Centre for International Health

The impact on respiratory ailments through reduction of Indoor Air Pollution by smokeless metal stove and solar lighting: Results of a study in rural Nepal

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DECLARATION

"I certify that this thesis does not incorporate, without acknowledgment, any material previously submitted for a degree or diploma in any institution of higher education and that, to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where due reference is made in the text."

Signature:

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Date:

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Abstract

Indoor air pollution (IAP) is a known cause of respiratory disease which has a major impact on the world's burden of disease, particularly evident in developing countries. The major contributor to their polluted home environment is attributed to the indoor use of solid fuels for cooking, heating and light.

Objectives: (1) To determine whether the Smokeless Metal Stove (SMS) and solar lighting affect the prevalence of respiratory ailments in the Humla district, Nepal. (2) To explore the impact of the SMS and solar lighting on the reported prevalence of respiratory symptoms by comparing the statistical impact between groups with relation to age and gender. (3) To explore the influences confounding factors such as smoking and seasonality have upon the reported prevalence of respiratory symptoms.

Design: Analysis of secondary data collected as part of an ongoing evaluation for the Holistic Community Development (HCD) programme developed and implemented by the non-government organisation (NGO) RIDS-Nepal who introduced SMS and solar lighting in its project area in Humla district. The evaluation used an open cohort design comparing the prevalence rates of respiratory ailments (between 2004-07) before and at least one year after the introduction of the interventions.

Participants: 404 households (2469 individuals) were initially surveyed who were using the traditional open fire; 265 of these households (1601 individuals) were re-surveyed following the implementation of the SMS and solar lighting. The study sample was made up of those who wanted to participate in the HCD programme in the project area.

Intervention: As part of the HCD programme all households surveyed received a SMS and solar lighting with ongoing support.

Results: The installation of the SMS and solar lighting was associated with a distinct reduction in the prevalence of respiratory ailments. Compared to households following the intervention the relative risk of respiratory symptoms among those with a traditional open fire was 1.53 (95% confidence interval 1.2 to 1.96, $p = 0.0006$). While the very young and old together accounted for 70% of all people with respiratory symptoms and had no significant

change following the intervention, the people between the ages of 5 to 49 years with a traditional open fire had a relative risk of respiratory symptoms of 2.9 (95% confidence interval 1.7 to 4.9, p = <0.0001). Males benefited over females, tobacco smoking increased from before to after the intervention and winter had a higher prevalence of respiratory symptoms than summer.

Conclusion: In Humla, the prevalence rates of respiratory ailments decreased markedly after the implementation of the SMS and solar lighting.

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1.0 Introduction

Indoor air pollution (IAP) and the resulting respiratory diseases have a major impact on the world's burden of disease, measured in both death and disability-adjusted life years (DALYs). The effect is felt most in developing countries where access to safe living environments is difficult to attain for various reasons. The major contributor to people's polluted home environment is attributed to the use of solid fuels for cooking, heating and light. While seemingly insignificant in a modern industrial society, access to simple technology has the ability to radically change this risk factor.

Adoption of new knowledge into traditional societies however, is a long and complex process, wrought with unforseen difficulties by those trying to assist in their development. Rural Integrated Development Service (RIDS-Nepal), an NGO based in Nepal and their major contributor, the ISIS foundation, have assisted in the development and implementation of the Holistic Community Development (HCD) Program called 'Family of 4'. This project is aimed at improving the health and wellbeing of the people in the remote Humla district of Nepal. Through community involvement they have developed local and culturally appropriate technology to deal with various focus areas. Specific to this study, the smokeless metal stove (SMS) has been created with local needs and cooking practices in mind in association with the implementation of solar lighting and a supportive infrastructure. These technologies combined dramatically reduce the levels of IAP, particularly particulate matter and carbon monoxide.

This study aims to briefly outline the risks associated with IAP in the Humla region while providing the base for the more specific analysis of the respiratory effects associated with the implementation of these technologies.

Aim

To assess, through secondary data analysis, the respiratory health benefits of the Smokeless Metal Stove (SMS) and solar lighting in the remote Humla region of Nepal.

Objectives

1) To determine the impact of an improved SMS and solar lighting on the reported prevalence of respiratory symptoms in comparison with the traditional open fire.
2) To explore the statistical impact of the intervention in relation to age and gender by using the reported prevalence of respiratory symptoms as a means by which to compare differences between groups.
3) To explore the influences of confounding factors, for example smoking and season on the reported prevalence of respiratory symptoms with relation to the intervention of the SMS and solar lighting.

Test hypothesis

Null hypothesis: The reduction in IAP from the implementation of the SMS and solar lighting will not change the prevalence of respiratory symptoms.

Alternative hypothesis: The implementation of SMS and solar lighting with subsequent reduction in IAP will decrease the prevalence of respiratory symptoms.

2.0 Background/Review of Literature

This chapter looks at the background of IAP and its relationship with developing countries. We also investigate the known health effects of carbon monoxide and airborne particulate matter which are the main constituents measured in IAP. The study population and intervention (SMS and solar lighting) are also introduced.

2.1 Indoor Air Pollution

It is estimated that more than half of the world's population depend on solid fuels, such as biomass (wood, dung, agricultural residues) and coal, to meet their basic energy needs: cooking, heating, lighting and boiling water. This use of solid fuel on open fires and traditional stoves results in high levels of indoor air pollution (IAP), which is responsible for 1.5 million deaths a year (WHO, 2006). In Nepal 81% of the population use solid fuels and each year according to a report issued in 2007 by the WHO, approximately 4820 deaths occur from acute lower respiratory infection (ALRI) in children under 5 years and 2680 deaths from chronic obstructive pulmonary disease (COPD) in people 30 years and over, can be attributed to solid fuel use. Australia as a comparison has less than 5% use of solid fuels and no deaths attributable to solid fuel use (WHO, 2007a).

The burning of solid fuels produces a number of pollutants which are potentially harmful to human health. Particulate Matter (PM) and Carbon Monoxide (CO) are two of the main components frequently associated, measured and studied in relation to incomplete combustion of biomass. Due to the traditional social structure in most developing countries, it is primarily women who are responsible for cooking and subsequently they and their children are exposed to higher levels of these pollutants than the men. There are several interventions that can effectively reduce IAP levels (see appendix 1) but not all are accessible to those populations most affected. The majority of people who use solid fuels for energy live in developing countries and their ability to adopt the recommended changes is limited due to issues to do with affordability, knowledge, accessibility and local traditions.

The known health effects of Indoor Air Pollution (IAP) identified with consistent evidence are; ALRI in childhood, particularly pneumonia; chronic bronchitis and chronic obstructive pulmonary disease; and lung cancer. Other conditions with emerging evidence are; low birth weight, peri natal mortality, asthma, and middle ear infection for children, cardiovascular disease, tuberculosis, nasopharyngeal and laryngeal cancer, and cataracts in adults. (Schirnding et.al. 2002)

2.11 Airborne Particulate Matter

While the health effects of airborne particulate matter (PM) are broad, they are predominantly associated with respiratory and cardiovascular disease. Through population studies the growing amount of evidence suggests that particulate matter adversely affects human health even at relatively low concentrations (Pope et.al., 1995). With increased exposure comes increased risk but we do not know the exact exposure-response relationship. The World Health Organisation (WHO) has produced air quality guidelines for particles smaller than 2.5µg (PM2.5) and 10µg (PM10) based on the United States Environmental Protection Agency figures;

PM2.5: $\leq$ 15 µg/m^3 annual mean

$\leq$ 35 µg/m^3 any 24-hour mean

PM10: $\leq$ 20 µg/m^3 annual mean

$\leq$ 150 µg/m^3 any 24-hour mean

(U.S.EPA, 2009)

These figures are based on ambient outdoor air pollution exposure from epidemiological studies, reproduced here to provide a rough guide to what is considered a ‘safe’ level of exposure before harmful effects become evident. With IAP the figures of exposure may be much higher as seen in appendix 2.

The observed health effects of particulate matter can be divided into acute and chronic exposure that can lead to an increased incidence of morbidity and/or mortality.

Acute exposure: decreased lung function measured by Forced Expiratory Volume (FEV) and Peak expiratory flow (PEF); increased respiratory symptoms such as cough, wheeze, and combined lower respiratory symptoms; increased respiratory morbidity measured by absenteeism and decreased activity; increased Chronic Obstructive Airway Disease (COPD) mortality and transient COPD exacerbations; pneumonia; and increased cardiovascular disease symptoms such as angina or death.

Chronic exposure: chronic bronchitis; COPD; chronic cough; Asthma and wheeze; emphysema; a gradual loss of respiratory function (FEV and PEF); and cardiovascular disease.

(Pope et.al., 1995)

2.12 Carbon Monoxide

Carbon Monoxide (CO), although not so much of an individual issue in outdoor air pollution due its diffusion into the surrounding environment, has a much greater role in IAP. Carbon Monoxide is a toxic gas easily absorbed through the lungs and is dependent upon the minute ventilation, the duration of exposure, and the relative concentrations of CO and Oxygen in the environment. A high concentration of CO can reach the same blood levels in 1 hour as low concentrations can reach in 6 hrs (Forbes et. al., 1945). The majority of absorbed CO (80-90%) binds to haemoglobin to form carboxyhaemoglobin (COHb), which is used as a biomarker of exposure in the blood. Carbon Monoxide competes directly with oxygen for binding to haemoglobin. The affinity of haemoglobin for CO is 200 to 250 times greater than its affinity for Oxygen. The consequences of this competitive binding are the reduced oxygen carrying capacity of the blood and therefore the impaired oxygenation of extra vascular tissues. The toxic effects of CO become evident in organs and tissues that consume high amounts of oxygen such as the brain, heart, skeletal muscles and the developing foetus (WHO, 2000).

Carbon monoxide exposure has a particularly harmful effect on pregnant women because of the foetus being especially sensitive to the gas. Animal studies for example, have suggested there is a significant lag time between mother and foetus with CO uptake, occurring up to 40 hours after exposure creating an environment where the mean carboxyhaemaglobin levels in the foetus significantly exceed the mothers (Longo & Hill, 1977). Data on chronic CO exposure during pregnancy has also demonstrated its association with low birth weight and increased neonatal mortality rates (Longo, 1977).

Studies have also shown a marked neuropsychological impairment to an acute low-level exposure of CO in the form of 'dysfunctions in memory, new learning ability, attention and concentration, tracking skills, visuomotor skills, abstract thinking, and visuospatial planning and processing' (Amitai et.al., 1998, pg. 845). Again, as with PM there is little known about the exposure response-relationship. By using an equation which takes into account all the known physiological variables affecting carbon monoxide uptake a set of minimal guidelines for CO have been established by the WHO (2000, pg 78) :

- 100 mg/m^3 (90 ppm) for 15 minutes
- 60 mg/m^3 (50 ppm) for 30 minutes
- 40 mg/m^3 (35 ppm) for 1 hour
- 10 mg/m^3 (9 ppm) for 8 hours.

(U.S.EPA, 2009)

These values are worked out in order not to exceed HbCO 2.5%, which is aimed at avoiding the hypoxic effects of CO upon vulnerable groups such as the elderly, people with latent coronary artery disease and the foetuses of pregnant women. The effects increase with pre-existing cardiovascular disease, with prolonged exposure exacerbating myocardial damage or coronary artery disease (Lawther, 1975).

