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Association of short-term exposure to ambient air pollution and weather conditions with deaths of despair among U.S. Veterans

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Joint work with

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Background

- Past studies have established a link between deaths of despair and both air pollution and temperature changes in the general U.S. population.
- However, the relationships between air pollution, temperature, and the risk of deaths of despair among U.S. Veterans—a subgroup that may be uniquely vulnerable to these exposures—are not well understood.
- Additionally, air pollutants and temperature exposure exhibit distinct seasonal variations across the U.S. which can influence these outcomes in complex ways.

Aim

Our study aims to explore two key questions:

- How does **ambient air pollution** (including $PM_{2.5}$, NO_2, and O_3), stratified by season, influence the risk of deaths of despair among U.S. veterans, while accounting for the effects of *maximum temperature*, *precipitation*, and *solar radiation*?

- How does **maximum ambient temperature**, stratified by season, affect the risk of deaths of despair among U.S. Veterans, considering the influence of $PM_{2.5}$, *precipitation*, and *solar radiation*?

Data

Veteran Decedents

- U.S. Veterans who died between 2018 and 2019 are recorded in the joint VA and DoD Mortality Data Repository, which includes ICD-10 coded death *dates* and *causes* from the National Death Index.

- Deaths of despair in this study encompass suicide and both intentional and unintentional drug overdoses. The specific outcomes assessed are:
    - **Suicide**: N=6,394 (Primary cause codes: U03, X60–X84, Y870)
    - **Drug Overdose**: N=4,414 (Primary cause codes: X40–X44, X60–X64, X85, Y10–Y14)
    - **Opioid Overdose**: N=2,762 (Primary cause: overdose with contributing cause codes: T400–T404, T406)

- The FIPS code for each decedent's county of residence at the time of death was obtained from the Veterans Health Administration (VHA) database.

Data (Cont'd)

Meteorological data

Daily, average county-level values of

- precipitation [mm/day]
- maximum temperature [degrees C]
- shortwave radiation [W/m^2]

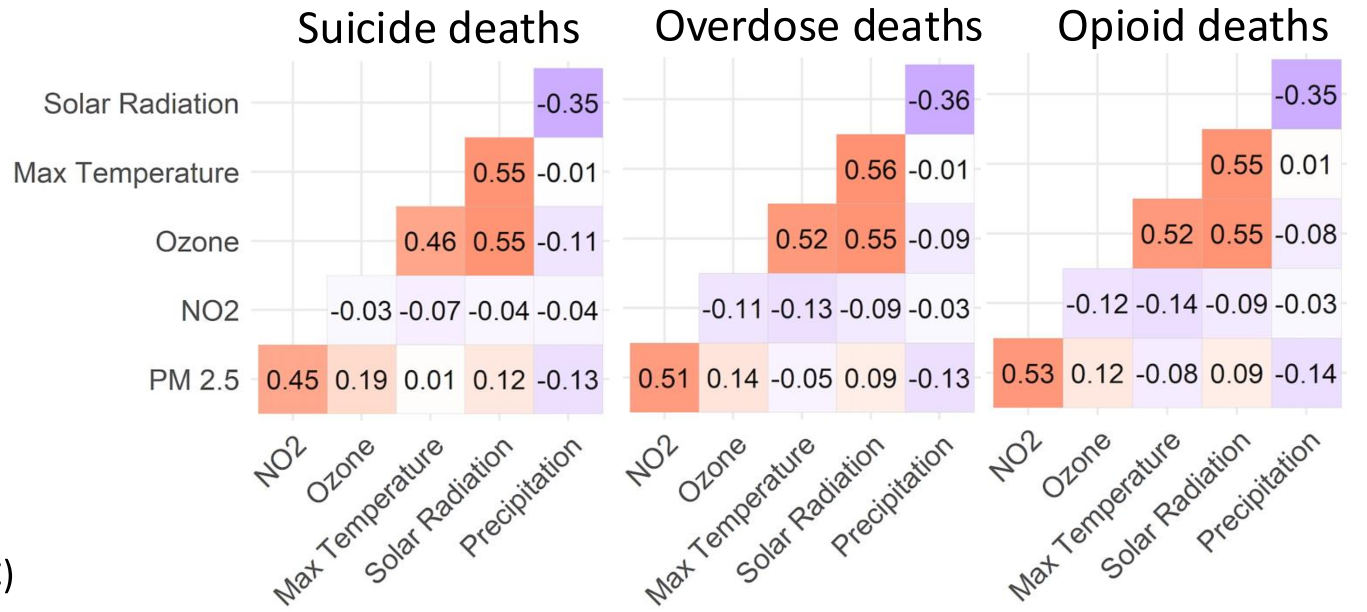
Source: Daymet 1-km grid estimates from the NASA's Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC)
https://daymet.ornl.gov/overview

