The identification of behavioural intervention opportunities to reduce child exposure to indoor air pollution in rural south africa

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TABLE OF CONTENTS

Figures:

Tables:

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ACRONYMS

ALRI	Acute lower respiratory infections
ARI	Acute respiratory infections
CO	Carbon monoxide
COLD	Chronic obstructive lung disease
EHP	Environmental Health Project
IAP	Indoor air pollution
IMCI	Integrated Management of Childhood Illness
LPG	Liquid petroleum gas
MRC	Medical Research Council of South Africa
NO_2	Nitrogen dioxide
$PM_{2.5}$	Particulate matter of 2.5 μm or less
RSP	Respirable suspended particulates
SO_2	Sulphur dioxide
SPSS	Statistical Package for the Social Sciences
TB	Tuberculosis
USAID	United States Agency for International Development
WHO	World Health Organisation

EXECUTIVE SUMMARY

Acute lower respiratory infections (ALRI) such as pneumonia have been linked to exposure to indoor air pollution (IAP), and account for the deaths of millions of children in developing countries each year. While interventions to prevent child exposure to IAP have been characterised by technological approaches such as stove improvement programmes, very little is known about the effectiveness of behavioural interventions in reducing child exposure to IAP.

In response to the paucity of information in this regard, the aim of this project, which is divided into a number of phases, is to evaluate the effectiveness of a behavioural intervention approach in reducing child exposure to IAP. The goal of this, the first phase of research, is to inform the design of the behavioural intervention to be implemented in subsequent phases. To do this, the specific objectives of phase one are:

- To describe all observable practices that might have an effect on child exposure to IAP and respiratory health.
- To understand the factors that influence practices.
- To describe how practices may differ between households that care for a child with a history of severe ALRI (hereafter high ALRI group) and households that care for a child with minimal ALRI (hereafter low ALRI group).

METHODS

An exploratory study design using observations, post-observation interviews and focus group interviews was employed. Research was conducted during winter 2001. Forty caregivers (20 who care for a high ALRI child and 20 who care for a low ALRI child) were included in the sample for observations and post-observation interviews. A further 27 caregivers with one or more children under five years of age were included in the sample for focus group interviews. Air-quality data were also collected in five households.

RESULTS

<u>IAP-related practices and the factors that influence those factors</u>

Burning practices: Households used wood, cow dung, maize cobs and kerosene for their domestic energy requirements. Fuels were used either on their own or in combination with each other. The most commonly used fuel was wood (used by 67% of the sample at least once during the observations), followed by kerosene (52.5%), cow dung (30%) and maize cobs (15%). The two most frequently used appliances were wood stoves and kerosene stoves.

The cumulative duration of burning ranged from 12 to 780 minutes (13 hours), with the average cumulative burning time being 285 minutes (4 hours 45 minutes). Generally, solid fuels were burned for longer durations but less frequently than kerosene. Depending on the fuel type, burning occurred most often in the mornings and declined during the course of the day until the early evening.

The appliances available generally determine whether solid fuels or kerosene is used. Among the solid fuels, wood is preferred to cow dung and maize cobs because it reportedly burns for longer, is believed to produce less pollution and the smoke it produces is less pungent than the other solid fuels. Kerosene is preferred because of the relative speed at which a caregiver can get cooking done. Given the choice, most households would use wood, kerosene or a combination of the two without cow dung and maize cobs for their domestic energy requirements.

However, both of the preferred fuels have to be purchased. In practice therefore, wood is reportedly used exclusively when money is available. As supplies diminish, it is used in combination with cow dung and maize residues (both of which are freely available). When wood supplies are exhausted, cow dung and maize cobs are used exclusively. Similarly, kerosene is used until the supply is exhausted.

Child location practices: The average time that reference children were in the room while a fire was burning equals 146 minutes (2 hours 26 minutes). This ranged from one minute to as long as 385 minutes (6 hours 25 minutes). In general, children spent approximately 16% of the total burning time within one metre of the appliance, 42% of the burning time in the room that burning took place (but further than one metre away from the stove), and 42% of the total burning time either in another room of the house or outside. Children were more likely to be closer to the stove in the morning than in the afternoon or early evening.

Warmth generated by the fire was cited as a major factor for having the child close to the stove. However, for caregivers who kept their child away from the stove, the intention to protect the respiratory health (from inhaling fumes) and physical health (from getting burned) were cited as major motivations for doing so. In addition, the presence of someone who is able to keep the child in another location during burning was cited as an important determinant of whether the child was in the room where burning was taking place for extended periods of time or not.

Ventilation practices: Overall, the majority of households (72.5%) displayed variable ventilation practices, i.e. opened and closed windows/doors at various stages during burning 15% had their windows and doors open throughout the burning, and 12.5% had their windows and doors closed for the duration of burning. The most common variable practice was to open windows and/or doors during ignition, leave them open until the visible smoke had cleared out of the room and then close them again. Maintaining a balance between warmth and an attempt to protect the respiratory health of the child as well as the perception that non-visible emissions are not harmful are the main factors determining ventilation practices.

Air quality monitoring: Results from air quality monitoring in selected households showed levels of respirable suspended particulates (RSP) and particulate matter of 2.5 μm or less ($PM_{2.5}$) to be extremely high.

Differences between the high and low ALRI group

In high ALRI households, reference children were significantly ($p < .05$) more likely to spend extended periods of time within one metre of the stove while it was burning, were less likely to have someone take an active role in caring for the child in a location away from the stove, and were more likely to have their burning appliances further away from ventilation than low ALRI households. It is worth noting that, although not significant, high ALRI households tended to burn wood for longer and were over-represented in the group that closed both windows and doors for the duration of burning.

Knowledge of the link between IAP and ALRI

Overall, caregivers recognised that emissions from indoor fires were dangerous and identified coughs, eye irritation, asthma and tuberculosis (TB) as health effects of exposure to IAP.

Caregiver recommendations

To reduce their children's exposure to IAP, caregivers recommended keeping the child away from the room where burning took place and opening ventilation for longer periods of time during burning. Caregivers also suggested better maintenance of wood stoves, e.g. fixing holes in the stove, covering broken stove doors, unblocking blocked chimneys and fixing leaky chimneys. Other suggestions included extinguishing fires after cooking and heating (e.g. throwing leftover maize porridge over the coals) instead of allowing the fire to extinguish on its own and throwing uncooked maize meal over burning embers to reduce the amount of smoke they produce.

BEHAVIOURAL INTERVENTION RECOMMENDATIONS

Based on suggestions from caregivers, current behaviours of household members, likely cost to households, required effort and probable reductions in exposure to IAP, it is recommended that the intervention should focus on behaviour change in the following areas:

- Improve stove maintenance practices.
- Open ventilation for longer periods of time during burning.
- Move the child to a location away from the stove during burning.
- Reduce the duration of solid fuel burning.

It is further recommended that the intervention should include a focused education component. The education should focus on the diseases associated with exposure to IAP and the reasons that children are more susceptible than adults. Because of the perception that non-visible emissions are not harmful to respiratory health, the fact that they are should be a key message of the education component. It is further recommended that before the main intervention is implemented an additional phase of formative research should be conducted to determine the feasibility and acceptability of the proposed/recommended practices among a small group of research participants.

1. BACKGROUND

Recent estimates indicate that Acute Lower Respiratory Infections (ALRI) account for a significant proportion of all deaths and illness due to infectious diseases globally, with children under 5 years of age in developing countries being a particularly high risk group (Smith, Samet, Romieu & Bruce, 2000). The World Health Organization (WHO) has sought to complement the clinical management of ALRI through the Integrated Management of Childhood Illness (IMCI) by developing a range of primary prevention initiatives (Kirkwood et al., 1995). Reviews of the potential for prevention of a range of risk factors have been carried out, and have identified indoor air pollution (IAP) as a potentially important, yet neglected factor[1] (Bruce, 1999; Smith et al., 2000).

IAP in developing countries mostly arises from the indoor burning of solid biomass fuels (wood, dung and crop residues) and coal in open fires or poorly functioning stoves. Pollutants produced by these indoor fires include respirable suspended particulates (RSP), carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) (Smith, 1987). It is estimated that at least two-thirds of all households in developing countries are still primarily dependent on biomass fuels and coal affecting approximately 3.5 billion people worldwide (The World Resources Institute, 1998).