Much of the health effects of IAP are derived from studies conducted in developed countries. Developing countries lack the infrastructure and finances for recording accurate health statistics which would enable regional inferences on population health. The aforementioned pollutants have the same effects on all people, however any initiatives to curb the problem are somewhat different between a developed and developing nation due to the complexities of the individual life circumstance. The following section gives a brief introduction to the circumstances of people who live within the Humla district.

2.2 The Study Population

The Humla district is situated in the mountainous far North-west corner of Nepal, ranging in altitude from 1900 to 4700 metres. The district headquarters of Simikot (2950m) is located about 10-16 days walk from the nearest metalled road in Nepal and 6-7 days walk to the nearest road in Tibet. The only other access is via air with a seasonal strip in Simikot. Due to its remote location transportation costs to the area are very high which makes any imported materials very expensive. Considering the majority of people are subsistence farmers there is little generation of capital and normal commercial services that do exist are only accessible to and controlled by a few wealthy people. The two main religions that shape people's social beliefs and practices in Humla are Buddhism in the north and Hinduism in the south. The Hindu caste system remains a strong factor in social structure, this hierarchy adds to the complexity of equitable development and access to resources for the lower classes. This coupled with the traditional household structure where the women spend a lot of their time cooking and caring for young children increases the potential for exposure to indoor air pollution (IAP) and warrant special consideration.

Nepal's ranking on the United Nations Development Programme Human Development Index (HDI) is 145 of 179 countries. The HDI measures three dimensions of human development, namely life expectancy, educational attainment, and income (United Nations Development Programme, 2009). When ranking the 75 districts of Nepal, Humla was situated at number 74 in the overall composite index. This ranking is based on the index of poverty and deprivation, socioeconomic, infrastructural development and women empowerment (Humla Development Initiative, 2006). In a paper by Bhusal et.al. (2007), using local figures in the prescribed method for the calculation of the HDI the Humla district score was 0.244, which is lower than the value for Sierra Leone (0.329).

The present study focused on the impact of improved SMS and solar lighting on respiratory effects of IAP in this impoverished community. Their indoor living space generally consists of a simple one or two room dwelling, where all activities of living take place. Windows, if any, are small and ventilation is poor due to their simple design and function of warmth and protection from the elements. An open fire inside the home is traditionally used for cooking, heating and as a light source. The other light source usually used is "jharro", a resin soaked wooden stick made locally from the high altitude pine producing a small amount of smoky illumination. The amount of illuminance produced is 2 lux up to 1 metre from the source and less than 1 lux beyond that, just enough to move around the room but not adequate for tasks requiring greater visual acuity such as reading or needlework (Bhusal et.al., 2007).

The Humla district is not connected to the electricity grid and is unlikely to be so in the foreseeable future. Over the last 10 years there has been a push by the Nepal government for small solar systems through government subsidies and NGO support. Although somewhat successful in dispersing these systems their sustainability is somewhat questionable due to lack of technical knowledge and supportive infrastructure. Similar problems have been shown to be evident in other areas and countries where rapid deployment of solar systems occurred without adequate thought of sustainability in relation to local culture and economy (Foley 1995). Experience in the Pacific Islands suggests that the following are important considerations; design, reliability and accessibility of high-cost components; proper installation, maintenance and most importantly end user education and expectation (Liebenthal, Mathur & Wade, 1994). Therefore, sustainability is a common problem for the continued use of solar systems in developing countries without the needed commercial infrastructure.

The holistic community development programme addresses sustainability issues by implementing long term community based initiatives combined with ongoing technical expertise and research which are needed for such schemes. In the Humla district geography is a hindering factor and accommodated by having locally manufactured SMS with ongoing education and technical support. Zahnd and McKay (2007) discuss some of the other identified problems specific to Himalayan villages and provide possible remedies through looking at community needs and village geography. These include solar photovoltaic (PV) village electrification according to the village geography i.e. single, cluster or village systems supported by a High Altitude Research Station (HARS) in locations such as Simikot in Humla for the continued monitoring, evaluation and support of the local community.

2.3 Interventions

The Rural Integrated Development Services- Nepal (RIDS-Nepal) is an NGO that in conjunction with the ISIS foundation have developed a HCD approach to long term sustainable development in its project areas. By working in partnership to identify the basic needs as determined by the community, they have developed the "Family of 4" concept (RIDS-Nepal, 2009):

1. Pit Latrine – improved hygiene
2. Smokeless Metal Stove (SMS) – to reduce IAP and improve efficiency of cooking and heating
3. Light – use of LED lighting powered by photovoltaic panels or small pico-hydro power plants. Providing smoke free quality lighting suitable for visual activities.
4. Drinking water – By tapping into local springs or building a slow sand water filter to provide improved access to clean drinking water.

The SMS is designed specifically for the purposes needed by the local population. The SMS is made locally, has three pot holes for cooking, a stainless steel hot water tank attached for continuous hot water supply and a slot in which the traditional bread can be baked on the ambers. The semi-closed system with flu reduces IAP; the design improves combustion efficiency and enables three pots to share the stove top at once, and at the same time improves the space heating capabilities of the room (Rai, Zahnd & Cannell, 2006).

A recent unpublished study by Alex Zahnd (appendix 2) of ambient IAP measurements taken in the Humla district of Nepal gives us some insight into not only the toxic environment experienced with the traditional open fires but also the huge reductions in PM and CO experienced with the SMS. The following data is only a guide with which to compare with the WHO values quoted previously:

Open Fire	Smokeless Metal Stove
$PM_{2.5}$ – 3.582 mg/m^3 24-hour mean	$PM_{2.5}$ – 0.059 mg/m^3 24-hour mean
CO - 25.6 ppm over 24 hours	CO - 0.0016 ppm over 24 hours
PM_{10} – 1.308 mg/m^3 24-hour mean	PM_{10} – 0.058 mg/m^3 24-hour mean
CO - 26 ppm over 24 hours	CO - 0.3 ppm over 24 hours

A graphical representation of $PM_{2.5}$, PM_{10} and CO comparing the SMS and open fire cooking is shown in appendix 2.

It has also been established that the stove reduces wood consumption by 40% which would have a dramatic effect upon the wood collection time, done primarily by the women and young girls, and which can take up to 7 hours a day (Zahnd, McKay & Komp, 2006). Also, due to the increased capacity of the stove, cooking time is decreased because more than one pot can be used at a time. This coupled with greater availability of light at night theoretically extends the time for other developmental pursuits. With the decreased IAP and its reduction in neuropsychological impairment there is also the potential for improved learning ability and education. In conjunction, RIDS-Nepal has developed the "Family of 4 PLUS" Holistic Community Development (HCD) concept which aids at improving access to non-formal-education projects for mothers and out-of-school children. The main aim of this extended venture is to assist people to become more aware of their needs in order to live a healthy and fulfilled lifestyle.

The "Family of 4" concept was implemented as a whole in partnership with individual households and the community. The HCD project not only provides solutions to common health problems but also goes toward fulfilling the Millennium Development Goals (MDGs) and empowers the community through shared responsibility and cost. While nothing exists in isolation and all of these interventions would have some impact upon the other, this paper's focus is on respiratory health through the reduction of IAP by the SMS and improved lighting.

Whilst the SMS and solar lighting provides decreased levels of IAP there is a need to draw attention to the direct health benefits of these interventions. Acute respiratory symptoms are easily quantifiable with the resources available, are well documented in relation to IAP and the most directly influenced by the reduction of IAP. Chronic conditions such as COPD, cardiovascular disease and other long term evaluations such as birth weight, learning capacity and development are unable to be measured on the short term and difficult to measure with the infrastructure currently available. Evidence from other countries however suggests that these interventions do have a beneficial effect on these outcomes. For example, a study in China showed the risk of COPD was reduced significantly about 10 years after installation of a chimney to reduce IAP. (Chapman, He, Blair & Lan. 2005). With the resources available and the need for locally gathered evidence in support of the interventions with regard to health, respiratory symptoms provide the ideal data set for initial analysis with which to support the continuation and expansion of the project.

The next chapter describes the methods used to accomplish the study aims.

3.0 Methodology

The following section outlines the source of the data, the particulars of the data collection process and how it was used in order to gain the results. We also explore the reliability, possible bias with regards to the variables identified and the statistical methods used in the final analyses.

3.1 Study Design

The original data was collected by RIDS-Nepal as part of monitoring the social and health changes associated with the 'Family of 4' programs implemented in villages of the Humla district. The baseline surveys were conducted before the intervention, and then at least one year later householders were re-interviewed in order to note any changes that may have occurred due to the project.

This Open Cohort design study uses secondary data from the before and after intervention questionnaires co-ordinated by RIDS-Nepal and *The ISIS Foundation* with interviews conducted the by the local RIDS-Nepal staff with the indigenous people. The data was extracted from the broader questionnaire to attain specific information relative to respiratory health and the changes of indoor air pollution associated with the implementation of the SMS and solar lighting. These figures were used in the analysis to gauge association between the intervention and respiratory health.

Once the data gathering interviews were conducted by the local RIDS-Nepal staff and translated from Nepali to English the raw data was emailed to the ISIS foundation research manager for collation. Once received, the interviews were printed and the data entered into a database by research assistants using the statistical software package (SPSS v. 16.0). During this data entry process any anomalies and problems were discussed and the resultant form and management of the digitalized database was decided. The ensuing database, that being 669 rows (households) and 411 columns (variables), was used as the original dataset for initial analysis.

Only variables directly relevant to the effects of IAP were used in the final analysis of respiratory symptoms for which the results of this study are based. All other variables were collated as previously discussed or omitted as being irrelevant in relation to the objectives of this research project

3.2 Setting

3.21 Relevant dates

The data for the base-line study was collected from the summer of 2004 to January 2007with the follow-up survey conducted during the period of January 2006 to December 2007.

After controlling for confounding variables, the data to test the study hypothesis was collected in August 2005 and May 2006 for the baseline survey and follow-up in August 2007. Therefore each household in the study had a SMS and solar lighting for at least a 1 year period before resurvey.

3.22 Data Collection

The baseline and re-survey questionnaires (Appendix 3 & 4) were filled in by the interviewer, who had previous experience and training in data collection through their work with RIDS-Nepal. The interview was conducted in the local language and translated into English. The questionnaire, while initially developed in English was cultivated from the local culture. The questions were simple and unambiguous and were developed by the programme director in conjunction with local staff for local relevance and understanding.

As data in the original study was collected and collated per household certain individual associations and analyses were unable to be conducted. These minor anomalies in the data collection process became significant limitations during the analysis stage. While the main objective of the study could be addressed, other correlations between individual circumstance, conditions and personal habits could not be easily drawn.

3.3 Participants

3.31 Sampling

Households within the Humla region were invited to participate in the 'Family of 4' project, if they were willing to contribute to the planning, a small financial outlay and labour required for the project to go ahead. The participation in the study survey was voluntary and not a requirement of receiving assistance with the 'Family of 4' project, all recipients who gave informed consent and interviewed were included in the survey. The ISIS foundation research guidelines are included in appendix 6 which contain the ethical guidelines under which the survey was conducted.

Households participating in the study were interviewed prior to the commencement of the project. All households used the traditional open fire method for cooking and jharro wick for lighting, which was verified by the interviewer. The cohort was then re-surveyed at least one year after the implementation and use of the SMS and solar lighting.

From the initial sample only the households that were surveyed at baseline and follow-up in the same season were used for analysis of respiratory symptoms. All residents of each household were included in the survey.

