

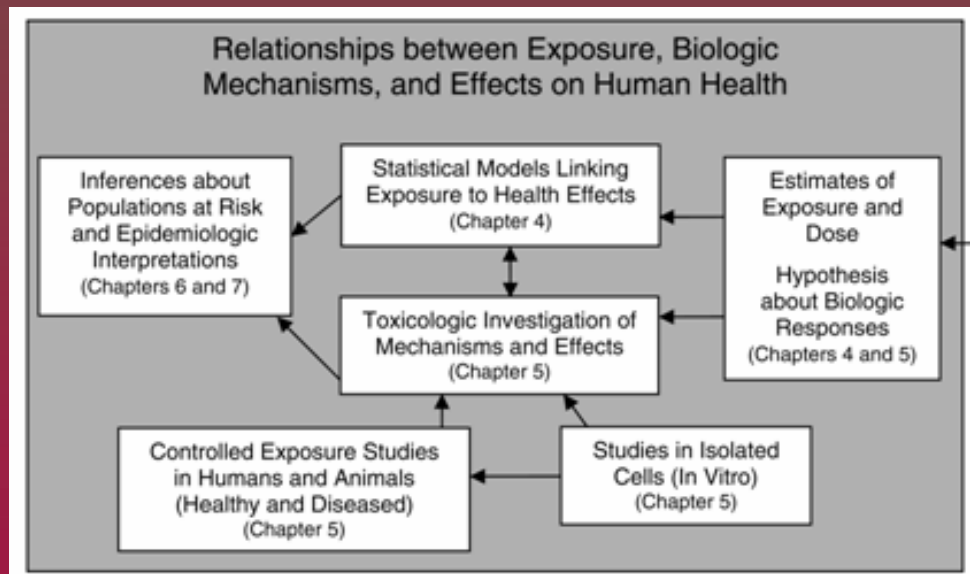
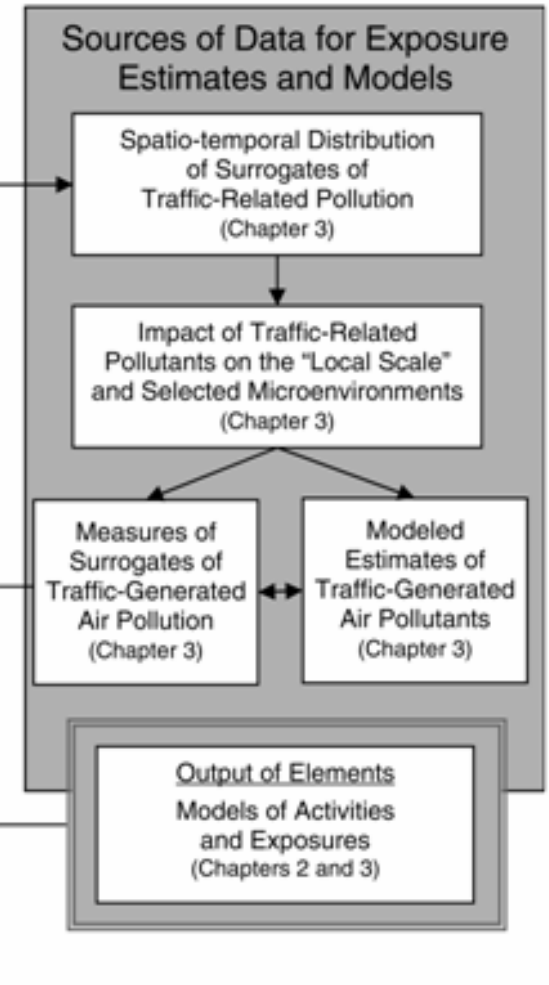
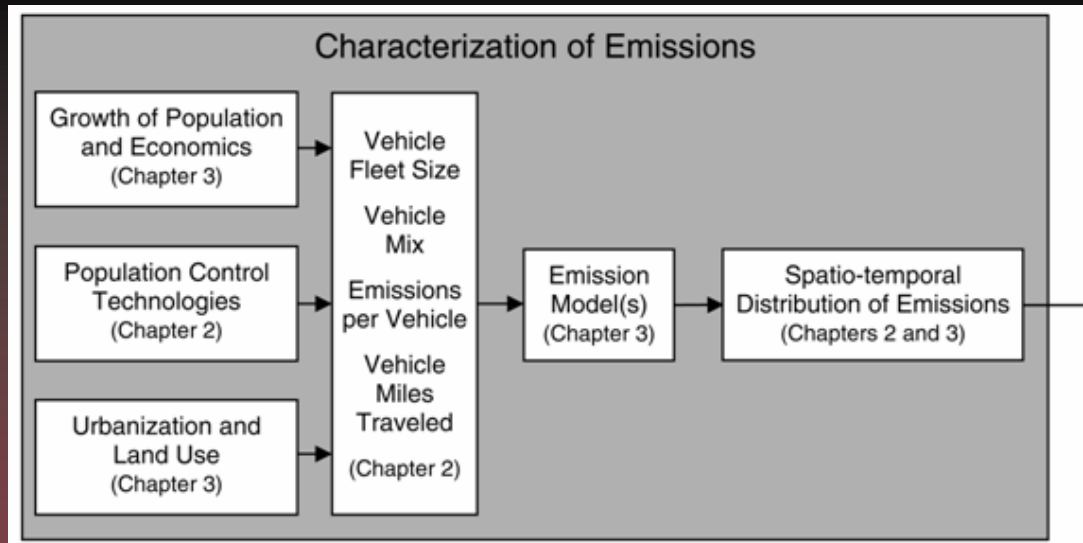
Critical Review of Health Effects of Traffic Related Air Pollution: Summary of the Conclusions

