RELATIONSHIP BETWEEN IN DOOR AIR POLLUTION AND ACUTE RESPIRATORY INFECTIONS AMONG CHILDREN IN UGANDA.'

BY

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Acronyms

ARI	Acute Respiratory Infections
CO	Carbon monoxide
CI	Confidence Interval
DALY	Disability-Adjusted life Years
EPA	Environmental Protection Agency
ETS	Environmental Tobacco Smoke
IAP	Indoor Air Pollution
LPG	Liquefied Petroleum Gas
LPM	linear Probability Model
MoH	Ministry of Health
OLS	Ordinary Least Squares
OR	Odds Ratio
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
SES	Socioeconomic Status
TSP	Total Suspended Particulate
UDHS	Uganda Demographic and Health Survey
UNEP	United Nations Environmental Program
WHO	World Health Organization
WRI	World Resources Institute

Declaration

This research paper is my original work and has not been presented for award in anv other university.

Ambrose Sansa

C50/7190/2002

Approval

This research paper has been submitted for examination with our approval as university supervisors.

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Finally, I would like to state that I am wholly responsible for any errors in this paper.

Dedication

To Dan Kirabo.

Abstract

Evidence from die UDHS 2000/01 data suggests that the prevalence of acute respiratory infection among children below the age of 5 year is 18.33 per cent. Children between the ages 6-35 months were more likely to suffer from ARI compared to their counterparts below 5 months and above 35 months. The highest percentage of children who suffered from ARI were from the Northern region followed by Eastern region. Central and western regions had the lowest ARI prevalence. The logistic results showed that exposure to cooking smoke from biomass combustion increases the odds of contracting ARI. Relationship between ARI and other fuels such as LPG and electricity was found to be not significant.

The logit results showed that living standards of households were significantly related to the ARI case. The highest percentage of children, who suffered from ARI within 2 weeks prior to the survey, lived in households with low living standards. Children from medium and high-income household had much lower probability of suffering from ARI compared to those from low-income households.

The most vulnerable group is the rural poor who predominantly use biomass for long hours in poorly ventilated shelter. Even with biomass, using improved stoves could minimize exposure to carbon monoxide and improve efficiency. Efficient stoves use less biomass to obtain the requn-ed amount of energy and reduce the quantities of particulate matter emitted. Government policies should be designed towards increasing income of the rural poor and basic health care education should be available to rural communities regularly to sensitize households of the potential dangers of indoor air pollution.

CHAPTER ONE

1.0 Introduction

Traditional environmental hazards, such as lack of safe water and sanitation, exposure to disease vectors and indoor air pollution, determine by far the health outcomes of the poor in developing countries. For that matter detenoration in the environment affects the poor who constitute the majority of the population in developing countries. Environmental hazards that increase health risks are generally categorized under environmental health. Environmental health refers to aspects of human health, including quality of life, that are determined by physical, biological, social and psychosocial factors in the environment (WHO 2001). Table 1 depicts the burden of disease from major environmental risks by region.

Table 1: Burden of disease from major environmental risks

Percent of all Disability-Adjusted Life Years'									
Environmental health risks	SSA	India	Asia& Pacific	China	MN A	LAC	FSE	IC	All DCs
Water supply and Sanitation	10	9.0	8.0	3.5	8.0	5.5	1.5	1.0	7.0
Vector iseases (malaria)	9.0	0.5	1.5	0.0	0.3	0.0	0.0	0.0	3.0
Indoor air pollution	5.5	6.0	5.0	3.5	1.7	0.5	0.0	0.0	4.0
Urban air pollution	1.0	2.0	2.0	4.5	3.0	3.0	3.0	1.0	2.0
Agro-industrial waste	1.0	1.0	1.0	1.5	1.0	2.0	2.0	2.5	1.0
All causes	26.5	18.5	17.5	13	14	11	6.5	4.5	18

*(Source: Murray and Lope% 1996)**

DALYs are a standard measure of the burden of disease. The concept of DALYs combines life years lost due to premature death and fractions of years of healthy life lost as a result of illness or disability.

Notes: * Regions slightly differ from World Bank Regions. See a definition in World Bank 1993 and Murray and Lopez 1996. Note that Asia and Pacific includes countries from East and South Asia, except for china, India, Pakistan, and Afganistan. FSE means "former socialist economics of Europe" and does not include Central Asia. SSA is sub-Saharan Africa, LAC is Latin America and Canbbean, MNA is Middle East and North Africa, ICs stands for industrialized countries, and DCs is developing countries. Source: Murray and Lopez 1996.

