What difference do cleaner burning cookstoves make?

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Associate Editor: Lindsey Hall

Abstract

In Malawi, a country in sub-Saharan Africa, pneumonia is one of the main causes of death in children under 5 years of age. Pneumonia is a lung infection, which makes it hard for you to get enough oxygen into your bloodstream (i.e. you have low oxygen saturation).

Pneumonia in kids has been linked to exposure to smoke from open fires as their mothers cook family meals on them.

We predicted that replacing open fires with cleaner burning cookstoves would reduce the number of cases of pneumonia in young children. To find out if this was true, we ran a two-year trial in Malawi, comparing the effects of using a cleaner burning cookstove with continuation of open fire cooking on childhood pneumonia rates.

After two years, we found no evidence that using cleaner burning cookstoves reduced the risk of pneumonia in young children. But the improved cookstoves were beneficial for other important reasons (e.g. avoiding cooking-related injuries such as burns).

Introduction

In Africa, 700 million people use biofuels (like charcoal, wood, crop waste and animal dung) to cook their meals. Families burn the fuel on open fires in their homes, which leads to high levels of household air pollution from the smoke (Fig. 1).

Figure 1: Collecting wood for use as fuel in open fires for cooking places a high burden on women and is an inefficient use of this increasingly scarce resource; cleaner burning cookstoves use less wood and are more efficient (Photos: CAPS/HANDSTAND Productions).
This leads to a range of health problems including pneumonia, lung cancer and asthma. In Malawi, pneumonia is the most common cause of death in young children.

Cleaner burning cookstoves are now available that improve burning efficiency. In laboratory tests they have reduced the amount of smoke by up to 90% compared to open fires. Unfortunately, most people in Malawi are unable to afford them. The Global Alliance for Clean Cookstoves (GACC) launched in 2010 with an aim to provide clean cookstoves to 100 million households by 2020.

However, there is little evidence of the benefits of these cookstoves on the health of the people that use them, and their children.

We set out to find out whether using cleaner burning cookstoves would reduce the number of cases of pneumonia in children under 5 years old living in rural Malawi (Fig. 2), compared to continuing with open-fire cooking.

**Methods**

We invited households with children under 4 and a half years old (over 10,000 kids) to take part in our trial. We then assigned them randomly into two groups of equal size using a computer program. One statistician put the households in group A or B, and then another statistician determined whether A or B would be the “intervention”, or “control” group. The data on the children’s’ health remained “blinded” until the very end of the trial so that neither the participants nor the researchers knew what group they were in. We did this to make sure that there was no bias in the allocation of groups, or in the results. We call this a *randomized controlled trial*.

The intervention households received two cleaner burning cookstoves, a solar panel to charge the battery for the stove fan, and user training. The fan makes the cookstoves more efficient (i.e. using less fuel). The control households carried on using open fires.
At the end of the trial, we gave the households in the control group the same cooking equipment. This was really important for the trial to be ethical, as we were carrying out our study on real people who must be treated with consideration and respect.

The main focus of our trial was the incidence of pneumonia episodes (as defined by standards set by the World Health Organisation/WHO - see Glossary). The health facilities notified us when they treated a pneumonia case.

We also recorded other cases of pneumonia that didn’t meet the WHO standards, severe pneumonia and death in children under 5 years old.

A fieldworker visited each household every three months to record all cases of pneumonia, and of cooking-related injuries such as burns.

We recorded other variables, including other sources of fire or smoke that the child was exposed to on a regular basis, and the number of times the child had previously had pneumonia.

## Results

By the end of the trial we had a total of 15,991 child-years of data. (A child-year is the number of children in the trial, multiplied by the amount of time that they participated in it - see Glossary.)

There were 2506 episodes of WHO pneumonia, with an incidence rate of 15.67 per 100 child-years. This means that for every 100 years of collective data, there were 15.67 incidents of WHO-standard pneumonia.

The incidence rate ratio for WHO pneumonia for the intervention versus control was 1.01 (p=0.80). This means that there was no significant difference between the two groups (Table 1).

The difference between minor burns, however, was highly significant (p<0.0001): 549 cases in the intervention group compared to 956 in the control group.

By monitoring the usage of clean burning stoves in a sample of the households we found they were used on average 51 days in every 100 during the first year. During the second year, this dropped to 34 days in every 100.

<table>
<thead>
<tr>
<th></th>
<th>INTERVENTION (5297 CHILDREN)</th>
<th>CONTROL (5246 CHILDREN)</th>
<th>INCIDENCE RATE RATIO (IRR)</th>
<th>p VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO standard pneumonia</td>
<td>1255 (Incidence rate 15.76 per 100 child-years)</td>
<td>1251 (Incidence rate 15.58 per 100 child-years)</td>
<td>1.01</td>
<td>0.80</td>
</tr>
<tr>
<td>Severe pneumonia</td>
<td>186 (2.33)</td>
<td>145 (1.80)</td>
<td>1.30</td>
<td>0.06</td>
</tr>
<tr>
<td>Oxygen saturation &lt; 90%</td>
<td>17 (0.21)</td>
<td>11 (0.14)</td>
<td>1.56</td>
<td>0.28</td>
</tr>
<tr>
<td>Death</td>
<td>3 (0.04)</td>
<td>4 (0.05)</td>
<td>0.76</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Table 1: Incidence rate and incidence rate ratio of pneumonia, severe pneumonia, oxygen saturation less than 90%, or death.

