The Air We Breathe: Metro East Community Air & Health Forum

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Forest for the Trees: A Systems Approach to Human Health Research

J Gohlke & C Portier, Environmental Health Perspectives, 115(9):1261-63 (2007)

Figure 1. Systems biology framework for the individual. Current systems biology methodologies take advantage of high-throughput data generated at the molecular level in the hope of one day translating these maps of molecular interactions into cellular-level responses, then intercellular responses, and finally to an organ-level response. The interconnections between organ systems will need to be elucidated to understand an organism-level system.

Figure 2. Interaction network between our environment and our health. Human health is determined not only by various molecular, cellular, and organ system-level systems, but by our environment, including social (all interaction within our species), ecosystem (all interactions with other life on earth), physical (all interactions with nonliving components of the earth), and extraterrestrial (planetary position, energy from sun, gravity). Arrows indicate major highways of interaction determining potential routes of global or local changes within these systems. All systems have the potential to affect the individual’s health status.
Philip James de Loutherbourg - *Coalbrookdale by Night* - (1801)
An ounce of prevention is worth a pound of cure…

http://gu.com/p/2hk9z/iw
U.S. GREENHOUSE GAS POLLUTION INCLUDES:

**CARBON DIOXIDE (CO2)**
- 84%
- Enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement).

**FLUORINATED GASES**
- 2%
- Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

**NITROUS OXIDE (N2O)**
- 5%
- Emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

**METHANE (CH4)**
- 9%
- Emitted during the production and transport of coal, natural gas, and oil as well as from landfills.

**TOTAL U.S. GREENHOUSE GAS EMISSIONS BY ECONOMIC SECTOR IN 2011**
- 33% Electricity
- 28% Transportation
- 20% Industry
- 11% Commercial & Residential
- 8% Agriculture

SOURCE: EPA
Recent News Stories

• Soaring Cost of a Simple Breath-NY Times

• Children’s Hospital aims to cut asthma-related ER visits-Washington Post
Agenda for today

• What is asthma?
  – Definition, symptoms, anatomy, physiology, immunology

• What causes asthma?
  – Inflammation, allergens, irritants, pollution, epidemiology

• How should we care for asthma?
  – EPR3 Guidelines, ICS, bronchodilators, education

• What does asthma cause?
  – Costs, personal, societal, medical

• What can we do about it?
  – Changing our approach
Wikipedia: Definition of Asthma

• Asthma (from the Greek ἄσθμα, ásthma, "panting") is a common chronic inflammatory disease of the airways characterized by variable and recurring symptoms, reversible airflow obstruction, and bronchospasm.

• Common symptoms include wheezing, coughing, chest tightness, and shortness of breath.
World Health Organization
Definition of Asthma

• Asthma attacks all age groups but often starts in childhood. It is a disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person. In an individual, they may occur from hour to hour and day to day.

• This condition is due to inflammation of the air passages in the lungs and affects the sensitivity of the nerve endings in the airways so they become easily irritated. In an attack, the lining of the passages swell causing the airways to narrow and reducing the flow of air in and out of the lungs.
Role of the Immune System

• The immune system is a system of biological structures and processes within an organism that protects against disease. To function properly, an immune system must detect a wide variety of agents, from viruses to parasitic worms, and distinguish them from the organism's own healthy tissue.

http://en.wikipedia.org/wiki/Immune_system
Causes and Treatments of Asthma

**Causes**

- Environmental Factors
- Genetic Factors

**Treatments**

- Environmental Triggers
- Medicines

- Controller for Inflammation “Swelling”
- Rescue for Bronchoconstriction “Squeezing”
Indoor Environment Factors
Indoor Air Quality (IAQ)

Biological
- Bacteria/Viruses
- Cockroaches
- Dust mites
- Mold
- Pets
- Pollen
- Rodents

Chemical
- Tobacco smoke
- Building materials
- Carpet/furniture
- Combustion from stove/heater/etc...
- Household chemicals
- Pesticides

Structural
- Water/moisture
- Heating ventilation & air conditioning
- Deteriorated buildings
- Appliance disrepair
- Old carpet/upholstery
Healthy Homes Principles

Keep It:

1. Dry
2. Clean
3. Ventilated
4. Pest-Free
5. Safe
6. Contaminant-Free
7. Maintained
Structure of Trachea and Major Bronchi

