Indoor Air Quality Problems and Health Effects: Recognition and Evaluation

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Fiduciary Relationship

- One founded on trust, confidence (and responsibility) reposed by one person in the integrity and fidelity of another -
  Black's Law Dictionary

- An obligation to serve others morally, ethically and competently

- Professionals in the fields of medicine, law, education, and religion

Work to protect children from environmental hazards is commonly associated with strengthening air and water standards, conjuring up images of mammoth smokestacks and congested highways. Often, through, the most dangerous environmental exposures can come from the very place children usually feel the most safe: their homes (and their schools).

The Nation's Health, April 2006, American Public Health Association

Indoor Air Problem Challenges

- Complexity of problem
- Science yet evolving
  - Identification of causative agent (s)
  - Chemical & biologic agents and health endpoint associations
  - Identification of disease mechanisms/disease characterization
  - Testing methods (medical and environmental)
  - Remediation methods
- Misinformation disseminated/false perceptions

Elements that Impact on the Indoor Environment

- Outdoor air toxins and allergens
- Building/furnishing materials
- Mechanical equipment
- Occupants and their activities

Major Indoor Air Pollutants

- Environmental tobacco smoke
- Other combustion production
  - Carbon monoxide (CO)
  - Nitrogen dioxide (NO2)
  - Sulfur Dioxide (SO2)
- Heavy metals
- Volatile organic compounds
- Formaldehyde
- Biological contaminants
- Particulates
- Pesticides
- Radon
- Asbestos

General Modes of Action of Indoor Air Pollutants

- Irritants (VOCs)
- Asphyxiants (CO)
- Neurotoxins (mercury, Pb, VOCs, pesticides)
- Allergens (dust, mold)
- Pathogens (Legionella)
- Carcinogens (asbestos, benzene)
- Developmental and reproductive toxicants (mercury, Pb)

Adverse Effects: Indoor Air Pollutants

- Clinically evident disease
- Increased risk for disease – biologics & chemical irritant exposure & asthma/RADS
- Exacerbation of established disease – CO & CAD
- Physiologic impairment - Pb
- Symptom responses – HA & VOC exposure
- Comfort issues – temperature, humidity, noise, odor, lighting, ambient hygiene
- Psychosocial issues – perception of exposure