South Africa is no different and a number of studies have shown a relationship between IAP (arising from the use of wood, coal and kerosene) and ALRI. As early as 1982, Kossove found that over 70% of infants less than 13 months of age with severe lower respiratory tract infections had a history of daily *wood* smoke exposure from cooking and heating fires. This was significantly higher than infants studied in the 'non respiratory problem' group (Kossove, 1982). Similarly, the Vaal Triangle Air Pollution & Health study found that the use of *coal* for cooking and heating was the most significant risk factor for the development of respiratory illness in children. Children living in homes using coal had a 3.9 times higher risk of developing respiratory illness compared to children living in homes using electricity (Terblanche, 1998). People living in informal settlements in and around major urban centres are also at risk of the effects of IAP. Two studies have shown that *kerosene* is the most commonly used alternative to electricity in these areas and that a significant number of homes have levels of pollutants (CO, NO_2 and SO_2) above international guidelines (Bailie et al., 1999; Sanyal & Maduna, 2000).

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[1] Strong evidence shows that exposure to IAP is also associated with an increased risk of chronic obstructive lung disease (COLD) in adults and moderate to weak evidence exists for TB, adverse birth outcomes, eye problems and cardiovascular disease.

At the level of interventions to prevent exposure to IAP, theorists have identified a number of mitigation options: technologies that aim to improve burning devices (stoves), improve fuels (e.g. switch from biomass fuels to cleaner fuels such as liquid petroleum gas (LPG) or electricity), technologies that aim to improve the living environment (e.g. partitions to separate burning areas from the rest of the home or increase the size of ventilation in the burning area), and behaviour change (e.g. reduce the time spent in proximity to the burning stove, proper stove maintenance and improve ventilation practices) (cf. World Bank, 2002).

While existing interventions have been characterised by technology-based approaches mostly in the form of stove improvement programmes (see for example Albalak et al, 2001, Wafula et al, 2000 & Schwela, 1997), very little is known about the role of behavioural interventions to reduce child exposure to IAP. The lack of information is so pronounced that a recent Environmental Health Project (EHP) publication on the effectiveness of behavioural interventions in environmental health deferred including the issue of behaviour to prevent ALRI because, "the effectiveness of behaviours to reduce exposure to indoor air pollution is largely untested" (Favin, Yacoob & Bendahmane, 1999, p. 9). In response to the paucity of information in this regard and calls for cheaper, more sustainable interventions that build on what people are doing already (Bruce & Doig, 2000), the overall goal of this study is to design, implement and evaluate a behavioural intervention to reduce child exposure to IAP and improve child respiratory health.

2. GOAL AND OBJECTIVES OF PHASE ONE

The goal of phase one is to inform the design of the intervention to be implemented in subsequent phases. The specific objectives of phase one are:

- To describe all observable practices that might have an effect on child exposure to IAP and respiratory health.
- To understand the factors that influence practices.
- To describe how practices may differ between a group of high ALRI households and a group of low ALRI households.

3. STUDY SETTING

The study took place in the rural villages of Brooksby and Enselsrust situated in the Tribal-Delareyville magisterial district in the North West Province of South Africa. The villages are located approximately 65 kilometres south west of the capital city, Mafikeng, and 400 kilometres from Johannesburg. The two villages are within 20 kilometres of each other.

Brooksby and Ensulsrust have a combined population of approximately 2474 people, of whom, 432 (approximately 17%) are children under five years of age (Statistics South Africa, 1998). Residents live in houses of relatively poor quality, constructed either with homemade bricks, concrete blocks or mud. Almost all houses have corrugated iron roofs. In total there are 421 dwellings in both villages with an average of four rooms per dwelling. The mean number of people per dwelling is seven (Mathee, Röllin & Bruce, 2000).

Figure 1 Typical dwelling in the study area

Unemployment levels are high with only 35% of dwellings having one or more persons with a full-time job (Mathee et al., 2000). The unemployment rate stands at 37.9% and of those working, 30.6% earn less than R500 ($50) per month and a further 10% earn between R1,000 ($100) and R1,500 ($150) a month (Statistics South Africa, 1998).

Education levels are low: 21% of adults have no formal education and a further 20% have had some primary school education. Only 27% of caregivers have a primary school education with the rest having very little, or no formal education (Mathee et al., 2000). Setswana (67.2%) is the language spoken by the majority of people, followed by Afrikaans (7.5%) and isiXhosa (5.4%) (Statistics South Africa, 1998).

It is extremely cold in the villages during winter, with average minimum winter temperatures ranging from 5.1 degrees Celsius to 6.4 degrees Celsius, although temperatures have been known to drop below 0 degrees Celsius. The coldest month is June, with an average minimum of 5.1 degrees Celsius (South African Weather Bureau, 2001).

Preliminary investigations in the area showed that people tend to use more solid fuels (such as wood) during winter both for cooking and heating purposes. The use of liquid fuels (such as kerosene) decreases in winter for cooking compared to summer. Children were also found to follow caregivers around while burning was taking place indoors (Mathee et al., 2000).

In terms of the health status of children in the study area, the local Gelukspan Community Hospital paediatric admission records indicate that a total of 318 children under the age of 18 months were admitted during 1999. Using a combination of available folders and information from the admissions record book, approximately 70 of these children (22%) under the age of 18 months were admitted to hospital for pneumonia during 1999, 85 (27%) were admitted for other respiratory conditions, and 148 (47%) for non-respiratory conditions. Altogether, pneumonia and other respiratory infections accounted for 155 (48,7%) of all paediatric admissions of children under 18 months in 1999. Based on these figures, a crude estimate of pneumonia in the area for 1999 was approximately 4.7/1000 child years (Mathee et al., 2000).

In short, the two villages were chosen for this study mainly because preliminary investigations indicate that:

- There is evidence that child ALRI is a health concern in these communities.
- Solid fuels are burned indoors by the majority of households during winter.
- Young children are often in the burning area during times of peak use.
- There appears to be an absence of ambient air pollution from motor vehicles and industry to bias the presence of child ALRI due to IAP.

4. PHASE ONE METHODOLOGY

4.1 Study design

An exploratory study design using observations, post-observation interviews, focus group interviews and air quality monitoring was employed. The study was completed during the winter months of 2001.

4.2 Research participants

Forty households - 20 who care for a high ALRI child and 20 who care for a low ALRI child - were included in the sample for observations and post-observation interviews. A further 27 caregivers (13 who care for a high ALRI child and 14 who care for a low ALRI child) were included in the sample for focus group interviews.

4.3 Procedure

- To identify the sample of high ALRI children and low ALRI children, a village ALRI survey was conducted. Research assistants visited each household in both villages to identify households with a child/ren less than five years old. Overall the ALRI questionnaire was administered to the caregiver of 150 children about their child's respiratory health. The questionnaire (based on WHO criteria for the diagnosis of pneumonia) included items on the demographic composition of the household; ALRI symptoms in the previous 2 weeks; ALRI symptoms in the previous 6 months; ALRI diagnoses in the previous 6 months; child immunization status and tobacco smoking patterns of household members.

  From this sampling frame, 20 households with a low ALRI child and 20 with a high ALRI child were selected for the observations and post-observation interviews. To select children for the high ALRI group and the low ALRI group the following criteria were used: Children in the high ALRI group must have either been diagnosed by a doctor in the last 6 months as having ALRI OR been taken to a health worker in the last 6 months for respiratory illness + have experienced at least 5 or more key symptoms in the previous 2 weeks. Children in the low ALRI group must have never been diagnosed with ALRI by a health worker and have experienced less than 4 selected symptoms in the previous 2 weeks. Once identified, the 20 most severe cases were selected for inclusion in the high group and 20 of the least severe cases were selected for the low group.

- To describe household energy practices, trained research assistants observed household occupants' behaviours for a one-day period, from the first fuel activity (approximately 06h30) to approximately 18h30, using a pre-structured observation sheet. This instrument included sections on household structural information (number of rooms, roof material, wall material, number of windows/doors in the burning room, appliances, diagrammatic layout of the house and diagrammatic layout of the room where burning took place i.e. the 'burning room'). In addition, the instrument had sections on the location of burning, the appliance used for burning, the purpose of burning and the fuel used. Once a fire was burning, research assistants completed sections on child location practices, child activity, ventilation practices, and location of caregiver and other persons during the burning. The time each event occurred was also recorded. It is important to note that, to avoid bias, research assistants were not aware of the ALRI status of the children they were observing but were randomly assigned to households each day.

