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E. M. Wafula, MBChB, MMed (Nbi), Department of Paediatrics and Child Health, College of Health Sciences, University of Nairobi, P.O. Box 19767, Nairobi, M.M. Kinyanjui, MBChB, MPH (Nbi), Family Health Unit, Division of Primary Health Care, Ministry of Health, P.O. Box 30016, Nairobi, L. Nyabola, BSc, MSc (Nbi), MS (Havard), Dip. Epid. & Bios (McGill), Department of Community Health, College of Health Sciences, University of Nairobi, P.O. Box 19767, Nairobi and E.D. Tenambergen, MD (Munster), MSc. CHDC (Lon), Saudi Arabia, Formerly in the Department of Community Health, University of Nairobi.

Request for reprints to: Professor E.M. Wafula, Department of Paediatrics and Child Health, College of Health Sciences, University of Nairobi, P.O. Box 19767, Nairobi.

# EFFECT OF IMPROVED STOVES ON PREVALENCE OF ACUTE RESPIRATION INFECTION AND CONJUNCTIVITIS AMONG CHILDREN AND WOMEN IN A RURAL COMMUNITY IN KENYA

E. M. WAFULA, M. M. KINYANJUI, L. NYABOLA and E. D. TENAMBERGEN

## ABSTRACT

***Objectives:*** **To estimate the effect of improved stoves on the prevalence of ARI and conjunctivitis among children aged below five years and women aged between 15 and 60 years.**

***Method:*** **A field trial or intervention study design, in which cluster and random sampling were used to recruit households with improved stoves. Nearest households with traditional three-stone stoves were recruited as controls. Prevalence of ARI and conjunctivitis among the study subjects was estimated by clinical evaluation and physical observation, and by history (including clinical and socioeconomic information), and compared between the two study groups.**

***Results:*** **The prevalence of ARI among children aged below five years and among women aged between 15 and 60 years were significantly higher in households with the traditional three-stone stoves than in those with the improved stove $\chi 2$ =31.45 $\rho$ = 0.00000, relative risk = 2.6, C.l. 1.86,3.63, and $\chi 2$ = 30. 13, $\rho$ = 0.00000, Relative Risk = 2.8, C.l. 1.93, 4.06, respectively). Similarly the prevalence of conjunctivitis among children aged below five years and among women aged between 15 and 60 years were significantly higher in households with traditional three-stone stoves than in those with the improved stoves (c2 = 24.18, p = 0.00000, Relative Risk = 3.3, C.l. 2.05,5.32, and $\chi 2$ = 7.6, $\rho$ = 0.0057, Relative Risk = 3, C.I. 1.38, 6.54. respectively).**

***Conclusion:*** **Prevalence of ARI and conjunctivitis among children aged below five years and also among women aged between 15 and 60 years in households with the traditional three-stone stoves was significantly higher than that in households with improved stoves.**

## INTRODUCTION

Acute respiratory infections (ARI) are a leading contributor to the high morbidity and mortality among children aged below five years in developing countries. Most of the severe morbidity and mortality are due to severe ARI in the form of pneumonia. The leading causative agents for pneumonia in developing countries are bacterial pathogens, mainly *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Staphylococcus aureus*(1,2).

Although there are effective and affordable antimicrobial agents against these organisms, there is still high morbidity and mortality attributable to pneumonia because children who are affected present late in their illness to the health facilities and/or receive inadequate or inappropriate medication at presentation(3). In an effort to reduce this high morbidity and mortality in developing countries, the World Health Organisation has been promoting ARI case management as an effective and appropriate strategy for this purpose, and lately integrated management of childhood illness (IMCI). ARI case management, and now IMCI, uses simple clinical parameters, namely fast breathing and chest-retraction, as proven diagnostic tools for early detection of pneumonia by even the least skilled health worker, with additional simple guidelines for effective management of ARI. This strategy has been found to be effective(4).

It has, however, been recognised that the prevalence and severity of ARI is influenced by a number of risk factors. Such risk factors include malnutrition, indoor air pollution, chilling, overcrowding, and the age of the child(5). Indoor air pollution is mainly due to high levels of particulate and gaseous material generated by especially incomplete combustion of biomass fuels that are used for cooking and heating. Although previous studies have suggested increased morbidity and mortality from severe ARI among children exposed to increased levels of indoor air pollution, and also increased conjunctivitis rates among such children, this effect has not been adequately quantified, partly because of methodologic constraints(6,7).