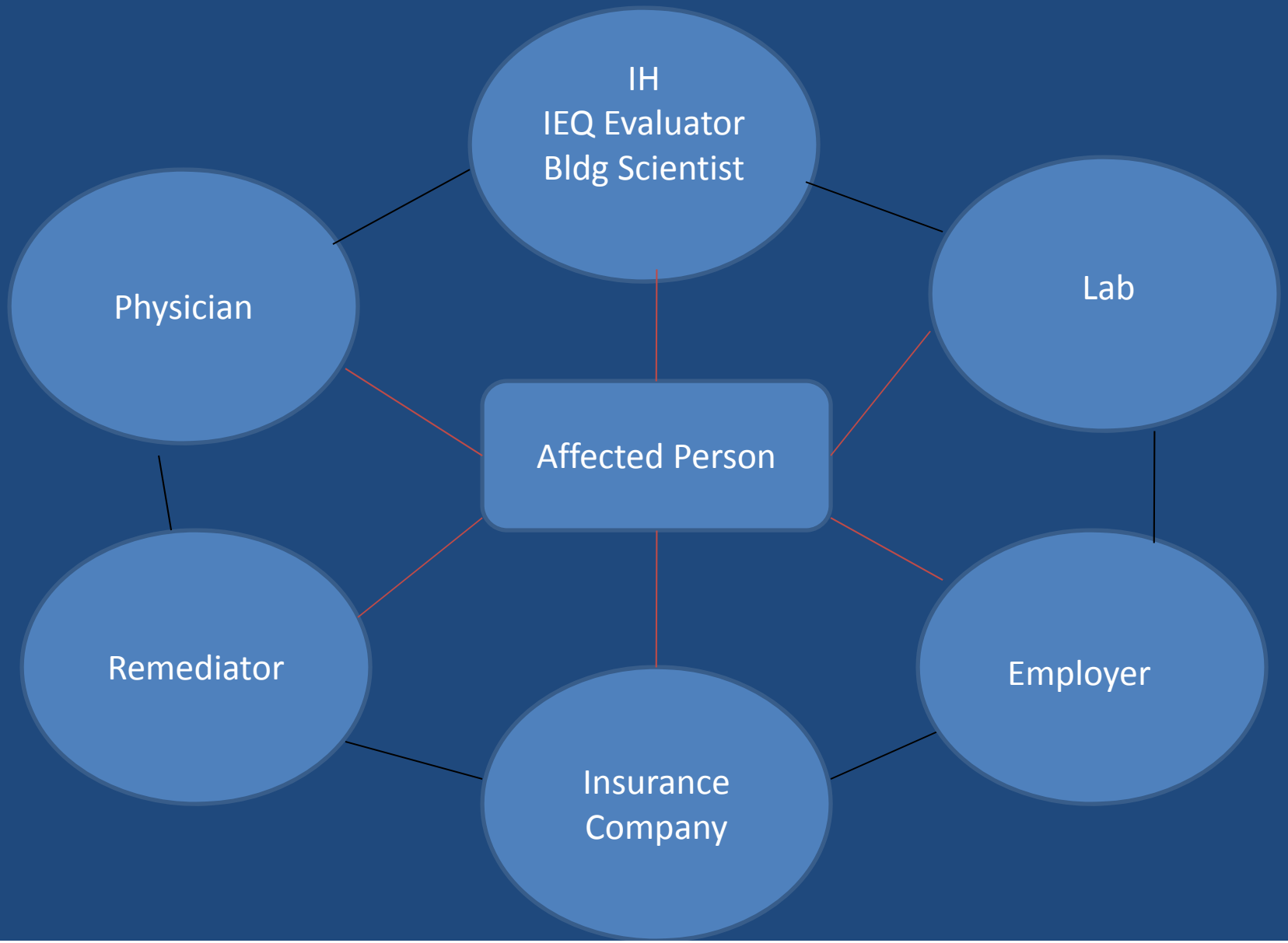
IAQ Health Determinants

- Complex mixtures of biological, chemical and physical agents
- Varied host vulnerabilities
- Psychosocial dynamics of human interactions

Evaluation of Indoor Air Problems require:

- Multidisciplinary interactions
- Detailed, comprehensive & systematic evaluation