Air pollution data

Daily, average county-level concentrations of

- particulate matter $PM_{2.5}$[μg/m^3]
- nitrogen dioxide NO_2 [ppb]
- ozone 0_3 [ppb]

Source: Community Multiscale Air Quality (CMAQ) spatially fused surfaces 12-km grid estimates
https://www.epa.gov/hesc/rsig-related-downloadable-data-files
https://www.epa.gov/cmaq



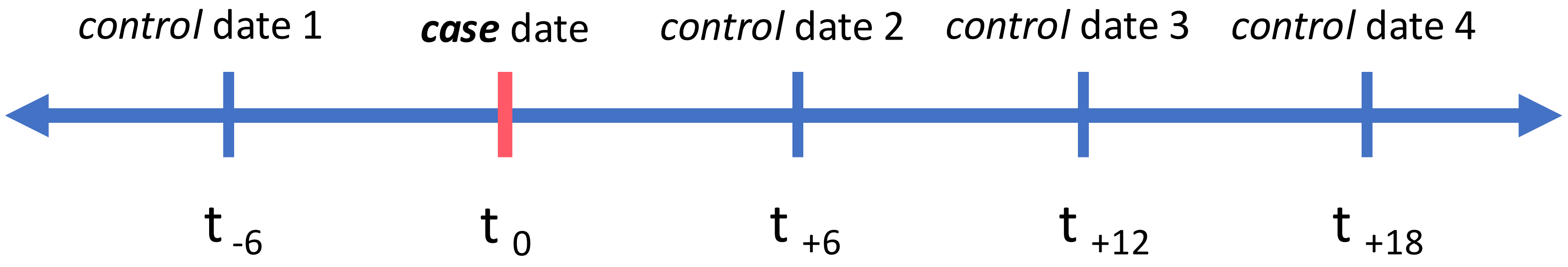
Correlation matrix for meteorological and air pollution variables, by outcome

Study design

This study employs a **bi-directional**, **time-stratified** case-crossover design:

- Each suicide case was matched with control periods spanning 7 days, including the day of death and up to six days prior.
- Control dates were restricted to the same day of the week and month as the date of death.
- Control periods are bidirectional, selecting 3 to 4 days before and after the event.

Example of time-stratified control date selection for day *j*=6 with *J*=0,1,…,6



Model

- Adjusted conditional logistic regression models were developed for each exposure of interest:
  - *Air pollution* models *($PM_{2.5}$, NO_2 , 0_3)* were adjusted for *temperature, precipitation, and solar radiation.*
  - *Temperature* models were adjusted for *$PM_{2.5}$*, *precipitation*, and *solar radiation.*

