In the entire Medicare population there was significant evidence of adverse effects of short- and long-term PM$_{2.5}$ and O$_3$ exposure below the National Ambient Air Quality Standards. Previous studies have predominantly focused on urban populations, due to lack of exposure information availability and statistical power at rural areas. We conducted two nationwide studies to investigate the impacts of short- and long-term PM$_{2.5}$ and O$_3$ exposure on mortality and assess if effect estimates differ among populations living below the national standards.

### Health Data
- All Medicare participants (N > 67M) in the continental US (2000 - 2012).
- Outcomes: all-cause mortality.
- Individual level information: date of death, age, year of entry, sex, race, Medicaid eligibility (proxy for SES).
- Residence zip code and other area-level covariates.

### Exposure Model
- Highly spatio-temporally resolved Validated prediction models to estimate zip-code level daily and annual PM$_{2.5}$ and O$_3$ exposures.

### Results: Short-Term Effects
- Highly statistically harmful effects overall.
- For short-term effects: 1.05% (95% CI: 0.95-1.15%) and 0.51% (95% CI: 0.41-0.61%) increase in mortality per 10 µg/m$^3$ increase in PM$_{2.5}$ and O$_3$ in warm-season O$_3$.
- No evidence of a threshold in either exposure-response relationships.

### Results: Long-Term Effects
- 7.3% (95% CI: 7.1-7.5%) and 1.1% (95% CI: 1.0-1.2%) increase in mortality per 10 µg/m$^3$ increase in PM$_{2.5}$, and 10 ppb increase in O$_3$.
- Analyses restricting to person-years with PM$_{2.5} < 12$ µg/m$^3$ and $< 50$ ppb O$_3$: 13.6% (95% CI: 13.1-14.1) and 1.6% (95% CI: 0.9-1.1).

## References

## Conclusions
- In the entire Medicare population there was significant evidence of adverse effects related both to short- and long-term exposure to PM$_{2.5}$ and O$_3$.
- These effects persisted even at concentrations below the current national standards.
- Our findings suggest that these standards may need to be re-evaluated.