Due to the study participants being surveyed before and after the intervention, with no inference being made to the greater population there was no need for a random sampling method to be identified. The data results focus on the effects of the SMS and solar lighting upon the test population.

3.4 Variables

All related respiratory symptoms were included in the analyses. The protocol the interviewers followed in order to classify the respiratory symptoms into Upper and Lower respiratory tract is shown in appendix 5. Respiratory symptoms were used as a proxy measure of indoor air pollution because of the well documented association between air pollution and its effect on respiratory health.

In the statistical analyses, factors considered confounders were age, sex, smoking status, household and season (winter and summer).

3.5 Data sources/measurement

All data used in the analysis was simple categorical data extracted from the original survey.

Respiratory symptoms were assessed by the reported presence or absence of symptoms related to Acute Upper Respiratory Infection (AURI) and Acute Lower Respiratory Infection (ALRI) among household members. While during data collection each person was categorised into either AURI or ALRI, due to the subjective classification method these categories were collapsed into a single category of respiratory symptoms for analysis. During the analysis each individual was only measured once in each phase and given a score of 1 for respiratory symptoms present or 0 if no respiratory symptoms present. In the parent survey the interviewer categorised each person with respiratory symptoms into either AURI or ALRI according to the guidelines set out in Appendix 5.

Due to the data collection methods and inconsistencies found in the parent survey, in order to control for household and season, the sample size was dramatically reduced which decreased the statistical power of the results (from $n=404$ to $n=105$, $p<0.05$). In order to attain accurate results on the same household, only houses surveyed before and after the intervention in the same season were included in the analyses of association between respiratory symptoms and the intervention.

Some of the inconsistencies were related to the before and after dataset provided;

1) The time difference between pre and post data collection varied from 1 to 3 years
2) Different villages/households were surveyed pre and post, i.e. some not before and some not after.
3) Some households were collected initially in summer then followed up in winter and vice versa.
4) The gross difference in population surveyed before (2469) and after (1601) the intervention.
5) The interviewee provided the information for the household, who may or may not have been the same person interviewed during the follow-up survey.

Since the SMS and solar lighting was installed into a particular household and therefore the pattern of usage more likely to not vary, household specific pre and post information was used.

Reasons for these inconsistencies in data collection are unknown.

3.6 Bias

This experimental pre-test/post-test design is subject to bias due to the broader 'Family of 4' community development project. While the influences of improved overall health outcomes may not directly affect respiratory symptoms they indirectly affect the individual's ability to deal with the infective process. Indoor air pollution has a direct influence on respiratory symptoms as shown in various other studies and it is this relationship the present research explored.

There are known behavioural modifications as listed in appendix 1 that can be used to reduce the exposure to IAP. The questionnaire did not allude to any of these interventions.

In controlling for households, it was noted that there were small changes in the structure of household demographics due to local migration patterns. These changes are related to local customs, family structure and travel for trade where more than one member of the household may be absent for extended periods at any one time or new members who had not been counted at the pre-intervention phase appeared on the scene. Similarly, the distribution of children in households could also change due to local family and marriage (polygamy) customs.

Smoking also has the potential to influence the data due to the well known link between smoking, passive smoking and lung disease. This confounder was also addressed in the analysis.

3.7 Study Size

The baseline study consisted of 404 households (2469 individuals) conducted from 2004, with 265 households (1601 individuals) re-surveyed from 2006 onwards.

The study size to test this research hypothesis only consisted of households which had been surveyed both before and after the intervention of the SMS and solar lighting. Once controlled for confounding variables, the usable data from the survey conducted by the RIDS-Nepal staff was 105 households (629 individuals) at baseline and 105 households (677 individuals) at follow-up.

3.8 Quantitative variables

The household data was collated to provide numbers of people affected by respiratory symptoms according to age group and gender. While the number of people per house according to age group, sex and smoking status could be determined, no direct relationship between the prevalence of smoking and respiratory symptoms could be drawn. We examined the association of respiratory symptoms and the presence of the SMS and solar lighting, that is, the prevalence rates of self-reported respiratory symptoms before and after the intervention.

From the initial study, binary data in relation to season (summer or winter) and Phase 1 and 2 in order to determine before and after the intervention was used to divide the main proposed influences on respiratory symptoms. Age groups and gender categories were used for further division and this data used for analysis. The population per household was divided into commonly categorised age groups, that being; 0-4 years, 5-14 years, 15-49 years and 50+ years.

3.9 Statistical Methods

1. The main technique for controlling for the main confounding variables such as season was exclusion from the usable data when testing for prevalence of respiratory symptoms
2. A simple cross tabulation technique was used to calculate the prevalence rates of the variables and compare the before and after results. The test for statistical significance and association was calculated using the Chi square statistic. For 2 cells where the observed value was less than 5, the Yates correction for the Chi square was used. The cells where the Yates correction was used was in the phase 2 age groups of Males 5-14 and 15-49.
3. With the use of primarily binary categorical data for analyses any missing data would not have been recognised as such. The variables with missing data found in the initial survey (such as age when collecting anthropometric data) were not used in the analysis for respiratory symptoms.
4. With the open cohort study design, loss to follow up was dealt with by exclusion. Only households measured before and after the intervention were used in the analysis for respiratory symptoms, individual cases were not used. There were a significant number of households lost to follow-up, no reason for this anomaly was provided by the RIDS-Nepal or the ISIS foundation.
5. Sensitivity analyses; due to the large volume of excluded data in order to control for household and season a trend comparison between all of the data and the sample used for final analyses was conducted. When observing for prevalence of respiratory symptoms, although the values were different, the trends were the same.

4.0 Results

The following results are divided into two distinct datasets for analysis. The uncontrolled or raw data from the initial interviews as supplied by the ISIS foundation and the data specifically controlled for the variables that may affect respiratory ailments and therefore the integrity of the results. The controlled and matched for household data is used to test the main hypothesis of this study whereas the uncontrolled or “All data” is used to draw inferences from the population surveyed. The methods of exclusion are detailed below, as with tables for data comparison between the different categories such as; Phase one (before) and Phase two (after implementation of SMS and solar lighting), season, smoking and respiratory symptoms.

4.1 Participants

The dataset on which this analysis was carried out contained 404 households surveyed just prior to the implementation of the SMS and solar lighting (Phase One survey), and 265 households in the follow-up survey carried out more than a year after the implementation of the SMS and solar lighting (Phase Two survey). During analysis, a significant proportion of the households had to be excluded from both phases. The reasons for this are as follows:

Of the 404 households in Phase One, 299 had to be excluded from the analysis. These included 211 households that were not surveyed in the Phase Two survey and 88 households that were surveyed at a different season to the season when the Phase Two survey was conducted. The project authorities could not provide a satisfactory explanation for why the 211 households were not re-surveyed in Phase Two. The 88 households surveyed at a different season were excluded because seasonality would have been a significant confounder in a study of respiratory symptoms, as there are seasonal variations in respiratory symptoms, with prevalence being higher in winter months than in summer. The effect of seasonality is explained in greater detail in the section Seasonality below.

Among Phase Two households, 160 of 265 had to be excluded from the analysis. These included 98 who had been surveyed in a different season from that in Phase One, and 62 who had not been surveyed in Phase One.

As a result, only those households that had been surveyed in both phase 1 and phase 2 at the same season were analysed. One hundred and five (105) households could satisfy these criteria, and were included in the final analysis.

Figure 1 provides a diagrammatic representation of this method of exclusion.

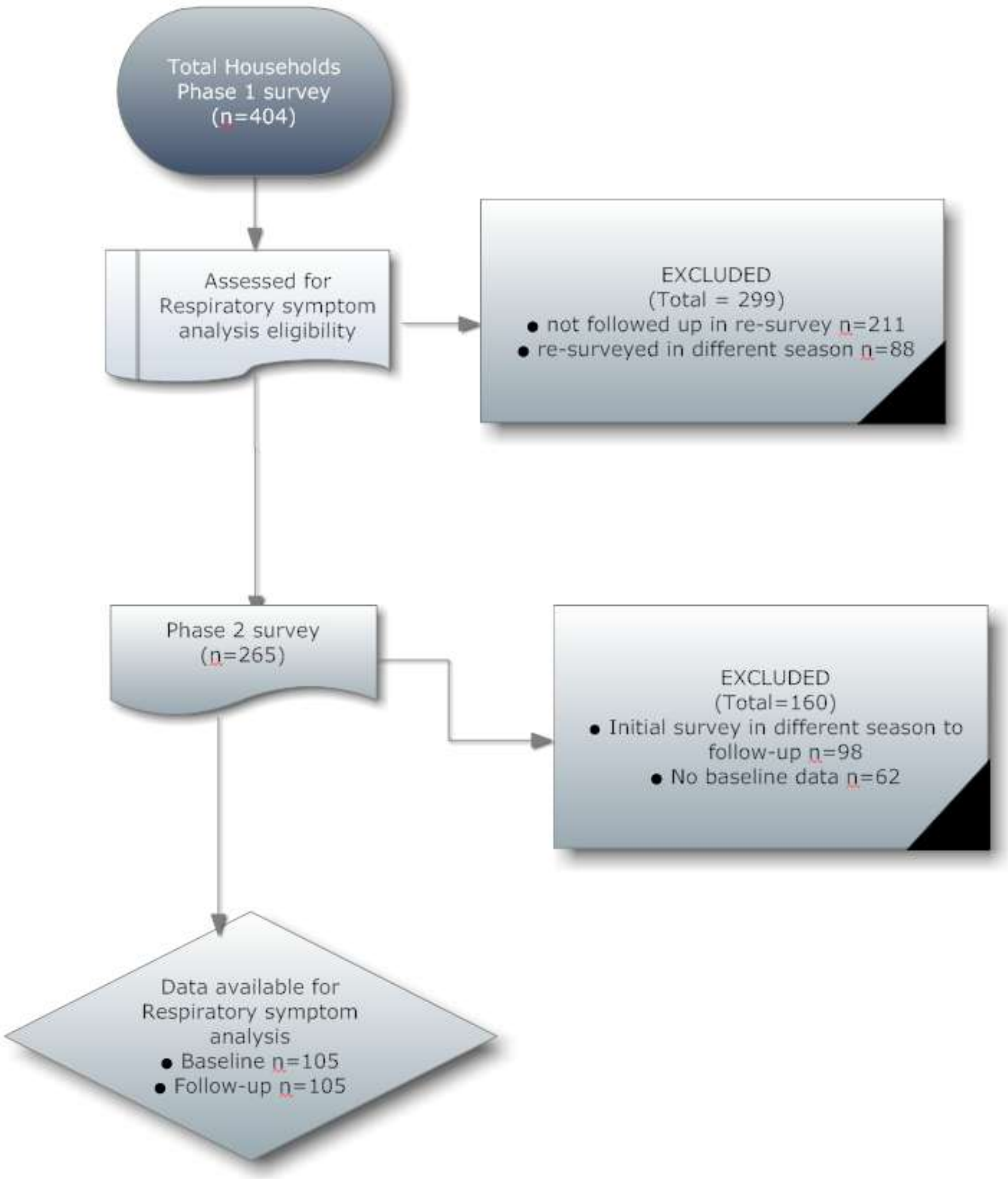

Figure 1. Method of exclusion to provide Data for Respiratory Symptom Analysis.