The degree of indoor air pollution has been shown to be very high in many studies within developing countries far above the maximum levels recommended by World Health Organisation. The pollution has been measured by estimation of the levels of respirable suspended particles or RSP, carbon monoxide, nitrogen dioxide, formaldehyde, benzene, and hundreds of other simple and complex organic compounds such as polyaromatic hydrocarbons(8). These pollutants are known to adversely affect the respiratory system and the conjunctiva.

There is evidence to suggest that use of improved stoves in households is associated with significant reduction of indoor air pollutants from biomass. Improved stoves seem to contribute to reduction in production of indoor air pollutants by virtue of more complete combustion of fuels in such stoves, and also by the resultant use of less biomass fuels to achieve the same amount of cooking than the traditional three-stone stove(10,11).

The long-term control of ARI, especially pneumonia, and also of conjunctivitis, must be based on preventive strategies of dealing with their risk factors rather than solely dealing with the specific diseases themselves, because it is easier to prevent diseases than to treat them. A useful strategy would be that of dealing with indoor air pollution, an important risk factor among many risk factors for pneumonia and conjunctivitis.

Although the biologic basis for the deleterious effect of the various components of the biomass pollutants on the respiratory tract and the conjunctiva are reasonably well documented, the magnitude of the effect with regard to ARI and conjunctivitis have not been adequately demonstrated(9,11). This study therefore, tries to demonstrate and estimate this effect so as to provide a rational basis for preventive intervention strategies that would target indoor air pollution.

## MATERIALS AND METHODS

The study was carried out in Lari and Limuru Divisions of Kiambu district. These divisions had the highest proportion of improved stoves installed during the period 1983 to 1986, during a women's energy project. The project was a women's project with a lot of grassroots publicity and advocacy and the stoves themselves were very cheap, such that even the poor within the community were able to install them.

The cluster sampling and random selection used in the selection of the 200 households with improved stoves, and also the recruitment of one household with the traditional three-stone stove that is nearest to each of the improved stoves selected, reduced bias. It is assumed rightly that the members of the households with improved stoves have been exposed over a long time to reduced indoor air pollution compared to their counterparts using the traditional three-stone stoves. The assigning of the improved stove to the respective households was done over 10 years earlier during the women and energy project in Kenya as a "Special Energy programme" of the Ministry of Energy. It was a community programme with the support of a political party, the Kenya African National Union (KANU) and Maendeleo ya Wanawake Organisation and did not discriminate against anybody in terms of the installation of the improved stove, and the stove was relative cheap to install at that time, such that the poor in the community had them installed in their households. Women aged between 15 and 60 years and children aged below five years were selected because they were the most likely to receive the highest exposure to indoor air pollution from burning biomass fuels in the kitchens.

The sampling unit was the household. Multi-stage sampling was used with the villages used as clusters. The sampling frame was all households in the six locations selected from the two divisions in the study area. The two divisions were selected because their communities had installed the highest number of improved stoves. At the divisional level, three locations in each division were systematically selected by asking for the ones where there were the highest level of installation of improved stoves. At the locational level, three villages were randomly selected. At the village level, the interviewers moved from household to household until they came to a household with improved stove. For the control group, the nearest household using the traditional three-stone stove was selected. For a household to be selected, it had to have a woman aged between 15 and 60 years. The study subjects comprised of all women aged between 15 and 60 years and all children aged below five years in the selected study households.

Using community enrolled nurses who were given prior specific training on recognition of ARI and conjunctivitis, and also on how to fill the study questionnaire, all the study subjects were clinically evaluated with respect to the presence of ARI and conjunctivitis and the questionnaire filled with respect to the occurrence of conjunctivitis and/or ARI among the study subjects in the previous one week. Data was also obtained on the type of kitchen, socioeconomic status of the household, educational level of the mother and the type of kitchen used in the household.

Week prevalence of ARI and conjunctivitis among children and women in the households with the two types of stoves, namely improved stoves and 3-stone stoves, were compared using chi-square tests, by SPSS personal computer programme. Study subjects who were unwell were appropriately referred to the nearest health facilities.

## RESULTS

A total of 400 households, comprising 200 with improved stoves and 200 with traditional three-stone stoves were recruited. Although women were, by study design, found in all study households, children aged below five years were found in only 248 households or 62% of all the households. The data collection took 58 days.

A comparison of the sociodemographic parameters of the women from the households with the two types of stoves revealed marked similarities between them.

The week prevalence for ARI among children aged below five years was significantly lower among children from households with improved stoves than that among children from households using the traditional three-stone stoves (Table 1).