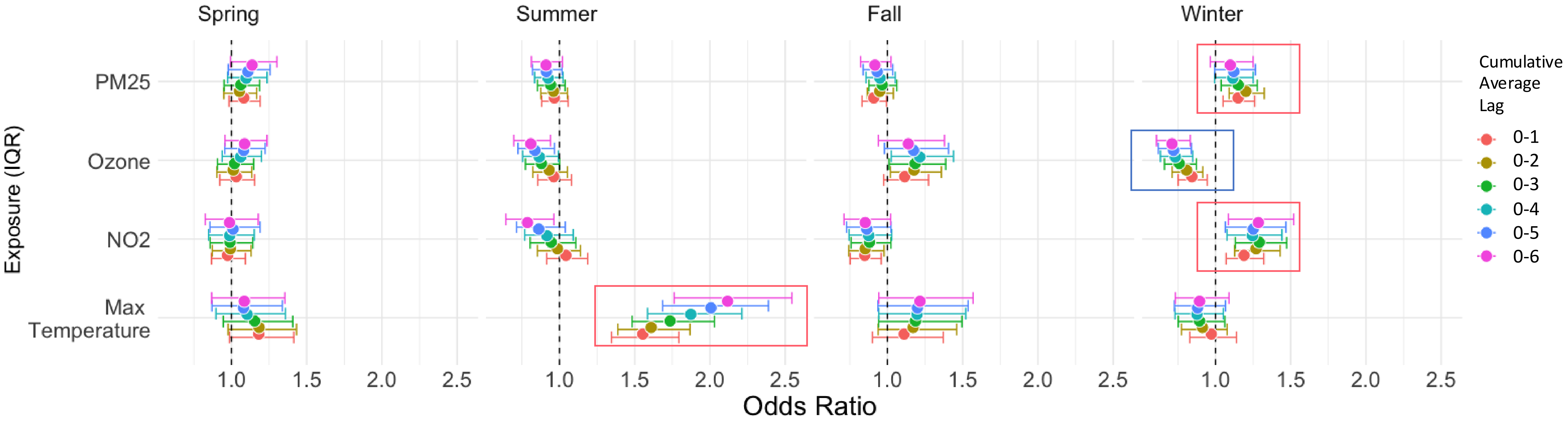
- Analyses were conducted by season.

- Single and cumulative lag exposures from 0 to 6 days prior to death were examined:
  - Single Lag: exposure on an individual day (e.g., lag 0, lag 1, lag 2, , …, lag 6).
  - Cumulative Lag: an average exposure measure over multiple lag days (e.g., 0-1, lags 0-2, …, lag 0-6).

- Odds ratios (OR) were calculated per interquartile range (IQR) increase of each exposure.