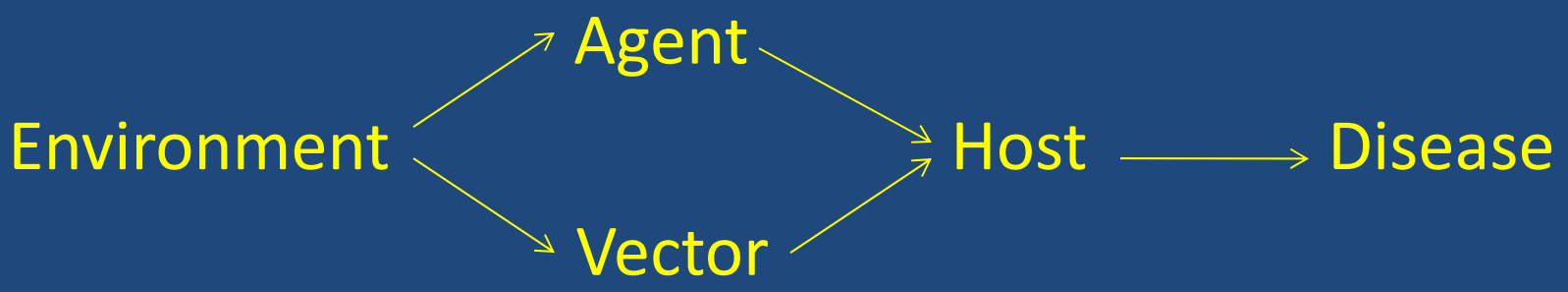
Multidisciplinary Interaction



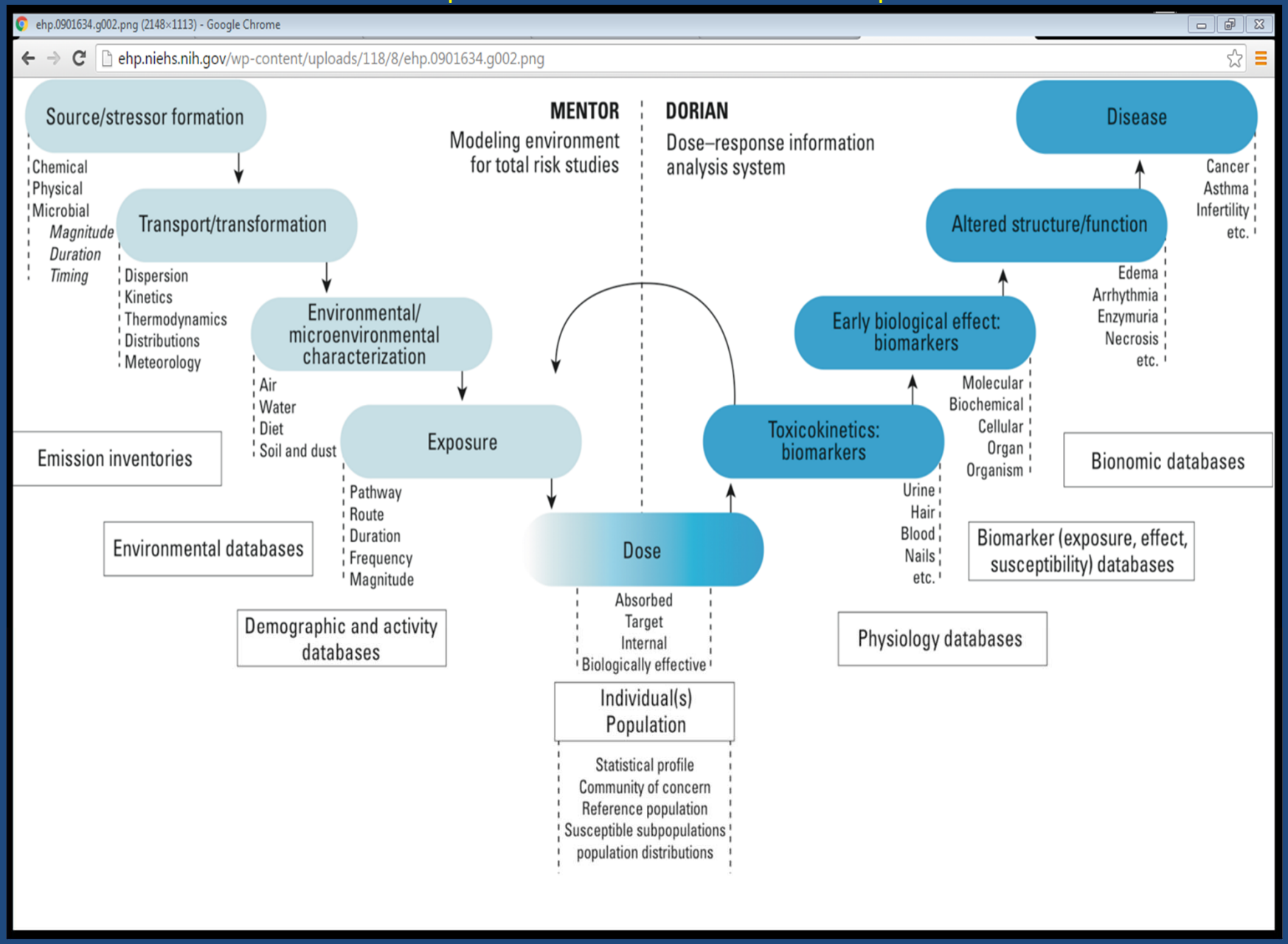
IAQ Problems: Multidisciplinary Expertise

- Occupants
- Health professionals
- Industrial hygienists/IAQ investigators
- Laboratory scientists
- Remediation professionals
- Building engineers/facilities managers
- Building administrators
- Architects

Environment-Host Disease Relationship



Exposure – Host Disease Relationship



Exposure Characterization

- Source (chemicals/particulates/biologics emitted)
- Transformation of pollutants
- Environmental accumulation (air, water, soil/dust, food)
- Offending Agent - innate toxicity, dose, duration, frequency
- Route of entry (inhalation, dermal, ingestion, mucosal)

Variables Affecting Absorption

- Size of particles
- Chemical composition of offending agents
- Activity of occupant (respiratory rate)
- Personal protective equipment/clothing

RESPIRATORY DEPOSITION OF PARTICLES

Chemical Characteristics	Anatomic Level	Size
Water Soluble (SO_2 and nitric acid vapors)	Nasopharynx	$\geq 10\,\mu m$
	Larynx	
	Conducting Airways	$2.5 - 6\,\mu m$
Low Water Solubility (NO_x and O_3)	Distal Airways & Alveoli	$0.5 - 2.5\,\mu m$*

*< $0.5\,\mu m$ are exhaled

Host Differences Affecting Susceptibility

- Genetic make-up
- Immune System
- Nutritional status
- Metabolism
- Prior disease

Subpopulations With Potentially Increased Responsiveness to Pollutants

- Infant/young children
- Elderly
- Chronic respiratory/cardiac disease
- Smokers
- Asthmatics
- Hypersensitivity disease (allergy)

