

ASSOCIATIONS BETWEEN EXPOSURE TO AIR POLLUTION AFTER A DUST EVENT AND HOSPITALIZATIONS.



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Gabriel Ibarra-Mejia, PhD. 2; & Soyoung Jeon, Ph.D. 3

1. Introduction

2. Background

3. Approach

4. Results &
Conclusions

5. Recommendations

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I. INTRODUCTION

- The northern Chihuahuan Desert is the one of the most significant sources of dust in the Western Hemisphere (Prospero et al. 2002)
- Large-scale dry climate, Köppen- hot and cold desert (BWh, BWk) (Lee et al., 2012)
- DEs in El Paso occur on average 15 times a year and last an average of 2 hours each from December - May (1932 through 2005) (Novlan et al., 2007).



A dust storm covers the sky outside the National Weather Service office in Santa Teresa, New Mexico, on Tuesday afternoon, March 16, 2021.
COURTESY NATIONAL WEATHER SERVICE EL PASO

Background

DEs particles combined with particles emitted by urban sources and biological particles



A dust storm hit El Paso on Tuesday, March 16, 2021. The view of the city from Scenic Drive was largely blocked out.
SAMUEL GAYTAN/EL PASO TIMES

AIR
POLLUTION

HEALTH EFFECTS

HEALTH
DISPARITIES

AIR POLLUTION

MINERALOGY



Mineralogy of PM @ El Paso, TX

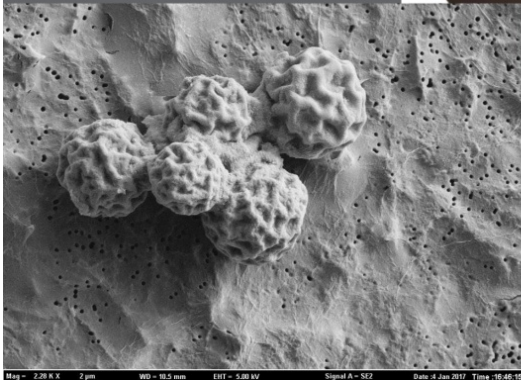
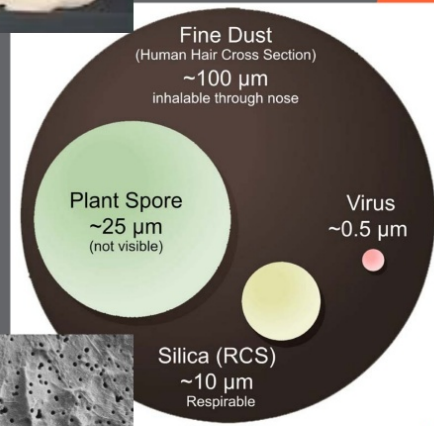
- El Paso- 35% of PM₁₀ -Geologic sources [Li et al., 2001]
- Dominated by quartz (silicon dioxide, SiO₂) with plagioclase, gypsum, and calcite [Gill, 2018]

Dominant aerosol elemental content:

Al, Si, S, Cl, K, Ca, Ti, Mn, Fe, Zn, Cr, Ni, Cu, Pb and Mn

with minor and trace elements

Rb, Zr, Na, Ag, As, Cd, Mo, Sb, Ba, Co, and Be



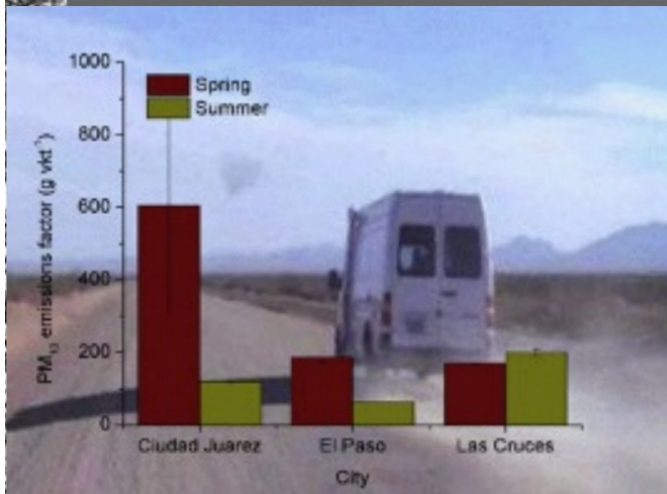
DUST,
FUGITIVE DUST,
AEROLS

BIOLOGICAL
AEROSOL
PARTICLES

FUGITIVE DUST & ROAD DUST

- **disease precursors**

Pb, platinum-group elements (Pt, Rh, & Pd), Zn, V,
& polycyclic aromatic hydrocarbons



