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

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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).
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
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
**Fugitive Dust & Road Dust**

- disease precursors

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

- 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]
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
ACCELERATES INFLAMMATION IN THE BODY & BRAIN

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

- PM<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.
**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]
To fill this gap in the literature, I studied the association between Dust events and dust exposure of 100μg/m³ increments in maximum daily hourly average PM_{10} 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.
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)

<table>
<thead>
<tr>
<th>Group</th>
<th>Code Range</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>001-139</td>
<td>Infectious and parasitic diseases</td>
</tr>
<tr>
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<td>140-239</td>
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</tr>
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<td>Diseases of the digestive system</td>
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<tr>
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<td>580-629</td>
<td>Diseases of the genitourinary system</td>
</tr>
<tr>
<td>11</td>
<td>630-679</td>
<td>Complications of pregnancy, childbirth, and the puerperium</td>
</tr>
<tr>
<td>12</td>
<td>680-709</td>
<td>Diseases of the skin and subcutaneous tissue</td>
</tr>
<tr>
<td>13</td>
<td>710-739</td>
<td>Diseases of the musculoskeletal system and connective tissue</td>
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<tr>
<td>14</td>
<td>740-759</td>
<td>Congenital anomalies</td>
</tr>
<tr>
<td>15</td>
<td>760-779</td>
<td>Certain conditions originating in the perinatal period</td>
</tr>
<tr>
<td>16</td>
<td>780-799</td>
<td>Symptoms, signs, and ill-defined conditions</td>
</tr>
<tr>
<td>17</td>
<td>800-999</td>
<td>Injury and poisoning</td>
</tr>
<tr>
<td>19</td>
<td>E000-E999</td>
<td>Supplementary classification of external causes of injury &amp; poisoning</td>
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PM\textsubscript{10} & Wind Speed Data

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

- Maximum hourly average PM\textsubscript{10} concentrations,
- Maximum hourly average wind speed (m/h),
- Maximum hourly & daily average temperature (F),
- Maximum hourly average & Daily average relative humidity
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
### Neurodegenerative Diseases (ND)
- Parkinson: 3330, 3320, 3321
- Alzheimer: 3310, 29411, 3319, 3312, 3314, 3315, 3316, 3318, 3319
- Huntington: 3324, 3311, 3332, 3330, 3310, 3312, 3318, 3319, 3330, 3332, 3334, 3338

### Mental Illness (MI)
- Depression: 311, 2980, 29630, 29621, 29622, 29623, 29624, 29626, 29630, 29631, 29632, 29633, 29614
- Anxiety: 29384, 30000, 30001, 30002, 39099, 39092, 39094, 39098

### Valley Fever (VF)
- Valley Fever: 140, 1142, 1143, 1144, 1145

### Asthma
- Asthma: 49310, 49311, 49312, 49313, 49314, 49315, 49316, 49317, 49318, 49319, 49320

### Coronary Atherosclerosis
- Coronary Atherosclerosis: 41400, 41401, 41402, 41403, 41404, 41405, 41406, 41407, 41408, 41409

### Associated Disease (AD)
- Associated Disease (AD) with matched NDC code
  - Respiratory System: 49121, 488, 49322, 51884, 46611, 46619, 51881, 49322
  - Circulatory System: 42731, 41071, 43991, 41401, 4280, 42823, 42833
  - Digestive System: 5770, 56211, 5699, 5589, 5580, 5409
  - Genitourinary System: 5849, 5990, 5626, 59080
  - Encountered for ambulatory chemotherapy: V5789, V5811
  - Unspecified endocarditis: 0189
  - Other endocarditis: 78659, 78680
  - Dehydration: 27891
  - Infections and abscesses of the hand: 6826, 6823
  - Oral conditions: 71536, 71538, 71516, 72210
  - Diabetes mellitus: 29613
  - Mental Disorders: 29840, 29869, 29830, 29900, 29920, 29903, 29023, 29020

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

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<td>Diseases of the digestive system: 18:V01-V91</td>
<td>Aftercare services or therapies (except mental disorders group 5 &amp; births-group 11)</td>
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</table>
A generalized linear model with quasi-Poisson or Poisson family -associations between DE and hospitalizations during eight-day period.

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

Several models were run for each outcome.

Demographic factors were added

\[ \log E[Y_{\tau}] = \alpha + (Selected\ variables\ in\ Aim\ 3) + \cdots + \delta_1 \text{Age} + \delta_2 \text{Income} + \delta_3 \text{Education} \]
3. Associations between exposure to air pollution after a dust event and hospitalizations in El Paso, Texas, USA
RESULTS

Total Hospitalization percentage before a regular day and after DE 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.
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).

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
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),
- Neurodegenerative Diseases (LD 7)
- Injury & Poisoning-ICD9-C (LD 0 & 7)
- 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 (Winquist et al., 2012).
4. Summary & Recommendations
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
Acknowledgements

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Health Effects of Dust Events in Lubbock, TX

Risk Ratios of DE Analysis after Dust Exposures

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)
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