Dxic Challenges: Environmental & Occupational Disease

- Most environmental & occupational diseases:
  - Manifest as common medical problems (skin eruptions, asthma); or
  - Have nonspecific symptoms (nausea, SOB, lightheadedness, fatigue, HA)
- Multiple organ systems can be targets of toxic exposure
- Latent intervals between exposure and disease expression
- Clinician's difficulty in ascertaining exposure data
- Varied susceptibilities of hosts

Bioaerosols

- Airborne particles, large molecules, or volatile compounds that are living or released from living organisms
  - Reservoir
  - Amplification
  - Dissemination

Indoor Bioaerosols

- Fungi
- Bacteria
  - ↑ gram negative – ↑ moisture
  - ↑ gram positive – inadequate ventilation
- Viruses
- Allergens (mold, dust mites, pet allergens, rodents & cockroaches)

Microbial Agents

- Intact organisms
- Constituents of cell walls
  - Endotoxin
  - Beta-(1,3)-D-glucan
- Metabolites
  - Microbial volatile organic compounds (MVOCs)
  - Mycotoxins

Varied Host Vulnerability: Immune Status

- Hypersensitive
  - immunologic responses to antigens ("foreign" proteins/glycoproteins)
- Immuno-compromised (eg.,AIDS,cancer/chemotherapy)
  - infection
- Immunocompetent
  - pre-existing asthma or RADS

Health Effects

- Hypersensitivity disease
  - Allergic rhinitis (and sinusitis)
  - Asthma
  - Hypersensitivity pneumonitis (extrinsic allergic alveolitis)
- Inhalation fever
- Infection (↑ed in immunocompromised)
- Toxic
- Irritant

IOM Summary: Association Between Health Outcome and the Presence of Mold or Other Agents Indoor Environments

- Sufficient Evidence of a Causal Relationship
  - no outcomes
- Sufficient Evidence of an Association
  - upper respiratory (nasal and throat) tract symptoms
  - asthma symptoms in sensitized asthmatic persons
  - hypersensitivity in sensitized patients
  - cough, wheeze
  - Hypersensitivity pneumonitis in susceptible persons
- Limited or Suggestive Evidence of an Association
  - Lower respiratory tract illness in otherwise healthy children

Damp Indoor Spaces and Health, The National Academies Press, 2004

General

- *Feingold BJ, Vegosen L, Davis M, Leibler J, Peterson A, Sibergeld EK. 2010. A Niche for Infectious Disease in Environmental Health: Rethinking the Toxicological Paradigm. Environ Health Perspect 118: 1165-1172.*

  This article focuses on the complex interactions of exposure to both chemical toxins and microbial pathogens, coupled with human host unique susceptibilities, and the need to incorporate infectious agents in environmental health studies

- *Mendell M et al. Respiratory and Allergic Health Effects of Dampness, Mold, and Dampness-Related Agents: A Review of the Epidemiologic Evidence. 2011. Environmental Health Perspectives 119(6): 748-756.*

  Epi and meta-analysis evidence revealed indoor dampness or mold to have positive associations with increased asthma development, and exacerbation, and current and ever diagnosis of asthma, dyspnea, wheeze, cough, respiratory infections, bronchitis, allergic rhinitis, eczema, and upper respiratory symptoms in both all allergic and non-allergic individuals.

Rhinitis

- Affects 40 million Americans
- Nasal itching, irritation, and congestion; watery nasal discharge; sneezing; itching of the eyes, ears, and throat; and fatigue
- 38% with rhinitis also with asthma
- 3.8 million lost work days/year

Rhinitis/Sinusitis

- Inflammation of nasal mucosa
- Thickening of nasal mucosa
  →↑ nasal & pharyngeal drainage (poss. purulent)
- HA; ear, throat, facial pain; halitosis; fever; cough
- Impaired work and learning efficiency

Asthma

- Increased prevalence (approx. 60%) over past 25 years
  - 7.5 % of US adult population
- Most common chronic childhood illness
- Pathology
    - *Airway inflammation*
    - Mucosal edema
    - Mucous secretion
    - Increased vascular & epithelial permeability
    - Smooth muscle hypertrophy/constriction
- Airway remodeling – chronic inflam. leads to structural changes in the airway wall,e.g. thickening of the sub-basement membrane with deposition of collagen

Asthma

- Manifested by bronchospasm
  (symptoms: cough, chest tightness, wheezing)
- Causation – complex interaction of exposures (e.g. allergens, endotoxin, particulate/chemical irritants) and genes affect pathophysiologic pathways:
  - Atopy (allergic disease)
  - Airway inflammation
  - Airway hyperresponsiveness
- Co-morbidity with allergic rhinitis