BIOLOGICAL AEROSOL PARTICLES

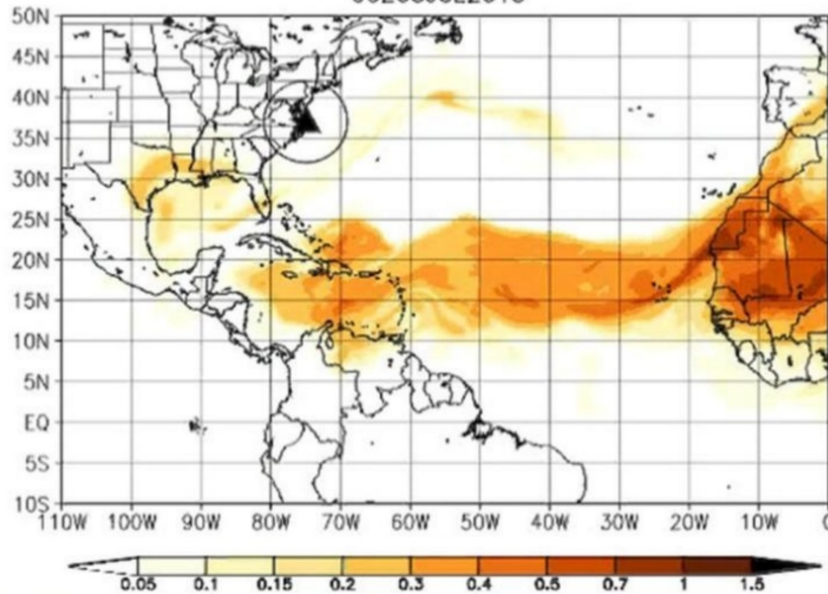
HEALTH EFFECTS

SAHARAN DUST CLOUD AccuWeather

THU 7:00 PM

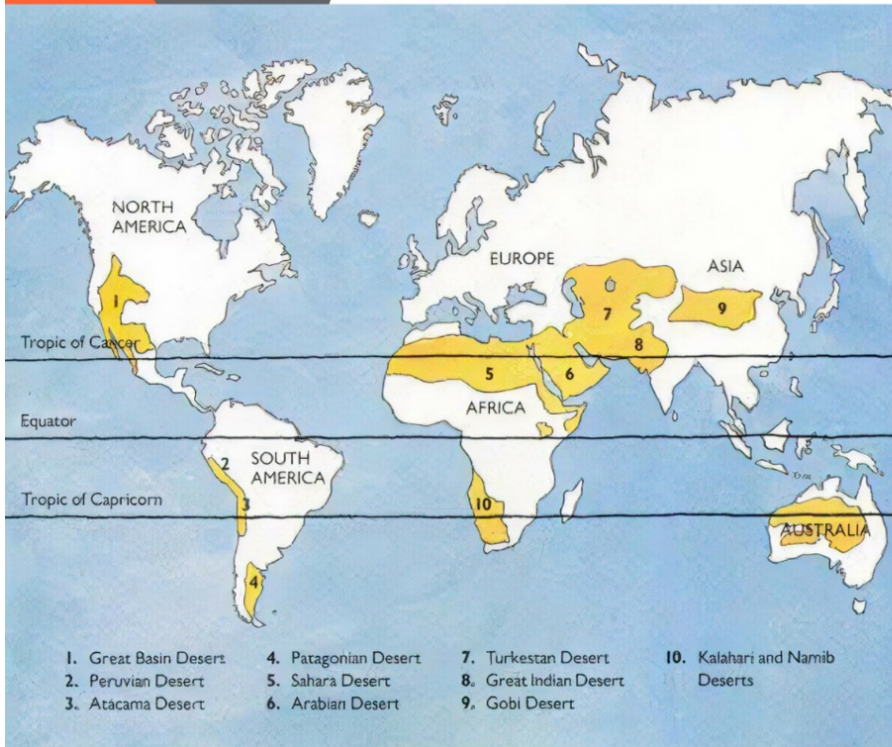
Dust AOD
00Z03JUL2015

SOURCE: NASA



- Sandstorms from the Sahara, Gobi and Taklamakan Deserts **Transport trillions upon trillions of microbes** into the air.
 - **Microorganisms** -bacteria, archaea, algae and fungi
 - **Dispersal material** -pollen, fungal spores, viruses and biological fragments [Fuzzi et al., 2015]
 - **Capable of thriving in harsh environmental conditions** [Etemadifar et al., 2016]

DES LEADS TO SIGNIFICANTLY HIGHER CASES OF



- **Influenza type A virus and H5N1, typhus, cholera, malaria, dengue and West Nile virus infection** [Griffin, 2007 & Chen et al., 2010]
- **Infectious disease epidemics**
 - **Bacterial meningitis, measles epidemic**
 - **Pneumonia, sinusitis, laryngitis and bronchitis** [Brown et al., 1935]
 - **Epidemics of pulmonary tuberculosis** [Wang et al., 2016]
 - **Valley Fever** [Tong et al., 2017]
 - **Kawasaki disease** [Rodo et al., 2014]

DESERT-RELATED PM HEALTH EFFECTS



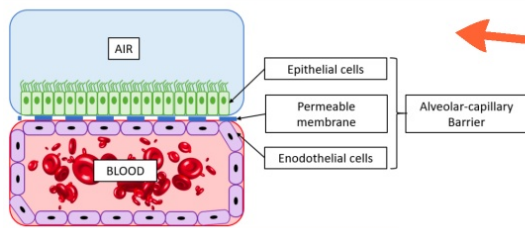
Some El Pasoans had no choice but to weather the dust storms that blew through El Paso on March 16, 2021.

