Residential Air Quality and COPD: Remote Real-time Monitoring

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Chronic Obstructive Pulmonary Disease

- Home environment is largely ignored in COPD medical management
- Many of same environmental triggers for asthma are the same with COPD
- QUESTIONS:
  - Should COPD home visits be added to the medical management of these patients?
  - Will COPD home visits significantly decease the hospital readmission rate?

Remote Monitoring of Residential Air Quality

- Overview
- Household Activities
- HUD-COPD Study

Remote Monitoring of Residential Air Quality

- FUNDING-
  - NIH National Children's Study, formative research project
  - HUD Office of Healthy Homes & Lead hazard Control, HH Technical grants
- RESEARCH TEAM-
  - CWRU-
    - Dept EHS: Dorr Dearborn, Jeno Mozes, Mary Ellen Scott
    - VA Hospital: Rich Silver, Frank Jacono, Kim Byrne
    - Dept EECS: Ken Loparo, Don Moore
  - Environmental Health Watch- Stu Greenberg, Matt Berges
  - Battelle MI- Thomas Kelly
  - Intwine Connect, Inc- Dave Martin, Ryan May

Remote Monitoring of Residential Air Quality

- Approach:
  - real-time sensor array with telemetry over cellular networks enabling data transfer to central server for translation, analysis, and storage
  - Home indoor air quality parameters-
    - temperature,
    - humidity,
    - particulates ($PM_{>2.5}$ and $PM_{>0.5}$),
    - total volatile organic compounds (VOCs),
    - nitrogen dioxide (NO_2)
    - carbon monoxide (CO)
    - carbon dioxide (CO_2)
    - ozone

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Air Quality Monitoring Units

Intwine air quality monitor (AQM)

DYLOS particulates unit

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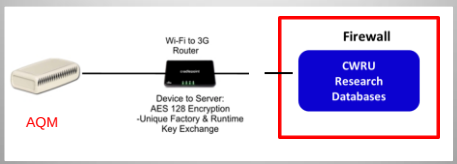
Data Transmisson



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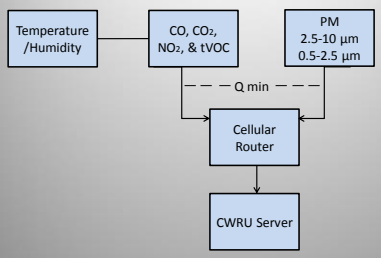
Residential Air Quality



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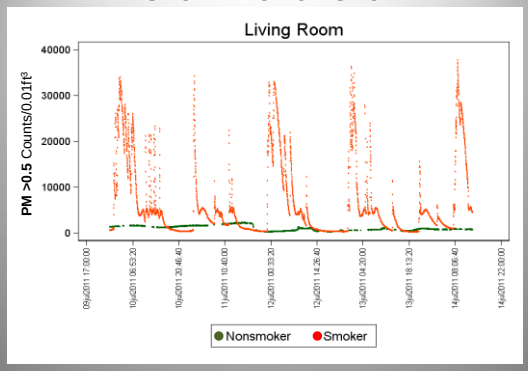
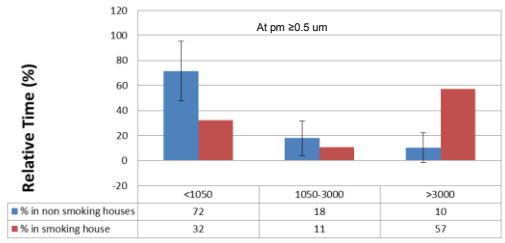
Household Activities

- Smoking
- Screen shots of air quality perturbations

SMOKER vs NON-SMOKER



Frequency Analysis of Particulate Level in Non Smoking Houses Vs. Smoking House -Indoor



	<1050	1050-3000	>3000
% in non smoking houses	72	18	10
% in smoking house	32	11	57

Particle Number Concentration (Counts x10⁵/ft³)

