Clean Cooking and Child Survival Workshop Meeting Report

United Nations Foundation Offices
Washington DC
May 13th, 2014

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Overview and Objectives

On May 13th, 2014, the Alliance brought together researchers from various academic institutions and countries in the fields of child health and environmental science and experience in clean cookstoves and/or child survival to discuss the past, present and future of research efforts on child survival and clean cooking (see Appendix 1 for a listing of participants). The purpose of this meeting was to convene researchers currently or potentially conducting randomized control trials focused on the link between exposure to household air pollution and child survival. Additional topics to be addressed were intended to facilitate the harmonization of approaches taken across studies, including: evaluation of the intensity of adoption, challenges with outcome assessments in field settings, and potential methods and approaches to exposure assessment.

Confirmed participants included researchers from ongoing Alliance-funded studies on clean cooking and child survival in Ghana, Nepal, and Nigeria; the recently launched study in Malawi; and the Guatemala trial. Also participating were colleagues working in Bangladesh, Ethiopia, Kenya, and India. This meeting provided an opportunity for researchers to share progress, interim results, and learnings from their experience. A few representatives of the public and private sector with an interest in child survival also participated.

Workshop Agenda

Clean Cooking and Child Survival

May 13th, 2014

8:30 **Breakfast and informal introductions**
9:00 **Welcome and introductions**
9:30 **Overview and objectives** *Mehta*
9:40 **Brief Update on Ongoing Child Survival Studies**
9:40 Ghana *Asante, Jack*
9:55 Nepal *Khatry, Tielsch*
10:10 Nigeria *Olopade and team*
10:25 Malawi *Havens*
10:40 *break*
10:55 **Intervention choice: selecting 'clean' and feasible interventions for evaluation**
10:55 Case study: Kenya mixed methods approach to informing choice of interventions *Sage*
11:15 Clean fuels: electricity, LPG, ethanol *Tielsch, Jack, Olopade*
11:55 Standards, testing, and the clean cooking catalog *Chiang*
12:15 **Design considerations to maximize optimal use and in-field performance** *Havens, Jack, Sage*
training / education / maintenance
minimizing and measuring stove stacking

competing sources of pollution: kerosene, smoking, community sources
13:00 *lunch*
13:45 **Outcome assessment: practical lessons from the field**
13:45 Preterm birth and low birth weight *Thompson, Asante*
14:30 Pneumonia *Olopade, Khatry*
15:15 **Exposure Assessment: new innovations in methods and modeling, and practical lessons from the field**
15:15 New innovations in modeling *Berhane*
15:45 *break*
16:00 Fine particulates *Balakrishnan*
16:45 CO *Northcross*
17:15 **Summary and Conclusions**
17:45 **Adjourn**

Ongoing Clean Cooking and Child Survival Studies

The Ghana Randomized Air Pollution and Health Study (GRAPHS)

Presented by: Drs. Asante and Jack

- GRAPHS is a cluster-randomized controlled trial involving 35 communities in the Kintampo area,
    - Including three cookstove groups: Biolite, LPG and the traditional 3-stone and
    - Community engagement to use clean cookstoves is emphasized.
- Hypotheses: clean cookstove and fuel use before 3rd trimester will lead to increase in birth weight and decrease pneumonia incidence.
- Outcome assessment: birth weight within 24 hours of delivery, active ALRI case finding, self-report ALRI and clinical examination.
    - 70% of women have facility births.
    - In case of home delivery, woman or head of household reports labor pains.
- Personal exposure measurements: CO, 4 pre-natal and 3 post-natal; and $PM_{2.5}$ in a subset of participants.
    - CO and questionnaire will be used to estimate PM data.
    - Sling developed to wear personal monitors and no loss to follow-up due to use.
- Currently 748 enrolled, 317 births captured and stove compliance is high.
- Additional health outcome, economic and exposure studies are planned for cohort.
- Challenges: durability of Biolite, logistics of LPG supply, failure rate of exposure measurement equipment and financial constraints.

In the discussion following the presentation it was made clear that Alliance funding is being used to collect nasal swabs from all ill children for PCR analysis. Additionally, the sample size calculation factored in the current vaccine program coverage in Ghana. The researchers believe that it may be possible to achieve clean levels of exposure because of initially low $PM_{2.5}$ concentrations (~150µg/m^3).