4.11 Seasonality

As described earlier, seasonality was a confounding factor in the impact of the interventions on the prevalence of respiratory symptoms. Both Phase One and Phase Two surveys were staggered over winter and summer, and it was found that for Phase One, the prevalence of respiratory symptoms was significantly higher during winter than in summer (21% versus 16%, chi square 10.15, $p < 0.001$). However, there was no significant differences between winter and summer in Phase Two in the prevalence of respiratory symptoms (please see tables 1 & 2 below).

	Summer	Winter	Total	Chi square
Male & Female				
# resp Sx	241	204	445	10.15
% resp Sx	16.05%	21.10%		p-0.0014
Total people	1502	967	2469	

Table 1. Respiratory Symptoms........Season/Phase 1 (All data)

	Summer	Winter	Total	Chi square
Male & Female				
# resp Sx	125	94	219	0.13
% resp Sx	13.95%	13.33%		p-0.7214
Total people	896	705	1601	

Table 2. Respiratory Symptoms.........Season/Phase 2 (All data)

4.12 Tobacco Smoking

The second variance discovered was the prevalence of smoking for winter (24.61%) compared to summer (35.15%) in phase 1. When statistical differences between the smoking rates were calculated for summer and winter in phase 1 and 2 the results showed winter to have a significant increase of smoking from phase 1 to phase 2 as seen in table 3. This therefore led to the exclusion of all households interviewed in winter and the judgement to only include summer data in matching households.

Column1	Phase 1	Phase 2	Total Phase 1&2	Chi Square
Summer				
No. smokers	528	339	867	1.748
% who smoke	35.15%	37.83%		p-0.1865
Total	1502	896	2398	
Winter				
No. smokers	238	310	548	69.357
% who smoke	24.61%	40.52%		p-<0.0001
Total	967	705	1672	

Table 3. Smoking rates between phase 1 and 2 divided by season. (All data)

While it is well recognised that smoking and passive smoking increase the risk of respiratory disease and would undoubtedly influence the results of the study; due to its high prevalence amongst the study population and lack of meaningful change (Chi square: 2.7, p-0.0992) between phase 1 and 2 in the controlled dataset as shown in table 4, the variable was not excluded and regarded as a constant. Of the 105 households used in the baseline survey 7 did not have a resident smoker and only 3 in the follow-up. Unfortunately due to the data being collected per household, individual comparisons such as incidence of respiratory symptoms and smoking could not be analysed.

	Phase 1	Phase 2	Total	Chi Square
Males				
# of smokers	145	161	306	0.3
% who smoke	43.41%	45.87%		p-0.5186
Tot # males	334	351	685	
Females				
# of smokers	78	109	187	3.6
% who smoke	26.44%	33.44%		p-0.0581
Tot # females	295	326	621	
Males & Females				
# of smokers	223	270	493	2.7
% who smoke	35.45%	39.88%		p-0.0992
Tot # males & females	629	677	1306	

Table 4. Smoking rates between Phase 1 and 2. Controlled for season (all summer) and household (matched pre & post).

4.2 Descriptive Data

From the data collected in the Humla region there is a gender division of 47.5% female and 52.5% male. This compares to the gender distribution prevailing in Nepal, with 50.4% females and 49.6% males (World Bank, 2007). Further descriptive data for the region generated from the survey are as follows;

Descriptive data	Male	Female	Total
Gender	47.5%	52.5%	
Average age	23.7 yrs	22.9 yrs	23.3 yrs
Percentage of pop.			
0 to 4	14.1%	14.0%	14.0%
5 to 14	27.6%	26.5%	27.1%
15 to 49	45.2%	47.8%	46.4%
50+	13.2%	11.7%	12.5%
Av. formal education	1.9 yrs	0.6 yrs	1.2 yrs
Av. No. per household	3.2	2.9	6.1

Table 5. Demographic stats of Humla region from survey. (All data)

4.3 Outcome Data

The original data was gathered at baseline between the summer of 2004 and the winter of 2007 whilst the follow-up data was gathered between the winter of 2006 and the winter of 2007, with a range of 1 to 3 years follow-up time.

For the data used to test the study hypothesis, once controlled for confounding variables one group of households (n=27) was surveyed in the summer of 2006 and followed up in summer 2007 (1 year). The remainder (n=78) was surveyed in the summer of 2005 and followed up 2 years later in the summer of 2007. Although not long enough to show a trend over time there is a large enough difference to warrant including a chart with the results of this comparison to show the disparity between 1 and 2 years, as shown in table 6.

		Phase 1	Phase 2	Total	Chi square
1 year	Male				
Follow-up	Resp Sx	15	19	34	0.08
	Tot pop.	81	94		p-0.7791
	% resp Sx	18.50%	20.20%	175	
	Female				
	Resp Sx	12	12	24	0.169
	Tot pop.	72	84		p-0.6840
	% resp Sx	16.70%	14.30%	156	
	Male & Female				
	Resp Sx	27	31	58	0.003
	Tot pop.	153	178		p-0.9562
	% resp Sx	17.70%	17.40%	331	
2 Years	Male				
Follow-up	Resp Sx	58	26	84	15.202
	Tot pop.	253	257		p-0.0001
	% resp Sx	22.90%	10.10%	510	
	Female				
	Resp Sx	43	33	76	2.706
	Tot pop.	223	242		p-0.1011
	% resp Sx	19.30%	13.60%	465	
	Male & Female				
	Resp Sx	101	59	160	15.675
	Tot pop.	476	499		p-<0.0001
	% resp Sx	21.20%	11.80%	975	

Table 6. Respiratory Symptoms over time. (Controlled/Matched data).

4.4 Main Results

Overall, analysing the controlled data for both sexes, there is a statistically significant difference between the frequency of respiratory symptoms in Phase 1 compared to that of Phase 2. Table 7 breaks down the respiratory symptom results into gender and Figure 2 provides a graphical representation of the confidence intervals at 95% in relation to the prevalence rates for each sex individually and collectively. Among the 73 males in Phase

One, there was a statistically significant reduction in the prevalence of respiratory symptoms from 22% to 13% (relative risk 1.71, 95% CI: 1.21-2.4). Among females, the reduction was less marked, from 19% to 14% (relative risk 1.35, 95% CI: 0.94-1.94). Overall, for both genders combined, respiratory symptoms reduced in frequency from 20% to 13%, which was statistically significant (relative risk 1.53, 95% CI: 1.2-1.96). Another way of expressing the benefit of the SMS and solar lighting in relation to the measured respiratory ailments for the population following the intervention is a 34.7% reduction of relative risk when it comes to respiratory symptoms. This means you would be 34.7% less likely to suffer from a respiratory symptom if you used a SMS and solar lighting in comparison to traditional methods.

	Phase 1	Phase 2	Total	Chi Square
Males				
# with respSx	73	45	118	9.799
% males with Sx	21.86%	12.82%		p-0.0018
Tot # males	334	351	685	
Females				
#with respSx	55	45	100	2.686
%females with Sx	18.64%	13.80%		p-0.1021
Tot # females	295	326	621	
Males & Females				
# with resp Sx	128	90	218	11.6
% of people	20.35%	13.29%		p-0.0006
Tot # of people	629	677	1306	

Table 7. Respiratory Symptoms........Phase 1 & 2/sex. Controlled for season (all summer) and household (same pre & post).

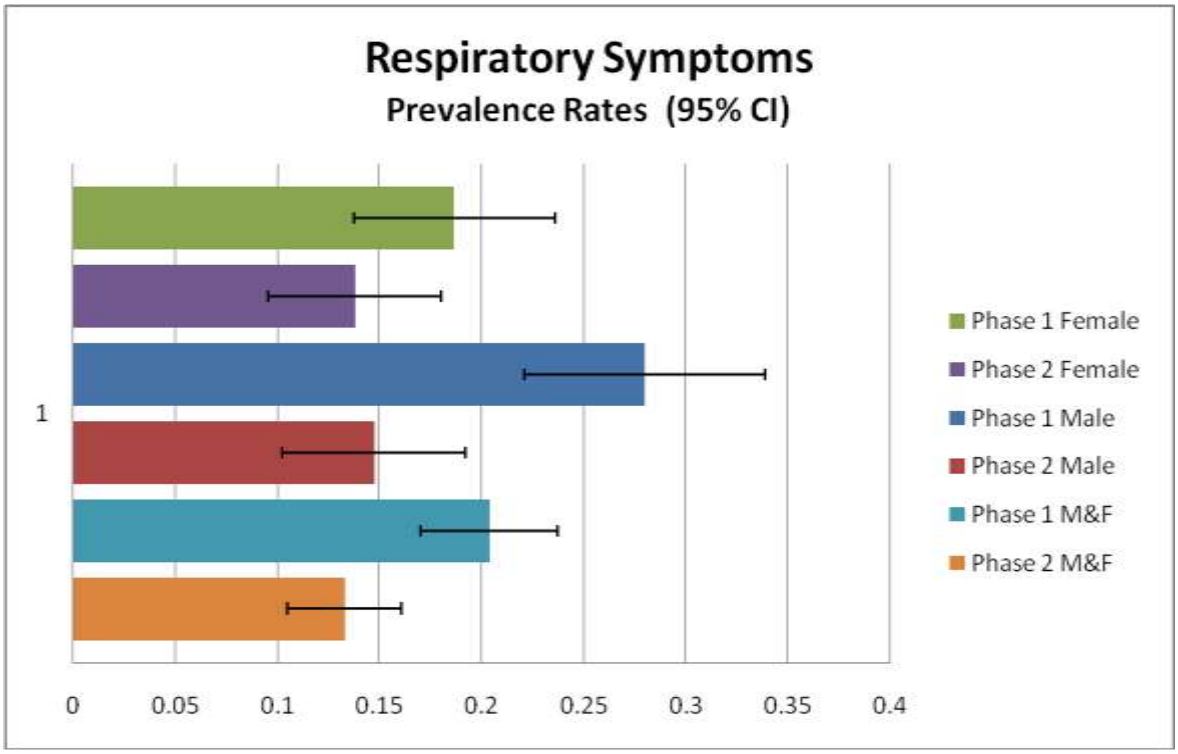

Figure 2. Respiratory Symptoms: Prevalence rates (Confidence Interval 95%).....Controlled data.

The reduction in risk of respiratory symptoms due to the interventions can also be expressed in terms of the Absolute Risk Reduction (ARR), which refers to a decrease in risk of developing respiratory ailments in relation to using a SMS and solar lighting. The ARR value was computed to be 0.071, and this means that for every 100 members of the population using the SMS and solar lighting, about 7 respiratory ailments would be averted.

4.5 Effect of mediating factors

4.51 Age Groups

When the controlled data is further broken down into age groups, a number of interesting patterns emerge, as can be seen in table 8 below.

In females in the age group 0-4 years, the prevalence of respiratory symptoms actually doubled in Phase Two, while among males in the same age group, the prevalence was unchanged.