- Post-observation interviews were conducted with all 40 caregivers directly after each observation. The primary aim of the interviews was to discuss the determinants of the practices that were observed. Research assistants using a semi-structured interview schedule asked a number of questions based on what was observed during the day. This instrument included questions on cooking, space heating, ventilation practices and child location practices. Each interview took between 10 and 30 minutes to complete. The interviews were tape-recorded and transcribed using an adapted Jefferson transcription method (Potter & Wetherell, 1987).

- After each day's work, a team meeting was held during which researchers and research assistants discussed the details of the observations and post-observation interviews. Based on this, the focus for the next day's observations and interviews were agreed upon.

- An additional 14 low ALRI and 13 high ALRI mothers/caregivers participated in the focus group interviews. Overall, 2 high and 2 low ALRI focus group interviews were conducted. The discussions were facilitated by an experienced focus group moderator and were held in a crèche in Brooksby and in a local church in Ensulsrust. Apart from validating the preliminary findings of the observations and post-observation interviews, the focus group interviews were also used to explore gaps in the data already collected. In addition, a special focus was placed on factors that influence practices at the community level. The focus group interviews were tape-recorded and transcribed.

Figure 2 Focus group interview in Brooksby

- Of the 40 observation households, research assistants agreed upon and selected what they perceived (based on their experiences in the observations) were the five most polluted households for air quality monitoring of respirable suspended particulates (RSP) and $PM_{2.5}$ (four of the selected households were high ALRI households and one was a low ALRI household). Portable constant flow battery-powered air sampling Gilian pumps were used. Dorr-Oliver cyclones (which conform to the ACGIH standard for respirable particles) with 4.5-µm particle cut point were used as a pre-separator. To collect 24-hour RSP, the pumps with cyclones holding 37 mm PVC filter cassettes were sited at the standard height (adult breathing height) and distance (approximately 1.5 meters) from the stove. In each household repeated 24 hour collections over 4 days took place. A portable battery operated laser photometer (TSI's DustTrak^{TM} Aerosol Monitor) was used to collect continuous $PM_{2.5}$ in three households (all high ALRI) over a 24-hour period.

Sampling (150 households)

⇓

Observations & post-observation interviews (in 20 households with a high ALRI child & 20 households with a low ALRI child)

⇓

Focus group discussions (13 caregivers who care for a high ALRI child & 14 who care for a low ALRI child)

⇓

Air quality monitoring (5 households)

Figure 3 Summary of phase one research process

4.4 Analysis

Data from the observations were captured and analysed using the Statistics Package for Social Sciences (SPSS) (version 10) software package. To observe overall trends in the data, descriptive statistics such as frequency distributions and measures of central tendency were used. To identify differences between the high and low ALRI groups, cross tabulations using the chi-square statistic (Π^2) were used for categorical data while the Mann-Whitney non-parametric test was employed for ordinal data. The Pearson's product-moment correlation coefficient (Pearson's *r*) was used to determine correlations between sets of ordinal data.

To identify factors that influence observed practices, the transcribed (post-observation and focus group) interviews were analysed using a thematic analysis (Miles & Huberman, 1994). This method was also used to determine caregivers' understanding of the link between IAP and ALRI.

5. PHASE ONE RESULTS

5.1 Background

The ages of the observation children ranged from 2 to 60 months with the mean age of 22.6 months (1 year and 8 months old).

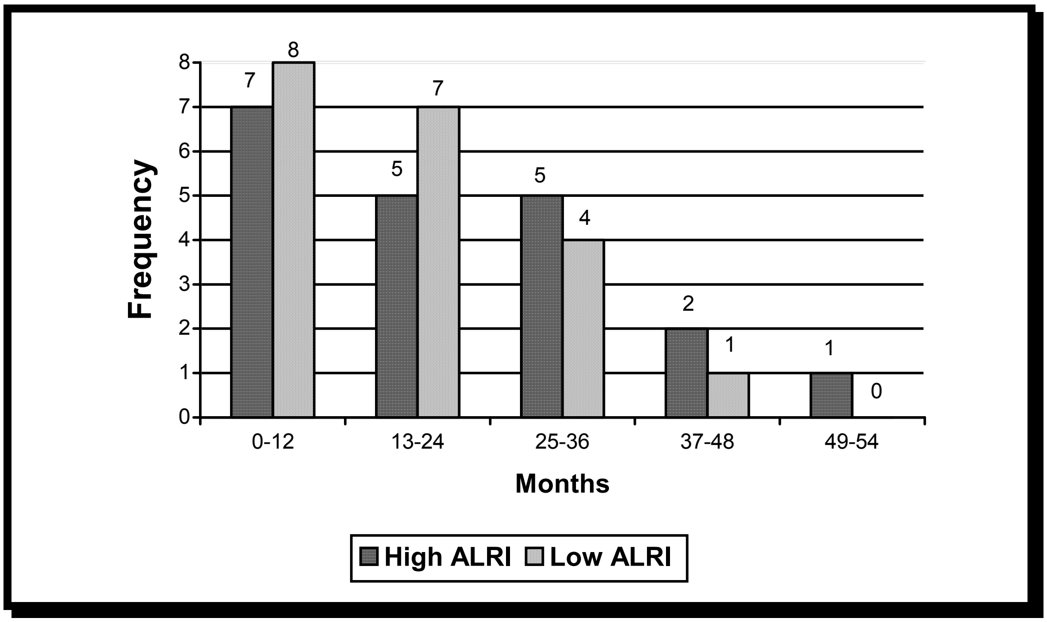

Figure 4 Age distribution of the study sample

Because of their particular susceptibility to IAP, a greater proportion of younger children were selected for inclusion in the study sample. For example, 37.5% (n=15) of the sample were less than 12 months of age and 67.5% (n=27) of the sample were less than 24 months of age. The ages of the high and low ALRI children were matched with similar numbers in each age category.

The number of rooms per observation household ranged from one to eight with an average of 3.5 rooms per household. Households with high ALRI children had an average of three rooms while households with low ALRI households had an average of four rooms. The average area of the burning room was 9.96 m^2. The number of windows in the burning room ranged from one to three, with the majority (49%) having just one window. The number of doors in the burning room ranged from 1 to 4 with the majority (54%) having only one door.

In terms of wall material, 65% of the households' walls were built with homemade bricks, 20% with concrete blocks, 10% with corrugated iron and 5% with mud. All roofs were constructed with corrugated iron.

5.2 Indoor Air Pollution related practices and the factors that influence those practices

5.2.1 Burning practices

Appliances: The most commonly used appliances were wood stoves, kerosene stoves and braziers (*mbawula*). Braziers were used by only four observation households during the observations and burned outside, while no observation households used gas stoves.

Table 1 Type of appliances present in the burning room

	Frequency	**Percent**
Wood stove & kerosene stove	18	45
Kerosene stove only	10	25
Wood stove only	6	15
Wood, kerosene & gas stove	4	10
Brazier only	1	2.5
Kerosene stove & brazier	1	2.5
Total	**40**	**100**

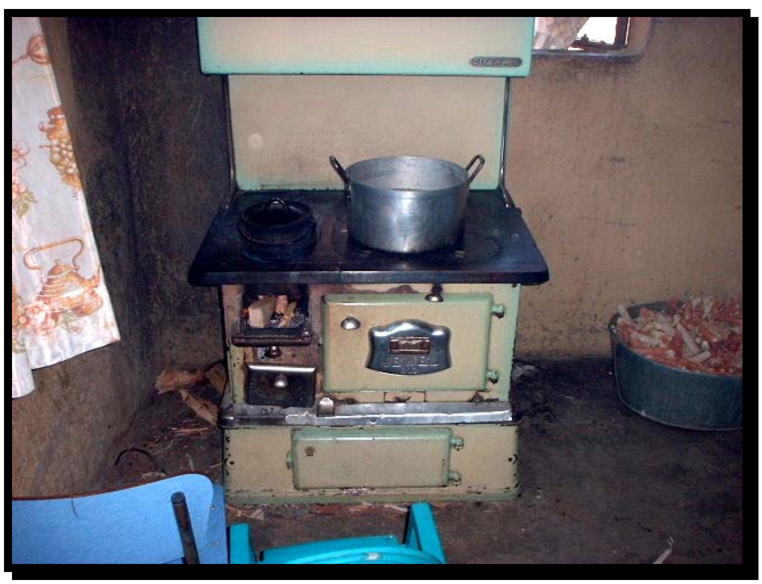

Figure 5 Typical wood stove

Figure 6 Typical kerosene stove

Maintenance of burning appliances was poor, with many stoves being in a state of disrepair. For example, the doors of many wood stoves did not close properly, lids were missing, chimneys had visible holes and cracks in them and many chimneys were reportedly blocked. Many of the stoves were old, having been handed down over generations, contributing to their poor condition. Unfortunately, no data on the proportion of households with dilapidated stoves were collected.