AARON E. MARTINEZ / EL PASO TIMES

WHY IT'S A
DISEASE
PRECURSOR

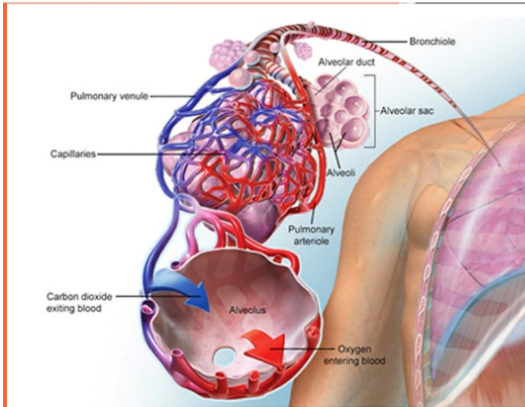
WHY IT CAUSES
ILLNESS

ACCELERATES INFLAMMATION IN THE BODY & BRAIN



Breakdown

- Nasal Barrier to the Brain
- Alveolar Capillary Barrier
- General Blood Brain Barrier



Calderón-Garcidueñas, Lilian & Torres-Jardón, Ricardo & Kulesza, Randy & Park, Su-Bin & D'Angiulli, Amedeo. (2014). Air pollution and detrimental effects on children's brain. The need for a multidisciplinary approach to the issue complexity and challenges. *Frontiers in human neuroscience*. 8. 613. 10.3389/fnhum.2014.00613.

• PM₁₀ < 10 μm can penetrate into the lungs and exposures are based upon respirable dust (5 μm) [Middleton, 2017].

• Silica size fractions in ambient dust -2.5-15 μm [Bhagia, 2012]

Disruption of the nasal and olfactory barriers
Olfactory sensory neurons and the surrounding respiratory epithelium

- 1- Direct damage to the sensory neurons
- 2- Inflammation and oxidative stress

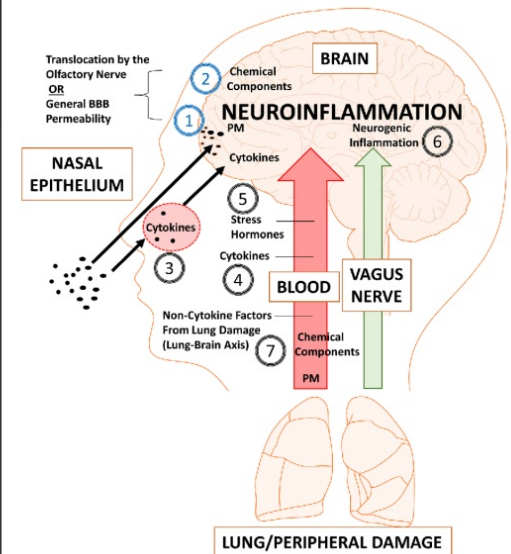
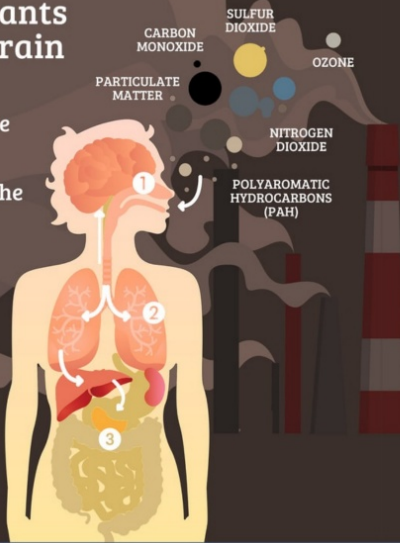


Fig. 3 Mechanisms of urban air pollution-induced neuroinflammation.

A Jayaraj, R.L., Rodriguez, E.A., Wang, Y., & Block, M.L. (2017). Outdoor Ambient Air Pollution and Neurodegenerative Diseases: the Neuroinflammation Hypothesis. *Current Environmental Health Reports*, 4, 166-179.

How pollutants enter the brain

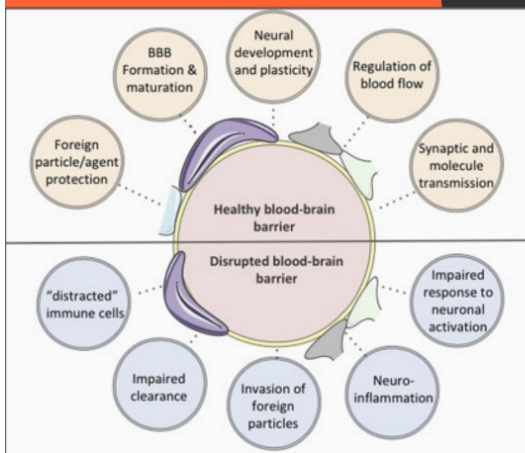
- 1 In through the nose
- 2 Inhaled into the lungs
- 3 Via the gut



Dr. Suzanne Gazada, Integrative Neurology

WHY BRAIN AND OTHERS ILLNESSES?

- Decreases - **brain CD3+ T cells** after DE with silica & heavy metals [Keil et al., 2016];
- Trigger **systemic inflammation**
- **Reduces immune response** [Keil et al., 2018];
- Passes BBB and **enters fetal liver & brain** [Yamashita et al., 2011];
- Risk factor for **preterm birth & low weight** [Zhao et al., 2015]
- Combination of SiO₂ exposure with **hypertension, stress, & environmental toxicants could aggravate** pathology [Sharma et al., 2013]





HEALTH DISPARITIES

- **Health disparities are health differences**

- Race/ethnicity,
- Skin color,
- Religion, or nationality,
- Socioeconomic resources or position
- Gender, sexual orientation, gender identity,
- Age,
- Geography,
- Disability, illness,
- Political or other affiliation,
- or other characteristics associated with discrimination or marginalization.

