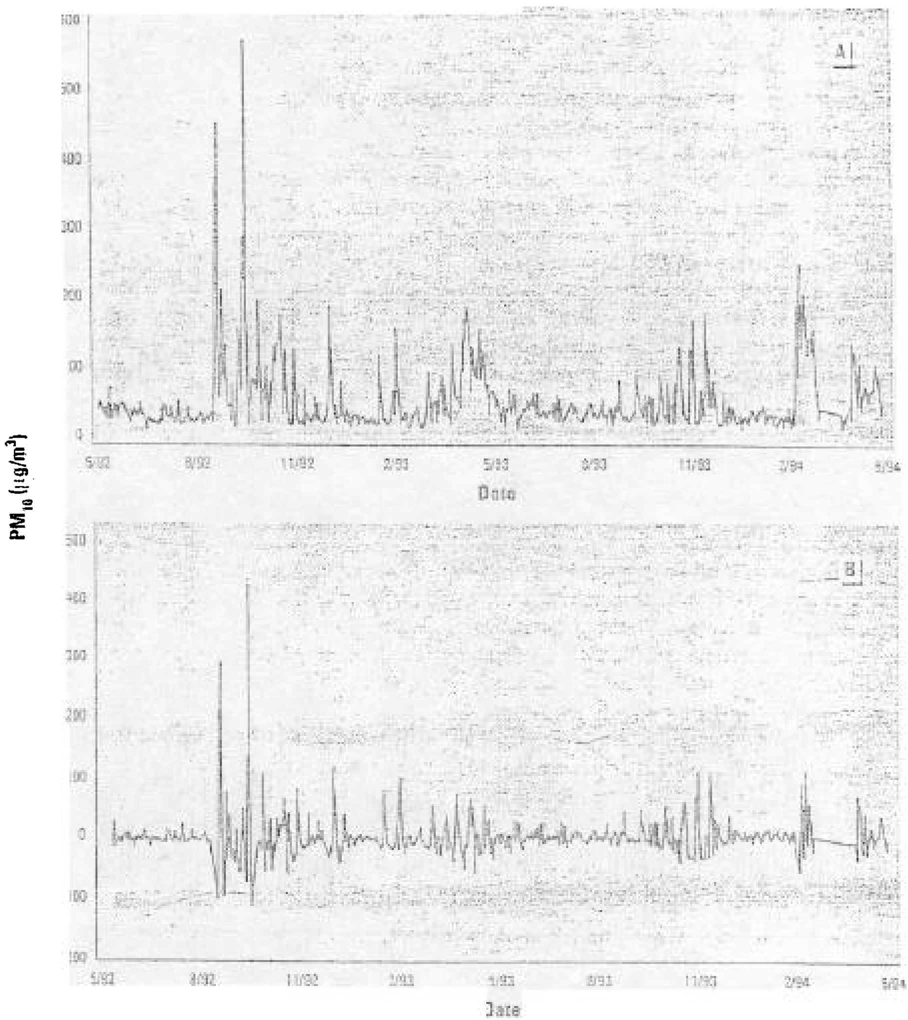

Figure 1. Measurements of PM_{10} (particulate matter <10 µm in diameter) in Anchorage, Alaska (Gambell site). (A) Original data; (B) filtered data.

Statistically significant associations were found between both same-day and previous-day PM_{10} (lag 0, lag 1) and asthma visits and between same-day PM_{10} and URI diagnosed outpatient visits based on model 3 and 4 specifications. The statistical association found between lag 1 PM_{10} and visits for asthma was stronger and more significant than the association found between same-day PM_{10} and visits for asthma (Tables 2 and 4). Other lags (i.e., lag 2,3) of PM_{10} were also studied but not found to be significant in the models tested. Using the coefficients from model 3 and model 4, the magnitude of the projected PM_{10} effect on outpatient visits for each 10 $\mu g/m^3$ increase in PM_{10} is 2.5–3.5% excess outpatient visits for asthma and 1.2% excess outpatient visits for URI (Table 2).