Figure 7 Wood stove in a state of disrepair

<u>Fuels</u>: The most commonly used fuels were wood (*dikgong*), kerosene (*paraffini*), cow dung (*boloko jwa kgomo*) and maize cobs (*ditlhotla*). These fuels were burned either on their own or in combination with one or more other fuels. Most households (48%) used various combinations of solid fuels, 32% used kerosene-only whilst 20% used a combination of kerosene and solid fuels for their cooking and heating requirements.

When broken down by fuel type, wood was the most commonly used fuel with 67.5% of households using wood at least once during the observation period, followed by kerosene (52.5%), cow dung (30%) and maize cobs (15%).

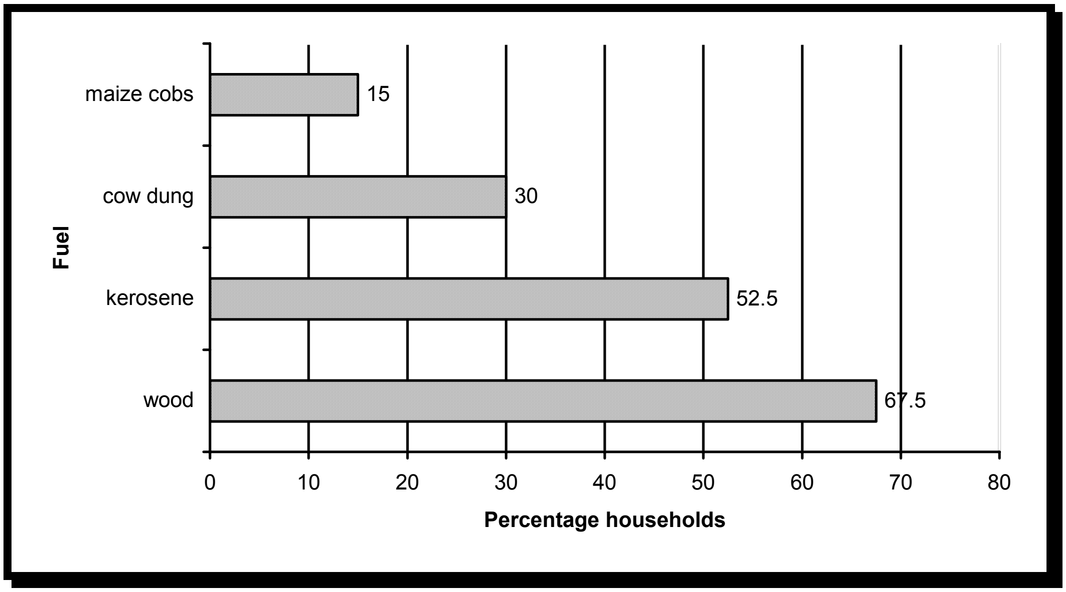

Figure 8 Percentage of households by fuel used at least once during the day

Burning activities: The number of burning activities ranged from 1 to 4 during the observation period. Those using kerosene tended to burn more frequently (but for shorter periods of time) than those using solid fuels. For example, kerosene accounted for 41% of the total number of burnings, 'wood only' accounted for 25%, 'wood + cow dung' for 22%, 'maize cobs only' for 4%, 'wood + cow dung + maize cobs' in combination for 4%, 'wood + maize cobs' in combination for 2% and 'cow dung only' for 2%. Put slightly differently, kerosene stoves accounted for 4, 'wood-only' for 2.5 and 'wood + cow dung' for 2.2 out of every 10 burnings observed.

Burning duration: The cumulative burning time per household (the total of all burnings per household during the observation period) ranged from 12 to 780 minutes (13 hours), with the average cumulative burning time being 285 minutes (4 hours 45 minutes).

Although those households using kerosene ignited a fire more frequently, households using solid fuels burned for much longer periods of time. For example, burning activities involving 'wood only' were observed to burn for the longest periods of time (ranging from

108 to 677 minutes, average of 290 minutes), followed by those using a combination of wood and cow dung (ranging from 88 to 695 minutes, average of 288 minutes). In contrast, those burning activities involving kerosene lasted for an average of 121 minutes (ranging from 6 to 476 minutes).

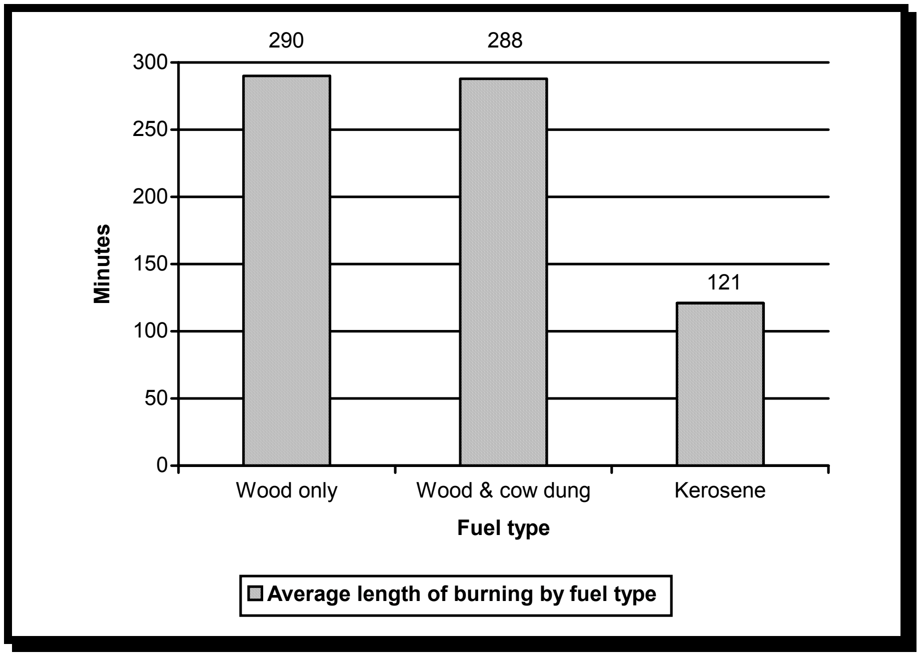

Figure 9 Length of burning by fuel type

Timing of burning: Most burning occurred during the morning (06h30 to 10h00), with a steady decrease through the afternoon (12h00 to 15h00) until the early evening (15h30 to 18h30). For example, the burning duration of 'wood only' decreased from 215 minutes average in the morning to 155 minutes average in the afternoon and decreased further to 107 minutes average in the early evening. The 'wood + cow dung' fuel category showed a similar trend. The use of kerosene, however, declined in the afternoon but increased in the early evening. It should be noted that observations stopped at 18h30 and it is possible that the duration of burning increased during the late evening and beyond.