- [Braveman et al., 2011]

APPROACH

VARIABLES

To fill this gap in the literature, I studied the **association** between Dust events and dust exposure of $100\mu\text{g}/\text{m}^3$ **increments** in maximum daily hourly average **PM₁₀** and/or 10mph daily maximum **wind speed & DEs & hospital admissions the day of DE and 7 days after due to:**

- Neurodegenerative disease (ND; Parkinson's, Alzheimer's, and Huntington's),
- Mental Illness (MI -depression and anxiety),
- Valley Fever (VF), Asthma, Coronary Atherosclerosis,
- Other Associated Diagnoses (AD) [Genitourinary System, Septicemia, Chemo & Births]
- All ICD-9 categories

If incidences of certain diseases were **moderated** by age, and by **SES** indexed by income, and education level.

METHODOLOGY

OBTAINED DATA @ EL PASO, TX



HOSPITAL
ADMISSIONS

PM & WIND
SPEED DATA:

SOCIO-
ECONOMIC
DATA



HOSPITAL ADMISSIONS DATA

Texas Hospital Inpatient Research Data files from TDSHS from **2010-2014**.

- **Date of admission,**
- **CBG of the patient,**
- **Patient's age, gender, &**
- **The principal diagnostic code, Ninth Revision (ICD-9)**

Codes from the International Classification of Diseases, Ninth Revision (ICD)-9.

Group	Code Range	Diagnosis
1	001-139	Infectious and parasitic diseases
2	140-239	Neoplasms
3	240-279	Endocrine, nutritional and metabolic diseases, and immunity disorders
4	280-289	Diseases of the blood and blood-forming organs
5	290-319	Mental disorders
6	320-389	Diseases of the nervous system and sense organs
7	390-459	Diseases of the circulatory system
8	460-519	Diseases of the respiratory system
9	520-579	Diseases of the digestive system
10	580-629	Diseases of the genitourinary system
11	630-679	Complications of pregnancy, childbirth, and the puerperium
12	680-709	Diseases of the skin and subcutaneous tissue
13	710-739	Diseases of the musculoskeletal system and connective tissue
14	740-759	Congenital anomalies
15	760-779	Certain conditions originating in the perinatal period
16	780-799	Symptoms, signs, and ill-defined conditions
17	800-999	Injury and poisoning
19	E000-E999	Supplementary classification of external causes of injury & poisoning



PM10 & WIND SPEED DATA

2010-2014 data from CAMS-12 & CAMS 41 located in El Paso - TCEQ

- Maximum hourly average **PM10** concentrations,
- Maximum hourly average **wind speed** (m/h),
- Maximum hourly & daily average **temperature** (F),
- Maximum hourly average & Daily average relative **humidity**

TCEQ CAMS-12 located near the University of Texas at El Paso (UTEP)



TCEQ CAMS 41 at Chamizal in El Paso,



SOCIO-ECONOMIC DATA

For each patient CBG based on U.S. Census Bureau's American Community Survey 2010-2014

- Income &
- Education attainment
- Population increase or decrease



SOCIOECONOMIC
DISADVANTAGE

ICD-9 codes hospitalizations admissions for ND, MI, VF, Asthma, Coronary Atherosclerosis, High frequency ADs and ICD-9 category in El Paso, TX

Neurodegenerative Diseases (ND)			
Parkinson	3330, 3320, 3321		
Alzheimer	3310, 29411, 33119, 3312, 3313, 3315, 33182, 33189, 33181, 33182, 3319		
Huntington	3334, 3331, 3332, 3335, 3336, 33382, 33383, 33385, 33390, 33391, 33392, 33394, 33399		
Mental Illness (MI)			
Depression	311, 2980, 29620, 29621, 29622, 29623, 29624, 29630, 29631, 29632, 29633, 29634		
Anxiety	29384, 30000, 30001, 30002, 30009, 30921, 30924, 30928		
Valley Fever (VF)			
Valley Fever	1140, 1142, 1143, 1144, 1145		
Asthma			
Asthma	49300, 49301, 49302, 49310, 49311, 49312, 49320, 49321, 49322, 49381, 49382, 49390, 49391, 49392		
Coronary Atherosclerosis			
Coronary Atherosclerosis	41400, 41401, 41402, 41404, 41405, 41406, 4148, 4149		
Associated Diseases (ADs) with most frequent hospitalizations			
Births	V3001, V3000, 66411, 66401, 65421, 650, 64421, 66331, 65971, 64891, 64511, 65811		
Respiratory System	49121, 486, 49392, 51884, 46611, 46619, 51881, 49391		
Circulatory System	42731, 41071, 43491, 41401, 4280, 42823, 42833		
Digestive System	5770, 56211, 5609, 5589, 57400, 5409		
Genitourinary System	5849, 5990, 6262, 59080		
Encounter for antineoplastic chemotherapy	V5789, V5811		
Unspecified septicemia	0389		
Other chest pain	78659, 78650		
Dehydration	27651		
Cellulitis and abscess of leg	6826, 6823		
Osteoarthritis	71536, 71535, 71516, 72210		
Diabetes mellitus	25013		
Mental Disorders	29680, 29689, 29633, 29630, 29570, 29690, 29650, 29623, 29620		
Category Codes from the International Classification of Diseases, Ninth Revision (ICD)-9			
Code Range	Diagnosis	Code Range	Diagnosis
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4: 280-289	Diseases of the blood and blood-forming organs	13: 710-739	Diseases of the musculoskeletal system and connective tissue
5: 290-319	Mental disorders (Depressed mood, dementia)	14: 740-759	Congenital anomalies
6: 320-389	Diseases of the nervous system and sense organs (Alzheimer's disease)	15: 760-779	Certain conditions originating in the perinatal period
7: 390-459	Diseases of the circulatory system	16: 780-799	Symptoms, signs, and ill-defined conditions
8: 460-519	Diseases of the respiratory system	17: 800-999	Injury and poisoning
9: 520-579	Diseases of the digestive system	18: V01-V91	Aftercare services or therapies (except mental disorders-group 5 & births-group 11)