Next we examined the age dependence of the results by repeating the model 3 analysis for daily visits recorded separately

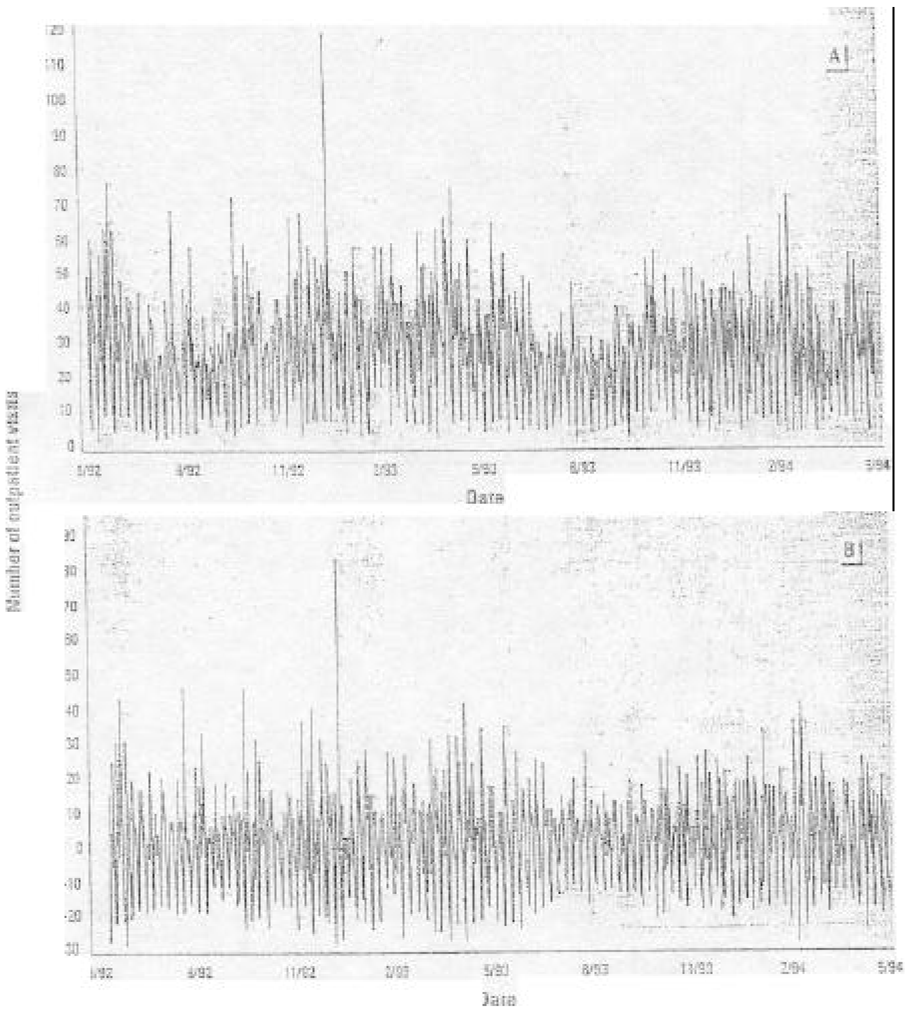

Figure 2. Daily outpatient visits for upper respiratory infections in Anchorage, Alaska. (A) Original data; (B) filtered data.

under the three age categories: <10 years, between 11 and 45 years, and >46 years (but typically less than 65 years). Table 3 presents these regression results. Due to the small number of daily counts, some of the age-specific regression estimates were not significant. For asthma visits, the effect estimate for the 11- to 45-years age group (2.6% excess visits) was not significant (p = 0.14) but similar in magnitude to one previously found for the all ages combined. However, statistically significant associations were found between PM_{10} and URI-related outpatient visits for children under 10 years of age and adults over 46 years of age. The predicted PM_{10} effect on URI visits associated with an increase of 10 µg/m^3 PM_{10} was 1.9% and 1.2%, respectively, in these two age categories. Outpatient visits for diarrhea were not significant either in models 2 or 3.