Factors Contributing to Increased Asthma Prevalence

- Air pollutant exposure (tobacco smoke, ozone, diesel exhaust) (Gilmour etal.2006)
- Indoor exposures to allergens and other biologics
- Increased incidence of obesity
- Decreased exercise
- Change in diet
- Decreased exposure in early life to allergens(hygiene hypothesis)
- Increased viral respiratory infections

Burden of Asthma in NJ (NJDHSS 2009 Data)

There are significant disparities in the burden of asthma among specific populations in New Jersey

- Approximately 9.1% of children (188,000) currently have asthma
- Approximately 7.7% of adults (511,000) currently have asthma
- Life-time and current asthma are more common in male children as compared to female children
- The number of women with asthma is nearly double the number of men with asthma
- In 2009, there were 16,608 asthma hospitalizations among residents
- During the same year, there were also 52,753 emergency department visits for asthma
- Children under five years of age experience the highest emergency department and hospitalization rates for asthma when compared to all other age groups
- Hospitalization rates for black and Hispanic residents are higher than white residents
- In 2006, asthma was reported as the underlying cause of death for 108 residents and asthma was listed as a contributing cause of death for another 148 residents

Asthma Prevention and Management Tools

- Reduced asthma morbidity due to a comprehensive intervention to reduce asthma triggers (allergens & ETS) in homes and schools
- Guidelines for the Dx and management of asthma – NAEPP of US National Heart Lung Institute
- Continued support of NJ DHSS efforts and programs (PEOSH, Disease Surveillance and Education)

BRI Health Investigation Tools/Methods

- Interview occupants with complaints (building or health)
- Interview other occupants (unaffected)
- Interview & review records of medical personnel on-site
- Interview building administrators/facilities managers
- Questionnaire survey of entire occupant population
- For potentially “adversely affected” occupants
  - review of medical records
  - discussion with treating physicians
  - interview/direct medical evaluation

Outline of the Medical (Environmental/Occupational) History

1. Descriptions of all jobs & duties - past and present
2. Work exposures/protective equipment/engineering controls
3. Timing of symptoms in relation to work
4. Characteristics and distribution of symptoms or illnesses among other workers
5. Non-work exposures

Are Symptoms Building-Related?

- Occur at a particular time
- Associated with the entire building or with a particular building area
- Improve on leaving building
- Coincide with event /activity or operating condition in building
- Shared by other building occupants

BIOAEROSOL HEALTH EVALUATION

A. Detailed Medical/Environmental History: Cornerstone of Exam
   1. Characterize symptoms/illnesses
      - onset, temporal relation to location/activities
      - co-occupants with similar problems
   2. Define: - pre-existing disease
      - family history
      - medications
      - behavioral habits (i.e. smoking, alcohol)
   3. Characterize bioaerosol, chemical, and particulate specific exposure or ambient conditions (dampness, H_2O intrusion, visible mold, odors) in:
      - occupation
      - residence
      - recreation

      with attention to nature, duration, and degree of exposure

Bioaerosol Health Evaluation (cont'd)

C. Diagnostic Testing (Judicious!)
   - Spirometry, full pulmonary function tests with lung volumes and diffusing capacity, challenge testing, peak flow measurements
   - CXR, CT scan, lung biopsy, BAL
   - Allergy testing – skin & RAST, IgE, IgG (sensitivity, specificity, reagents)

D. Review of results of bioaerosol sampling/building investigation (possible on-site assessment guided by Industrial Hygienist)

E. Diagnosis of disease, potentially establish causal association with building

F. Treatment of specific health problem

G. Potentially relocate/remove patient from environment (severity of exposure or disease ,or immunocomp)

H. Remediate environment

I. Evaluate clearance sampling

J. Monitor patient in remediated environment (e.g. symptoms, peak flow)

Recommended Criteria for Professionals Involved in Bioaerosol Investigations

- Education, experience, certification
- Detailed, systematic, and comprehensive protocol based on:
  - purpose of the investigation
  - exposure potential
  - unique susceptibilities of hosts
  - limitations of sampling/dxic testing and laboratory techniques
  - knowledge and application of the scientific literature
- Presentation of results clearly and understandably
- Communication /collaboration with and respect for other professionals with the common goal of assisting the affected individual/s (understanding of boundaries of one's professional expertise)
- Adherence to professional ethics, and agreement with full disclosure of evaluation results