MODEL

A generalized linear model with quasi-Poisson or Poisson family -associations between DE and hospitalizations during eight-day period.

$$\begin{aligned} \log E[Y_{\tau}] = & \alpha + \beta_1 PM_{10_{\tau,\tau+7}} + \beta_2 WS_{\tau,\tau+7} + \gamma_1 Temp_{\tau,\tau+3} + \gamma_2 Humd_{\tau,\tau+5} + \gamma_3 s(time) + \\ & \gamma_4 s(day\ of\ year) + \gamma_5 DE + \gamma_6 DE_{7d} + \gamma_7 season + \gamma_8 holiday + \gamma_9 Weekday + \\ & \gamma_{10} Weekend + \gamma_{11} Population \end{aligned}$$

Several models were run for each outcome



Demographic factors were added

$$\log E[Y_{\tau}] = \alpha + (\text{Selected variables in Aim 3}) + \dots + \delta_1 Age + \delta_2 Income + \delta_3 Education$$




RESULTS

CONCLUSIONS

LIMITATIONS

3. Associations between exposure to air pollution after a dust event and hospitalizations in El Paso, Texas, USA

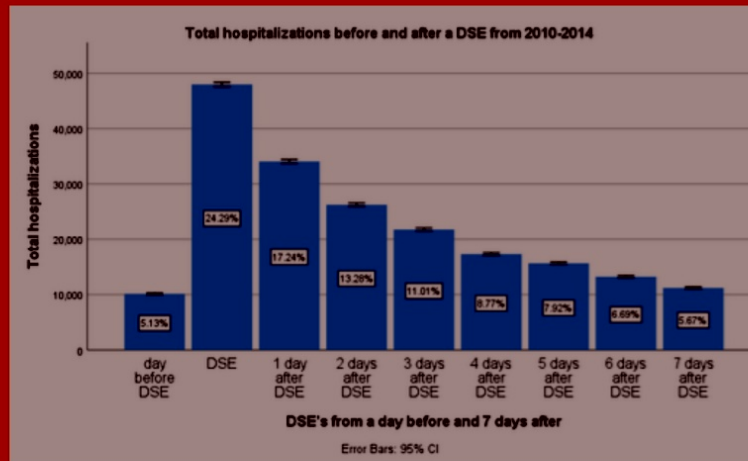


Share

RESULTS

Total Hospitalization percentage before a regular day and after DE in a week period and from 2010-2014 at El Paso, TX

The effect of a DE on hospitalizations might be highest during the actual day of the DE week and such effect decreases after that.