Nepal Cookstove Intervention Trials

Presented by: Drs. Tielsch and Khatry

- 2-phase study of enhanced step wedge design in Sarlahi District, Nepal:
    - 1) 6 months of run-in, 12 months of step-in installation of Envirofit stove, n ~ 4,200
    - 2) Individual homes randomized to continue with Envirofit or receive LPG, n ~1,900.
- Chose Envirofit because only rocket stove available at time and too difficult to maintain quality with local production of clean cookstove.
- LPG phase added because of multiple stove use in one family
- Primary aims with cookstove replacement: incidence of ALRI among children <36 months, rate of birthweight and rate of pre-term birth.
- Secondary aims: PM and CO concentrations, respiratory function in adults, blood pressure in adults and growth of children <36 months of age.

- Primary aim assessment: weekly home visits for ALRI detection and measure LMP with in-field pregnancy surveillance and will use previous data to back calculate true birth weight.
    - >90% home births
- Exposure measurement: 24-hour in-home PM and CO before and after installation.
- Currently, all 1,900 homes in Phase 2 enrolled and analysis planned for end of May.

In the discussion following, the researchers reported that adoption of the Envirofit was limited by the fact that the stove was not sufficient for families with more than 4 members. The LPG in the community is accessible but not affordable. Gravimetric PM concentrations were too difficult to collect in the field. Therefore, a nephelometric to gravimetric correction curve will be used to estimate gravimetric PM concentrations. The study also took into account community ambient air and PM/CO escape from home.

Improved Bioethanol Cookstoves and Pregnancy Outcome in Nigeria

Presented by: Drs. Olopade and Alexander

- Randomized intervention trial of 2-burner ethanol stove comparison to kerosene and firewood users in pregnant women.
- Hypothesis: use of ethanol stove and bioethanol fuel will reduce exposure to PM and CO and reduce adverse pregnancy outcomes.
- Personal exposure measurements: 72-hour $PM_{2.5}$, CO and PAH combined with GPS every trimester.
- Outcome measurements include:
    - 6 ultrasound measurements for intrauterine growth;
    - Spirometries;
    - Biomarkers for nutrition, oxidative damage and systemic inflammation;
    - Birth weight, preterm delivery, intrauterine growth restriction, stillbirth and miscarriage.
- Currently, 161 participants randomized and 89 births, of which 90% have a complete ultrasound series.
- Challenges are getting women to deliver at primary health centers, getting CO tanks for flushing monitors, amount of staff required for delivery and weighing of ethanol, and recruitment of firewood users because of subsidy on kerosene.

Following the presentation, the researchers verified that the ethanol, originally from Brazil, is decolorized and de-natured to prevent drinking and families are educated regarding ethanol safety. Women fill the canisters every morning with ethanol to prevent interruption of meals. Those women who do not receive the ethanol stove are provided with other cooking materials as compensation for not receiving free fuel during the study. The current price of ethanol is $1.10/L and women use around 20L/month. The stove is approximately $50 and manufactured in South Africa.

Cooking and Pneumonia Study (CAPS) in Malawi

Presented by: Dr. Haven

- A cluster randomized controlled trial of intervention of two Phillips cookstoves, n = 9,000 children, in households in Chikhwawa and Chilumba.
    - SUMS is place on one intervention stove
- Primary outcome: pneumonia in children under 5 years of age with use of a health passport assessment card.
    - Every child has health passport or is provided on upon clinic visit
- Exposure measurement: personal 48-hour CO measurement in all children every 6 months, 24-hour black carbon and $PM_{2.5}$ in 400 households and adults.
    - CO assumed to be correlated with PM for exposure analysis.
- Adult lung function measured according to BOLD protocol with 2 years of follow-up in 2,000 adults in Chikhwawa.
    - 48-hour PM and CO measured twice (1 wet season, 1 dry season) and spirometry measured at 0, 1 and 2 years
- Current status: n=3,700 enrolled in Chikwawa in April and Chilumba site will begin in June.
- Challenge is failure rate of Phillips stove.

Intervention choice: selecting 'clean' and feasible interventions for evaluation

Case study: Kenya mixed methods approach to informing choice of interventions

Presented by: Mike Sage

The CDC became a founding member of the Alliance and initiated a study on six clean cookstoves to support the Alliance's goals. The cross-over study was conducted in 45 households. Every home used one type of clean cookstove for two weeks, had a week off and then a different clean cookstove was installed and used for two weeks until the household had rotated through five to six stoves. The data collected included: PM and CO exposure measures, SUMs data, personal and household; kitchen performance tests of fuel consumption and moisture; and urinary biomarkers (PAHs). The team also included a qualitative assessment through semi-structured interviews and focus groups.

It was found that none of the clean cookstoves tested achieved the emission reductions observed in laboratory testing. Four of the six stoves did achieve statistically significant reductions when stove stacking was not a factor, but the emission levels remained above levels needed for maximum public health benefit. Focus group results were superior to interviews and women were interested in the clean cooking technology and chose either the Envirofit stove or the Biolite stove. An unexpected observation was the high level of kerosene lamps use in the kitchens. The use must be adjusted for in the $PM_{2.5}$ measurement and the gravimetric filters.