	Phase 1	Phase 2	Total	Chi Square
Males 0-4				
# resp Sx	14	15	29	0.0029
% resp Sx	31.11%	30.61%		p-0.9586
Tot males 0-4	45	49	94	
Males 5-14				
# resp Sx	8	2	10	4.29
% resp Sx	8.79%	2.06%		(Yates correction)
Tot males 5-14	91	97	188	p-0.0440
Males 15-49				
# resp Sx	22	3	25	17.07
% resp Sx	14.01%	1.79%		(Yates Correction)
Tot males 15-49	157	168	325	p-<0.0001
Males 50+				
# resp Sx	29	25	54	0.091
% resp Sx	70.73%	67.57%		p-0.7647
Tot males 50+	41	37	78	
Females 0-4				
# resp Sx	11	22	33	2.12
% resp Sx	28.21%	43.14%		p-0.1486
Tot females 0-4	39	51	90	
Females 5-14				
# resp Sx	8	5	13	1.06
% resp Sx	9.30%	5.32%		p-0.3122
Tot females 5-14	86	94	180	
Females 15-49				
# resp Sx	10	8	18	0.51
% resp Sx	7.30%	5.26%		p-0.4799
Tot females 15-49	137	152	289	
Females 50+				
# resp Sx	26	10	36	12.45
% resp Sx	78.79%	34.48%		p-0.0005
Tot females 50+	33	29	62	

Table 8. Respiratory Symptoms.........Age group/Phase 1 & 2/sex/season. Controlled for season (all summer) and household (matched pre & post)

The highest prevalence of respiratory symptoms was reported by adults in the over 50 years group, with 71% of males and 79% of females reporting symptoms in the Phase One survey. Females in this age group reported a marked reduction in respiratory symptoms by Phase

Two, with 35% reporting symptoms, while among males there was no appreciable reduction in the prevalence.
Reduction in reported prevalence of respiratory symptoms by Phase Two was less marked in the other age groups, with statistically significant reductions being reported only for males in the 5-14 and 15-49 age groups. The other groups reported either no changes or only minor insignificant reductions.

Overall, the age groups 0-4 years and over 50 years together accounted for 70% of all people with respiratory symptoms, although these two age groups comprised only a quarter of the surveyed population.

While the 0-4 and 50+ age groups had the greater percentage of reported respiratory ailments, the greatest effects on relative risk were seen in the 5-49 years age bracket. Particularly with males aged 5-49 years there was a significant reduction in prevalence 12% to 2% (relative risk 6.4, 95% CI: 2.5-16.3). Among females in this age category, the reduction was less marked at 8% to 5% (relative risk 1.5, 95% CI: 0.8-3.1).

4.52 Seasonality

When analysing the uncontrolled data from the original study we can see certain anomalies emerge in relation to season. For the conditions that are known to be related to IAP such as Eye symptoms and Respiratory symptoms different patterns emerge.

- **Eye Symptoms**

During the summer when comparing between phase 1 and phase 2, there was a small reduction in the reported prevalence of eye symptoms, but this did not reach statistical significance. During winter however the prevalence of eye symptoms significantly improved after the implementation of the SMS and solar lighting, as can be seen in table 9 below.

- **Respiratory Symptoms**

The original dataset shows there is a significant difference in respiratory symptoms between phase 1 and phase 2 for winter (Chi- 16.776, p-<0.0001) compared to summer (Chi-1.903, p-

0.1682) as seen in table 1 and 2. This considerable decrease in reported respiratory symptoms between the before and after group is also combined with a significant increase (15.91%) in the prevalence rates of smoking in the population for winter (Chi-69.357, p-<0.0001), as seen in table 3.

Season/House with eye disease	Phase 1	Phase 2	Phase 1 & 2	Chi square
Winter				
# of households	35	12	47	8.094
% of households	22.20%	9.50%		p-0.0047
Tot households	158	126	284	
Summer				
# of households	29	20	49	0.396
% of households	12.10%	14.40%		p-0.5314
Tot households	239	139	378	
Winter & Summer				
# of households	64	32	96	2.098
% of households	16.10%	12.10%		p-0.1487
Tot households	397	265	662	

Table 9. Households with Eye disease....Phase 1 & 2/season....(All data)

4.6 Sensitivity analyses

Due to the large volume of excluded data in order to control for household and season a trend comparison between all of the data and the sample used for final analyses was conducted. When observing for prevalence of respiratory symptoms, although the values were different, the trends were the same. Table 10 contains the differences in prevalence between phase 1 and 2 for both sets of data used, that is the original data (n=669) and the dataset which controlled for household and season (n=210).

Comparison between All and Controlled data

Age Group	Gender	Matched Data		All Data	
		Phase 1	Phase 2	Phase 1	Phase2
0 to 4	Male	31.10%	30.60%	27.90%	26.50%
	Female	28.20%	43.10%	27%	41.10%
5 to 14	Male	8.80%	2.10%	9.30%	4.30%
	Female	9.30%	5.30%	10.50%	6.30%
15 to 49	Male	14%	1.80%	9.30%	2.40%
	Female	7.30%	5.30%	9.70%	4.40%
50+	Male	70.70%	67.60%	57.70%	55%
	Female	78.80%	34.50%	54.90%	41.20%
All Ages	Tot Males	21.90%	12.80%	18.20%	13.30%
	Tot Females	18.60%	13.80%	17.80%	14.10%
	M & F	20.40%	13.30%	18%	13.70%

Table 10. Differences in Prevalence (%) rates between Phase 1 and 2 with regard to Respiratory Symptoms.

5.0 Discussion

Our study demonstrated that the implementation of the SMS and solar lighting was statistically associated with a significant decrease in reported prevalence of respiratory symptoms in the study population. This chapter discusses the key findings of the study in the light of the published literature, and examines their implications for development and health. A number of recommendations are also presented.

5.1 Significance of main study findings

5.11 Reduction in prevalence of respiratory symptoms

Provisional testing (Appendix 2) has shown a marked decrease in IAP following the change from the traditional open fire cooking and jharro candles to the SMS and solar lighting. This reduction in exposure to household pollution is expected to lead to a corresponding fall in prevalence of respiratory ailments. Similar studies into the effects of IAP and flued stoves on respiratory health have shown comparable results. An extensive intervention study conducted in rural Guatemala for example, showed a 40% reduction in severe cases of respiratory sycitial virus (RSV) following the introduction of a flued stove (WHO 2007b, p.5). Due to the generalised measurements used to determine the effects of the SMS and solar lighting and lack of direct association with pollutant measurements no dose-response relationship could be gauged in this study. More specific figures on pollutant levels with direct correspondence to lung function are needed. Closer monitoring of individuals and their exposure would be recommended.

A preliminary analysis showed a small association with the improvement of respiratory symptoms over time, as seen in table 6. Further investigations in regards to time would be warranted, especially considering the more fatal effects of IAP that could only be shown conclusively with a long-term longitudinal study.

The impact of the SMS and solar lighting had varying effects according to age and sex. From the data it would appear that males between the ages of 5 to 49 and females 50+ years would benefit most from the intervention. Considering in the Nepalese culture it is primarily the females who are responsible for cooking and therefore have the greatest potential for IAP exposure it seems the males receive the most benefit. Further investigation into specific exposure and peoples roles in relation to the household and in turn relative exposure to IAP would need to be further investigated.

According to this study, the implementation of the SMS and solar lighting has improved the respiratory health of the study population. The results give the impression however, that the benefits are skewed towards a certain demographic. While certain roles with relation to gender and age could be hypothesised, an observational study would be needed to explain this further. For any relative associations or conclusions to be drawn, all exposures to potential environmental pollutants need to be examined; that is in the house (for example, beer brewing fires) and external to the house (for example, flour mills). Further study into other potential exposures to pollution external to the house would need to be conducted for further explanation.

While seasonality is a recognised determinant of acute respiratory ailments it is a variable that can be easily controlled for in a study by repeating the interviews at the same time each year. The primary analysis indicates marked seasonal differences in the prevalence of respiratory ailments and the relative risk reduction with the use of the SMS and solar lighting. Winter sees a higher stove usage for heating and longer periods indoors. This, accompanied by decreased house ventilation further increases the level of exposure to IAP. While the questionnaire collects living standard questions it does not see if there are any livelihood changes. Further study would need to be conducted in order to ascertain if there are any livelihood strategies that are also seasonal and could result in more or less exposure to IAP.

Smoking and passive smoking are known causes of morbidity and mortality, with 20% of all deaths in developed countries attributed to tobacco smoking (Wald & Hackshaw 1996, p.3). Smoking would undoubtedly have an influence on the occurrence of respiratory ailments in the study population, either directly or indirectly. The lack of change in the respiratory symptoms prevalence rates of the 0-5 age group could be partially explained by the high incidence of smoking among the households. Due to the increased vulnerability to passive smoking experienced by this age group and proven relationship between paternal smoking and respiratory symptoms (Cook and Strachan, 1997), the greater the chance a small dose like that received through passive smoking could influence the results. While smoking would influence the results, due to its prevalence being statistically insignificant between phase one and two the net reduction could be attributable to the SMS and solar lighting.

5.12 Age and sex

When exploring the impact of the intervention with relation to age and sex some anomalies were found. Males benefited most from the intervention with a statistically significant reduction in respiratory symptoms; compared to females whose prevalence decreased but without statistical significance. The reasons for this can only be speculated upon, namely that women spend more time indoors anyway for cooking and other household work, so would have a greater total exposure to indoor air pollution than males.

The age groups of 0-4 and 50+ years contained the majority of the respiratory ailments with the most significant improvements found between the ages of 5-49 years. This group would be the ones most likely to be outdoors most of the time, compared to the very young or elderly, and thus would be less exposed to IAP.

5.13 Tobacco smoking and season

Season was shown to have a confounding effect on the prevalence of respiratory symptoms. Winter with its higher prevalence rate also had a larger reduction between phase 1 and phase 2 when compared to summer. This was also noted in the prevalence of eye disease where winter had higher initial rates and a subsequent significantly pronounced drop in rate when compared to summer. The decrease in respiratory ailments during winter occurred even though there was a discernible increase in the rate of tobacco smoking during the winter months.

5.2 Limitations

5.21 Season

As explained in the methods chapter, the dataset we used for analysis was abstracted from a larger dataset after controlling for season, smoking and household matching. Although the controlled data showed statistical significance in its association with respiratory symptoms in regards to the SMS and solar lighting, our estimates may underestimate the true reported prevalence rates and therefore impact of these interventions. Households lost to follow-up and before and after surveys conducted in different seasons may also influence the true prevalence of the intervention. When analysing all the data provided we could infer that winter would have shown us greater differences in the before and after prevalence rates of respiratory symptoms. This is supported in other studies into the relationship between respiratory disease and seasonal influences such as done by Kim et.al. (1969). Their study indicated a strong association between respiratory infections (specifically pneumococcal bacteraemia, respiratory syncytial virus (RSV) and influenza) and seasonal influences, concluding that the number of cases peaked in midwinter and declined markedly midsummer, indicating a high inverse correlation with the ambient temperature. Due to lack of discernable data such conclusions were unable to be made in this study.

5.22 Smoking

The smoking rates of the Humla region are similar to that of the rest of the developing world with men smoking predominantly more than women and unlike developed countries is also slowly increasing in popularity; for example the male smoking prevalence ranges from 45% in India to 73% in Vietnam (Edwards, 2004). The short and long term effects of IAP and smoking are almost indiscernible in their differences. IAP is primarily a developing nation concern and therefore little direct evidence into the health affects is available, particularly intervention studies that measure the exposure/response relationship. Smoking on the other hand is well researched and the adverse health effects are extensive.