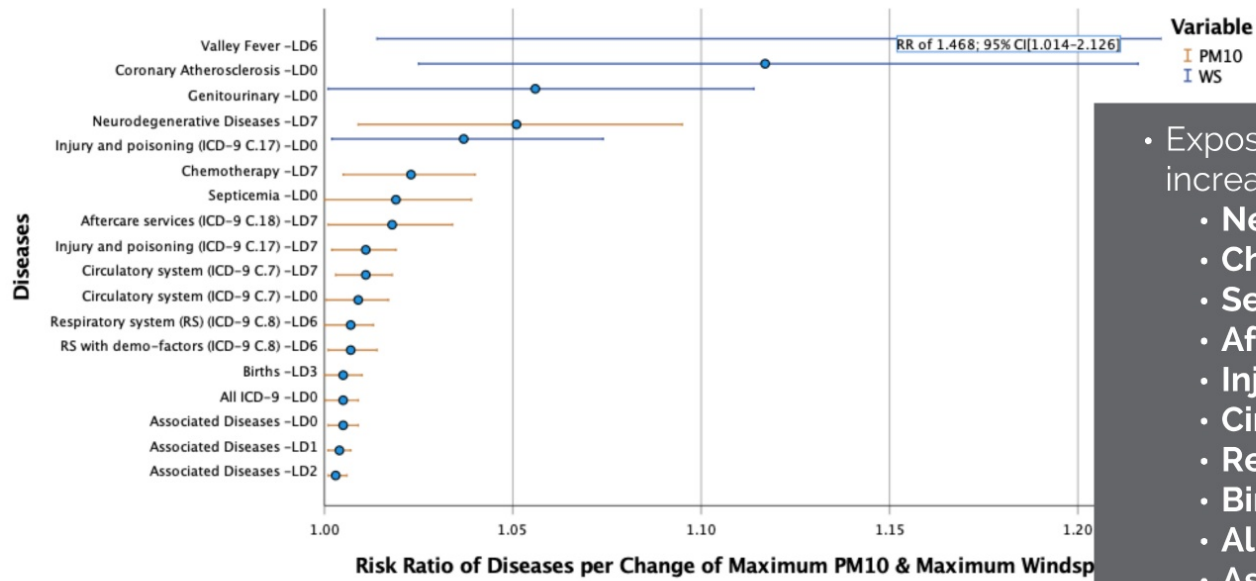
MAXIMUM
HOURLY PM10
ASSOCIATIONS

MAXIMUM
WIND SPEED
ASSOCIATIONS

WEEKEND,
SEASON AND
HOLIDAY
ASSOCIATIONS

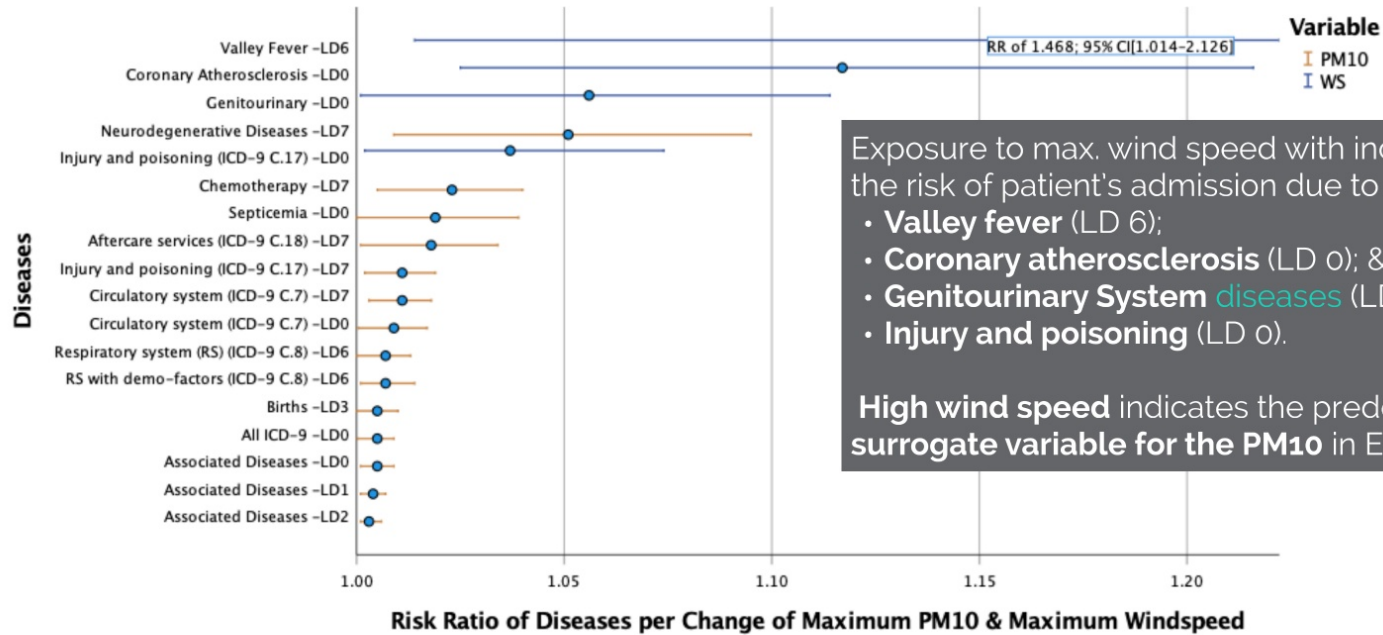
DEMOGRAPHIC
ASSOCIATIONS

MAXIMUM HOURLY PM10 ASSOCIATIONS



- Exposure to max, PM10 of 100 µg/m3 increases the risk of patient admission :
 - **Neurodegenerative Diseases (LD 7),**
 - **Chemotherapy (LD 7),**
 - **Septicemia (LD 0),**
 - **Aftercare services (LD 7) &**
 - **Injury and poisoning (LD 7),**
 - **Circulatory system (LD 0 & 7),**
 - **Respiratory system (LD 6).**
 - **Births (LD 3),**
 - **All ICD-9 category (LD 0)**
 - **Associated Diseases (LD 0-2),**

MAXIMUM WIND SPEED ASSOCIATIONS



Exposure to max. wind speed with increments of 10mph increases the risk of patient's admission due to

- **Valley fever** (LD 6);
- **Coronary atherosclerosis** (LD 0); &
- **Genitourinary System** diseases (LD 0);
- **Injury and poisoning** (LD 0).

Acute kidney failure,
 Kidney infection (Pyelonephritis),
 Urinary tract infection, &
 Disorders of menstruation

High wind speed indicates the predominance of coarse particles - **surrogate variable for the PM10** in El Paso (Staniswalis et al., 2005),

Genitourinary System -vascularization is vulnerable to toxins lifted up (Yang, et al., 2017).

Valley Fever, it is known that symptoms may appear in a minimum of 7-10 days (CDC, 2021). This study at El Paso, TX shows that VF cases appear early in the 6th day after DE.