In conclusion, the story is more complex than stove itself: it is the stove design and performance, women's needs and use, other sources of household pollution, fuel moisture content, ventilation and availability/cost. All of these factors make it difficult to achieve clean cooking with biomass in rural Kenya. Therefore, investigation into clean fuels will be a priority, considering 1/3 of the population is emerging from severe poverty and may be able to transition to clean fuels. Investment in clean fuels.

The research team plans to return for follow-up results on stove durability, use and adoption in the households.

Mr. Sage announced that this project generated a lot of data that may be useful for future research projects.

Standards, testing, and the clean cooking catalog

Presented by: Dr. Chiang, Senior Technical Manager for Standards and Testing, Alliance

The impact of clean cookstoves can be approached as a cycle: perform research on impacts, create standards from research, drive innovation for improved products based on standards, adoption and scale up of improved technologies, research on improved impacts restarts the cycle again.

The Alliance framework for standards and testing to drive technology for improved products is made up of three parts: 1) an online clean cooking catalog as a resource of cookstove and fuel options, 2) RTKCs and 3) guidelines linking health-based targets with intervention-based targets.

The clean cooking catalog presents independent data that is traceable to its sources. This database could be expanded to include the "true" availability of the products evaluated and contact information of distributors/manufacturers. Researchers requested support for analysis of federally funded data after the grant period has completed. Additionally, the catalog serves as a platform for a coordinated approach to housing and sharing cookstove data following completion of specific aims analysis by primary investigators.

The RTKC's current emphasis is independent laboratory testing. There is a need for the standardization of field methodology; although it is a highly variable situation. Experienced researchers located in the regions would improve the centers by adding their in-field emission monitoring expertise.

An example of guidelines linking health based target (pneumonia) with performance target (emissions) produced a computational model mapped tiers of child pneumonia. However, pneumonia rates of disease are changing due to other influences, such as vaccines. Cookstoves can be classified based on laboratory emissions data in to tiers of "cleanliness." The tiers can be translated to the field. Additionally, stove stacking with a clean cookstove can achieve reductions dependent on percentage of clean cookstove and three stone fire usage.

Clean fuels: LPG, electricity and ethanol

LPG procurement can be difficult, especially in a rural study area. A supply chain from supplier to home and a secure and safe storage area must be taken into careful consideration. LPG regulation is not consistent globally and could affect the supply to a study site. It is advisable to understand the regulation in the study country. Areas where regulation of LPG is highly valued will have dependable distribution systems. Building relationships with suppliers can be useful when a shortage does occur. Household usage will determine the amount of LPG to store and the timing for replacement of the fuel. A restriction on the frequency of fuel provision may help to deter unnecessary fuel consumption by the household. LPG consumption may be controlled with the provision of a pressure cooker, especially in

high altitude areas like Guatemala. Weighing tanks before and after captures usage by the household. Tanks of LPG should be exchanged instead of refilled because over time they become less reliable and a safety hazard. Other safety hazards can overcome with education or selecting a technology that has eliminated many of these hazards.

LPG serves as a transition state, for example in India, before electricity reaches an area. In India, the LPG subsidies are transferring from the urban areas to the rural areas. Electric, solar induction cookers are rapidly gaining popularity in India due to their low wattage and decreased cooking time. A village-level solar panel could potentially power all induction cookers for the entire village.

Sources of ethanol may be microdistilleries, oil companies or the government production; dependent on availability. However, many countries' supplies of ethanol are exported or used in electricity production. Storage needs to include security, ventilation and temperature control. The ethanol must be pure in order for use as a clean fuel. Delivery of ethanol to the households requires calculations in household use and potentially extra support in field staff or transport. The ethanol stoves in the Nigeria study were seen as status symbols and men wanted their wives to become pregnant in order to receive a stove. The concern is the sustainability of the clean fuel use because although microdistilleries are present, the durability of the stove is in question.

Outcome assessment: practical lessons from the field

Pre-term birth

Collecting an accurate last missed pregnancy (LMP) in order to determine a pre-term birth can be a challenge in the field. Options for reducing recall error include or collecting an ultrasound confirmed LMP include: incentivizing or campaigns to encourage woman to receive early antenatal care, education in communities to desensitize the inquiry process by study personnel and conducting pregnancy surveillance. Encouraging antenatal care and facility births increases clinic attendance and provides opportunities for additional outcome measures to be added to intake forms or mining clinic data for study outcome measures.