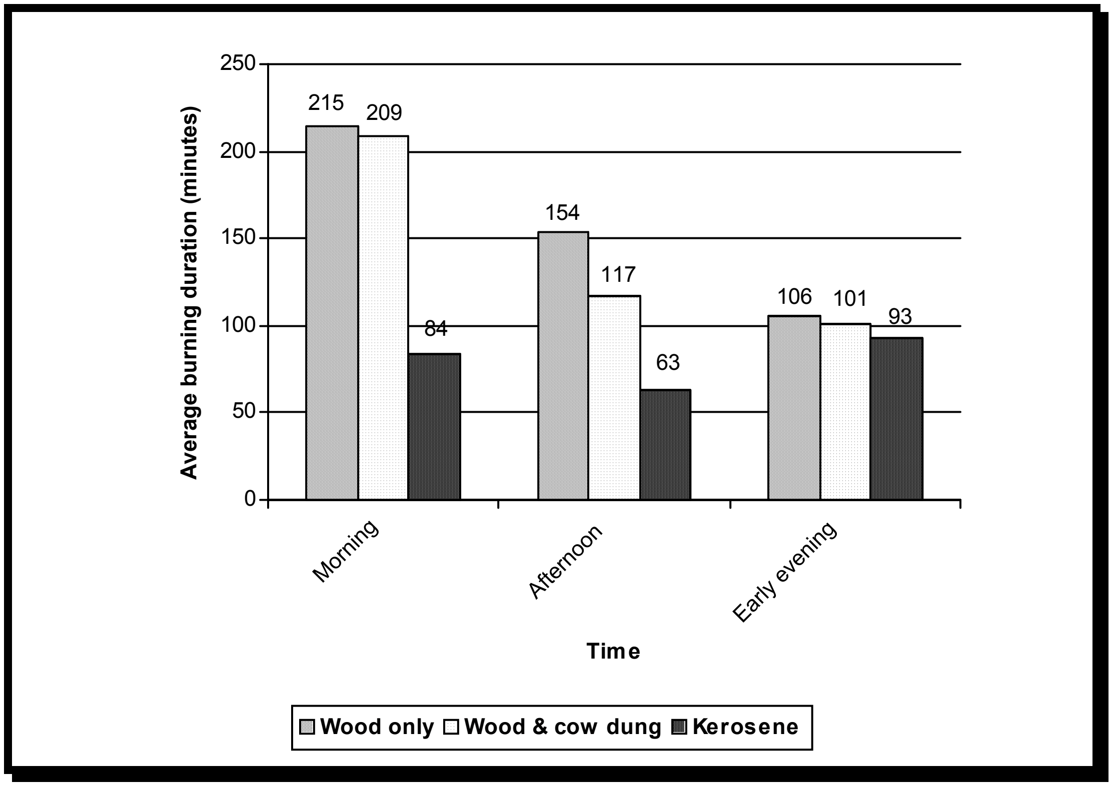

Figure 10 Distribution of burning throughout the day

The type of household appliance was cited as one of the most important determinants for whether solid or liquid fuels are used. For example, households with only a kerosene stove tended to burn kerosene exclusively (except possibly to burn solid fuels outside in open fires), households with only a wood stove tended to burn solid fuels, and households with both tended to burn both solid fuels and kerosene.

Given the appliance/s available to each household (i.e. a wood stove, kerosene stove or a brazier), it is important to understand what determines the type of fuels used in the stoves. To do this, caregivers were asked about which fuels they *prefer* to use and the reason for their preference. This was compared to responses obtained when asked about which fuels they *actually* used and why.

In terms of fuel preferences, among the solid fuels (wood, cow dung and maize cobs), most caregivers indicated that they preferred wood for three reasons. Firstly, wood is believed to burn longer than cow dung or maize cobs. Secondly, wood is believed to produce less smoke and thirdly, the smoke from wood is believed to be cleaner smelling than the other solid fuels. For households with a kerosene stove, kerosene was also preferred because of the ease and efficiency of working with it.

Given the choice, most households indicated that they would use wood, kerosene or a combination of the two without cow dung and maize cobs for their domestic energy requirements. However, in practice, the *availability* of fuels is the main factor influencing the type of fuel used. In turn, the availability of preferred fuels is influenced by the amount of money a household has to purchase those fuels. Unfortunately both preferred fuels (wood and kerosene) have to be purchased. Most caregivers indicated that when their 'preferred fuels' (wood and kerosene) have run out and they do not have sufficient money to replenish the supply, they usually switch to fuels such as cow dung and maize cobs that are freely available in fields nearby. The following extracts highlight how the availability of fuels influences which fuels are used at any given point in time. The extracts are taken from two post-observation interviews:

<u>Extract 1</u>

Respondent: *It is not expensive to get things to make a fire with, all I need to buy is wood,* ***when I don't have money for wood when I've run out, I just go to the veld [field] and pick up some cow dung, it doesn't cost me anything****.*

<u>Extract 2</u>

Respondent: ***It depends on what is available, it depends on what has been bought,*** *sometimes you find that there is no wood and then you have to use cow dung, and sometimes you do find wood.*

Because money largely determines the fuels that are used, a considerable amount of fuel switching occurs within households during winter based on how much money a household has for fuels. For example, a particular observation household reportedly used a combination of wood and kerosene when they had the money to purchase those fuels. As the month proceeded and kerosene supplies diminished, wood was used on its own. As the wood supplies diminished, wood was used in combination with cow dung or maize cobs. When wood supplies were finished, cow dung or maize cobs were used exclusively. When finances became available again, e.g. from a pension, people switched back to their 'preferred' fuels and the cycle continued.

Fuel switching based on availability of fuels has implications for how much each available appliance is used and for the duration of burning. For example, for households with both a wood and a kerosene stove, at the beginning of an economic cycle when kerosene and wood are available one would expect that the wood stove would be burning for much longer periods of time (based on the observation above that people burning wood tended to burn it for much longer), while the kerosene stove would be ignited more frequently but for shorter periods of time. At the end of the cycle, the kerosene stove may not be in use at all and the wood stove may only burn for shorter periods of time.

5.2.2 Child location practices

Although all 40 reference children were present in the burning room during burning, the amount of time spent there ranged from one minute to as long as 385 minutes (6 hrs. 25 mins.) with the average time being 146 minutes (2 hrs. 26 mins). The average time a caregiver was in the room was 150 minutes (2 hrs. 30 mins.). Therefore, the amount of time a child spent in the burning room was significantly correlated with the amount of time a caregiver spent in the burning room (Pearson's $r = 0.866$; $p < .01$). The amount of time spent in the burning room did not differ between age groups with younger and older children spending equal amounts of time in various locations. However, younger children were more likely to be carried on their caregiver's back than older children.

Data were further analysed according to location categories based on proximity of the child to the stove. Research has shown that the concentrations of pollutants within the burning micro-environment display spatial gradients and are greatest in those areas closest to the stove (possibly as little as 0.5 metres from the stove) (Ezzati, Saleh & Kamen, 2000). One metre and less from the stove was chosen as a particular high-risk category. The time a child spent within one metre of the stove, the time spent within the burning room but further than one metre away from the stove, and the time spent outside of the burning room (in another room of the house or outside) during burning were used as indicators of exposure to IAP.

Figure 11 Child sitting next to the stove during burning

On average, children were within one metre of the stove during burning for 39 minutes, were within the burning room (but further than one metre away from the burning stove) for 107 minutes and were either in another room or outside for 139 minutes of the total burning time. Put slightly differently, children spent on average 16% of the total burning time within one metre of the appliance, 42% of burning time in the burning room (but further than one metre away from the stove) and 42% of the total burning time in another room of the house or outside.

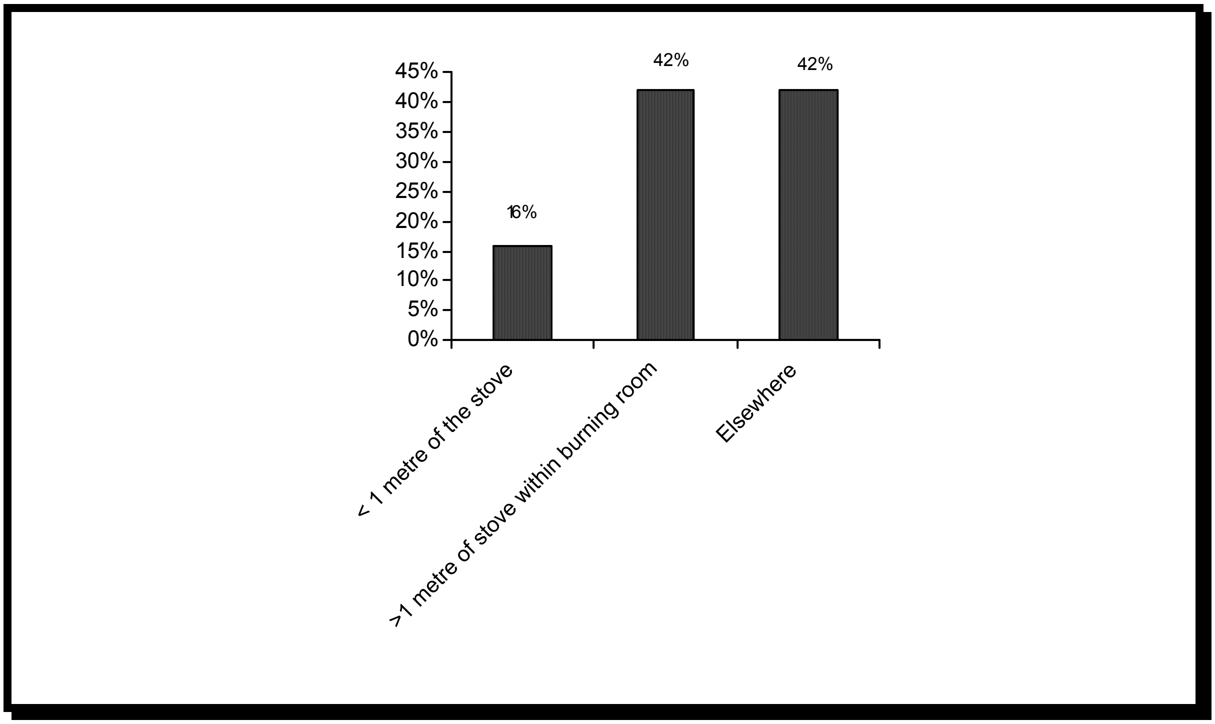

Figure 12 Percentage of burning time in various locations

Children were also observed in the burning room for longer periods of time during the morning (06h30 – 10h00) compared to the afternoon (12h00-15h00) and evening (15h30-18h30). The amount of time spent in close proximity to the fire declines substantially over the course of the day and then increases slightly toward the early evening.