We examined the association between daily CO and outpatient visits using the regression models (i.e., models 3 and 4). Table 4 presents the estimated regression coefficients for CO from models of outpatient visits for asthma, bronchitis, and URI. These results are based on model 3 specifications. Models with lag 1, 2, or 3 CO variables did not result in statistically significant coefficients. Same-day CO was highly significantly associated with outpatient visits for bronchitis and URI using the available CO series, obtained during fall/winter of 1992–1993. In comparison to the estimated PM_{10} effect, the magnitude of the estimated CO effect on URI and bronchitis outpatient visits seems to be greater. For an increase of 1 ppm (8-hr maximum) CO, it is estimated that doctor visits for bronchitis and URI will rise by 10% and 13%, respectively. The significant associations found between CO and bronchitis and URI are not influenced or confounded by PM_{10}. Models in which both PM_{10} and CO variables were included produced results essentially the same as the single pollutant regression models.

Temperature and Volcano Effects

The temperature coefficient was significant in only one of the models. The estimated coefficient for the filtered temperature variable from the model of CO and temperature on URI was 0.24 (p<0.04). We examined further the temperature and PM_{10}, and temperature and CO relationships, and found those to be weak. We re-ran the PM_{10} regression models with lag 1 temperature instead of the same-day temperature and obtained identical results. We assume that the 19-day weighted Shumway filter adequately removes not only the seasonal trends in the data, but multiday variations in the temperature observations that may influence respiratory diseases and symptoms more than the day-to-day variations in temperature. Variations in temperature may have less effect on health in a young, working population than on a more vulnerable population.

We also examined whether the estimated PM_{10} coefficients were influenced by seasonal or other compositional factors. We ran nested regression models to estimate separate PM_{10} slopes for summer (April–October) versus winter (November–March) seasons and also for the period influenced by the volcano eruption (18 August 1992–31 December 1992) versus the period not expected to be influenced by the Mt. Spurr volcano (1 May 1992–17 August 1992; 1 January 1993–1 March 1994). Table 5 presents the estimated PM_{10} and (lag 1) PM_{10} coefficients obtained from these models. The association found with PM_{10} and asthma does not seem to be influenced much by season. A significant (lag 1) PM_{10} coefficient is estimated for the winter season from models of asthma-related outpatient visits. For URI, because of sample size limitations, PM_{10} coefficient loses its significance when the data set is split by summer and winter season. However, the magnitude of the estimated summer and winter coefficients remain similar to the PM_{10} coefficient estimated from the full data set (see Tables 4 and 5). Interestingly, the period immediately after the volcanic eruption resulted in nonsignificant PM_{10} coefficients in models of asthma and URI outpatient visits. In contrast, the period not affected by the volcanic eruption resulted in statistically significant PM_{10} coefficients. Average PM_{10} concentration during the period influenced by the volcano was around 70 µg/m^3 , whereas the period not affected by the volcano had an average PM_{10} of 40 µg/m^3. The magnitude of the estimated same-day or previous-day PM_{10} effect on doctors visits for asthma, during the period not influenced by the volcano, was about 6%, corresponding to an increase of 10 μg/m³ PM_{10}. Likewise, doctors visits for URI are expected to increase by about 3% corresponding to increase of 10 μg/m³ PM_{10} during the period not influenced by volcanic activity.

Discussion

We analyzed 22 months of daily PM_{10}, temperature, and daily cause-specific outpatient visit data from Anchorage, Alaska, to study the acute relationship between PM_{10} and respiratory illnesses. The health data were obtained from a large health insurance provider to state and municipal employees in Anchorage. Even though the coverage was only partial (80–90%) and records may have included repeat visits to a doctor by the same individuals, the data set is considered to be representative. Furthermore, we applied conservative statistical methods to control for potential seasonal, weekly, and daily confounders of PM_{10} health effects. In particular, we controlled for potential influences of temperature on daily outpatient visits.

In Anchorage, continuous records for other pollutants such as ozone (O_3), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) were not available for the period of analysis. It is unlikely that these omitted variables could confound potential associations between PM_{10} and outpatient visits. Limited monitoring data available for these pollutants indicate very low levels [below the National Ambient Air Quality Standards (NAAQS) for O_3, NO_2 and SO_2. SO_2 concentrations measured in 1983–1985 were less than 10% of the NAAQS. The maximum hourly O_3 was 40 ppb, one-third the NAAQS during the 2 years of monitoring in 1983–1985. Although only 6 months of NO_2 data are available for Anchorage, levels of this pollutant did not exceed one-third the NAAQS. SO_2 was measured at the base of the volcano during the eruption, but not in the city of Anchorage. The measurement taken at the base of the volcano 60 miles from Anchorage was considered low for a volcanic eruption (750 tons/day) and unlikely to affect Anchorage.