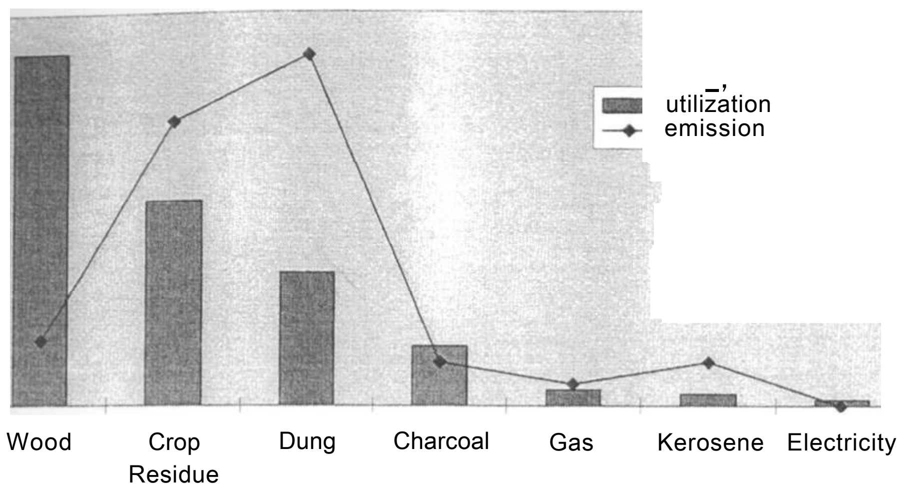
Overall the environmental health burden as a percentage of the total disease burden is highest in regions that house most of the world's poor (27 percent in Africa and 18 percent in Asia) and lowest in industrial countries. The impact of traditional environmental health hazards exceeds that of modern hazards by a factor of 10 in Africa, 5 in Asian countries (except China), and 2.5 in Latin America and Middle East. Modern threats to human health, that is, urban air pollution and agro-industrial waste, prevail predominandy in rich countries and in European countries undergoing economic transition than in poor countnes. Inadequate Water Supply and Sanitation pose the largest threat to human health as indicated in the table above, except for China and the transition economies of Europe, where air pollution causes the most damage. Indoor an- pollution is the greatest threat in India and Africa accounting for 6.0 and 5.5 respectively. Malaria has taken a heavy toll on the population of Sub-Saharan Africa.

According to the World Resources Institute and World Bank (1998), around two-thirds of the population of less developed countries still rely on bio-fucls (wood, dung and crop residues) for domestic energy. Smith (1987) further argues that this fuel is typically in open fires or simple stoves, often indoors, and rarely with adequate ventilation or chimneys. This situation leads to some of the highest ever-recorded levels of air pollution, to which young children and women in particular are exposed for many hours each day.

Smith (1983) emphasizes diat biomass fuels are at rhe low end of the energy ladder in terms of combustion efficiency and cleanliness. Smoke from biomass combustion produces a large number of health-damaging air pollutants including respirable particulate matter, carbon monoxide (CO), nitrogen oxides, formaldehyde, benzene, 1,3 butadiene, polycyclic aromatic hydrocarbons (such as benzo[a]pyrene), and many other toxic organic compounds. Although smoke from bio-fuels contains thousands of substances, many of which may be harmful to health, it is particulates that are thought to best describe the health-damaging potential of this pollution. Particles are defined by their diameter, expressed in microns. Smaller particles of less than 10 microns (PM$_{](1)}$),.are thought most harmful due to their ability to penetrate into the lungs. Concentrations are expressed as the weight of PM,$_{0}$ (in micrograms, or mg) per cubic meter of air sampled, written as mg/m^3. Current US Environmental Protection Agency (EPA) recommendations are that average 24-hour PM$_{1(}$, levels should exceed 150 m

g/m^3 only once in 100 occasions (99^{th} percentile level), and that the annual average should not exceed 50 m g/m\ Average particulate concentrations in homes in Uganda are at least 9q t^es the levels recommended by EPA. Figure 1 below shows the various fuel types used in households and the corresponding emissions.

Figure 1: Fuel type utilization and emission along the household fuel ladder in Uganda.



Source: Uganda National Bureau of Statistics (1999).

The survey carried out by die Uganda National Bureau of Statistics in 1999 showed that wood is the most used source of fuel at 45% followed by crop residue and animal dung at 25% and 20% respectively. Electricity is the least used source of domestic energy at about 1% followed by gas and Kerosene with 2% and 3% respectively. However, the most utilized energy sources in Uganda were unfortunately the least energy efficient and emitted the highest grams of particulate matter per meal. Animal dung and crop residue emitted 45g/meal and 35g/meal, whereas electricity emitted negligible amount.