**Ira Tager, Member Research Committee
On Behalf of the Writing Panel
and
Contributing HEI Staff**

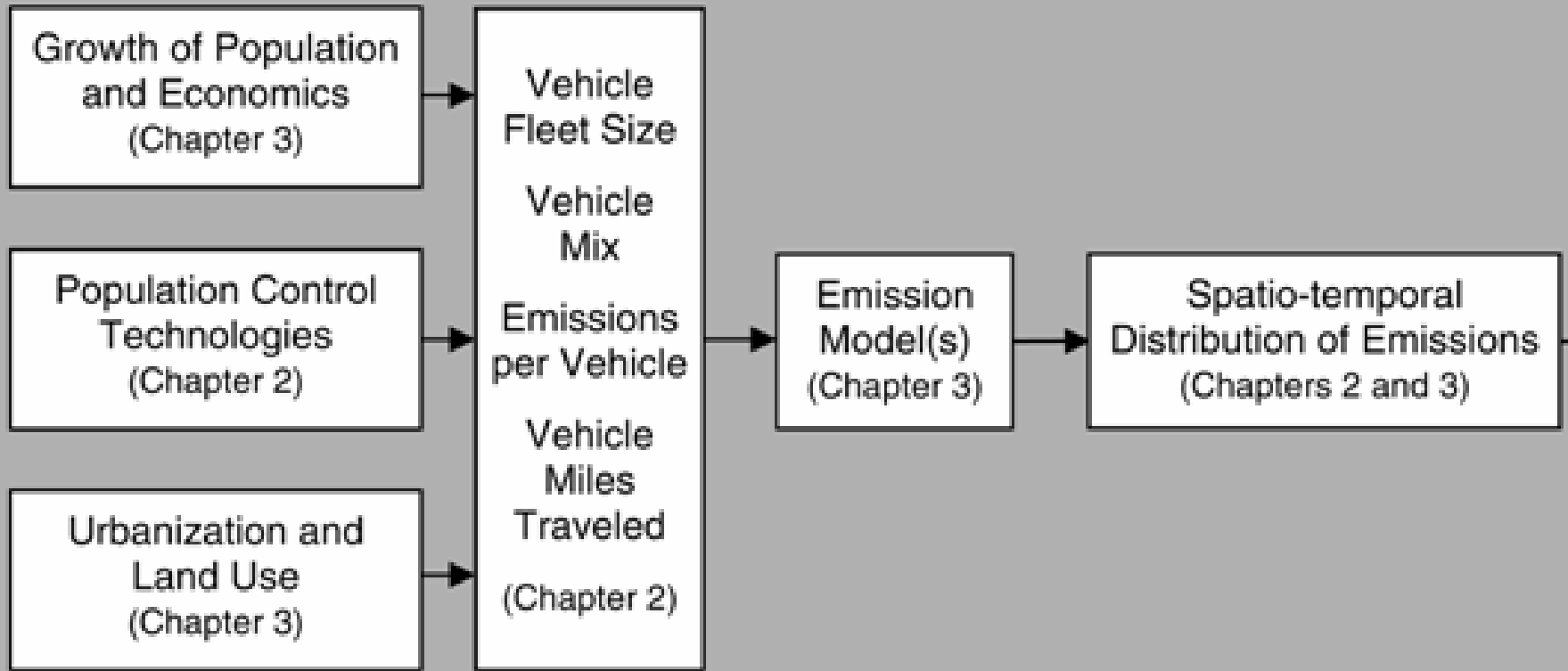


Goals of the Conclusion Chapter

- Summarize the main conclusions from each chapter
- Provide an overall synthesis that integrates current information on:
 - Motor vehicle (traffic) emissions
 - Exposure to primary traffic emissions
 - Epidemiologic studies of human health effects associated with exposure to primary traffic emissions
 - Toxicology of primary motor vehicle emissions



Characterization of Emissions



Emissions from Motor Vehicles

The Current Context

- **Significant progress has been made in reduction of pollutant emissions from motor vehicles despite increases in number of vehicles and vehicle miles traveled**
- **Increased urbanization and urban populations have:**
 - **Increased traffic congestion**
 - **Changed land use patterns such that more people are near traffic sources of pollution**