- Thyroid cartilage
- Cricothyroid ligament
- Cricoid cartilage
- Connective tissue sheath (cut away)
- Intercartilaginous ligaments
- Tracheal cartilages
- Mucosa showing longitudinal folds formed by dense collections of elastic fibers
- Eparterial bronchus
- To upper lobe
- To middle lobe
- To lower lobe
- R. main bronchus
- L. main bronchus
- Connective tissue sheath
- Cartilage
- Elastic fibers
- Gland
- Small artery
- Lymph vessels
- Nerve
- Epithelium
- Anterior wall
- Posterior wall
- Nerve
- Trachealis muscle
- Esophageal muscle
- Epithelium
- Lymph vessels

Cross section through trachea

Intrapulmonary
Extrapulmonary
Intrapulmonary
Pores of Kohn

Bronchi Bronchioles

480 million alveoli in the lungs

A Dime is 1.35 mm thick

A cube 1.35 mm on a side would contain

≈400 alveoli
Section of medium-sized bronchus
- Ciliated columnar epithelium with many goblet cells
- Basement membrane
- Blood vessels
- Lamina propria with elastic fibers
- Smooth muscle
- Submucosal glands
- Nerve fiber
- Lymph vessels
- Cartilage
- Alveoli

Section of bronchiole
- Ciliated cuboidal epithelium with few goblet cells, smooth muscle ring, blood vessels, and nerve fibers; stroma contains many elastic fibers. Cartilaginous plates, glands, and lymph vessels absent.
Pulmonary artery (unoxgenated blood) to lungs
Structure of Bronchi and Bronchioles; Light Microscopy

Section of large bronchus
- Ciliated columnar epithelium with many goblet cells
- Basal cells
- Basement membrane
- Blood vessel
- Lamina propria with elastic fibers
- Lymph vessel
- Smooth muscle
- Blood vessels
- Submucosal glands
- Nerve fiber
- Stroma with elastic fibers and lymphocyte collections
- Perichondrium
- Cartilage
- Lymph vessels

Higher magnification of epithelium
Pathology of Asthma

- Normal airway: Relaxed smooth muscles
- Asthmatic airway: Wall inflamed and thicken
- Asthmatic airway during attack: Tightened smooth muscles, Air trapped in alveoli
Child and Adult Asthma Prevalence
United States, 1980-2007

- Child
- Adult

12-Month

Current

Lifetime

Prevalence (%)
Morbidity and Mortality…A Century of Change
From Infectious Disease to Chronic Conditions

• Common
• Chronic
• Costly
• Controllable
• Complex
• Community Problem
Ambulatory care

- 13.3 million Number of visits (to physician offices, hospital outpatient and emergency departments) with asthma as primary diagnosis

Source: Ambulatory Medical Care Utilization Estimates for 2006, table 4

Hospital inpatient care

- 444,000 Number of discharges with asthma as first-listed diagnosis
- 3.2 days Average length of stay

Source: 2006 National Hospital Discharge Survey, tables 2, 4

http://www.cdc.gov/nchs/fastats/asthma.htm accessed July 4, 2010
Cost of Asthma Care

In 1994, an economic analysis found that asthma affected an estimated 14.2 million Americans, and cost the U.S. economy an estimated $10.7 billion.

Updated estimates for 23 million Americans
$18.3 billion the estimated cost of care

$10.1 billion in direct costs  (medicines and healthcare services)
$ 8.2 billion in indirect costs  (lost productivity due to missed days at school or work)

http://www.aafa.org/display.cfm?id=6&sub=63 accessed July 4, 2010
Asthma Deaths by County, 2000-2009

**Over 70 percent of the deaths in St. Louis City and County occurred in people younger than 65 years old and almost 30 percent were under age 35**
Morbidity
• 16.4 million Number of adults who currently have asthma
• 7.0 million Number of children who currently have asthma
• 7.3% Percent of adults who currently have asthma
• 9.4% Percent of children who currently have asthma

Source: Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2008, tables 3, 4
Source: Summary Health Statistics for U.S. Children: National Health Interview Survey, 2008, table 1

Mortality
• 3,613 Number of deaths
• 1.2 Deaths per 100,000 population:

Source: Deaths: Final Data for 2006, tables 10, 11

http://www.cdc.gov/nchs/fastats/asthma.htm accessed July 4, 2010
Why is asthma in kids so hard to treat?