Two pollutants do occur in Anchorage in significant amounts. They are CO and benzene. A year-long monitoring study of ambient air for volatile organic compounds in Anchorage was completed in 1994. The study showed that the levels of benzene in the winter in Anchorage were higher than the levels reported in any other U.S. city in a national study done in 1987 (*10*). Benzene monitoring was done at the CO monitoring sites and was highly correlated with CO concentrations (ρ = 0.97) (*11*). Both benzene and CO are exhaust emissions of incomplete combustion of Alaskan gasoline, which is high in benzene (5%) and other aromatic compounds. An increase of 1 ppm CO is equivalent to an increase of 3 ppb benzene in Anchorage.

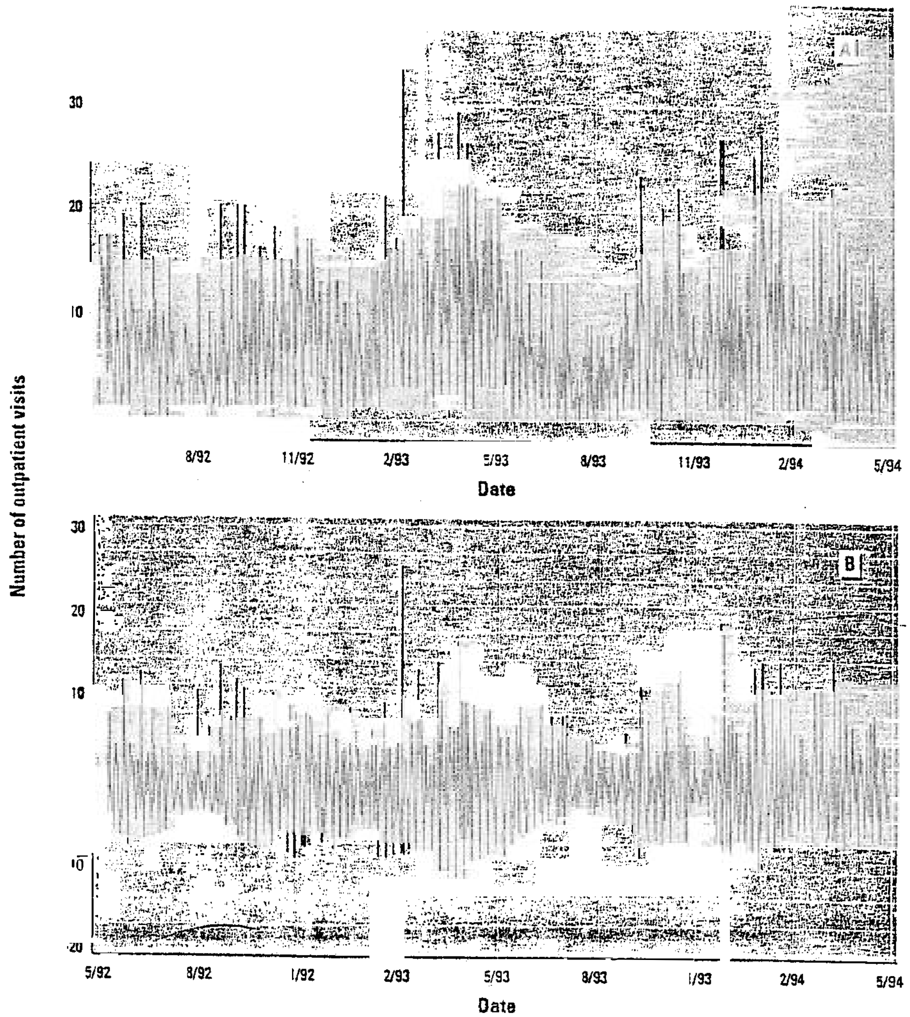

Figure 3. Daily outpatient visits for bronchitis in Anchorage, Alaska. (A) Original data; (B) filtered data.