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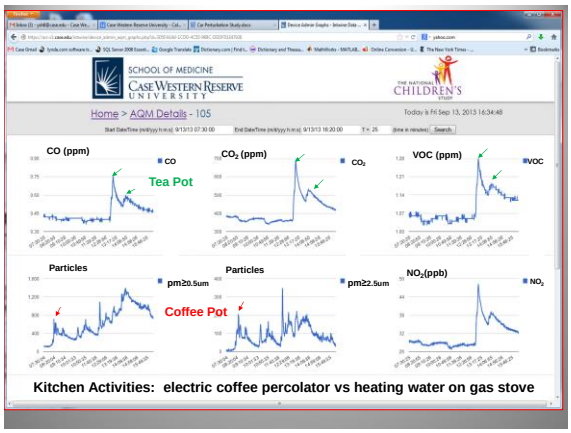
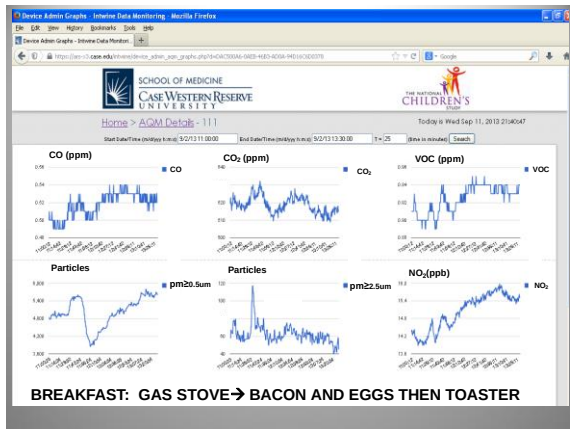
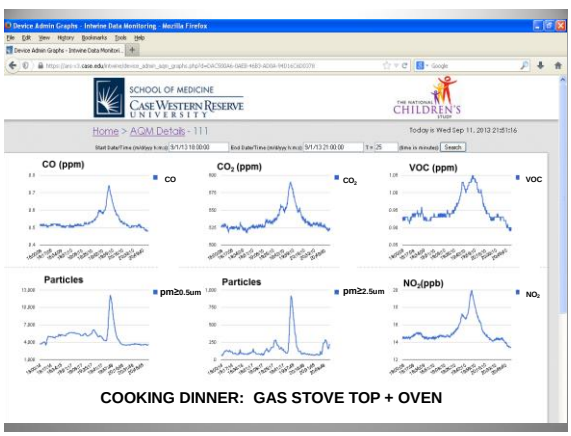


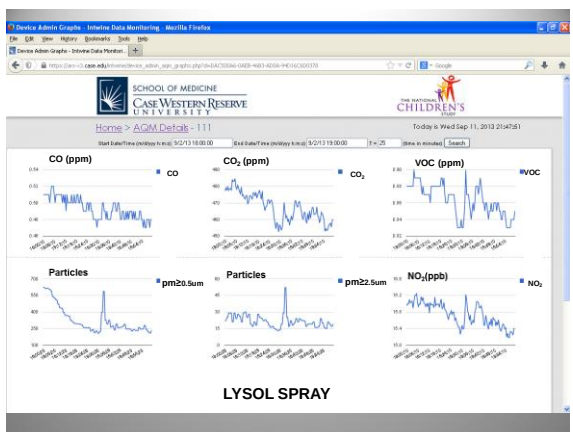
Kitchen Activities: electric coffee percolator vs heating water on gas stove



BREAKFAST: GAS STOVE→ BACON AND EGGS THEN TOASTER



COOKING DINNER: GAS STOVE TOP + OVEN

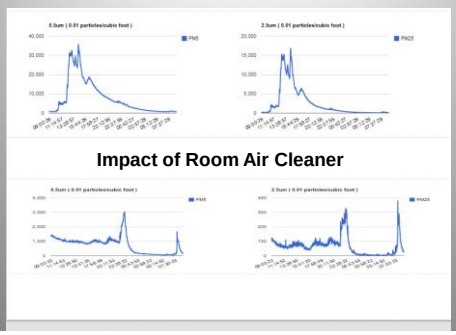


LYSOL SPRAY

ATTACHED GARAGE: CAR RUNNING

ATTACHED GARAGE: CAR RUNNING

Dry wall sanding clean-up: Particle counter in upstairs bedroom



GENERATION 4 SYSTEM

- Sensor array platform
  - Optimal sensor selections, e.g. new CO_2 sensor, added O_3
  - Optimized sensor placement and interface circuits
  - Upgrade AQM mechanical / industrial design
- Local server-class Gateway router
  - Local calculations, storage, batch transmission
  - Remote selection of data window viewing

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Health Effects of NO_2

- Know to be an inducer of airway inflammation
- Prior exposure associated with more severe virus-induced asthma exacerbations.