• Patient is . . .a child & parents
• Medication regimen is complex, hard to understand (relievers, controller, etc)
• Medications are inhaled
• Intermittent symptoms
• “I’m fine” (new baseline)
• Lack of objective measurement at each visit
• Environmental component triggers disease while kids at multiple sites (school, home, grandma’s, outdoors, etc)
EPR3 Documents available online

440 pages
http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.htm

74 pages
http://www.nhlbi.nih.gov/guidelines/asthma/asthsumm.htm

52 pages
http://www.nhlbi.nih.gov/guidelines/asthma/gip_rpt.pdf
EPR3* 4 Components of Asthma Care

• Assessing and Monitoring Asthma Severity and Asthma Control
• Education for a Partnership in Care
• Control of Environmental Factors and Comorbid Conditions That Affect Asthma
• Medications

Community Based Asthma Care

• Primary Care Providers
• Hospitals, Emergency Rooms
• Environmental Assessment
• Schools & School Nurses
• Child Care Providers

...and MOST IMPORTANTLY
– the Person with Asthma and their family
Where might we educate a child affected by Asthma?

Teach at Every Touch

• Home
• Child Care Center or School
• Medical Care System
  – Primary Care Provider
  – Allergist, Pulmonologist, Respiratory Therapist
  – Pharmacy
  – Emergency Room, Urgent Care Center
  – Hospital
Community-Based Asthma Care

Environmental Assessment
Evaluation of Home "Healthy Homes"

Change in Levels of Asthma Triggers
dust mites, particulates, tobacco smoke, cockroaches, mold

Change in Asthma Control
Use of Rescue Medications, Change in asthma exacerbations

Change in Asthma Maintenance
i.e. controller medications, asthma action plans, controller medication use

Change in Health Care Utilization
Hospitalization
ED Visits
Subspecialist Visits
Primary Care Visits
Medication Use

Change in Physiologic Measures
Change in Immune Response
Change in Pulmonary Function

Change in Productivity
Change in Missed School Days
Change in School Performance
Change in Work Days Missed

Change in Quality of Life
Change in Activity Limitations
Change in Symptom Free Days
Change in other health related QoL

Health Literacy
Self Management Skills
Navigating the System
Medication Use
Home Cleaning Skills

School Health Nurse

Community Health Worker
Home Visit Team
Asthma as Two Conditions: Medical and Environmental

Moving patients to lower cost, “higher touch” services

High cost

High touch

We should be moving care resources in this direction TOWARD THE COMMUNITY
Promising Policy Areas
Returns on Investment??

• School nurses
• Community health workers
• Environmental trigger controls

• Places to start looking:
  – Massachusetts
  – Rhode Island
  – Seattle-King County (Community Guide)
The approach of our current health care system leads to poor control of asthma...

...We need to change our approach

The CHOICE Survey

Comprehensive Survey of Healthcare Professionals and Asthma Patients
Offering Insight on Current Treatment Gaps and Emerging Device Options

- 49% of the patient with asthma participating in the study were not using controller medications
- 79% of those not using controller medications had persistent asthma
- Of those using controller medications, only 14% were well controlled.

The CHOICE survey: high rates of persistent and uncontrolled asthma in the United States
Causes and Treatments of Asthma

**Causes**

- ENVIRONMENTAL FACTORS
- GENETIC FACTORS

**Treatments**

- Environmental Triggers
  - SYMPTOMS WORSE
- Person With ASTHMA
  - SYMPTOMS BETTER
- Medicines
- Controller For Inflammation “Swelling”
- Rescue For Bronchoconstriction “Squeezing”
Do Inhaled Corticosteroids Work?

**Figure 1.** Fitted Rate Ratio for Death from Asthma as a Function of the Number of Canisters of Inhaled Corticosteroids Used during the Year before the Index Date.

The index date for case patients and matched controls was the date of each case patient’s death from asthma. The rate ratio is adjusted for the age and sex of the patient; the number of prescriptions for theophylline, nebulized and oral $\beta$-adrenergic agonists, and oral corticosteroids in the year before the index date; the number of canisters of inhaled $\beta$-adrenergic agonists dispensed in the year before the index date; and the number of hospitalizations for asthma during the two years before the index date.

Do Inhaled Corticosteroids Work?