CO measurements at five sites in Anchorage were available for October–March during fall and winter of 1992 and 1993. CO measurements were not correlated with PM_{10} measured at the Gambell site (R^2 = 0.14). Nevertheless, potential confounding of PM_{10} associations due to CO were examined by running the outpatient visit-pollution models using average maximum CO as an independent exposure variable. Models were also run with both CO and PM_{10} together in model 3 and model 4 specification. Results indicated that CO and PM_{10} associations with outpatient visits are independent of each other. Because CO data are only collected in the cold season, the sample size for the CO models was about half of that used in the PM_{10} models. Therefore, we have less confidence in the associations detected for CO than those found for PM_{10}. Nevertheless, the significant associations detected for CO are intriguing. These results suggest that wintertime emissions from automobiles, CO, NO_2, fine particles, and volatile organic compounds (VOCs), may significantly contribute to bronchitis and URI in the Anchorage population. Because CO is a surrogate for many of the vehicular emissions, it is not possible to directly link CO with the inferred respiratory effects. Available epidemiologic data on respiratory effects of CO and VOCs are quite limited. A recent article by Morris et al. (*12*) showed that ambient CO levels were positively associated with hospital admissions for CHF among elderly people in seven large U.S. cities. Ware et al. (*13*) had shown respiratory and irritant health effects associated with ambient VOCs in Kanawha Valley, West Virginia. Both petroleum or auto-related compounds and chemical manufacturing emissions were determined to be the likely source of ambient VOCs and the estimated health effects in that

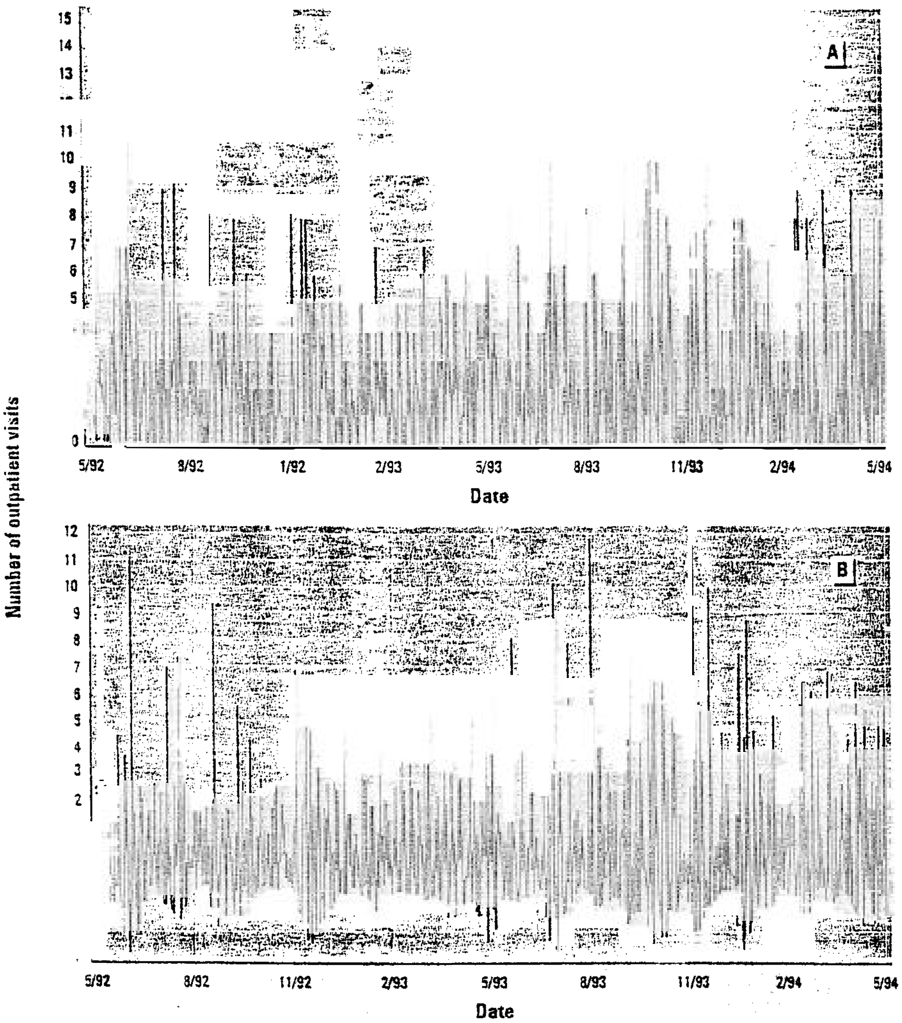

Figure 4. Daily outpatient visits for asthma in Anchorage, Alaska. (A) Original data; (B) filtered data.