Smoking has a strong dose response relation, the greater the consumption the greater the risk of developing a smoking related disease (Kuschner et.al. 1996) which is also seen in passive smoking (Maziak et.al. 2005). The adverse health effects of smoking are well documented causing lung cancer, other cancers, heart disease, stroke, emphysema, complications of pregnancy, and many other illnesses. Smoking cessation provides immediate effects by decreasing risk of disease and increases life expectancy; for example the risk of heart disease is reduced by about half after 1 year and declines gradually thereafter. The earlier one stops smoking the more beneficial but older people who give up can also expect to have a longer and healthier life (Novello, 1990). People with respiratory disease such as COPD can expect a small increase in lung function and reversal of the effects on subsequent rate of decline. Smoking during pregnancy has been associated with an increase in foetal and peri natal deaths, low birth weight, preterm delivery and other complications (Edwards, 2004). Even passive smoking has been shown to be responsible for respiratory disease and aggravation of allergic responses, particularly in children with an increase in risk of respiratory infection and childhood asthma (WHO, 2000).

In this study we controlled for smoking by having it as a constant and measuring the differences in respiratory symptoms before and after the intervention. This however does not account for the potential bias that may be caused by smoking and passive smoking, especially in relation to children under 5 years whose respiratory tract is particularly vulnerable and more susceptible to respiratory disease. By reducing IAP through the SMS and solar lighting intervention we can at best hope to reduce the dose of overall smoke inhalation and therefore decrease the burden of smoking related disease.

5.23 Immunity

It is well recognised that one's immune response is responsible for the symptomatic expression of disease, whether pathogenic or an environmental allergen. Therefore, anything that lowers the body's immune system would have a detrimental effect on a person's ability to ward off ill health. The people of the Humla region have many poverty related stressors that could potentially affect the immune system. The body's ability to respond to its environment can be influenced by physical and/or psychological stressors. Due to their agricultural and labour intensive lifestyle, deprived living conditions, climatic extremes and food security concerns, the issue of a lowered immunity is a concern. An article by Hinkle et.al. (1958) discusses peoples susceptibility to disease in relation to their perceived life experience, which was concluded to be a result of genetic and environmental influences. Prolonged physical exercise (Hoffman-Goetz & Klarlund Pedersen, 1994) and decreased nutritional status (Hamer, Wolvers & Albers, 2004) can lower the body's immune response and therefore act as a confounding factor to the effects of IAP. Smoking also has a detrimental effect on the immune system (Sopori, 2002) and although is equally distributed through the research participants and unlikely to cause internal bias, the overall influence upon the population as a whole could not be controlled for.

Although a reduced immune response would be present throughout the study, the inclusion as a potential confounding factor is because of the potential influence due to other parts of the holistic community development project. Decreased diarrhoea and improved nutritional status, decreased physical exertion due to closer water supply, less firewood gathering due to more efficient stove and general potential of improved quality of life are all possible outcomes of the project. Therefore, with an improved immunity there could be a change in the severity of the disease process and expression of symptoms.

5.24 Secondary data

The use of secondary data limits the scope of a study to only being able to use data that has already been collected. This becomes problematic when explicit health data is needed. Specific to this study the major data limitations were;

(1) The diagnostic techniques used to classify respiratory disease were broad and subjective, resulting in the use of reported respiratory symptoms as a proxy for the specific clinical or laboratory diagnosis or measurement.

(2) The use of households as cases limited the analysis to broad groupings rather than variables measured in individuals. Therefore more specific data analysis such as the relationship between smoking and respiratory symptoms could not be examined.

(3) There was no data on the amount or exposure measurements of IAP or smoking per household or individual. Therefore no dose response relationship could be observed.

The effects of IAP are much broader than just respiratory symptoms. We were unable to gauge the long term effects of IAP such as COPD, Ischemic Heart Disease, stroke and pneumonia.

While reported respiratory symptoms were measured, along with infant deaths, the local mortality rates and causes were not. Since respiratory disease features highly in Nepal's disease burden and mortality rates, deaths due to respiratory disease could have a significant impact on the data and therefore results of this study.

In order to control for confounding variables much of the data had to be excluded, thus decreasing the power of the results and restricting further reliable analysis, for example seasonality. More stringent methods of data collection could have improved the usability of the figures. Following up each household, same season collection pre and post and consistent periods of time between interviews would help in the provision of dependable data for analysis.

At time of interview certain behaviours can be observed but the overall adoption and consistent use of the SMS and solar lighting relies upon self-reporting. This may vary depending on the person interviewed especially if a different person is interviewed pre and post. The use of the SMS and solar lighting between periods of interview are unknown as they were not directly observed as part of the study. While technical support by RIDS-Nepal staff was available, the data available for analysis did not mention the uptake of this service. One of the problems initially mentioned were people not chopping the wood into smaller pieces in order to fit into the SMS, therefore the long sections of wood were hanging out, allowing smoke to come out of the door. Behavioural changes due to the increased knowledge and awareness of IAP may also influence the results.

5.25 Other potential confounding factors

Altitude- People living in high altitudes have known physiological adaptations to their environment. These adaptations are high resting ventilation rate with a moderate hypoxic ventilatory response; improved lung mechanics measured by higher peak flows and significantly elevated forced expiratory volume in 1 sec (FEV_1) and mid-maximal expiratory flow (MMEF) (Wood et.al. 2003); higher blood haemoglobin levels, sometimes to the point of excessive polycythemia (Kryger et.al. 1978). A study by Moore et.al. (1982) showed that pregnant women living at high altitudes had higher ventilation rates to those women in a non-pregnant state. It has also been suggested that the hypoxic effects of high altitude can have an inhibitory effect on the phagocytic activity of alveolar macrophages, thus contributing to the high occurrence of respiratory infections and chronic bronchitis seen in these populations (Rosati et.al. 2005).

Helminths (worms), infectious diseases and nutrition (food security)- Any deviation from the body's equilibrium lowers one's ability to cope with environmental pressures. In Nepal there is a high prevalence of easily preventable and treatable diseases such as diarrhoea and/or dysentery; helminthic infestations which are said to affect over 60% of the population, and lack of access to adequate nutrition to meet their daily needs (Rai et.al. 2002). All of these inflictions have been associated with an increased incidence of malnutrition and anaemia and implicated as an underlying cause of child deaths associated with infectious disease.

Hepcidin- A recently identified peptide involved in iron metabolism. It is thought to regulate the circulating iron levels by increasing the iron levels within the cells of the reticuloendothelial system (RES) and the reduction of intestinal iron absorption (Deicher &Horl. 2004). Hepcidin production is modulated by anaemia, hypoxia or inflammation. Anaemia and/or hypoxia which usually suppress the expression of hepcidin, in the case of inflammatory stimuli that is strong enough to induce acute-phase responses induce its release even in the setting of anaemia (Nicolas, Chauvet et. al. 2002). Therefore within the setting of Humla where altitude (hypoxia), helminths infestation (anaemia) and a CO rich indoor environment is combined with the chronic inflammatory response caused by the IAP the ensuing effects are unpredictable and deserve further investigation.

Women's proximity to stove and child on back – The Guatemalan study (WHO. 2006) also emphasised the variation in exposure dependant on time of exposure and proximity to the stove. Therefore the personal activities of each person would greatly influence their exposure level and in turn relative risk.

6.0 Conclusion

The significant reported reduction in respiratory ailments following the introduction of the SMS and solar lighting can be seen as an indicator of how the intervention reduces the effects of IAP. Although measured in this study by reported respiratory symptoms it is an indicator of the potential to reduce all the ailments caused by IAP. The possible improvement in morbidity and mortality of this impoverished region could advance the overall quality of life experienced by the people. Smoking/IAP are inextricably linked to ill health and poverty, through the reduction of IAP we subsequently decrease the intertwined diseases associated with it and provide the potential for a community to develop. Through a diminished burden of disease a community's potential can be augmented with an improved quality of life and increased life expectancy.

By dividing the population into specific groups by age and gender we saw not only how IAP affected specific sections of local society differently but also how the intervention affected these groups in relation to reported respiratory symptoms. Having a statistically significant improvement in males over females considering traditionally females spend more of their time at the stove than males poses the question as to why. One that cannot be answered from the data provided, only leading to the need for further enquiry. As expected the very young and very old in both sexes received the highest prevalence rates of reported respiratory symptoms, with the older females having a statistically significant improvement following the intervention as would also be expected in view of local family roles. The very young had no significant change in reported respiratory symptoms which was unexpected considering they are the most vulnerable to IAP. All of which leads to the need for closer scrutiny of the behaviours and traditional practices of the family in relation to exposure to pollutants that effect respiratory health.

While factors such as smoking and season are known to effect respiratory health there may be other local exposures and practices that were not accounted for during the initial questionnaire formulation. These potential environmental and behavioural confounders may help explain the statistical results attained. While the process of continual qualitative improvement evaluates and develops the HCD programme, the growing knowledge of what influences the respiratory health of the study population can shape future interventions and ultimately decrease the mortality and morbidity related to respiratory disease.

In a society heavily dependent upon manual/physical labour, lacking in resources and social infrastructure to support disability the burden of disease has severe ramifications. This coupled with the community's fuel needs for cooking and heating places an additional strain on the already diminishing local forests and potentially adds to the cycle of poverty. Due to Humla's geographical isolation the people are unlikely to be able to change to cleaner fuels such as LPG so there will be a continued need for biomass fuel. As wood becomes scarce there is an increased distance to travel, adding time to an already full day. The need for wood outweighs the natural re-growth; with the average annual deforestation rate in Nepal being calculated at 1.35% (Mongabay 2005) there is a need for some sort of intervention. The SMS efficiency dramatically reduces the greenhouse gas emissions, wood consumption and cooking time which in turn decreases the time needed for wood gathering and the overall environmental burden of burning biomass fuel.

Since it is women who primarily gather the wood and do the cooking it is the women who potentially have the most to benefit. Decreasing the wood gathering time for women can reduce the injuries due to carrying heavy loads, falls, miscarriages, exposure to violence and civil unrest. Introducing a technology that is principally in the women's realm helps to begin the process of empowerment through improving their access to resources and a community developed support network and non-formal education. Over time with improved health outcomes and education the community can develop a sustainable future according to their physical, mental and social needs.