Exposure to these pollutants has been shown in several recent studies to be casually linked to several health effects especially in women who use these fuels for cooking and young children. Epidemiological studies" have shown that Indoor Air Pollution (LAP) from bio-fuels is responsible for the Acute Respirator^ Infections (ARI), Chronic Pulmonary diseases, Lung cancer, pulmonary tuberculosis, Cataract, and adverse pregnancy outcomes. In Uganda, as in many other developing countries, ARI are the leading cause of child-hood illness and mortality, accounting for an estimated 6.5% of the national burden of disease (Viau 2000). The table 2 below shows the estimates of diseases related to indoor and outdoor air pollution.

Table 2: Estimates for Indoor and Outdoor Air Pollution

Air pollution related diseases	Outdoor (%)	Indoor (%)	DALYs Attributed (OUT)	DALYs Attributed (IN)
Acute respiratory infections	0.1	0.9	1,856.46	16,708.14
Ischemic heart disease	0.6	0.4	142.02	94.68
Chronic Obstructive pulmonary	0.7	0.3	639.1	273.9
Asthma	0.5	0.5	178.25	178.25
Trachea,Bronchus,Lung Cancer	0.7	0.3	39.375	16.875
Cerebrovascular diseases	0.4	0.6	183.8	275.7
Tuberculosis	0.3	0.7	763.8	1,782.20
Trachoma	0.1	0.9	5.24	47.16
Cataract	0.1	0.9	16.22	145.98
			3,824.27	19,522.89

(Source: WHO 1999)

The table above shows that Disability-Adjusted Life Years (DALYs) attributed to indoor air pollution is about six times DALYs attributed to out door air pollution. The three major illnesses associated with air pollution include Acute Respiratory Infections, Tuberculosis and Chronic Obstructive pulmonary. Out door air ambience accounts for 70% of the Chronic Obstructive Pulmonary infections while in door air ambience accounts for 70% of Tuberculosis and 90% of the Acute Respiratory Infections. Other infections that rank lowest include Cataract, Ischemic heart disease and Trachoma accounting for 5.85%, 2.1% and 1% respectively.

1.1 Major Biomass Combustion Pollutants

1.1.1 Poly cyclic-Aromatic Hydrocarbons

Many traditional fuels emit polyty'clic aromatic hydrocarbons (PAH) such as benzo(a)pvrene v*

(BaP), naphthalene, fluorene, phenanthrene and acenaphthene, which have been identified as priority pollutants by the International Agency for Research on Cancer (IAllC) owing to their carcinogenic potential. Urinary 1-hydroxypyrene (1-OHP) has become a standard biological indicator for overall PAH exposure. Indoor inhalation of PAH from cooking appears to pose a substantial health hazard (Mishra, et al 1999). In Burundi, for example, villagers in two rural areas with traditional mud and thatch homes had average geometric mean unnarv 1-OHP levels 30 times that found among inhabitants of the capital Bujumbura. BaP exposure among the urban poor exposed to cooking wood smoke has been estimated to compare with an exposure of more than two packs of cigarettes per day.

1.1.2 Carbon Monoxide

Incomplete combustion of fuels produces carbon monoxide (CO). The CO and particle emission pose a serious problem when biomass fuels are used. Smith (1991) has estimated that about 38, 17, 5 and 2 g/meal carbon monoxide is released during die household cooking, using dung, crop residues, wood and kerosene respectively. During the use of liquid petroleum gas (LPG) a negligible amount of CO is released. A study 12 by the National Institute of Occupational Health (NIOH), Ahmedabad reported indoor air CO levels of 144, 156, 94, 108 and 14 mg/m^ air during cooking by dung, wood, coal, kerosene and LPG respectively. The short-term health effects of CO exposure are dizziness, headache, nausea, and feeling of weakness. The association between long-term exposure to carbon monoxide from cigarctte smoke and heart disease and foetal development has been described by several authors (Wvnder, 1979).

1.1.3 Formaldehyde

Patcl and Raiyani (1995) measured levels of formaldehyde in indoor environment during cooking bv different fuels. The formaldehyde mean levels were 670, 652, 109, 112 and 68 jiig/m [1] of air for catde dung, wood, coal, kerosene and LPG respectively. The formaldehyde is well recognized to be an acute irritant and long-term exposure can cause a reduction in vital capacity and chronic bronchitis. The formaldehyde is well known to form cross-links with biologic macro-molecules. Inhaled formaldehyde forms DNA and DNA-protein cross-links in the nasal respiratory mucosa. The formaldehyde has been shown to be carcinogenic in a dose dependent fashion in rodents (Swenberg, et al 1980). The studies done in workers occupational^ exposed to formaldehyde have consistendy shown higher incidence of leukaemia (Blair, A et al 1990).