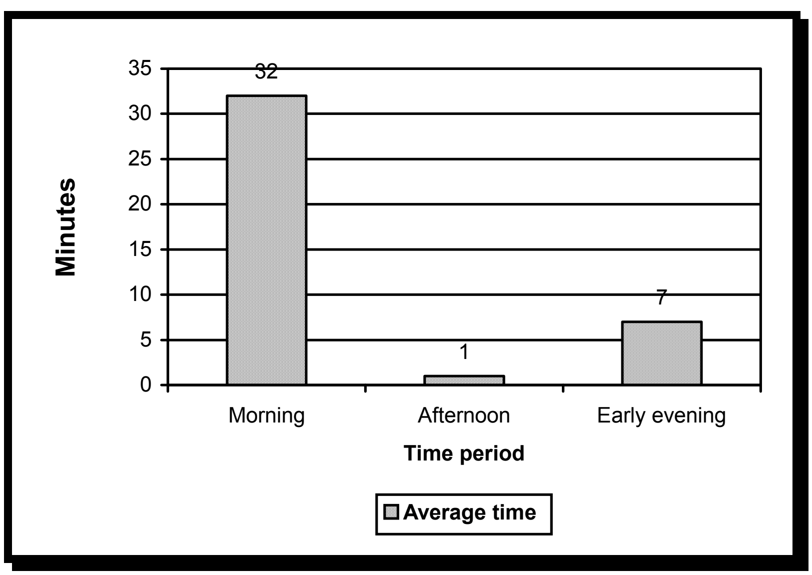

Figure 13 Average time (in minutes) spent within one metre of the stove over the course of the day

Put slightly differently, 82% (average of 32 minutes) of the total time spent within one metre of the stove was spent there in the morning, 2% (average of one minute) in the afternoon and 15% (average of seven minutes) in the early evening.

Data were also analysed according to the presence of other people in the household and whether those people took an active role in caring for the child while caregivers were involved in burning activities. Overall, 85% (n=34) of households had one or more persons in the burning room during burning. These included family members (living in the house) who were doing household chores in the burning room and neighbours who visited for short periods of time. When analysed as to how many of the people present in the burning room took an active role in caring for the child in areas away from the burning room, numbers decreased to 30% (n=12).

Caregivers who kept their children close to the stove cited warmth from the fire during the cold winter months as one of the main motivations for having the child in the burning room and in close proximity to the stove.

For caregivers who kept their children away from the stove, the intention to protect the respiratory health (from inhaling smoke) and physical health (from getting burned) of the child were cited as the main reasons for doing so. In addition, the existence of someone else to adequately look after the child in another location was cited as an important factor determining whether caregivers were able to keep the child out of the burning room or not.

Therefore, for some caregivers even though the intention to protect the physical and respiratory health of their child was evident, if someone else was not available or willing to look after the child in another location during burning, it was imperative to keep their child within eyesight to be able monitor that he/she did not get up to mischief, or more importantly, get injured. This often meant that the child had to be in the burning room while the caregiver was there. These reasons are highlighted in the following extracts taken from post-observation interviews and focus group discussions:

Extract 3

Interviewer:	*Why do you want to keep her away from you when you cook?*
Respondent:	***I don't want her inhaling the paraffin [kerosene] fumes.***

Extract 4

Interviewer:	*When you are busy cooking where do you prefer the baby to be?*
Respondent 2:	*I prefer the baby to be playing outside…*
Interviewer:	*Why do you want to keep him outside when you cook?*
Respondent3:	*He gets under my feet when I am cooking and* ***I sometimes fear that he might get burnt by a pot maybe falling off the stove****.*

Extract 5

Interviewer:	*Why do you keep your child close to you while you are cooking?*
Respondent:	***I don't have a choice, I have to keep the child with me because there is no one to look after her.***
Interviewer:	*Doesn't the child keep touching things while you are busy?*
Respondent:	*All the time that is why I say to you I want her close to me at all times so I can keep an eye on her because she is very naughty…I like to carry her on my back.*
Interviewer:	*Oh I see, keeping her close to you helps you to keep an eye on her …*
Respondent:	***I have to know where she is at all times…***

5.2.3 Ventilation practices

Households were classified according to whether they had both windows and doors open throughout the burning activity, whether they opened and closed windows/doors at various stages of the burning (i.e. variable ventilation practices) or whether they had both doors or windows closed throughout burning.

Overall, the majority of households (72.5%) (n=29) displayed variable ventilation practices by opening and closing windows/doors at various stages during burning, 15% (n=6) opened windows and doors for the duration of burning, and 12.5% (n= 5) closed windows and doors for the duration of burning. On average doors leading to the outside were opened (147 minutes) for slightly longer than windows (137 minutes), but were normally closed a few minutes after windows.

In the case of variable ventilation practices, windows and/or doors were usually opened during ignition and left open until the visible smoke (which normally lasted about 15 minutes) cleared. Thereafter, ventilation was closed until smoke reappeared after, for example, more fuel was added to the fire. Windows and/or doors were then re-opened until the visible smoke cleared. This practice was particularly evident in households using solid fuels burned in wood stoves.

For the five households that closed ventilation throughout burning, two reasons were commonly cited. The first relates to retaining the heat produced by the fires and the second is the fact that the wind produced by open ventilation often interferes with the performance of the stove, particularly kerosene stoves.

Extract 6

Interviewer:	*Why didn't you open the kitchen door?*
Respondent:	***Because of the cold.***
Interviewer:	*I understand. What difference would there have been if you had opened the kitchen door.*
Respondent:	***It would have been cold and we would end up getting the flu.***

Extract 7

Interviewer:	*While I was sitting here I noticed that when you cook, you don't open the windows, could you please tell me why?*
Respondent:	***If we open the windows, the wind will kill the fire.***

As mentioned above, the most commonly observed practice was to open windows and doors during ignition and then close them for extended periods thereafter. For most caregivers having the house warm is the main priority and the smoke produced by this process is an inconvenience. Therefore, ventilation is opened for just long enough to get rid of the visible smoke and then closed again to retain warmth. Part of this practice is influenced by the perception that emissions that one cannot see (often referred to as 'fumes' by the study participants) are not dangerous to respiratory health and only visible smoke is. The following extracts, taken from post-observation and focus group interviews, highlight this practice.