**Table 1**

*Effect of improved stoves on one week prevalence of ARI among children aged less than five years.*

| Type of stoves used in the household | Number of children with ARI in one week | Number of children without ARI in one week | Total number of children | Week Prevalence for ARI in one week as a percentage |
|---|---|---|---|---|
| Traditional three-stone stove | 75 | 52 | 127 | 59.1 |
| Improved stove | 28 | 93 | 121 | 23.1 |
| Total number of children | 103 | 145 | 248 | 41.5 |

$\chi 2 = 31.45$ $\rho = 0.00000$ Relative Risk = 2.6 (95% C.I. 1.86, 3.63)

**Table 2**

*Effect of improved stoves on one week prevalence of ARI among women.*

| Type of stove used in the household | Number of women with ARI | Number of women without ARI | Total number of women | Week prevalence of ARI as a percentage |
|---|---|---|---|---|
| Traditional three-stone stove | 76 | 124 | 200 | 38 |
| Improved stove | 27 | 173 | 200 | 13.5 |
| Total number of women | 103 | 297 | 400 | 25.8 |

$\chi 2 = 30.13$ $\rho = 0.00000$ Relative Risk = 2.8 (95% C.I. 1.93, 4.06)

**Table 3**

*Effect of improved stoves on week prevalence of conjunctivitis among children aged below five years*

| Type of stove used in the household | Number of children with conjunctivitis | Number of children without conjunctivitis | Total number of children | Week prevalence of conjunctivitis as a percentage |
|---|---|---|---|---|
| Traditional three-stone stove | 52 | 75 | 127 | 40.9 |
| Improved stove | 15 | 106 | 121 | 12.4 |
| Total number of women | 67 | 181 | 248 | 27 |

$\chi 2=24.18$ $\rho = 0.00000$ Relative risk=3.3 (95% C.I. 2.05, 5.32)

**Table 4**

*Week prevalence of conjunctivitis among women*

| Type of stove used in the household | Number of women with conjunctivitis | Number of women without conjunctivitis | Total number of women | Week prevalence of conjunctivitis as a percentage |
|---|---|---|---|---|
| Traditional three-stone stove | 24 | 176 | 200 | 12 |
| Improved stove | 8 | 192 | 200 | 4 |
| Total number of women | 368 | 32 | 400 | 8 |

$\chi 2 = 7.6$ $\rho = 0.0057$ Relative Risk=3 (95% C.I. 1.38, 6.54)

Similarly the week prevalence for ARI among women from households with improved stoves was significantly lower than that among women from households using the traditional three-stone stove (Table 2).

It was also noted that the week prevalence of conjunctivitis was significantly lower among children aged less than five years from households with improved stoves than that among those from the traditional three-stone stoves (Table 3).

It was similarly noted that the week prevalence of conjunctivitis among women staying in households with improved stoves was significantly lower than that from households with the traditional three-stone stoves (Table 4).

The effect of the type of stove on the prevalence of ARI among children and women and of conjunctivitis among children and women was maintained even after controlling for mother's level of education, socioeconomic status of the household, and the type of kitchen, using a logistic regression model.

## DISCUSSION

Morbidity and mortality among children aged below five years in developing countries is very high. acute respiratory infections (ARI) are important contributors to both this high morbidity and mortality while conjunctivitis is an important contributor mainly to its morbidity. Bacterial pneumonia, mainly due to *Streptococcus pneumoniae, Haemophilus influenzae,* and *Staphylococcus aureus,* are the main causes of the ARI related deaths and severe morbidity, that account for about 30% of all deaths and 30% to 50% of all admissions in this age groups. Less severe morbidity is however a lot more frequent and is mainly due to viral pathogens and has been estimated at three to eight episodes per child per year, with a point prevalence of 10 to 20% at any one time, in this age group(12-14).

The short-term strategy for the reduction of this high mortality and severe morbidity from ARI is standardised and simplified case management strategy for pneumonia, that emphasises early detection of pneumonia at the most peripheral health facility and the use of appropriate antibiotic(4).

The morbidity from conjunctivitis has not been adequately studied, especially in our local environment. Multiple aetiological factors have been identified for conjunctivitis, and include infections like *Chlamydia trachomatis, Neisseria gonorrhoea,* adenovirus, measles virus, *pneumococci,* and *staphylococci*. In addition allergens and irritants have been blamed for conjunctivitis. Persistent and severe conjunctivitis can lead to varying degrees of visual impairment, including blindness(15,16).

The long-term strategy for reduction of mortality and morbidity from ARI and morbidity from conjunctivitis in developing countries must of necessity be preventive in nature. Vaccine development and vaccination against the various aetiological agents for ARI has still many outstanding hurdles to climb over, that include multiplicity of the offending organisms, difficulty in developing effective vaccines to cover adequate numbers of strains of the various offending bacterial and viral pathogens, and the huge costs involved in vaccine programmes that often outstrip the resources of the developing countries where such vaccines would of necessity be used. A simpler approach appears to be that of targeting the various risk factors in terms of reducing their prevalence or modifying their effect. The risk factors that have been identified for ARI include malnutrition (including vitamin A deficiency). overcrowding, chilling, and indoor air pollution. On the other hand, risk factors for conjunctivitis have been identified as overcrowding. inadequate water supply, poor hygiene, and indoor air pollution(15).