Coronary atherosclerosis at lag day 0. Fasola et. al. (2021) found similar results in Tuscany, Italy,

WEEKEND, SEASON AND HOLIDAY ASSOCIATIONS

Increased on weekday as compared to weekend ($p < 0.01$).

- ND,
- Genitourinary,
- Coronary Atherosclerosis,
- Circulatory System,
- Respiratory System, .
- Births,
- Septicemia,
- Injury and Poisoning,
- Aftercare Services and
- Chemotherapy,
- AD,
- all ICD-9 categories,

Decreased in the cold season and holiday compared to in hot season and non-holiday ($p < 0.01$).

- Chemotherapy,
- Coronary Atherosclerosis,
- Circulatory System,
- Births,
- Injury and Poisoning,
- Aftercare Services,
- all ICD-9 categories, and
- AD

SES ASSOCIATIONS

Discrepancy in medical access in patients with **medium & low SES:**

- **Chemotherapy** encounters,
- **Associated Diseases,**
- **Births,**
- **Circulatory System,**
- **Injury & Poisoning,**
- **Aftercare Services,**
- **Respiratory System, &**
- **All ICD-9 ,**

As median education decreases, the chances of a patient being hospitalized due to **circulatory system, respiratory system & births increases.**

As average income decreases, the chances of a patient being hospitalized due to **Injury & poisoning & aftercare services increases.**

As age decreases, the **chances** of a patient being hospitalized due to **AD** and **all ICD-9** categories **increases.**

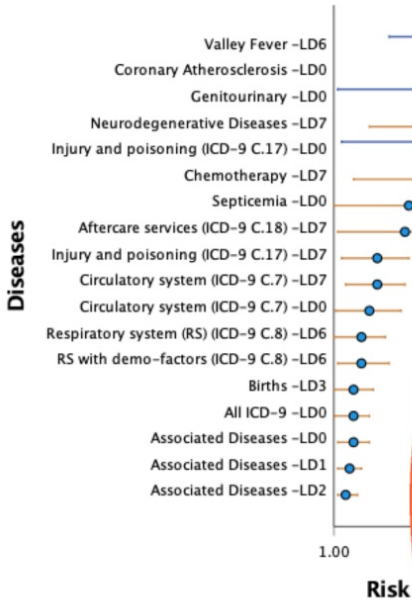
CONCLUSIONS

Significantly positively associated with DE, indicated from higher to lower risk.

- Valley fever (LD 6) (RR of 1.468),
- Coronary Atherosclerosis (LD 0),
- Genitourinary Diseases (LD 0), Acute kidney failure, infections of kidney, Urinary tract infection
- Neurodegenerative Diseases (LD 7) Disorders of menstruation and other abnormal bleeding
- Injury & Poisoning-ICD9-C (LD 0&7) Parkinson's & Alzheimer's disease
- Chemotherapy (LD 7)
- Septicemia (LD 0)
- Aftercare services ICD9-C (LD 7),
- Circulatory System Diseases ICD9-C (LD 0 & 7),
- Respiratory System Diseases ICD9-C (LD 6),
- Births (LD 3)
- All ICD-9 categories (LD 0) and Associated Diseases (AD) (LD 0-2)

Patients affected with medium and low SES

- Chemotherapy services,
- Circulatory system diseases,
 - Aftercare services,
 - Respiratory System,
 - Injury & poisoning, &
 - Births



LIMITATIONS

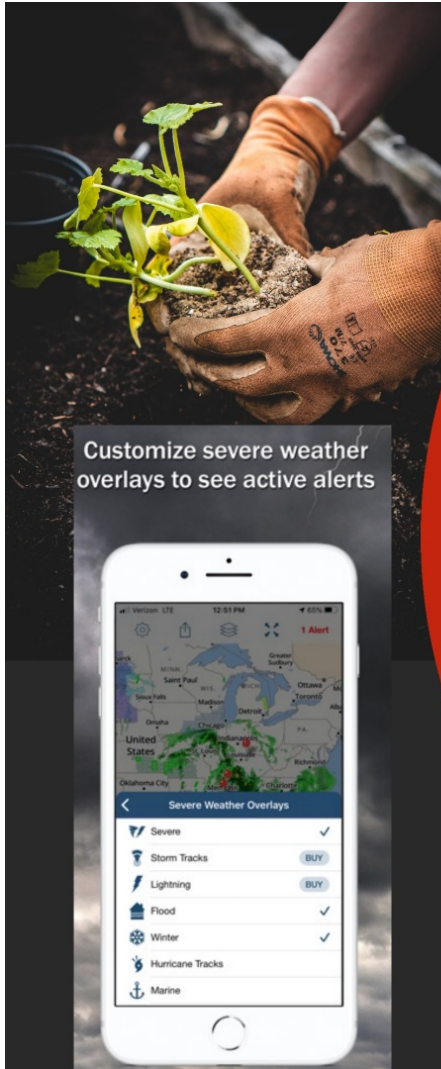
- **Principal diagnosis** was obtained, which does not indicate pre-existing conditions/comorbidities of the patient.
- Persons with neurodegenerative or **mental conditions**, especially anxiety and depression, often have **their disorder go unrecognized** (Bushnell et al., 2005).
- **Daily maximum** value **describes acute exposures** but does not explain chronic exposures/ lower-intensity dust exposures happening over long periods of time.
- There also is a difference between **emergency room (ER)** visits and **hospital admissions (HA)**. e.g., HA are less frequent than ER visits; & ER may be used for primary care by patients with low income (Winqvist et al., 2012).