community. Analyses of many years of daily mortality and daily air pollution in Los Angeles as well as in Toronto, Canada, have also shown statistically significant associations between CO, NO_2, index of fine particulate or carbonaceous air pollution, and daily total mortality (*14,15*).

We have found statistically significant associations between either the same-day or previous-day PM_{10} and outpatient visits for illnesses due to asthma and URI, in a location where the primary sources of PM_{10} are not combustion or secondary aerosols. Earth crustal and volcanic ash sources are believed to dominate the respirable particle mass in Anchorage. However, the association found between PM_{10} and asthma-related doctors visits seems to be higher and significant only during the period excluding volcanic activity. These findings could be explained by various exposure or source-related factors. After the volcanic eruption, PM_{10} levels exceeded hundreds of micrograms per cubic meter. Anchorage residents were advised to minimize their ambient exposures by staying indoors or limiting their outdoor activities. Businesses closed, work was curtailed, and events were postponed immediately after the eruption. Many people wore dust masks. Consequently, use of ambient PM_{10} concentrations following the period of volcanic eruption can lead to misclassification of personal exposures to PM_{10}. Past studies have shown that potential pulmonary toxicity of volcanic ash may be quite low. Beck et al. (*16*) showed that based on short-term animal bioassays, toxicity of Mt. St. Helens volcanic ash was low and similar to responses to aluminum oxide, a dust considered to be relatively inert. This result is also compatible with the possibility that volcanic ash is not toxic until after mixing with combustion-related fine particles.

Based on our findings, the toxicity of the aerosol mixture in Anchorage seems to be comparable to that inferred from other epidemiologic studies conducted in areas with more typical ambient or urban particulate pollution. For example, previous reports of estimated acute effects associated with a 10 $\mu g/m^3$ increase in daily PM_{10} on respiratory morbidity were: 1) Seattle, Washington (*17*): asthma emergency room visits for <65 year olds were increased by 4% ± 1%; 2) Utah Valley, Utah (*18*): hospital admissions for asthma and bronchitis for children under 5 years were increased by 7.1% ± 3%; 3) Birmingham, Alabama (*19*): hospital admissions for the elderly (>65 years) for COPD were increased by 2.4% ± 0.8% and for pneumonia by 1.8% ± 0.5; 4) Detroit, Michigan (*20*): hospital admissions for the elderly (>65 years) for COPD were increased by 2% ± 0.6% and for pneumonia by 1.1% ± 0.4%; 5) Minneapolis–St. Paul, Minnesota (*21*): hospital admissions for the elderly (>65 years) for COPD were increased by 4.5% ± 1.4% and for pneumonia by 1.6% ± 0.7%; 6) U.S. and European sites combined (*22*): URI increased by 0.7% and asthmatic attacks by 3%.

In comparison, our findings are quite similar in magnitude and indicate a 1–3% increase in outpatient visits for upper respiratory illness and about a 3–6% increase in asthma-related outpatient visits associated with 10 $\mu g/m^3$ increase in daily PM_{10} concentrations. Most of these other investigations, however, have been conducted in urban settings with numerous industrial and vehicular sources of particles, leading some researchers and regulators to suggest that these adverse particle-linked health effects are due to fine particles (<2.5 µm in diameter) generated largely by combustion sources. Because of the high ratio of coarse to fine particles in Anchorage, our analyses is somewhat unique in that it suggests that some morbidity may be related to coarse particles (>2.5 µm in diameter) that are primarily of geologic origin. This is consistent with a study done in rural, western Washington state, where PM_{10} also has a predominantly earth crustal component (*23*). If our results are confirmed through additional studies, they would bear significantly on some of the critical scientific uncertainties facing the U.S. EPA in its ongoing review of the ambient air quality standard for PM_{10}.