Emissions from Motor Vehicles

- Key steps for understanding relation of emissions from motor vehicles and exposure of humans
 - Release, Transformation and Dispersion
- Ideal data needed are very costly
 - Distribution of vehicles in time and space
 - Traffic counts
 - Types of vehicles and their operation
 - Fuels
 - Emission controls
- Conclusion—
 - At present, **vehicle miles traveled**, as estimated by traffic demand models, represents the best starting point to estimate regional emissions



Emissions from Motor Vehicles

- **Substantial uncertainty remains about estimates of emissions because models fail to account for factors such as:**
 - **Roadway grades**
 - **Operating modes**
 - **High emission vehicles**
 - **Non-combustion emissions (brake and tire wear, resuspended road dust)**
 - **Likely to be more important with introduction of controls on PM emissions**



Emissions from Motor Vehicles

Important Challenges For Estimation of Emissions

- **Need to cross-check PM emissions estimates against field data**
 - Major shortcoming of models for emission simulation and exposure
- **Limited availability of roadside monitors and measurements**
 - Makes it difficult to track trends in emissions of CO, VOCs, NO_x and PM



Emissions from Motor Vehicles

Important Challenges For Estimation of Emissions

- **Limited availability of roadside monitors and measurements**
 - **Makes it difficult to track chemical and physical transformations of pollutants from traffic**
 - **Transformations that occur in the early stages of the exhaust dilution and plume entrainment can produce toxic gases, semivolatile and particle-phase constituents that could be relevant to human health**
 - **Usually not measured currently**

Emissions from Motor Vehicles

Important Challenges For Estimation of Emissions

- The quality of the emissions profiles used to apportion the chemical composition of species-specific sources is not always adequate or current
 - Many emission profiles have not been updated for a decade or more
 - May not reflect technological advances
 - Adds uncertainties to species-specific emissions estimates



Emissions from Motor Vehicles

Summary of Current Needs

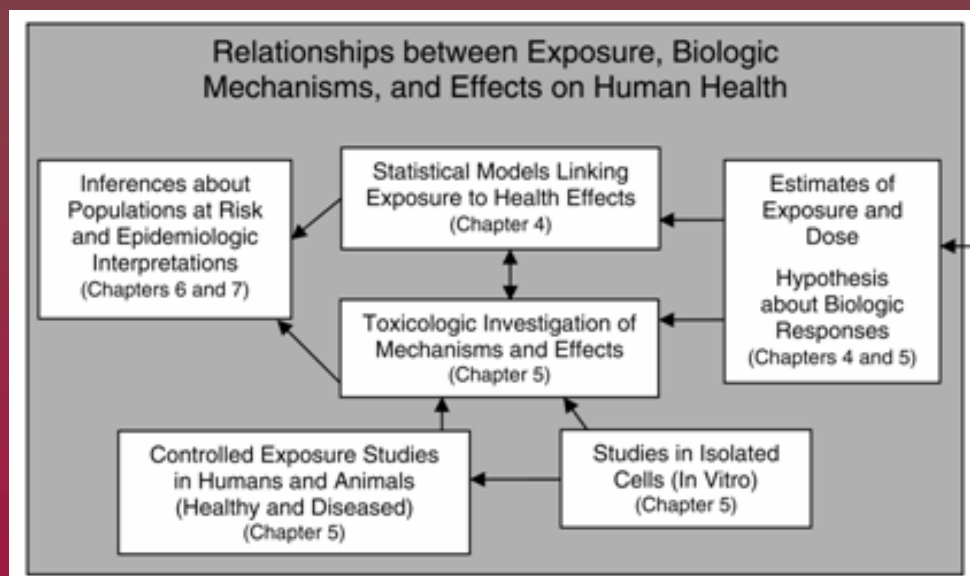
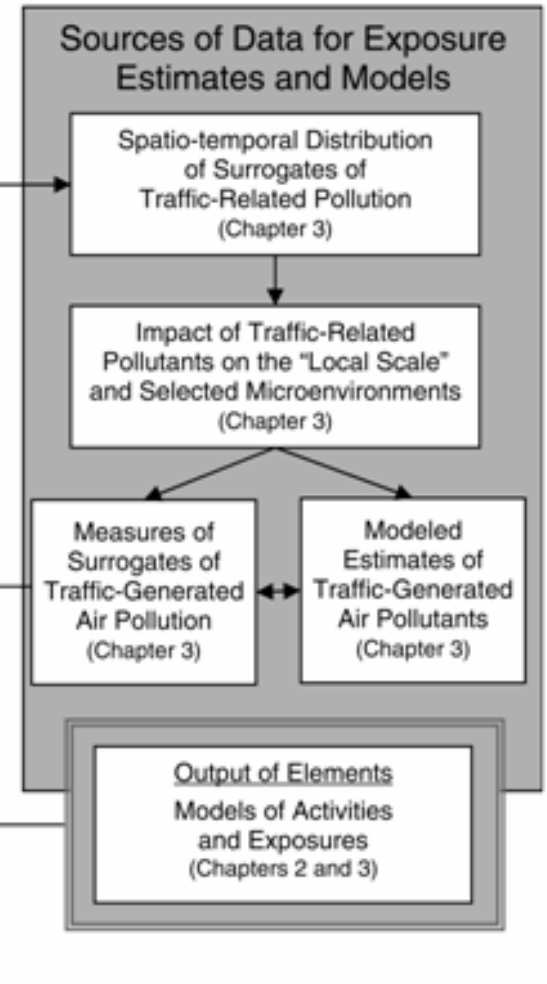
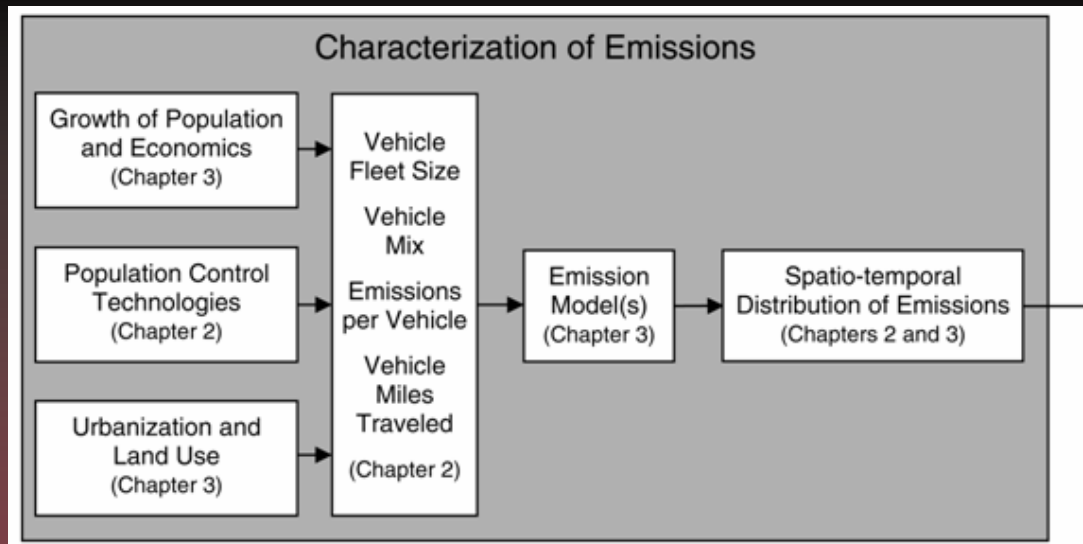
- **More extensive traffic monitoring networks**
- **Greater focus on near-roadside environments**
 - **Focus on wider range of pollutants derived from combustion and non-combustion sources**
 - **Physical and chemical transformations that primary emissions undergo**
- **Improved range and quality of emissions inventories**
 - **Expand range of factors associated with roadways and vehicle operation**

