The Ghana Randomized Air Pollution and Health Study (GRAPHS):

A mid-study assessment of exposure monitoring
Collaborating Institutions
(Since 2006)

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ABOUT GRAPHS
Kintampo, Ghana, West Africa

Primary fuel used for cooking

KDSS Cooking Practices Module

- wood
- lpg
- kerosene
- dung
- charcoal
- electricity
- other
- na

11 Jan 2008
Ghana-specific profile 2010

Burden of disease attributable to 15 leading risk factors in 2010, expressed as a percentage of Ghana DALYs
Critical questions:

• How clean is clean enough...
  – what interventions will get us there...
  – and what distribution strategies will deliver equitable, enduring public health results?

• Our study is designed to provide
  – Exposure response data for birth weight and child pneumonia
  – Evidence on the efficacy of stoves delivered to pregnant women (a scalable distribution strategy)
  – Relevant evidence Government of Ghana (efficient biomass cookstoves and clean fuels)
Study hypotheses

• Use of improved cook stoves before 3rd trimester of pregnancy will lead to:

  • a significant increase in average birth weight in newborns.

  • a significant reduction in the rate of physician-assessed severe pneumonia during the 1st 12 months of life.
Design: Cluster-randomized controlled trial involving 35 communities in the KHDSS area

Biolite

LPG

Control
Methods

• Sample size
  – 1415 maternal-infant pairs

<table>
<thead>
<tr>
<th></th>
<th>Cluster</th>
<th>Births</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biolite</td>
<td>13</td>
<td>455</td>
<td>525</td>
</tr>
<tr>
<td>Control</td>
<td>13</td>
<td>455</td>
<td>525</td>
</tr>
<tr>
<td>LPG</td>
<td>9</td>
<td>315</td>
<td>365</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>1225</td>
<td>1415</td>
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</tbody>
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• Study outcome measures
  – Infant weight at birth, controlling for gestational age
  – Infant severe pneumonia (FW assessed & physician confirmed)
As of 12 August 2014

Enrolled: 1115 households

- BioLite: 408
- LPG: 352
- Control: 355

Exposure Monitoring:
- 4824 CO measurements (72 hrs)
- 818 PM measurements (72 hrs)

Births:
- 615 (Assessed within 24 hours of birth)
EXPOSURE ASSESSMENT: Pilot exposure studies
PM$_{2.5}$ Site Exposure assessment
PM$_{2.5}$ (Mean ± SE) Personal and Area Concentrations (n=29)

![Bar graph showing PM$_{2.5}$ concentrations for enclosed, semi-enclosed, and open cooking environments.](chart.png)

- Enclosed: Area = 440 ± 102, Personal = 102
- Semi-enclosed: Area = 614 ± 145, Personal = 145
- Open: Area = 350 ± 174, Personal = 174

Kruskal-Wallis p > 0.05
PM$_{2.5}$ Assessment for different stoves
Mean Session Average PM 2.5 Concentration by Stove Type

PM 2.5 (µg/m³)

- 3 Stone: 955.6
- Stove Tec: 350.5
- LPG: 33.8
- Ambient 1: 47.6
- Ambient 2: 75.3

Stove Type
EXPOSURE ASSESSMENT: During Trial
Goals of exposure assessment

• Provide reliable estimates of individual exposures for use in exposure response analysis
• Determine sources of heterogeneity in treatment effects (who benefits most from the intervention)
Sampling approach

• 7 x 72 hour exposure monitoring sessions
  – Round 1 (CO only): at enrollment (baseline)
  – Round 2 (PM + CO): 3 weeks after intervention
  – Round 3 & 4 (CO only): spaced over remaining antenatal period
  – Round 5 (CO only): age 1 month
  – Round 6 (PM + CO): age 3 months
  – Round 7 (CO only): age 9 month

Post-natal
Instruments

RTI microPEM PM$_{2.5}$ monitor

Lascar CO monitor
EXPOSURE RESULTS
Lascar – deployment

- Database contains 4856 observations (as of August 15)
  - 568 children
  - 4288 adult

- Approx. 7% failure rate
  - 23 had mean of zero
  - 292 were short in duration (< 48 hours)
  - Due to battery or device failure
Measurements to date (as of 8/15)

Session 1: 1092
Session 2: 986
Session 3: 820
Session 4: 621
Session 5: 783
Session 6: 395
Session 7: 0
Distribution of CO by sampling session (Not by Study Groups)
CO Concentrations: Adults versus infants

Adults: 1.11ppm (0 – 4.9)

Children: 0.7ppm (0.0 – 4.8)
microPEM deployment summary

- 830 deployments
- Still processing data
- At present we have 635 usable observations (77% success rate), but this will increase as we reprocess files
- Gravimetric data is forthcoming. Currently using a correction factor from prior work in Ghana (van Vliet et al 2014)
Geometric Mean Concentration: 84.5 microgm/m³
(Range 0.81 – 249.9)
Day-by-day compliance for 72 hour microPEM sessions

Day 1

Day 2

Day 3
Lessons and challenges

• CO monitoring
  – Lascar sampling has gone well, and data appear to be reliable (against span gas)
  – Large scale 72 hour sampling is feasible in low income settings

• PM2.5 monitoring
  – Data management is substantial
    • complex data files require substantial post-processing
  – Compliance is better than we expected
Quality control is key

- Check all units every 3 months using certified span gas (50 ppm)

- Use correction factor to adjust data from that unit

- Inspect data at download to verify plausibility

- Duplicate samples every 20 deployments
Exposure monitoring require huge logistics

But

Feasible
Next steps

• Timelines:
  – Target for ending enrollment: October 2014
  – Target for ending birth data capture: March 2015
    • First Exposure data will be available by arm
  – Target for ending ALRI surveillance: March 2016
  – Final reporting: Summer 2016

• Use experiences to
  – support Government of Ghana LPG role out
  – evaluate new health interventions
  – Train others to sustain capacity developed
Acknowledgements

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