  [Chauhan et al., Lancet, 361:1939, 2003]
- Indoor NO_2 associated with increased asthma symptoms in inner city children.

  [Hansel et al., Envir Hlth Persp, 116:1428, 2008]
- Increased ambient NO_2 associated with increased prevalence of allergic sensitization.

  [Weir e al., Resp Med, 107:1763, 2013]

Natural Gas Cooking Burners

Logue et al., http://dx.doi.org/10.1289/ehp.1306673

-simulation modeling of Combustion Gases in Southern California homes (without ventilating hoods; winter)

A –estimated exposures exceeding health-based standards & guidelines.

B –estimated median values

	A	B
NO2	62%	100 ppb
CO	9%	3000 ppb
HCHO	53%	20 ppb

- Suggests that 55-70% homes using NGCB are in "non-attainment" by outdoor standards.

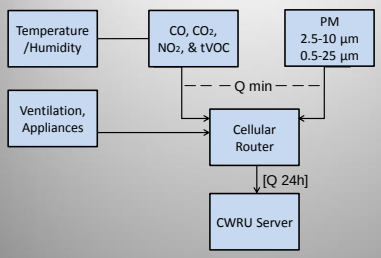
HUD-COPD STUDY

- HYPOTHESIS:
  - Air Quality in COPD patients' homes significantly impacts their respiratory health
- APPROACH:
  - OBSERVATION PERIOD (12 months)-
    - Continuous monitoring of residential Air Quality
    - Telemedicine monitoring of patients' respiratory health
  - INTERVENTIONS-
    - Major house cleaning, carpet cleaning, bedroom HEPA air cleaner
  - POST-INTERVENTION OBSERVATION PERIOD
    - Same monitoring of Air Quality & Telemedicine

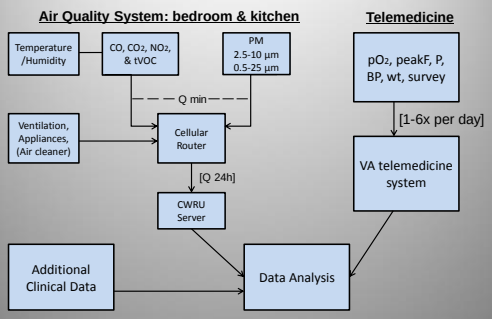
HUD-COPD STUDY

- **PLAN: pilot study of highly selected COPD pts**
  - **Monitor home air quality in parallel with daily telemedicine monitoring of pulse Ox, peak flow, pulse, BP, respiratory symptoms**
  - **Look for correlations with physiological parameters and clinical exacerbations**
  - **Interventions to improve air quality**
    - **look for changes in Air Quality, improved physiological parameters and clinical outcome**

Residential Air Quality



Residential Air Quality: COPD Study



COPD Project: Basic Design

- **Patients** (pilot study- before & after):
  - 15 COPD patients from VA hospital;
  - Highly selected- no longer smoke, no significant co-morbidities
  - Telemedicine and clinical parameters
- **Housing:**
  - Single family house without structural problems
- **Study:**

|__12 mo observation__|^|__12 mo F/U_____|

^ Major house cleaning; bedroom air cleaner

Chronic Obstructive Pulmonary Disease

- **QUESTIONS:**
  - **Should COPD home visits be added to the medical management of these patients?**
  - **Will COPD home visits significantly decease the hospital readmission rate?**

Disclaimer

The views and opinions expressed in this presentation are those of the author and do not necessarily represent official policy or position of the Ohio Department of Health.