<u>Extract 8</u>

Interviewer:	*Why do you think people don't open their windows when they have a fire burning in the house?*
Respondent 2:	*When it is too cold I keep the window closed because it lets in cold air.*
Interviewer:	*Even when you have just made a fire?*
Respondent 2:	***I keep it closed when there is no smoke, when you see that there is smoke you open the window.***
Interviewer:	*Do you then close it again?*
Respondent 2:	*Yes, when you decide that it is now okay to close the window.*
Interviewer:	***When is it okay to close the window?***
Respondent 2:	***When you can see that there is no longer smoke in the house.***
Interviewer:	*Do you open the window when you start making a fire or do you open it when you see that there is smoke in the house?*
Respondent 5:	***You open it when you start making the fire so that when the smoke starts you already have the window open**.*
Respondent 7:	*When it is winter we open them only when there is smoke.*

<u>Extract 9</u>

Interviewer:	*Some people don't open their windows at all when it is winter, how true is this?*
Respondent 1:	***Some people close them because they want to keep the house warm**.*
Interviewer:	*I want to understand the issue of opening the windows and closing them, how do you decide when to open the windows and when to close them?*
Respondent 2:	***When it is cold you open them long enough to let the smoke out and then you close them again so that the house can be warm**.*
Interviewer:	*Are there any of you here who keep their windows open the whole day in winter?*
Respondent 3:	*No, we just open them for the smoke and then we close them again.*
Interviewer:	*You have all agreed that when you make fire you open the windows to let the smoke out, how do you decide if it's okay to close the window?*

Respondent 3: ***When there is no more smoke in the house.***

5.3 Results of air quality monitoring

The mean concentration of RSP measured in five houses was found to be 551 (SD 263) µg/m^3 ranging between 198 - 841 µg/m^3. A portable battery operated laser photometer (TSI's DustTrak[TM] Aerosol Monitor) was also used to collect continuous $PM_{2.5}$ in three houses over a 24-hour period. The results of these measurements are shown in table 2 below.

Table 2 Results of PM $_{2.5}$ monitoring in three households

	House 1	House 2	House 3
Mean	1349	3691	838
Minimum	20	9	11
Maximum	30362	109 006	10 243

Levels of $PM_{2.5}$ ranged from 9 to over 109 000 µg/m^3 with the highest 24 hour average of over 3600 µg/m^3. In light of the fact that international guidelines stipulate no safe level of exposure to particulates, results obtained from both respirable particulates and $PM_{2.5}$ dust fractions were found to be high.

5.4 Differences between high and low ALRI groups

Overall, high and low ALRI groups displayed similar patterns in most of the variables considered. However, in high ALRI households study children were statistically ($p < .05$) more likely to spend longer durations within one metre of the stove during burning, were less likely to be looked after by another person in a location away from the stove and were more likely to have a burning appliance located further away from ventilation than low ALRI households. It is also worth noting that, although not significantly different, the high ALRI group burned wood for longer periods of time (mean of 355 minutes) compared to the low ALRI group (mean of 234 minutes). In addition, low ALRI households were over-represented in the group that opened at least two sources of ventilation during burning. Table 3 highlights these differences.

Table 3 Differences between high and low ALRI households

Aspect	ALRI status	
	High ALRI (n=20)	Low ALRI (n=20)
APPLIANCES USED AT LEAST ONCE DURING THE OBSERVATION	*Number of households*	*Number of households*
Wood stove	9	11
Kerosene stove	9	8
Brazier	1	3
LOCATION OF BURNING APPLIANCES	*Number of households*	*Number of households*
Appliance is located within 1 metre of working ventilation (Pearson Chi-Square = 8.3)**	13	4
Appliance is located > 1 metre of working ventilation	7	16
FUELS USED AT LEAST ONCE DURING THE OBSERVATIONS	*Number of households*	*Number of households*
Wood/cow dung/ maize cobs (solid only)	10	10
Kerosene only	6	6
Variable solid and kerosene	4	4
AVERAGE DURATION OF BURNING BY FUEL TYPE	*Minutes*	*Minutes*
Wood	355	234
Kerosene	176	160
Wood & cow dung	167	183
TIMING OF BURNING	*Number of households*	*Number of households*
Engaged in morning burning	20	20
Engaged in afternoon burning	14	12
Engaged in early evening burning	5	4
BURNING ROOM AREA	10 m^2	10 m^2
AVERAGE NUMBER OF WINDOWS IN THE BURNING ROOM	1-2	1-2
AVERAGE NUMBER OF DOORS IN THE BURNING ROOM	1-2	1-2
CHILD LOCATION PRACTICES DURING BURNING	*Minutes*	*Minutes*
Average duration that the study child spent within 1 metre of the stove (Mann Whitney = 164)*	52 (mean rank = 24)	27 (mean rank =16)
Average duration that the study child spent > 1 metre from stove within burning room	111	102
Average duration that the study child spent in another room or outside	126	152
Number of households in which 1 or more persons took an active role in caring for the child in a location away from the stove during burning (Pearson Chi-Square = 4.3)*	3	9
VENTILATION PRACTICES	*Number of households*	*Number of households*
Closed throughout burning	5	1
Variable opening and closing	14	15
Open throughout	1	4
AVERAGE NUMBER OF PEOPLE WHO LIVE IN THE HOUSE	5	6
CHILD SHARES A BED WITH SOMEONE ELSE	20	20
HOUSE EXPERIENCES A PROBLEM WITH DUST	19	17

	High ALRI (n=20)	**Low ALRI (n=20)**
HOUSE EXPERIENCES A PROBLEM WITH DAMP	18	14
SOMEONE REGULARLY SMOKES IN THE HOUSE	12	10

*Significant at $p < .05$

**Significant at $p < .01$

5.5 Understanding of the link between IAP and ALRI

Parts of the interviews focused on caregivers' understanding of the association between IAP and their child's respiratory health. Most caregivers were aware of the dangers of smoke and were able to describe what they perceived as the negative effect on health of exposure to smoke from indoor fires. These include coughing, effects on the child's eyes, colds, TB and asthma. The following extracts, taken from post-observation and focus group interviews, attempt to capture the general understanding displayed by most.

<u>Extract 10</u>

Interviewer: *What dangers are there for children if the windows are not open and there is smoke in the house?*

Respondent 3: *It would make them sick*

Interviewer: *How?*

Respondent 3: ***It will make them cough***

Interviewer: *What other problems would there be?*

Respondent 4: *It would also affect their eyes*

Interviewer: *How?*

Respondent 4: ***It makes their eyes brown.***

Interviewer: *What diseases are prevalent in your village?*

Respondent 6: *Asthma in most children*

Respondent 2: *They also have a rash*

Respondent 1: ***TB***

Interviewer: *Amongst the diseases that you have mentioned, which ones do you think are caused by smoke?*

Respondent 5: ***I think colds and flu, TB and asthma are mostly caused by smoke in the homes.***

Extract 11

Interviewer:	*I hear you talking about diseases that are caused by smoke, in your opinion what are those diseases?*
Respondent:	*It might cause lung disease because when you inhale the smoke goes straight to your lungs.* ***When you are in the rural areas, you have to make a lot of fires, so the smoke might block your lung sacs.***

Extract 12

Respondent:	*I only realized when we started having this [wood] stove, because sometimes when I inhale smoke I start coughing and the cough takes a long time to go away, then I realized that smoke is not good.*
Interviewer:	*Do you know of any diseases that are caused by smoke?*
Respondent:	***I don't know of any, but I know that smoke does cause diseases especially in children***

5.6 Caregiver recommendations

Caregivers were asked about what they could do to reduce their family's exposure to IAP. Two commonly cited suggestions were to move their children out of the burning room and to open ventilation for longer periods of time during burning. Caregivers also suggested better maintenance of wood stoves by, for example, blocking holes in the stove with a can, covering broken stove doors with a wet cloth and fixing up blocked and leaky chimneys.

Other suggestions included extinguishing fires after cooking and heating by throwing leftover 'pap' (maize porridge) over the coals instead of allowing the fire to extinguish on its own. Many caregivers also reported throwing uncooked maize meal over burning embers to reduce the amount of smoke they produce. The following extracts highlight these suggestions and are taken from focus group interviews.