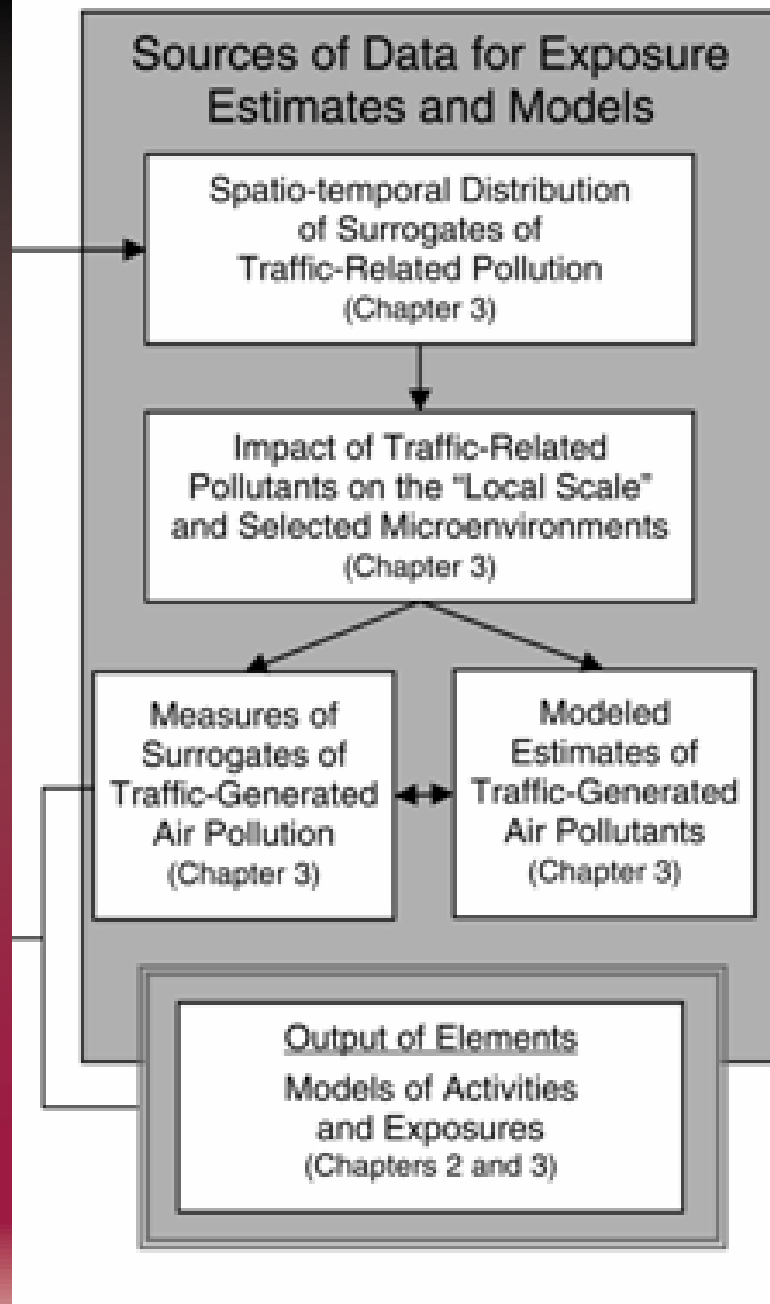


Emissions from Motor Vehicles

Relevance of Current Needs

- **Exposure estimates in epidemiologic studies of long-term exposure depend on:**
 - **The ability to apportion contributions of primary traffic pollutants to ambient air pollution**
 - e.g., by identification of improved surrogates for traffic-related pollutants
 - **Estimates of traffic contributions from receptor modeling over time**
- **Toxicological studies depend on similar knowledge**
 - **Particularly for traffic-source mixtures in animal and human exposure studies and *in vitro* studies**





Exposure to Primary Traffic-Generated Air Pollution

- **Accurate assessment to primary traffic-generated pollution (PTGP) is a *sine qua non* for evaluation of causal character of associations with human health**

Exposure to Primary Traffic-Generated Air Pollution

- **Theoretical characteristics of ideal surrogates for PTGP**
 - PTGP is only source for the surrogate
 - Concentrations of the surrogate vary over time with other constituents of PTGP
 - Can be measured cheaply and accurately
 - Does not have associated independent adverse health effects at concentrations observed in other settings
- **Considered surrogates used in epidemiologic studies**
 - CO, NO₂, PM mass and number, elemental (black) carbon, benzene and direct measures of traffic



Exposure to Primary Traffic-Generated Air Pollution

- **Apart from quality, utility of surrogates depend on identification of the spatial scale over which PTGP is likely to influence human health**
 - **Based on synthesis of evidence, 300-500 meters from roadway chosen**
 - **Estimated that 30%-45% of people in large cities in North American are likely to live within these zones**

Hierarchy of Models for Assessment of Exposure to PTGP

Model	Theory/Concept Match	Utility to Health Studies
Proximity	Low	Low (error prone, potential confounding)
Geostatistical	Medium	Depends on density of monitoring network
Land-use regression	Medium	Depends on density of monitoring network and quality of land-use data
Dispersion models	Medium	Often lacks adequate data
Hybrid (integration of personal and central site data)	High	Very good but expensive

Issues for Exposure to Primary Traffic-Generated Air Pollution

- Emissions from both light- and heavy-duty vehicles have varied greatly over time
 - Health associations based on past estimates of exposure might not be an accurate guide to future health associations
 - We do not know which emissions components/combinations, are responsible for the observed health effects
 - We cannot predict what effects on health will be as emissions continue to change in the coming years
 - Even if concentrations of traffic-related pollution decrease overall, it is possible that changes in the relative concentrations of its components could cause associated health effects to increase, decrease more than expected, or remain unchanged



Issues for Exposure to Primary Traffic-Generated Air Pollution

- None of the surrogates considered met all criteria for an ideal surrogate
 - Data not available to assess ratios of surrogates to emissions from all sources over time
 - CO, benzene, and NO_x [NO₂] found in on-road vehicle emissions are major components of emissions from all sources
 - All have significant ambient and microenvironmental sources, making it difficult to disentangle the contributions from motor vehicles
 - Reason why epidemiology studies reviewed were limited to surrogates that were documented to have been derived primarily from traffic



Issues for Exposure to Primary Traffic-Generated Air Pollution

- Concentrations UFP are very high in vehicle-exhaust plumes
 - Decay rapidly with distance from the road
 - These distance-decay gradients present significant challenges for exposure assessment, because they are difficult to characterize over space and time in a way that supports epidemiologic research
 - We do not yet have adequate data on actual exposure to traffic-related or other UFP



Issues for Exposure to Primary Traffic-Generated Air Pollution

- **EC has been used as a surrogate, primarily for diesel exhaust**
 - EC needs to be studied to better understand the contributions of gasoline-fueled motor vehicles and non-mobile sources to the amount of EC measured
- **EC has been used as a surrogate, primarily for diesel exhaust**
 - Needs to be studied to better understand contributions of gasoline-fueled motor vehicles and non-mobile sources