Rate Ratio for Death from Asthma

No. of Canisters of Inhaled Corticosteroids per Year

Key Asthma Messages

1. Utilization of Inhaled Corticosteroids
2. Development of an Asthma Action Plan
3. Determination of Asthma Severity
4. Assistance with Asthma Control
5. Following up with Asthma Patients
6. Controlling Exposure to Allergens and Irritants
Asthma Fact Sheets from Missouri Department of Health and Senior Services

- Asthma in Missouri

- African Americans and Asthma in Missouri
  [http://health.mo.gov/living/healthcondiseases/chronic/asthma/pdf/AA.pdf](http://health.mo.gov/living/healthcondiseases/chronic/asthma/pdf/AA.pdf)

- Asthma in Missouri Schools

- St Louis Metro (BRFSS Region)
  [http://health.mo.gov/living/healthcondiseases/chronic/asthma/pdf/StLouisMetroRegion.pdf](http://health.mo.gov/living/healthcondiseases/chronic/asthma/pdf/StLouisMetroRegion.pdf)
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- St Louis Metro (BRFSS Region)
  [http://health.mo.gov/living/healthcondiseases/chronic/asthma/pdf/StLouisMetroRegion.pdf](http://health.mo.gov/living/healthcondiseases/chronic/asthma/pdf/StLouisMetroRegion.pdf)

- Healthy Homes
  - [http://www.cdc.gov/HealthyHomes/ByTopic/AirQuality.html](http://www.cdc.gov/HealthyHomes/ByTopic/AirQuality.html)
Journal of School Health

• Supported by CDC and NHBLI
• In the U.S. 5 million school age kids have asthma
• 33 Articles on Asthma in school age children
• Poorly controlled asthma results in
  ▪ 15 million school absences per year
  ▪ Compromised academic performance
  ▪ Limitations on school activities and sports
• Life is tough for kids with asthma
• Life is tougher for school nurses who try to serve them
• Fixing our Health System is imperative
• Broad sweeping changes are needed in our Health System
• Partnering and accountability are critical in this exercise
Times change slowly...but they do change!!
Why is asthma in kids so hard to treat?

- Patient is a child & parents
- Medication regimen is complex, hard to understand (relievers, controller, etc)
- Medications are inhaled
- Intermittent symptoms
- “I’m fine” (new baseline)
- Lack of objective measurement at each visit
- Environmental component triggers disease while kids at multiple sites (school, home, grandma’s, outdoors, etc)
Figure 1. Fitted Rate Ratio for Death from Asthma as a Function of the Number of Canisters of Inhaled Corticosteroids Used during the Year before the Index Date.

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What Determines our health??

Figure 1. Determinants of Health and Their Contribution to Premature Death.
Adapted from McGinnis et al.\textsuperscript{10}
What Behaviors are important in health outcomes?

**Figure 2. Numbers of U.S. Deaths from Behavioral Causes, 2000.**

Among the deaths from smoking, the horizontal bar indicates the approximately 200,000 people who had mental illness or a problem with substance abuse. Adapted from Mokdad et al.\(^1\)
Child and Adult Asthma Prevalence
United States, 1980-2007

- Child
- Adult

12-Month Current

Lifetime

Prevalence (%)
Pivot Points in Asthma Care

- Patient locus of control
- Health literacy
- Social determinants
- Family support
- Living arrangements
- Community environment
- Insurance status
- Benefit design
- Inhalers use
- Medication use
- Availability of information

- Availability of services
- Physician office
- Emergency room
- Pharmacist
- School environment
- School nurse
- Classroom teachers
- Coaches
- Peer pressure
Community-Based Asthma Care

Environmental Assessment
- Change in Levels of Asthma Triggers
  - dust mites, particulates, tobacco smoke, cockroaches, mold
- Change in Trigger Reduction Behaviors

Home Visit Team
- Change in Asthma Control
  - Use of Rescue Medications, Change in asthma exacerbations
- Change in Asthma Maintenance
  - i.e. controller medications, asthma action plans, controller medication use

Community Health Worker
- Health Literacy
  - Self Management Skills, Navigating the System, Medication Use, Home Cleaning Skills
- Changes in Asthma Knowledge, Attitudes, Skills

School Health Nurse
- Change in Clinical Interactions with Health Care System
- "ACTIVATION"

Change in Physiologic Measures
- Change in Immune Response
- Change in Pulmonary Function

Change in Productivity
- Change in Missed School Days
- Change in School Performance
- Change in Work Days Missed

Change in Quality of Life
- Change in Activity Limitations
- Change in Symptom Free Days
- Change in other health related QoL

Change in Health Care Utilization
- Hospitalization
- ED Visits
- Subspecialist Visits
- Primary Care Visits
- Medication Use
Asthma as Two Conditions: Medical and Environmental

Moving patients to lower cost, “higher touch” services

High cost

High touch

Asthma Patient

Hospital

Emergency Room

Physician Office or Clinic

Community Site or Living Unit

We should be moving care this direction

TOWARD THE COMMUNITY