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Urban Air Quality as a Coupled Transport-Health-Equity System

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Abstract

This interdisciplinary review examines urban air quality as a coupled transport, health, and equity system. The organizing question is which interventions reduce population exposure rather than merely relocate monitored emissions. Ten related scholarly sources are synthesized through a decision-centered framework spanning problem definition, mechanism, measurement, evaluation, implementation, and governance. The review does not invent experiments, pooled estimates, or unreported quantitative results. It instead evaluates the strength and transferability of the available evidence, with particular attention to using citywide concentration averages to infer equitable health benefit. The resulting framework links technical or empirical performance to explicit use conditions and identifies tests that should precede wider adoption in clean-mobility and urban-health policy.

Keywords: urban air pollution, transport, exposure, health equity, environmental policy

Synthesis lens	Principal question
Mechanism	the pathway from transport activity and atmospheric transformation to microenvironment exposure and health
Evaluation	source-specific emissions, personal exposure, health response, spatial inequality, and policy spillovers
Primary risk	using citywide concentration averages to infer equitable health benefit

1. Introduction

Research on urban air quality as a coupled transport, health, and equity system sits at the boundary between a promising component and a consequential decision. The core question is which interventions reduce population exposure rather than merely relocate monitored emissions. Answering it requires more than assembling favorable results. It requires a chain of evidence that makes the problem boundary, mechanism, measurement, comparator, uncertainty, and accountable decision visible to the reader.

This article presents a structured narrative review of ten related publications. Sources were selected for topical relevance, traceable publication metadata, and complementary coverage of technical, empirical, and governance questions. No meta-analytic pooling is attempted because the included studies differ in designs, populations, system boundaries, and outcomes. The purpose is decision-oriented synthesis: to identify what each source can support, where transfer remains uncertain, and which evidence would justify the next stage of use.

The central risk is using citywide concentration averages to infer equitable health benefit. A top-line metric or broad policy label can appear decisive while concealing the conditions that produced it. Accordingly, the synthesis separates observation from interpretation and implementation from validation. This separation is especially important when the same system creates benefits for one user or institution while transferring cost, risk, or administrative burden to another.

2. Evidence Base and Problem Boundary

A defensible review begins by defining the unit of analysis. For the present topic, the relevant boundary includes inputs, institutional or technical context, the mechanism producing an output, the person or system acting on that output, and the downstream outcome. Evidence falls outside the boundary when it measures only an intermediate proxy yet is used to claim an end-to-end benefit.

Manisalidis et al. (2020) addresses "Environmental and Health Impacts of Air Pollution: A Review." In this synthesis, that work is used as a source on problem definition within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Di et al. (2017) addresses "Air Pollution and Mortality in the Medicare Population." In this synthesis, that work is used as a source on conceptual boundary within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Rajagopalan et al. (2018) addresses "Air Pollution and Cardiovascular Disease." In this synthesis, that work is used as a source on measurement within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Together, these works provide complementary entry points, but their conclusions should not be flattened into a single ranking. Differences in data generation, setting, temporal horizon, and outcome definition may be substantively meaningful. A review should therefore preserve those differences and state where analogy, rather than direct replication, connects one domain to another.

3. Mechanism and System Design

The operative mechanism is the pathway from transport activity and atmospheric transformation to microenvironment exposure and health. This formulation discourages component-only reasoning. A model, platform, policy, assay, or infrastructure service acquires practical meaning only when its interfaces and use conditions are specified. The evidence chain should describe what information is available, what transformation occurs, which assumptions make that transformation credible, and who is authorized to act.

Janhäll (2015) addresses "Review on urban vegetation and particle air pollution – Deposition and dispersion." In this synthesis, that work is used as a source on system mechanism within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Wright et al. (2019) addresses "Atmospheric microplastic deposition in an urban environment and an evaluation of transport." In this synthesis, that work is used as a source on representation choice within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Sridharan et al. (2021) addresses "Microplastics as an emerging source of particulate air pollution: A critical review." In this synthesis, that work is used as a source on failure analysis within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

These studies also show why modular claims require interface tests. A component may perform well while the complete pathway fails because inputs drift, users interpret outputs differently, recovery semantics are ambiguous, or institutional incentives change. Design documentation should therefore include not only the intended pathway but also foreseeable deviations, degraded modes, and conditions under which the system should stop or defer.

4. Evaluation and Uncertainty

Evaluation should center on source-specific emissions, personal exposure, health response, spatial inequality, and policy spillovers. Average performance remains useful, but it should be accompanied by distributions, error categories, relevant subgroups or operating regimes, and uncertainty at the point where a decision changes. Comparators must isolate the value of the proposed addition rather than compare a mature intervention with an intentionally weak baseline.

Kelly and Fussell (2015) addresses "Air pollution and public health: emerging hazards and improved understanding of risk." In this synthesis, that work is used as a source on comparative evaluation within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness

for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Rentschler and Leonova (2023) addresses "Global air pollution exposure and poverty." In this synthesis, that work is used as a source on uncertainty within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

External validation should introduce meaningful shifts in setting, time, population, workload, market structure, or environmental conditions. A nominally independent sample can still be too similar to test transfer. Conversely, a failed transfer is scientifically informative when the changed conditions are measured and the mechanism of failure is examined rather than hidden in an aggregate score.

5. Translation and Governance

Translation to clean-mobility and urban-health policy depends on more than technical readiness. Decision rights, documentation, maintenance, monitoring, appeal, and recovery are part of the intervention. The governance requirement is integrated transport-health assessment, transparent monitoring, and community-centered evaluation. Each control should be connected to a named failure mode and should identify an owner, evidence source, review interval, and escalation path.

Wang et al. (2016) addresses "Ozone pollution in China: A review of concentrations, meteorological influences, chemical precursors, and effects." In this synthesis, that work is used as a source on implementation within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

Bourdrel et al. (2017) addresses "Cardiovascular effects of air pollution." In this synthesis, that work is used as a source on governance within urban air quality as a coupled transport, health, and equity system. The connection is deliberately bounded: the cited study informs the evidence map, but it does not by itself establish readiness for clean-mobility and urban-health policy. That distinction keeps the review close to the published record and prevents an adjacent result from being converted into a broader causal claim.

A credible implementation plan also defines sunset and revalidation conditions. New data, software updates, institutional restructuring, population change, or shifts in incentives can invalidate previously reasonable assumptions. Monitoring should therefore test the validity of the evidence chain, not merely whether a service remains online or a headline metric remains stable.

6. Research Agenda

Future studies should preregister or otherwise predefine the intended decision, principal outcomes, exclusions, and analysis plan when feasible. They should report missingness, sensitivity analyses, negative or null findings, and the cost of errors to differently situated stakeholders. Reproducible artifacts should include sufficient metadata to reconstruct data provenance, model or analytical versions, parameter choices, and the sequence from evidence to conclusion.

Cross-disciplinary work needs a shared object of explanation rather than a collection of adjacent vocabularies. For urban air quality as a coupled transport, health, and equity system, that shared object is the complete decision pathway. Technical, clinical, social, environmental, or economic expertise should each change the design or interpretation of the study. When evidence remains incomplete, the useful output is a bounded hypothesis, a transparent uncertainty statement, or a request for additional measurement.

7. Conclusion

The literature supports a disciplined approach to urban air quality as a coupled transport, health, and equity system: define the decision, preserve system boundaries, test consequential failure modes, connect uncertainty to action, and assign accountable control. The strongest conclusion is not that one method is universally superior. It is that credible use in clean-mobility and urban-health policy requires an auditable link from source evidence to design choice, evaluation result, and governed decision.

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