# Protocol Air Pollution Vaccine Systematic Review

# PROTOCOL: Air Pollution Impact on Vaccine Effectiveness  
  
\*\*Systematic Review and Meta-Analysis\*\*  
  
\*\*PROSPERO Registration:\*\* CRD42024567892  
\*\*Date:\*\* December 12, 2025  
\*\*Version:\*\* 2.0  
  
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## Background  
  
### Rationale  
Ambient air pollution exposure affects nearly 80% of the global population, with emerging evidence suggesting immune dysregulation impacting vaccine responses. While laboratory studies indicate air pollution-immune interactions, there is no comprehensive synthesis of real-world vaccine effectiveness studies. This protocol outlines a systematic approach to address this critical knowledge gap.  
  
### Research Significance  
- \*\*Public Health Impact:\*\* Pollution affects millions of vaccine recipients annually  
- \*\*Clinical Relevance:\*\* Environmental factors influencing vaccination outcomes  
- \*\*Policy Implications:\*\* Air quality standards as indirect vaccine promotion  
- \*\*Research Gap:\*\* Missing systematic evidence on real-world pollution-vaccine interactions  
  
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## Research Questions  
  
### Primary Question  
Does chronic exposure to ambient air pollution (PM₂.₅, NO₂, O₃) reduce the effectiveness of routinely administered vaccines in human populations, as measured by real-world clinical effectiveness against vaccine-preventable diseases?  
  
### Secondary Questions  
1. What are the quantitative effects of different pollutants on vaccine effectiveness across pollutant concentration bands?  
2. Are there dose-dependent relationships between pollution levels and vaccine effectiveness reductions?  
3. Which population subgroups show greatest vulnerability to pollution-vaccine interactions?  
4. What are the differential effects across vaccine types and technology platforms?  
  
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## Eligibility Criteria  
  
### Types of Studies  
\*\*Prospective cohort studies, retrospective cohort studies, nested case-control studies, ecological studies with strong methodological rigor, and population-based vaccine effectiveness studies.\*\*  
  
#### Inclusion Criteria  
- Published prospective or ret...