Issues for Exposure to Primary Traffic-Generated Air Pollution

- **Central monitors cannot capture spatial variability in traffic-related pollution**
 - **The variability in the degree of association with health outcomes observed in epidemiologic studies may suggest different complex mixtures contributing to the pollutant mix used to assess population exposures**
 - **May be responsible for some of the differences in health effects observed between studies**

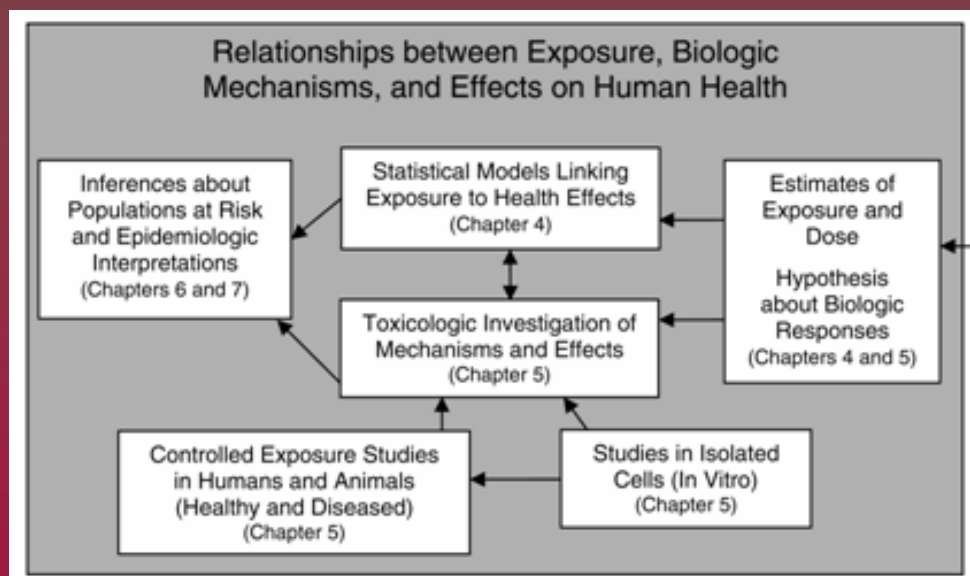
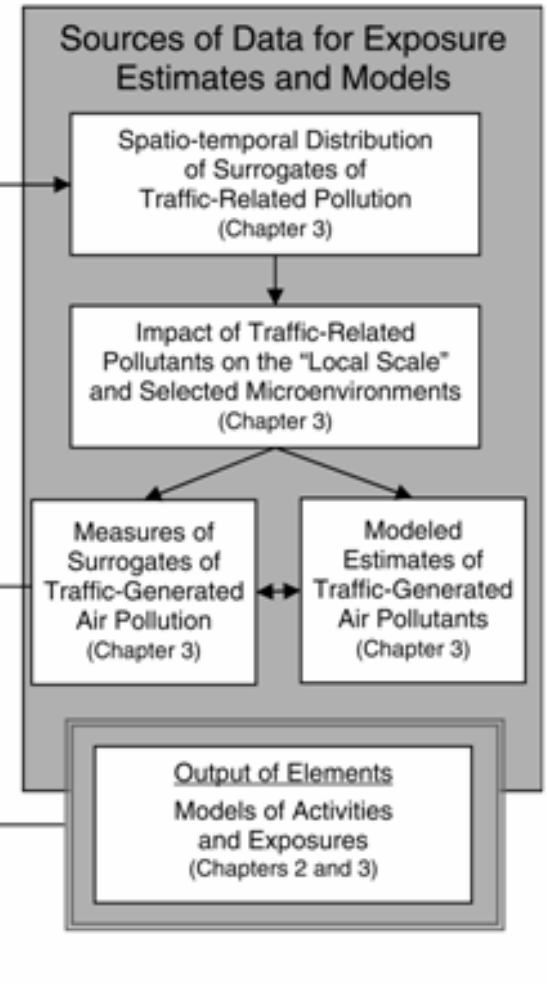
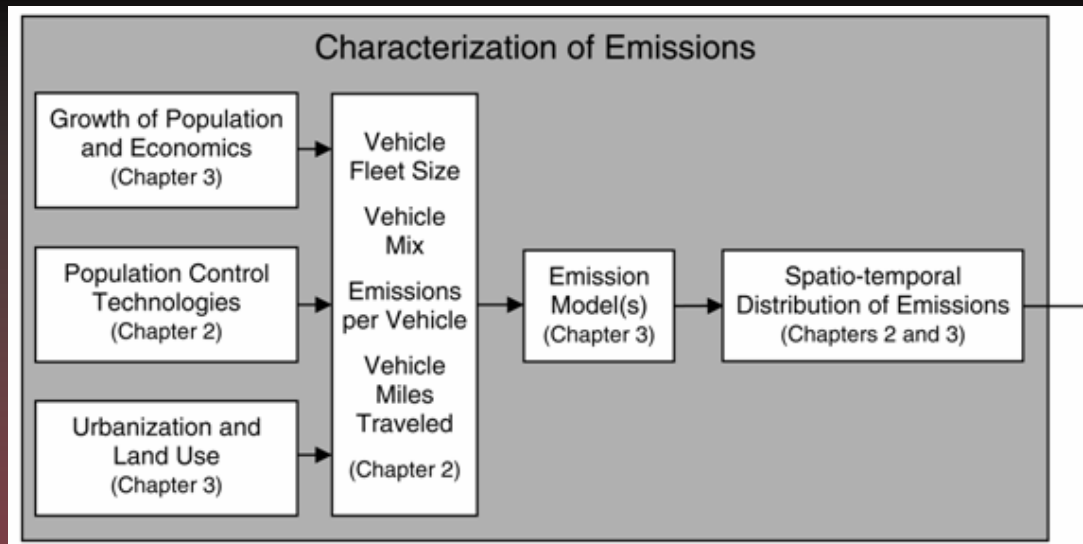
Issues for Exposure to Primary Traffic-Generated Air Pollution