## Discussion

The results of our study were unexpected. We predicted that replacing open fires with smokeless cookstoves would reduce the incidence of pneumonia in young children, but we found no evidence to support this.

Science can sometimes surprise us, and it is very important that we allow it to do so. Sometimes results do not come out as scientists predict and where we expect to find relationships, we do not.

In our study, we put in lots of measures to make sure that our expectations didn’t influence the results. Without randomization may have unintentionally allocated more children who were at greater risk of pneumonia to the...
control groups, and without blind data interpretation, researchers may have unwittingly interpreted the data differently. Without these measures, we may have ended up with different results, which may have suggested that there was a relationship between cookstove use and pneumonia in young children, but the results would have been incorrect. Ultimately, the lack of effect on pneumonia could have been due to exposure to other forms of smoke pollution (like rubbish burning and tobacco smoke). Possibly the stoves didn’t reduce smoke emissions enough to have an effect. We must look at all forms of air pollution, together with cleaner cooking solutions to try to find a solution.

### Conclusion

Although the study did not find a reduction in pneumonia cases, this doesn’t mean that cleaner burning cookstoves have no benefits. The reduced risk of minor burns in children was a valuable benefit. As the stoves burn more efficiently, they use less fuel and cook food faster. This reduces the time that women have to spend finding wood and cooking meals. This frees up some time which may be used to do other things such as earning money to improve their standard of life.

It remains uncertain whether or not the beneficial effects of cleaner burning cookstoves are sufficient to justify their costs.

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**Glossary of Key Terms**

**Blinded study** – a study where the identity of participants and their data are kept hidden from researchers to prevent bias, until after the results are known.

**Burning efficiency** – otherwise known as "combustion efficiency", this is a measure of how well the fuel is used as it burns. The more efficient the process is, the less fuel the household will need to cook the same amount of food, the less smoke will be produced by the fire, and the less time cooking will take. In our cookstoves, burning efficiency was increased with a fan that drew more air into the fire ensuring a more complete combustion process.

**Child-year** – the number of children in the trial multiplied by the amount of time that they participated in it. For example, if there are 5,000 children in a trial that lasts 2 year, the number of child-years is 10,000.

**Incidence rate** – is the number of new cases per population in a given time period.

**Incidence rate ratio (IRR)** – a measure of the difference between the incidence rates we are comparing. We reach this figure by dividing one incident rate by the other. A ratio of 1 means that the two incident rates we are comparing are the same.

**Pneumonia** – an infection that causes the air sacs of the lungs to fill up with fluid. This makes it hard for you to get enough oxygen into your bloodstream. "Non-severe WHO pneumonia" is defined by WHO as the presence of cough or difficulty breathing and fast breathing (60, 50, or 40 breaths per min or higher in those aged <2 months, 2–12 months, and 1–5 years, respectively). “Severe WHO pneumonia” is defined additionally by dangerous clinical signs such as an inability to drink or breastfeed, vomiting, convulsions, lethargy, or unconsciousness.

**Randomized controlled trial** – this trial method prevents bias by randomly putting the people taking part in the trial into either the intervention group (using the cookstoves) or the control group (using open fires). In our trial, this stopped the results from being affected by researchers wanting the study to show that the cookstoves reduced the chance of pneumonia in kids.

**Sub-Sahara** – the region of Africa to the south of the Sahara desert.

**Significant** – a result that is likely not due to chance, but rather due to a real process. Scientists define a result as “significant” if it would happen by chance less than 5% of the time (shown as p < 0.05). The more significant a result is, the lower its p value.

**World Health Organisation/WHO** – part of the United Nations responsible for monitoring public health, disease outbreaks, and the performance of health systems around the world.
WHAT DIFFERENCE DO CLEANER BURNING COOKSTOVES MAKE?

Check your understanding

1. If you could design your own clean cooking technology, what would it look like, how would it work, and what fuel would it use?

2. Why do you think that the usage of cleaner-burning cookstoves dropped off over the course of the trial? What impact do you think that the reduction in usage of the cleaner-burning cookstoves might have had on the study?

3. What environmental benefits do you think that use of the cookstoves could have had?

4. As of 2011, Malawi has had a program of vaccinations against the pneumococcal bacteria (which can cause pneumonia, meningitis, and other diseases). What other factors do you think would help to reduce the amount of childhood deaths from pneumonia?

Acknowledgement

The trial was funded by a Joint Global Health Trials Grant from the Medical Research Council, UK Department for International Development, and Wellcome Trust (MR/K006533/1) and a New Investigator Research Grant from the Medical Research Council (MR/L002515/1). Additional support was provided by a MRC Partnership Grant (MR/L009242/1). JG is part-funded by the North Thames Collaboration for Leadership in Applied Health Research and Care.