Extract 13

Interviewer:	*How can you protect your children from smoke?*
Respondent 1:	*You should keep them away from the stove when you are making a fire, take them to another room and close the door.*
Respondent 4:	*Try to decrease the smoke especially when using mielie cobs, you can put mielie meal in the stove on top of the mielie cobs, and then put a can where the smoke is coming out to reduce the smoke.*

Respondent 5:	*You can also make sure that the stove is closed properly so that the smoke cannot come out*
Respondent 4:	*You can also put a wet cloth on the stove to decrease the amount of smoke coming out…*
Respondent 8:	*We can make sure that our doors and windows are open at all times.*

Extract 14

Respondent 6:	*… when we go to bed we would put leftover pap in the stove and there would be no smoke in the house. I still do that in my house, and there is no more smoke by the time we go to bed.*

Extract 15

Respondent 4:	*If we can fix chimneys for all of our stoves.*
All:	*Yes.*

6. BEHAVIOURAL INTERVENTION RECOMMENDATIONS

Based on suggestions from caregivers, current behaviours of household members, likely cost to households, required effort and probable reductions in exposure to IAP, it is recommended that the intervention should focus on behaviour change in the following areas:

- Improve stove maintenance practices.
- Move the child to a location away from the stove during burning.
- Open ventilation for longer periods of time during burning.
- Reduce the duration of solid fuel burning.[2]

Given that most people in the study area use relatively sophisticated wood stoves i.e. stoves that have doors and a chimney, but which are in poor condition, we believe that part of the intervention should focus on stove maintenance practices. This includes filling holes in chimneys, cleaning chimneys, fixing hinges on doors and replacing missing cooking plates. Maintaining stoves can be done occasionally, is relatively cheap yet can still have significant value. To be successful, part of the intervention should focus on making those materials available to community members, possibly through the local village store. Motivations to improve the quality

[2] It is important to note that the replacement of current stoves with improved stoves, switching to the use of cleaner fuels such as LPG and improving housing design (such as increasing the size of windows and partitioning off cooking areas) were considered as possible intervention strategies but were discarded because the projected costs of these interventions to the user were thought to be prohibitive for sustainable use in this context. More importantly, caregivers did not offer these recommendations.

of wood stoves could include the fact that the stove will emit less smoke, therefore the house will be cleaner smelling, housework will be easier because there will be less dust in house, the stove will use less fuel (thus saving money) and the health of family members will improve.

In light of the fact that most (85%) of households had someone else present during burning, but only 30% of these people took an active role in caring for the child, part of the intervention could focus on getting someone else to look after the child in a location away from the stove while it is burning. This aspect will have to focus on ways of keeping the child warm and occupied in those locations for long periods of time. This may be particularly effective, given that low ALRI children were less likely to be closer to the stove and more likely to have someone look after them in another location during burning than high ALRI children were. Motivations to move their children away from the burning room during burning include the possibility that the child will be healthier because of the reduced risk of respiratory illness, burns and eye problems. A healthier child also means lowered transport costs, time and effort associated with taking children to hospital.

Most (87.5%) of the study households opened their windows and doors during burning, 72.5% opened them for short periods when smoke was visible and then closed them. Because people are already opening windows and doors, part of the intervention could focus on increasing the duration of these practices. Similar to improving stove maintenance, motivations for opening ventilation for longer durations could include a healthier child, less smoke in the house, a cleaner smelling house and easier housework because there will be less dust (from fires) in the house.

The study found that people burned solid fuels for extended periods of time even after cooking was done and the house appeared to be adequately heated. Caregivers often allowed the fire to burn out instead of extinguishing it. Part of the intervention could focus on decreasing the amount of time people burn solid fuels. Motivations for doing this include using less fuel (thus reducing the cost and effort of obtaining fuel) and improving the health of family members.

It is recommended that the intervention should include a focused education component. The educational message should aim to build on caregivers' intentions to protect their children by associating better ventilation, stove maintenance and location practices with a healthier child. Because there is the perception that non-visible emissions are not harmful, the dangers of this should be a key discussion point of the education component.

It is further recommended that, before the main intervention is implemented, an additional phase of formative research should be conducted to determine the feasibility and acceptability of the proposed practices among a small group of research participants. The information gathered from this exercise together with the information presented here should be sufficient to inform the design of the behavioural intervention which will be implemented and evaluated in subsequent phases of research.

7. CONCLUDING REMARKS

It is encouraging to note that most caregivers engaged in behaviours aimed at protecting their children from smoke to varying degrees, e.g. opened ventilation, moved their children out of the burning room during burning and tried to reduce the emissions coming from their stoves. This, together with a general awareness by most caregivers that smoke is bad for respiratory health and a genuine intention to protect and nurture their children bodes well for a behavioural intervention in this context. The recommendations presented here aim to build on this by consolidating household knowledge of the dangers of IAP, presenting behaviour change options for households to choose from (based largely on what they are doing already) and facilitating the creation of an enabling environment for caregivers to be able to perform those behaviours, e.g. having someone else look after the child in areas away from the burning room. Furthermore, the recommended behavioural options will incur little or no financial cost to the household, which will hopefully add to the sustainability of the intervention in the long-term.

8. REFERENCES

Albalak, R., Bruce, N., McCracken, J. P., Smith, K. R., & De Gallardo, T. (2001). Indoor respirable particulate matter concentrations from an open fire, improved cookstove and LPG/open fire combination in a rural Guatemalan community. Environ Sci Technol, 35(13), 1650-5.

Bailie, R. S., Pilotto, L. S., Ehrlic, R. I., Mbuli, S., Truter, R., & Terblanche, P. (1999). Poor urban environments: use of paraffin and other fuels as sources of indoor air pollution. Journal of Epidemiology and Community Health, 53, 585-586.

Bruce, N. (1999). Indoor air pollution: a neglected problem for the world's poorest communities. Urban Health and Development Bulletin, 2(2), 21-29.

Bruce, N., & Doig, A. (2000). Health and household energy - the need for better links between research and development. Boiling Point, 44, 7-10.

Crewe, E. (1995). Indoor air pollution, household health and appropriate technology. Women and the indoor environment in Sri Lanka. (pp. 92-9). Connecticut: Kumarian Press.

Ezzati, M., Saleh, H., & Kamen, D. M. (2000). The contributions of emissions and spatial micro-environments to exposure to indoor air pollution from biomass combustion in Kenya. Environmental Health Perspectives, 108(9), 833-9.

Favin, M., Yacoob, M., & Bendahmane, D. (1999). Behavior first: a minimum package of environmental health behaviours to improve child health. Washington D. C.: Environmental Health Project.

Graeff, J. A., Elder, J. P., & Mills Booth, E. (1993). Communication for health and behaviour change: a developing country perspective. San Francisco: Jossey-Bass.

Kirkwood, B., Gove, S., Rogers, S., Lob-Levyt, P., Arthur, P., & Campbell, H. (1995). Potential interventions for the prevention of childhood pneumonia in developing countries: a systematic review. Bulletin of the World Health Organisation, 73(6), 793-8.

Kossove, D. (1982). Smoke filled rooms and lower respiratory disease in infants. South African Medical Journal, April, 622-24.

Mager, R., & Pipe, P. (1984). Analyzing performance problems. Belmont, CA: Lake.

Mathee, A., Röllin, H., & Bruce, N. (2000). Household energy, indoor air pollution and health. The results of a feasibility investigation for a proposed epidemiological study in South Africa.

Johannesburg: MRC.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis (2 ed.). Thousand Oaks: Sage.

Naeher, L. P., Leaderer, B. P., & Smith, K. R. (2000). Particulate matter and carbon monoxide in highland Guatemala: indoor and outdoor levels from traditional and improved wood stoves and gas stoves. Indoor Air, 10(3), 200-5.

Potter, J., & Wetherell, M. (1987). Discourse and social psychology; beyond attitudes and behavior. London: Sage.

Sanyal, D. K., & Maduna, M. E. (2000) Possible relationship between indoor pollution and respiratory illness in an Eastern Cape community [Web Page].

Schwela, D. (1997). Cooking smoke: a silent killer. People and the Planet, 6(3), 24-5.

Smith, K. R. (1987). Biofuels, air pollution and health. New York: Plenum Press.

Smith, K. R., Samet, J. M., Romieu, I., & Bruce, N. (2000). Indoor air pollution in developing countries and acute lower respiratory infection in children. Thorax, 55, 518-532.

South African Government. (1998). Energy White Paper. Pretoria: SA government.

South African Weather Bureau. (2001). Weather conditions in the tribal Delareyville district 1995-2000. Pretoria:

Statistics South Africa. (1998). Census in Brief. Pretoria: South African government.

Terblanche, P. (1998). The Vaal Triangle Air Pollution Study. Pretoria: MRC.

The World Resource Institute. (1998). A guide to the global environment. Oxford: Oxford University Press.

von Schirnding, Y. E. R., Yach, D., & Klein, M. (1991). Acute respiratory infections as an important cause of deaths in South Africa. South African Medical Journal, 80(2), 79-82.

Wafula, E. M., Kinyanjui, M. M., Nyabola, L., & Tenambergen, E. D. (2000). Effect of improved stoves on prevalence of acute respiratory infection and conjunctivitis among children and women in a rural community in Kenya. East African Medical Journal, 77(1), 37-41.

World Bank (2002). PH @ a glance: Indoor air pollution. Web page [http://www.worldbank.org]