Capturing birth weight in the field relies on communication from the head of household or other appropriate family member to the field staff on labor pains so the birth can be under surveillance.

Pneumonia

Two innovative methods for pneumonia diagnosis were presented to the group: lung ultrasound and digital auscultation.

Lung ultrasound has been tested in a feasibility trial in clinics in Peru for the diagnosis of interstitial pneumonia with portable equipment and a measurement time of about seven minutes. The sensitivity and specificity is high compared to x-ray as the gold standard. The study group found low accuracy with the WHO pneumonia algorithm. Drawbacks to the measurement include: not a handheld method, no results on severity and high computing power requirement.

Digital auscultation for pneumonia of a child's chest from six points using a digital recording stethoscope was collected for every child with breathing difficulty during the cookstove trial in Nepal. The results did not produce high sensitivity, even after clinical validation. However, work is being done to develop an algorithm of chest sounds to diagnose independent of reviewers. The stethoscope would light up following the chest sound recordings to indicate care. This method has potential to reduce antibiotic use in communities.

Pulse oximetry does not work well as a diagnostic tool at low altitudes. However, it could be used in hospital with longitudinal trend data to predict potential interventions.

Exposure assessment: new innovations in methods and modeling and practical lessons from the field

New innovations in modeling

Dr. Berhane demonstrated modeling exposures into an integrated framework that combines individual and ecologic data. This method calculates an exposure model to predict exposures for the whole population based on measurements from a subsample. Different sampling strategies for the subsample can be used depending on the exposure of interest and measurements in the entire study population would not be necessary for population characterization.

Personal and household emissions

Differing viewpoints were presented on the site for exposure measurement: household versus personal sampling. The type of measurement may depend on the outcomes measured. Personal sampling prevents exposure misclassification. However, some believe that because a clean cookstove intervention is a household intervention, exposure should be measured at the household level. Household exposures are not necessarily predictive of personal exposures. Some researchers have observed that CO does not predict PM measurements. It is possible to use modeling to collect one site in a subsample using the modeling techniques already presented.

Evidence from clean cookstoves and clean fuels: moving forward

A major discussion point during the meeting was whether clean biomass cookstoves are clean enough to achieve child health benefits. Clean cookstove technology has matured and a lot of promising technologies are being evaluated. However, there is a lack of evidence on the ability of these promising cookstoves in the field to reduce emissions to a level required for an impact on the health of participants. Utilizing standardized definitions of 'clean' based on lab and field performance, it is now possible to label an intervention a clean cookstove versus just a cleaner cookstove. The perspective from the Kenyan Ministry of Health highlighted the need for evidence before action. Where possible, clean fuels should be recommended to ensure clean cooking. At the same time, there will continue to be vulnerable populations who will not have access to cleaner fuels in the short term, so there should still continue to be focus on the promising advanced biomass technology. In the longer term, as adoption of

clean cooking technologies are brought to scale, there will be opportunities to evaluate the health benefits across a range of geographies and technologies.

Action Items:

1. Link researchers to regional testing centers and what they can provide. Testing centers may be a useful resource for calibration gases, for example. The study sites have expertise in field exposure testing that can lend expertise to the testing centers. CDC is also a potential reference lab resource for processing study data.
2. Fill in gaps – at lower concentrations and the lower end of the exposure response curve for adult health outcomes to fill out the evidence base.
3. Develop a data repository for submission of data post-trial outcome analysis. Investigators could submit data. This would allow graduate student projects and aid in multi-country evaluations.
4. Develop a broader community of funders to get a concerted effort in funding.
5. Future topic for discussion: strategy for broad communication of health study results, more on clean fuels and PAH, learning from examples of successful communication approaches and models.
6. Continue to aggregate and share progress on studies that are on-going within and outside of the Alliance.

Appendix 1: Clean Cooking and Child Survival Meeting Participants

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Appendix 2: Acronyms and Abbreviations

ALRI	Acute Lower Respiratory Infection
CDC	Centers for Disease Control and Prevention
CO	Carbon Monoxide
Alliance	Global Alliance for Clean Cookstoves
HAP	Household Air Pollution
LMP	Last Menstrual Period
LPG	Liquid Propane Gas
NIAA	National Institute on Alcohol Abuse and Alcoholism
NIEHS	National Institute of Environmental Health Safety
NIH	National Institutes of Health
PAH	Polycyclic Aromatic Hydrocarbon
$PM_{2.5}$	Particulate Matter less than 2.5 micrometers in diameter
PM_{10}	Particulate Matter less than 10 micrometers in diameter
RTKC	Regional Testing Knowledge Center
SUMs	Stove Use Monitors