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Appendices

Appendix 1

Interventions for reducing exposure to indoor air pollution

Changing the source of pollution

Improved cooking devices
- Improved biomass stoves without flues
- Improved stoves with flues

Alternative fuel-cooker combinations
- Briquettes and pellets
- Kerosene
- Liquefied petroleum gas
- Natural gas
- Biogas, Producer gas
- Solar cookers
- Modern biofuels (e.g. ethanol, methanol, plant oils)
- Electricity

Reduced need for the fire
- Retained heat cooker (haybox)
- Efficient housing design and construction
- Solar water heating
- Pressure cooker

Improving the living environment

Improved ventilation
- Smoke hoods
- Eaves spaces
- Windows

Kitchen design and placement of the stove
- Kitchen separate from house reduces exposure of family (less so for cook)
- Stove at waist height reduces direct exposure of cook leaning over fire

Modifying user behaviour

Reduced exposure by changing cooking practices
- Fuel drying
- Pot lids to conserve heat
- Food preparation to reduce cooking time (e.g. soaking beans)
- Good maintenance of stoves and chimneys and other appliances

Reductions by avoiding smoke
- Keeping children away from smoke, e.g. in another room (if available and safe to do so)

(WHO, 2008 pg 7)

Appendix 2

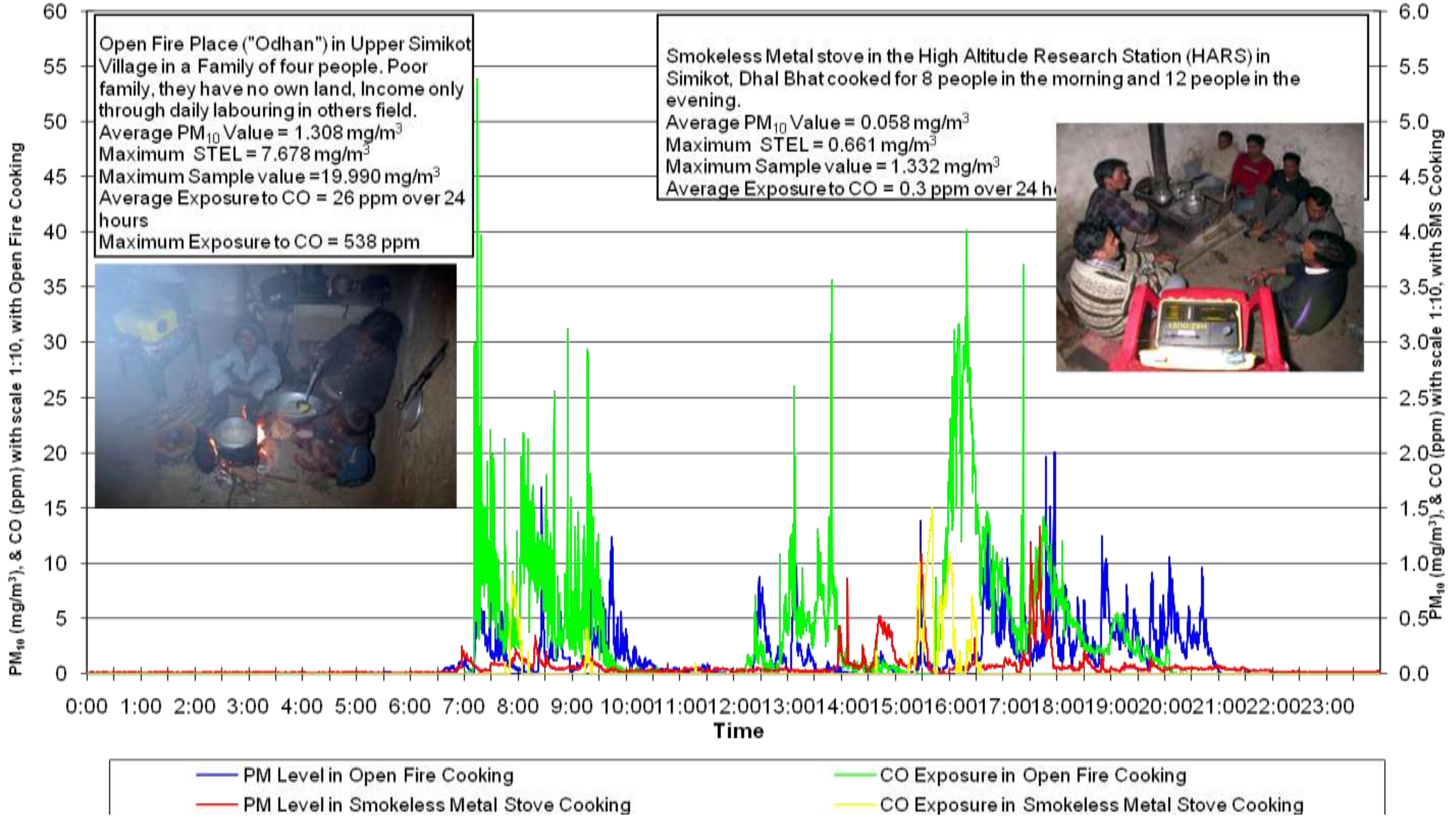
The following graphs were provided by Alex Zahnd, Program Director of RIDS-Nepal.

An EPAM 5000 Portable Environmental Particulate Air Monitor was used to measure the indoor air quality. This monitor uses light scattering to measure particle concentration providing real-time data recordings of airborne particle concentration in milligrams per cubic meter (mg/m^3).

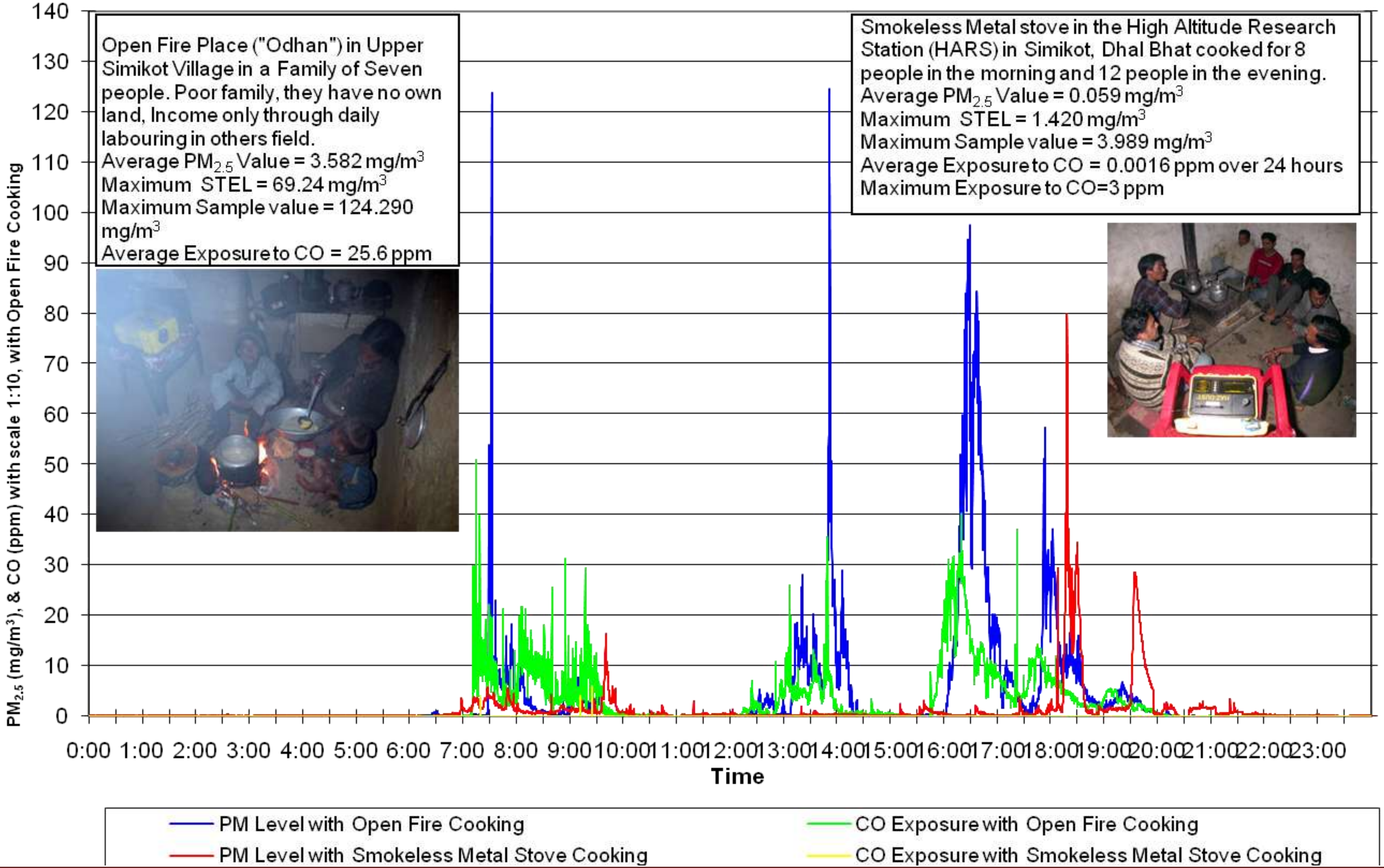
The Draeger Pac 7000 is a compact, pocket sized gas detector, used in this case to monitor the CO concentration in parts per million (ppm).

It has been shown in a Guatemalan study that the position of the monitors does affect the readings. This data is included here not for statistical analysis but as a graphical representation of the gross differences in IAP to give the reader an idea for the need for further investigation.

24 Hours Comparison of Indoor PM_{10} Air and CO Level between Smokeless Metal Stove (SMS) and Open Fire Cooking



24 Hours Comparision of Indoor $PM_{2.5}$ Air and CO Level between Smokeless Metal Stove (SMS) and Open Fire Cooking



Appendix 3

Social and Health Changes from the Family of 4

Baseline Questionnaire

The ISIS Foundation & RIDS-Nepal

General

1. Name of household head: Year house was built:
2. Household head is (circle one): male female
3. Marital type (circle one): monogamous polygynous Amount of household debt:
4. Self-described socio-economic status (circle one): Low Middle High
5. Group-described socio-economic status (circle one): Low Middle High
6. Kind and numbers of livestock

Type:	**Number:**
Cattle	
Yaks/Naks	
Dzopa/Dzoma	
Goats	
Sheep	
Horses	
Tolba/tolbini	

7. Amount of land:

Type:	**Days to plow**	**Describe fields (distance, quality of field, etc.)**
Irrigated		
Non-irrigated		

8. Months of food security from their own crops per year:

9. What do they eat when the food they have grown is finished? Where do they get this food? What food do they buy?

10. Cooking method:

    a. Open fire with stone support

    b. Open fire with metal/steel frame (that strong expensive ~6,000 NRp metal frame)

    c. Open fire with stones and odhan

    d. Smokeless metal stove (define the kind)

    e. "Jumla" design smokeless metal stove

    f. Other:

11. Heating method:

    a. open fire

    b. smokeless metal stove (define the kind)

    c. "Jumla" design smokeless metal stove

12. Lighting method:

    a. jharro

    b. matitel (tupi)

    c. candle

    d. hydro power

    e. solar

13. Does this household have a latrine?

14. If the household has a latrine, who uses it?

    a. Only household members

    b. Shared with other families

15. Who cleans the latrine?

16. Source of drinking/cooking water:

17. Distance to water?

18. Is drinking water boiled before it is consumed?

19. If water is boiled for drinking, is it then covered when left in the house (before consumption)?

Demographic

20. List **ALL** Household Residents

Name	**Sex** **(m/f)**	**Age**	**Relationship to household head**	**# Years of education**

Social /Attitudinal Data

21. What changes will solar lighting bring to your house? Circle the most important change.

    a. (Male response:)

    b. (Female response:)

22. What will you do with solar lighting that you didn't do in the past? Circle the most important thing.

    a. (male response:)

    b. (female response:)

23 What is good about your current heating/cooking method? Circle the most important thing.

    a. (male response:)

    b. (female response:)

24. What is good about a smokeless stove? Circle the most important thing.

    a. (male response:)

    b. (female response:)

25. What is bad about smokeless stoves? Circle the most important thing.

    a. (male response:)

    b. (female response:)

26. What changes will a pit latrine bring to your home? Circle the most important change

    a (male response:)

    b.(female response:)

27. What changes will clean drinking water bring to your home? Circle the most important change
    a. (male response:)

    b. (female response:)

28. # of hours per week spent gathering wood for this household (estimate):

29. # of bari of wood used per week by this household by males:

30. # of bari of wood used per week by this household by females:

31. If used properly, a smokeless metal stove uses up to ½ as much wood as your open fire. This will save you time. What will women do with the extra time? What will men do with the extra time?

32. What are your primary sources of stress in life right now? Get Male answer AND female answer. Circle male answer.

33. Is the stress you feel the same as 10 years ago? If not, what has changed? Get Male answer AND female answer. Circle male answer.