We believe that it is important to further examine the robustness of these results by analyzing a longer series of available records for outpatient visits and PM_{10} in Anchorage. It is also important to extend the analysis to more vulnerable segments of the population such as persons 65 years of age and older. The association found between CO and doctors visits for bronchitis and URI clearly needs to be pursued further, particularly in light of the recent findings associating urban CO with con-

Table 1. Descriptive statistics for air pollution and doctors' visits in Anchorage, Alaska, 1 May 1992-1 March 1994

Variable	Age category (years)		Mean	SD	Minimum	Maximum
		669				
		626	45.54	48.81	5.00	565.00
		364	2.54	1.24	0.50	7.00
	<10	669	0.50	1.05	0.00	7.00
	11–45	669	1.22	1.97	0.00	15.00
	>46	669	0.39	0.95	0.00	9.00
	All ages	669	2.12	2.54	0.00	15 00
Bronchitis	<10	669	1.59	2.07	0.00	17.00
	11–45	669	4.54	3.83	0.00	24.00
	>46	669	1.57	1.91	0.00	15.00
	All ages	669	7.70	5.85	0.00	37.00
Diarrhea	<10	669		0.77	0.00	8.00
	11–45	669	0.81	1.26	0.00	12.00
	>46	669	0.33	0.82	0.00	10.00
	All ages	669	1.50	1.81	0.00	14.00
RI	<10	669	6.64	5.36	0.00	41.00
	11–45	669	13.71	9.86	0.00	104.00
	>46	669	4.15	4.47	0.00	34.00
	All ages	669	24.50	15.65	0.00	116.00

Abbreviations: PM_{10}, particulate matter <10 µm in diameter; CO, carbon monoxide; URI, upper respiratory illness.

Table 2. Regression results for outpatient visits in Anchorage, Alaska for respiratory illness[a]

Dependent variable	Model[b]	R^2	Intercept	W_D	Temperature	PM	E(%)
	1	0.017	-0.0422	—	-0.0077	0.0088**	4.2
	2	0.194	0.6783†	2.3025†	-0.0226	0.0036	NS
	3	0.009	0.0124		0.0171	0.0053*	2.5
		0.014	0.0056		0.0094	0.0073**	3.5
Bronchitis		0.014	0.1191		0.0310	0.0180**	2.3
		0.378	2.0924†	7.14	0.0154	0.0020	NS
	3	0.003	0.0018		0.0006	0.0067	NS
URI		0.237	0.2958		0.1284	0.0650†	
	2	0.568	6.9938†	24.2439†	-0.0292	0.0105	NS
	3	0.007	0.0301	—	0.0332	0.0295*	

Abbreviations: PM_{10}, particulate matter < 10 µm in diameter; URI, upper respiratory illness.
[a]All variables are detrended using the Shumway filter (*9*); n = 610. *W_D* , weekend/weekday dummy; *E*, predicted percent change in outpatient visits for each 10 µg/m^3 increase in PM_{10} pollution.
[b]Model definitions: model 1: regression of daily doctors visits on daily PM_{10} and temperature; model 2: regression of daily doctors' visits on daily PM_{10} temperature, and *W_D*; model 3: regression of weekend/weekday adjusted daily doctors' visits on daily PM_{10} and temperature; model 4: regression of weekend/weekday adjusted daily doctors' visits on previous day's PM_{10} and same-day temperature.
*p<0 05; **p<0.01; †p<0.001; NS, not significant (p>0.05).

Table 3. Regression results by different age groups for respiratory illness in Anchorage, Alaska[a]

Dependent variable	Age category (years)	R^2	Intercept	mperature	PM_{10}	E(%)
Asthma	10		-0.0042		0.0012	NS
	11–45		0.0035		0.0032 (p = 0.14)	2.6 (NS)
	46		0.0081		0.0009	NS
	All ages		0.0124		0.0053*	2.5
URI	10		0.0137		0.0129*	1.9
	11–45		-0.1086		0.0062	NS
	46		0.0260		0.0102*	11
	All ages		-0.0301		0.0295*	1.2

Abbreviations: PM_{10}, particulate matter < 10 µm in diameter; URI, upper respiratory illness.
[a]All variables are detrended using the Shumway filter (*9*); n = 610. All regressions are weekei l/weekday adjusted (filtered) daily doctors visits on (filtered) daily PM_{10} and temperature; *E*, predic' 'd percent change in daily outpatient visits for each 10 µg/m^3 increase in PM_{10} pollution.
*p<0.05; NS, not significant (p>0.05).