- **Measurements of personal exposure are not feasible for large numbers of subjects, especially over time**
 - **Deployment of large numbers of monitors in a given geographic region likely to be useful, even necessary, in areas where exposure to traffic-related pollutants is highly variable**

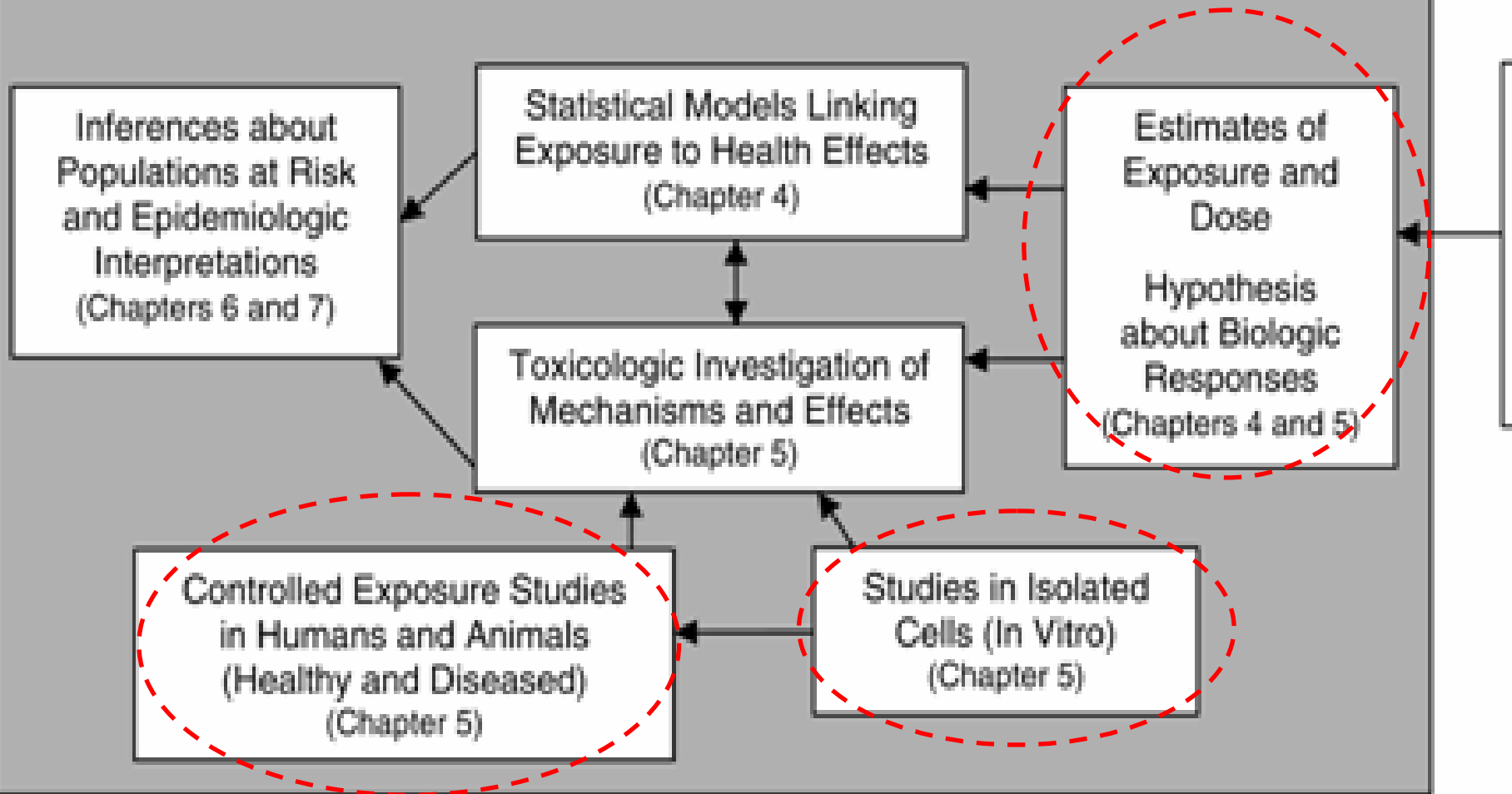
Issues for Exposure to Primary Traffic-Generated Air Pollution