4. Summary & Recommendations

Acknowledgments

Recommendations



Customize severe weather overlays to see active alerts

RECOMMENDATIONS

- Recommendations for reduction of outdoor and indoor exposures to DEs should be generated for El Paso County.
 - Alert general public & patients with associated diagnoses
 - Audiovisual messages
 - Improvement of early warning dust forecasting
- Public policies and individual actions are essential to reduce the human health effects of dust events.
 - Physical wind erosion control measures –
 - Paving streets and reforestation of eroded lands in Cd. Juarez;
 - Avoiding exertion and outdoor activities during a DE;
 - Wearing a mask and eye coverings
 - Improving household insulation by detecting air leaks,
 - Substituting/fixing drafty windows and doors by sealed ones -but ventilate the area
 - Urban Reforestation
 - Assist people on the streets-most vulnerable



© 2016 Looking for Detachment

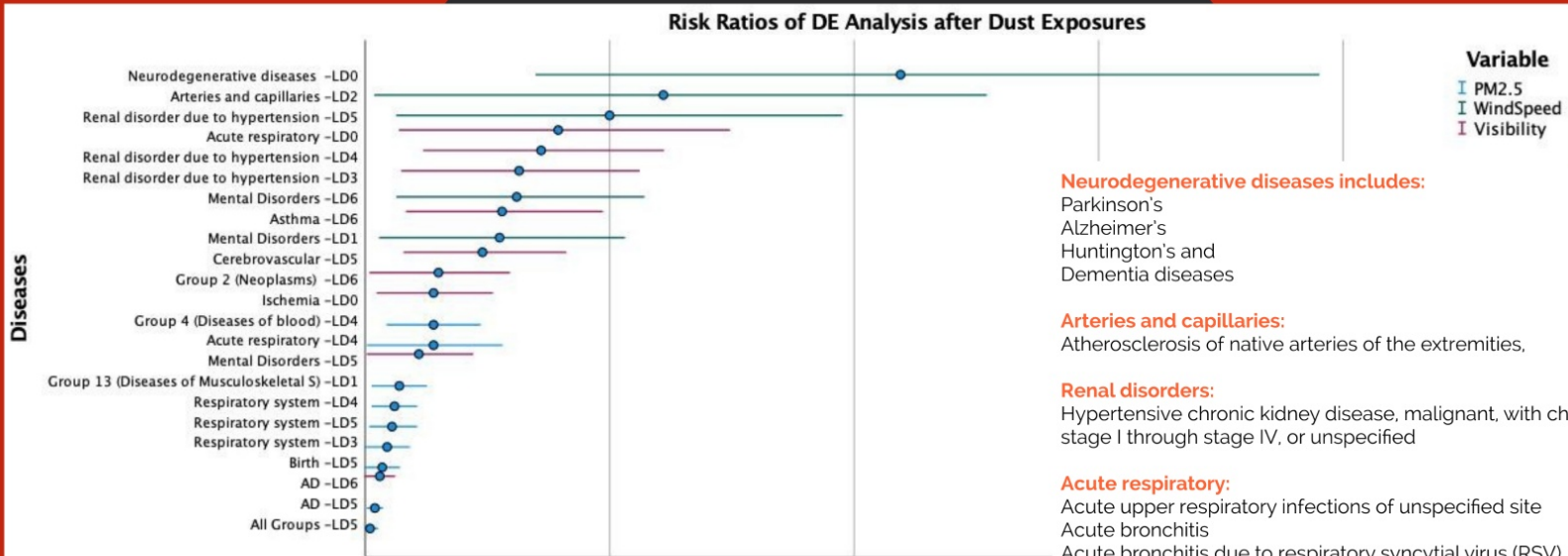
ACKNOWLEDGEMENTS

We express our appreciation to Hector Olvera for useful discussions.

Institutional Review Board approval was obtained from the University of Texas at El Paso, with permit #00001224.

PENDING
ARTICLE

HEALTH EFFECTS OF DUST EVENTS IN LUBBOCK, TX



Variable
I PM2.5
I WindSpeed
I Visibility

Neurodegenerative diseases includes:

- Parkinson's
- Alzheimer's
- Huntington's and Dementia diseases

Arteries and capillaries:

Atherosclerosis of native arteries of the extremities,

Renal disorders:

Hypertensive chronic kidney disease, malignant, with chronic kidney disease stage I through stage IV, or unspecified

Acute respiratory:

- Acute upper respiratory infections of unspecified site
- Acute bronchitis
- Acute bronchitis due to respiratory syncytial virus (RSV)
- Acute bronchitis due to other infectious organisms

Mental Disorders:

- Bipolar,
- Schizophrenia,
- episodic mood disorder and psychosis.

Respiratory System :

- Acute respiratory
- Pneumonia and influenza
- COPD (Bronchitis, and asthma)
- Other diseases of the Respiratory S., (Post inflammatory pulmonary fibrosis, Acute respiratory failure)

Risk Ratio of Diseases per Change of Maximum PM2.5, Max



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