Table 4. Regression coefficients for PM_{10} and CO from models of outpatient visits in Anchorage, Alaska[a]

Dependent variable	R^2	n	PM_{10}	(lag 1) PM_{10}	CO
Asthma	0.009	610	0.0053*		
	0.014	610	—	0.0073**	
	0.003	304	—	—	NS
Bronchitis	0.003	610	NS		—
	0.001	610	—	NS	
	0.036	306	—	—	89†
URI	0.007	610	0.03		
	0.001	610	—	NS	
	0.075	306	—		

Abbreviations: PM_{10}, particulate matter < 10 µm in diameter; (lag 1)PM_{10}, PM_{10} on the previous day; CO, carbon monoxide; URI, upper respiratory illness.
[a]All variables are detrended using the Shumway filter (*9*). All models are regressions of weekend/weekday adjusted daily doctors visits on daily temperature and pollution.
[b]Variable not included in the model.
*p<0.05; **p<0.01; †p<0.001; NS, not significant (p>0.05).

Table 5: Estimated pollution regression coefficients for different study periods from models of outpatient visits in Anchorage, Alaska[a]

Dependent variable	Period	$PM_{1,}$	)PM_{10}
	Summer	0.004 (NS)	0.008**
	Winter	0.011*	0.006 (NS)
	Volcano	0.001 (NS)	0.005 (NS)
	No volcano	0.013**	0.012**
URI	Summer	0.027 (p<0.1)	-0.008 (NS)
	Winter	0.039 (NS)	0.011 (NS)
	Volcano	0.012 (NS)	-0.016 (NS)
	No volcano	0.064**	0.022 (NS)

Abbreviations: PM_{10}, particulate matter < 10 µm in diameter; (lag 1)PM_{10}, PM_{10} on the previous day; URI, upper respiratory illness.
[a]All variables are detrended using the Shumway filter (*9*); n = 610. All models are regressions of weekend/weekday adjusted daily doctors visits on daily temperature and pollution. Summer = April–October; Winter = November–March; volcano period = 18 August 1992–31 December 1992; No volcano period = 1 May 1992–17 August 1992 and 1 January 1993–1 March 1994.
*p<0.05; **p<0.01; NS, not significant (p>0.05).

gestive heart failure. Additional years of data should be analyzed to confirm that the results are not influenced by limited sample size. It is also important to better characterize the combustion or petroleum pollutants by collecting and analyzing long-term measurements of fine particles ($PM_{2.5}$ <d_a<2.5 µm), coarse particles (2.5 µm<d_a<10 µm), NO_2, CO, selected VOCs (e.g., benzene, toluene, xylenes), and trace elements of combustion (Br, Pb, V, Ni, etc.). Finally, the feasibility of examining other health records from Anchorage, such as emergency room visits, hospital admissions, and mortality should also be considered in subsequent studies.

Conclusions

The results from analysis of 22 months of daily PM_{10} and outpatient visits for respiratory illness in Anchorage, Alaska showed that an increase of 10 $\mu g/m^3$ in PM_{10} is associated with a 3–6% increase in medical visits for asthma and a 1–3% increase in medical visits for upper respiratory illness. This study is one of few which shows that silicaceous or earth crustal coarse particulate pollution may have an acute, adverse effect on respiratory health even at relatively low ambient concentrations. It also suggests that the increased morbidity is associated not just with a vulnerable segment of the population, but with a relatively young, healthy working group as well. These findings could have important implications to U.S. EPA in the ongoing review of the ambient air quality standard for PM_{10}. Whereas most of the past epidemiologic studies have linked particulate air pollution with daily health effects in urban settings, our results suggest that anthropogenic sources are not the only sources that may have an impact on respiratory health. Additional studies in Alaska or other environments with similar aerosol composition are highly recommended to confirm the statistical associations found between respiratory illness and coarse particle dominated PM_{10}.

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