- **Source-apportionment (SA) models are useful for developing surrogates for exposure to traffic sources**
- **Have several important limitations**
 - Failure to identify specific sources
 - Misidentification of sources among commingled sources
 - Inconsistency among, or implausibility of, results for the same location when using two or more source-apportionment models
 - Failure to distinguish statistically based factors from actual sources
- **Successful application of SA models will depend on collection of sufficient quality, quantity and frequency**





Relationships between Exposure, Biologic Mechanisms, and Effects on Human Health



Challenges for Toxicology Studies of Traffic-Generated Air Pollution

- **Difficult to design studies that capture effects exclusively from traffic pollution**
- **Limited in ability to study dose-response**
- **Concentrators not useful to study gases**
- **Costs and small samples for controlled human exposures**
- **Difficult to extrapolate findings in animals to humans and different responses in different animal species**



Overall Synthesis

- **Surrogates for traffic-related emissions have played, and are likely to continue to play, a preeminent role in exposure assessments in epidemiologic studies**
- **The ability of source-apportionment models to characterize pollution sources accurately depends on the availability of a rich emissions-profile database extending over time and over appropriately small-scale spatial areas**



Overall Synthesis

- **With the upcoming changes in engines and fuels, the quality of data over time will become critical to determine the extent to which quantitative and qualitative changes in traffic emissions are affecting human health over the near and long term**
 - **Failure to see health improvements in the elderly related to improved emissions, for example, could easily be explained by cohort effects related to the character of past emissions**
 - **Might make it appear that the emissions improvements were having little near-term (up to a generation's worth) effect on the cardiovascular and other chronic diseases**

Overall Synthesis

- **Knowledge of emissions and their transformation products will also help toxicologists design studies that more accurately identify the chemical and physical characteristics of traffic-related pollution that are potentially toxic and might play a role in the pathophysiology of the health effects observed in epidemiologic studies**
 - **Improved understanding of the toxicology of emissions might also lead to hypotheses that can then be tested in epidemiologic studies through the identification of possible new and more specific biomarkers of exposure to emissions components.**

Overall Synthesis

- **To the extent, that the deficiencies identified persist in the quality and quantity of emissions data and the models used for emissions characterization, exposure assessments for future epidemiologic studies will find it hard to:**
 - **Improve the accuracy of effect estimates where substantial uncertainties still remain**
 - **Strengthen exposure assessments for health effects for which causal inferences appear to be warranted but for which population exposure–response relations are not well understood**
 - **Test new hypotheses about exposures and health effects as motor-vehicle fleets and fuels change over time**

Overall Synthesis

- **Proximity as a surrogate for exposure no longer should be used in future epidemiologic studies of health effects associated with traffic-generated air pollution**
 - **Particularly prone to be an “impure” surrogate**
 - **Confounded with important of factors**
 - **Socioeconomic status for which there are good surrogates**
 - **Stress, noise, poor housing, indoor environments**
 - **These often are difficult to measure**
 - **Despite inclusion of these factors in statistical models, the probability of residual confounding remains high**

IN CONTRAST



Overall Synthesis

- **Although other methods suffer from inaccuracy caused by measurement errors**
 - **Unlike the proximity method, any potential confounding with these methods likely is due to physical factors**
 - **e.g., meteorology, physical and chemical transformations, other pollutant sources with similar emissions characteristics**
 - **In theory, accurate measurements could be made for these factors**
 - **Accurate measurements would reduce the problem to one of random errors and errors in model specification**



Overall Synthesis

- “Sufficient” evidence to infer causal associations
 - **Exacerbations of asthma**
 - *Asthma incidence and prevalence in children*
- “Suggestive but insufficient” to infer causal associations
 - Mortality (all-cause and cardiovascular)
 - Decreases in lung function
 - General respiratory symptoms
- “Inadequate and insufficient” evidence to infer causal associations
 - Adult onset asthma
 - Health care utilization for childhood and adult respiratory diseases
 - COPD
 - Non-asthmatic allergy
 - Birth outcomes
 - Cancers

Summary

The data are incomplete with respect to emissions and their transformations and exposure assessment

- **However, there was enough evidence to find**
 - **sufficient evidence for a causal inference for exacerbation of asthma**
 - **Suggestive but not sufficient evidence for a number of other health effects**
- **In light of improvements in emissions, there is a need to do new studies to best project future health effects**

Summary

- **Given the large number of people living within 300- 500 meters of a major road, the Panel concluded that exposures to primary traffic generated pollutants are likely to be of public health concern and deserve attention**

THE END