Results

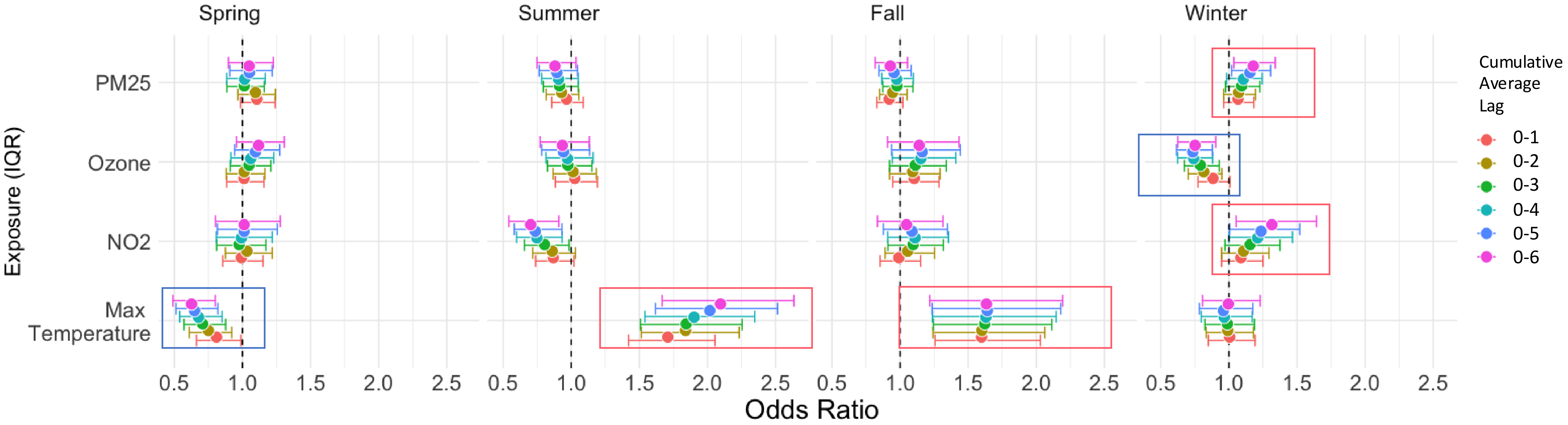
Suicide



- Increasing *temperature* in the *summer* are associated with a higher risk of suicide.
- Increasing *NO_2* concentrations in the *winter* are associated with a higher risk of suicide.

Results

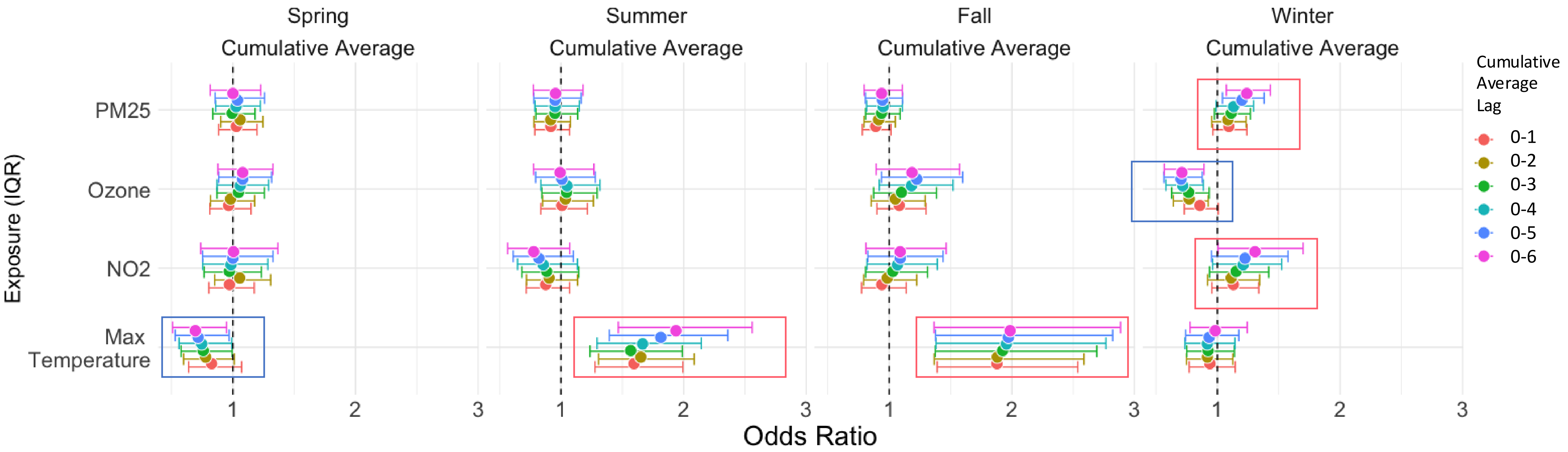
Overdose



- Increasing *temperatures* in the *summer* and *fall* are associated with a higher risk of overdose.
- Conversely, *spring temperatures*, often considered ideal, may have a protective effect.

Results

Opioid Overdose



- Increasing *temperatures* in the *summer* and *fall* are associated with a higher risk of opioid-specific overdose.

Conclusions & Next steps

- This study on U.S. veterans uses a national dataset and outcome measures as in the *clinical predictive models* such as REACHVET and STORM, which are being updated in collaboration with the VA's Office of Mental Health and Suicide Prevention.

- With deaths of despair rising amid climate change, understanding how temperature and air pollution impact vulnerable populations is crucial for effective prevention.

- Further research should explore how seasonal and geographical factors interact with environmental exposures to refine preventive strategies.

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