Whereas most of the indoor air pollution in developed countries is due to tobacco smoke, the greatest cause of indoor air pollution in developing countries is smoke and other effluents from combustion of biomass fuels which are used by the great majority of the populations in these countries for heating and also for cooking. The biomass material used include wood, coal, animal dung and crop residues.

Many constituents of the biomass combustion that have been identified and measured include respirable suspended particles (RSP), carbon monoxide, nitrogen dioxide, sulphur dioxide, formaldehyde and polyaromatic hydrocarbons. The concentration of these pollutants have been found to be extremely high in households in developing countries where such studies have been carried out. For example, RSP measured over 24 hours has been found in a number of these studies carried out within developing countries to range from 1000 µg/m$^3$ to 9000 µg/m$^3$ with peak levels reaching 21000 µg/m$^3$, being far higher than the less than 100 µg/m$^3$ to 150 µg/m$^3$ recommended by the WHO or the less than 260 µg/m$^3$ recommended by the Environmental Protection Agency(8).

The high levels of indoor air pollutants are due to many factors that include inadequate ventilation for the households and incomplete combustion of the biomass fuels leading to use of large amounts of biomass fuels and release of greater amounts of pollutants from a given amount of biomass fuel. Preventive strategies for reduction of the indoor air pollution from biomass fuels consequently include increased ventilation to let out of the household the effluents from the combustion of the fuels and also improvement of the efficiency for the burning of the fuels. Both of these strategies involve modification of structural designs at the cooking area. Increased ventilation can be achieved by putting more windows in the cooking area, or allowing greater space between the wall and the roof, increasing the available space in the cooking area and constructing a chimney in the cooking area. All these modifications may involve reasonably high costs and major changes in the housing design that might he unaffordable or unacceptable to the involved household owners or community. On the other hand, increased efficiency in combustion can be achieved by using cheap but well designed and acceptable improved stoves that achieve fuel utilisation of up to 30% to 50%, as compared to only 7% to 8% fuel utilisation by the traditional three-stone stove, and also saves fuel by up to 50%, at a construction cost of less than KSh. 50/= (11,18,19).

In spite of these very high concentrations of pollutants in households studied in many developing countries, the influence of this degree of pollution on the prevalence or severity of ARI or conjunctivitis have not been adequately demonstrated, mainly because of methodological constraints. A major constraint has been homogeneity in the exposure to indoor air pollution between comparison groups or populations(6,7,9,17).

The present experimental or field intervention study design offers peculiar advantages for addressing the issue of exposure to indoor air pollution. In this study, the exposure in the form of indoor air pollution is represented by the improved stove, on the one hand, and the traditional three-stone stove, on the other.

A study carried out earlier in the same district on indoor air pollution found the average concentration of respirable suspended particles (RSP) to be 4459 µg/m3 in households with traditional three-stone stoves and 1725 $\mu g/m^3$ in households with improved stoves(10). This study indicated that indoor air pollution in households where improved stoves had been installed was less than 50% that found in households with the traditional three-stone stove. It is likely that the improved stoves were responsible for this greater than 50% difference or reduction in the levels of indoor air pollution.

This study has demonstrated that the probability of having ARI within the households with traditional three-stone stoves was 2.6 times that for households with improved stoves for children aged below five years, and 2.8 times for women aged between 15 and 60 years. This represents a reduction in prevalence of ARI among residents by improved stoves (over traditional three-stone stoves, which had also been in these households previously) by 61% for children aged below five years and 64% for women aged between 15 and 60 years. The study also demonstrated that the chances of having conjunctivitis within the households with the traditional three-stone stoves was 3.3 times more than that within households with improved stoves for children aged below 5 years and 3.0 times for women aged between 15 to 60 years. This represents a reduction in prevalence of conjunctivitis among residents by improved stoves (over traditional three-stone stoves, which had also been in these households previously) by 70% for children and 67% for women aged between 15 and 60 years.

Although this study specifically addressed itself to ARI as a whole, most of which was mainly mild ARI, this significant effect of indoor air pollution is expected to be true even for the more severe ARI as pneumonia.

This study has demonstrated that use of improved stoves in households significantly reduce the prevalence of ARI and conjunctivitis among children aged below five years and also among women aged between 15 and 60 years.

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