34. If people in this village have solar lights, latrines, drinking water, and smokeless stoves, what else will be needed? Get Male answer AND female answer. Circle male answer.
35. What changes will occur in this village when every house has lights, drinking water, smokeless stove and a latrine? Get Male answer AND female answer. Circle male answer.

36. What diseases are currently present in this household (use local name and English name)? Record the age and sex of the person with each disease listed.

37. For each disease, what is being done to cure the disease (amchi, dhami, doctor, what medicines, what herbs)?

Health Data (for ANM to collect)

38. Household residents with acute upper respiratory infection (AURI):

Name	**Sex**	**Age**

39. Household residents with acute lower respiratory infection (ALRI):

Name	**Sex**	**Age**

40. Household residents currently suffering from diarrhea:

Name	**Sex**	**Age**	**Blood in**

			diarrhea? (y/n)

41. Household residents suffering from diarrhea within last 3 months:

Name	**Sex**	**Age**	**Blood in diarrhea? (y/n)**

42. Household residents currently suffering from worms:

Name	**Sex**	**Age**

43. Household residents suffering from intestinal worms within last 3 months:

Name	**Sex**	**Age**

44. How many children do you wish to have? And why?
45. How many children is ideal? And why?
46. Is this different from your mother's ideal?
47. If it is different, why are your ideas different from your mother's?
48. Do you have access to contraception?
49. Where can you access contraception?
50. Do you and your husband want the same number of children?
51. Do you and your husband agree on contraception?
52. What kind of contraception have you used?
53. What can be done to improve the hygiene of each family member?
54. How can this be done?

55. For each child (under age 5) in the household, record the following information:

Measurement	**Name**	**Name**	**Name**	**Name**
Sex				
Age in months				
BCG Scar Y/N				
Mid-upper arm circumference (cm)				
Weight				
Height/length (cm)				
Diarrhea Y/N				
Blood in diarrhea Y/N				
Dehydrated Y/N				
Worms Y/N				
Palmar pallor				

56. For each woman of childbearing age in the household, record the following information:

Measurement	**Name**	**Name**	**Name**	**Name**
Month and year of marriage				
Age				
Weight				
Height (cm)				
Palmar pallor				
Do you have to stop to catch your breath when walking at a moderate speed (do you stop more than normal)				
Do you walk more slowly than persons as old as you because of difficulty breathing?				
Fertility Data:	**Child's Name:**	**Sex:**	**Birth Date:**	**Surviving? (if no, when died and how?)**
First Child				
Second Child				
Third Child				
Fourth Child				

Appendix 4

Social and Health Changes from the Family of 4

Follow-up Questionnaire

The ISIS Foundation & RIDS-Nepal

General

1. Name of household head: Year that house was built:
2. Household head is (circle one): male female
3. Marital type (circle one): monogamous polygynous Amount of household debt:
4. Self-described socio-economic status (circle one): Low Middle High
5. Group-described socio-economic status (circle one): Low Middle High
6. Kind and numbers of livestock

Type:	**Number:**
Cattle	
Yaks/Naks	
Dzopa/Dzoma	
Goats	
Sheep	
Horses	
Tolba/tolbini	

7. Amount of land:

Type:	**Days to plow**	**Describe fields (distance, quality of field, etc.)**
Irrigated		
Non-irrigated		

8. Months of food security from their own crops per year:
9. What do they eat when the food they have grown is finished? Where do they get this food? What food do they buy?

10. Cooking method:

    a. Open fire with stone support

    b. Open fire with metal/steel frame (that strong expensive ~6,000 NRp metal frame)

    c. Open fire with stones and odhan

    d. smokeless metal stove (define the kind)

    e. "Jumla" design smokeless metal stove

    f. Other:

11. Heating method:

    a. open fire

    b. smokeless metal stove (define the kind)

    c. "Jumla" design smokeless metal stove

12. Lighting method:

    a. jharro

    b. matitel (tupi)

    c. candle

    d. hydro power

    e. solar

13. Does this household have a latrine?

14. If the household has a latrine, who uses it?

    a. Only household members

    b. Shared with other families

15. Who cleans the latrine?

16. Source of drinking/cooking water:

17. Distance to water?

18. Is drinking water boiled before it is consumed?

19. If water is boiled for drinking, is it then covered when left in the house (before consumption)?

Demographic

20. List **ALL** Household Residents

Name	**Sex** **(m/f)**	**Age**	**Relationship to household head**	**# Years of education**

Social /Attitudinal Data

21. What changes have solar lighting brought to your house? Circle the most important thing.
    a. (Male response:)
    b. (Female response:)
22. What changes has the smokeless stove brought to your house? Circle the most important thing.
    a. (male response:)
    b. (female response:)
23. What was good about your old heating/cooking method? Circle the most important thing.
    a. (male response:)
    b. (female response:)
24. What is good about a smokeless stove? Circle the most important thing.
    a. (male response:)
    b. (female response:)
25. What is bad about the new smokeless metal stoves? Circle the most important thing.
    a. (male response:)
    b. (female response:)
26. What changes has the pit latrine brought? Circle the most important thing.

27. # of hours per week spent gathering wood for this household (estimate)

28. # of bari of wood used per week by this household by males/females (circle the response for males):

29. If used properly, a smokeless metal stove uses up to ½ as much wood as your old open fire. This has saved you time. . What will women do with the extra time? What will men do with the extra time?

30. What are your primary sources of stress in life right now? Get Male answer AND female answer. Circle male answer.

31. Is the stress you feel the same as 10 years ago? If not, what has changed? Get Male answer AND female answer. Circle male answer.

32. Now that people in this village have solar lights, latrines, and smokeless stoves, what else is needed? Get Male answer AND female answer. Circle male answer.

33. What changes have occurred in this village now that every house has lights, smokeless stove and a latrine? Get Male answer AND female answer. Circle male answer.

34. What diseases are currently present in this household (use local name and English name)? Record the age and sex of the person with each disease listed.

35. For each disease, what is being done to cure the disease (amchi, dhami doctor, what medicines, what herbs)?

Health Data (for ANM to collect)

36. Household residents with acute upper respiratory infection (AURI):

Name	**Sex**	**Age**

37. Household residents with acute lower respiratory infection (ALRI):

Name	**Sex**	**Age**

38. Household residents currently suffering from diarrhea:

Name	**Sex**	**Age**	**Blood in diarrhea? (y/n)**

39. Household residents suffering from diarrhea within last 3 months:

Name	Sex	Age	Blood in diarrhea? (y/n)

40. Household residents currently suffering from worms:

Name	Sex	Age

41. Household residents suffering from intestinal worms within last 3 months:

Name	Sex	Age

42. How many children do you wish to have? And why?

43. How many children is ideal? And why?

44. Is this different from your mother's ideal?

45. If it is different, why are your ideas different from your mother's?

46. Do you have access to contraception?

47. Where can you access contraception?

48. Do you and your husband agree on ideal family size?

49. Do you and your husband agree on contraception?

50. What kind of contraception have you used?

51. For each child (under age 5) in the household, record the following information:

Measurement	**Name**	**Name**	**Name**	**Name**
Sex				
Age in months				
BCG Scar Y/N				
Mid-upper arm circumference (cm)				
Weight				
Height/length (cm)				
Diarrhea Y/N				
Blood in diarrhea Y/N				
Dehydrated Y/N				
Worms Y/N				
Palmar pallor				

52. For each woman of childbearing age in the household, record the following information:

Measurement	**Name**	**Name**	**Name**	**Name**
Month and year of marriage				
Age				
Weight				
Height (cm)				
Palmar pallor				
Do you have to stop to catch your breath when walking at a moderate speed (do you stop more than normal)				
Do you walk more slowly than persons as old as you because of difficulty breathing?				
Fertility Data:	**Child's Name:**	**Sex:**	**Birthdate:**	**Surviving? (if no, when died and how?)**
First Child				
Second Child				
Third Child				
Fourth Child				

Appendix 5

Guidelines for the nurse:

Acute Upper Respiratory Infection--AURI

Infection is present if the person has some (not necessarily all) of the following symptoms:

1. Cough
2. Sore throat
3. Stuffy nose
4. Sneezing
5. Runny nose
6. Low fever

Acute Lower Respiratory Infection—ALRI

Infection is present if the person has all of the following symptoms:

1. Persistent cough for more than 4 days, AND
2. Chest in drawing (lift shirt, observe breaths--if lower chest goes in when person breathes in, that child has "in drawing"), AND
3. Person breathes more than 40 times per minute (under 12 months of age) or more than 50 times per minute (more than 12 months), more than 30 times per minute (adult)
4. Noisy breathing (you can hear chest sounds when person breathes in)

Palmar Pallor

The child/woman has palmar pallor if you hold their hand in an open position and observe that the palm of their hand is whiter than yours and whiter than people in the village who are the same age.

Dehydration

The child is dehydrated if the skin on the abdomen is pinched and it takes longer than 2 seconds to go back to its normal position.

Appendix 6

I. ISIS RESEARCH GUIDELINES:

1. Ethics:

Researchers will initial and abide by the following provisions.

a. Information jeopardizing the safety of individuals will not be collected.

b. Subjects will never be misled as to the use of the information being collected from them, and will be informed as to the purpose of the project .

c. Subjects will be informed that they do not have to participate in the research project, or to answer questions they do not wish to answer, and that nothing will be withheld from them should they decide not to participate, nor will any benefits brought to the community by ISIS/RIDS-Nepal depend in any way on their participation in the research project .

d. Researchers will regularly and faithfully report the results of their data analysis to the ISIS RM and the research project partner(s), to benefit the ongoing work and mission of The ISIS Foundation.

2. Confidentiality of subjects:

a. Data will be collected in a way that will protect the confidentiality of subjects.

b. This protection will be provided by:

c. Data sheets will not identify the name of the head of household/interviewee.

d. Data will be stored in a locked cabinet in the field or on password-protected computer.

3. Researchers will use pseudonyms in any material produced from the result of this research:

   a. No project village will be referred to by name.

   b. No NGO or INGO, including ISIS, will be referred to by name.

   c. No individual will be referred to by name, though information such as age, sex and occupation may be attributed to quotes or anecdotes told by interviewees.

4. Generation and publication of data collected by ISIS employees or using ISIS project equipment or ISIS funding:

   a. All research projects conducted with ISIS funding or using ISIS equipment must be approved by the ISIS Foundation Research Manager prior to commencement.

   b. All published reports using data generated with ISIS funding or using ISIS-funded equipment or staff time must be co-authored by the ISIS Foundation Research Manager.

   c. All published reports from research funded by ISIS or using ISIS equipment must acknowledge The ISIS Foundation's support, using the following language:

      i. "The author/authors gratefully acknowledge the support of The ISIS Foundation, without which this research would not have been possible."

5. Research funded by or conducted with ISIS equipment will:

   a. Determine need in the target region.

   b. Monitor outcomes associated with ISIS-funded projects.

   c. Provide information that is useful to partner NGOs.

d. Provide information that is useful for other INGOs/NGOs working in the same/similar field.

6. ISIS employees intending to do research in a project area/region that is not funded by nor directly relating to ISIS projects will alert the ISIS Research Manager to the proposed research (initial if ISIS employee)

7. ISIS employees or volunteers intending to be interviewed on behalf of the ISIS Foundation for radio/TV/newspapers/etc. will alert the ISIS Research Manager to the proposed interview and will make a draft of the story available to the ISIS Research Manager with enough advance time for us to suggest changes if necessary.