1.2 Health Effects

Epidemiological studies have been limited by the fact that both short-term outcomes such as acute respiratory infections (ARI) and long-term outcomes like cancer and obstructive lung diseases can have multiple determinants. Long latency periods between exposure and disease outcomes have also clouded the picture. More subde household and socio-economic confounding factors such as arrangement of rooms, floor type and ownership of a television or radio have also hampered some studies on respiratory health in developing countries. Nonetheless, a growing body of literature has begun to document a variety of health problems of enormous proportions.

1.2.1 Acute Respiratory Infections

ARI comprise a set of clinical conditions of various etiologies and sevendes that are generally divided into two main forms: upper respiratory tract infections (UR1) and lower respiratory tract infections (ALRI). The risk of severe ARI, which can be fatal, is highest in very young children and in the elderly. Clinical and epidemiological criteria are available for separating URI from ALRI but, unfortunately, worldwide there are no uniformly accepted criteria and the definitions in use are not fullv consistent. For research and case management under field conditions in less developed countries the WHO defines URI to include any combination of the following symptoms: cough with or widiout fever, blocked or runny nose, sore throat, and/or ear discharge. URI can usually be treated successfully with supportive therapy at home. ALRI include severe ARI involving infection of the lungs, with pneumonia being the most serious form (Pasternack, 1998). Serious infections are most commonly caused by bacteria, although they may sometimes be viral. Clinical signs of ALRI include any of the above symptoms of URI widi the addition of rapid breathing chest indrawing and/or stridor. Severe ALRI caused by bacteria are treated with antimicrobial therapy, without which they can sometimes be fatal (WHO, 1991).

1.2.2 Chronic pulmonary diseases

In Sub-Saharan Africa alone, indoor pollution is responsible for over 80% of cases of chronic bronchitis^ and for most cases' of emphysema and chronic obstructive pulmonary disease. Padmavati, (1964) pointed out to the relationship between exposure to indoor air pollutants and chronic obstructive lung disease leading to chronic cor pulmonale. These studies showed that in Gambia, the incidence of chronic cor pulmonale is similar in men and women despite the fact that 75% of the men and only 10% women are smokers. Further analysis of the cases of chronic cor pulmonale in men and women showed that chronic cor pulmonale was more common in younger women. The prevalence of chronic cor pulmonale was lower in the southern districts than the northern districts of Gambia. This is attributed to higher ambient temperatures during most part of the year allowing for greater ventilation in the houses during cooking. The authors attributed this higher prevalence of chronic cor pulmonale in women to domestic air pollution as a result of the burning of solid biomass fuels leading to chronic bronchitis and emphysema which result in chronic cor pulmonale. Numerous studies from other countries, including ones with cross-sectional and case-control designs, have reported on the association between exposure to biomass smoke and chronic bronchitis or chronic obstructive pulmonary disease (Dutt, 1996). Other health effects associated with indoor air pollution include Lung cancer, pulmonary tuberculosis, cataract, and adverse pregnancy outcomes.

1.3 ARI Prevalence in Uganda

Kirkwood et al (1995) reported a significant relationship between use of biomass fuels and ARI on the basis of analysis of data collected from the National household survey for Uganda. Persons living in households burning biomass fuels were reported to have odd ratio of 2.58 (1.98-3.37) compared to the persons using cleaner fuel, with an adjustment for confounding factors such as separate kitchen, indoor overcrowding, age, gender, and urban or rural residence. The analysis further indicated that, among persons aged 20 years and above, 51% of the prevalence of active ARI was attributed to smoke from cooking fuel.

This study did not control for the confounding factors except for age. It was pointed ouL in this study that besides the fuel quality, the impact of indoor air quality depends dnectlv on ventilation and air mixing of the space. There was experimental evidence to show that reduction in ventilation increased exposure to wood smoke, which consequently increased susceptibility of the lungs to infections* Hxposure to smoke interferes with the mucociliary defenses of the lungs and decreases several antibacterial properties of lung macrophages, such as adherence to glass, phagocytic rate and the number of bacteria phagocytosed (Beck and Brain, 1982). Chronic exposure to smoke has been associated with tuberculosis blindness of 1.32 (1.16-1.50) in respect of persons mainly using biomass fuel compared with other fuels after adjusting for housing and geographical variables; there was a lack of information on smoking, nutritional state, and other factors that might have influenced the prevalence of ARI. The figure below shows emissions per meal of the various energy sources used across die country.

1.4 Problem Statement

World Health Organization has estimated that around three quarters of the total global burden of exposure to particulate air pollution is experienced indoors in developing countries: 50% in rural areas and 25% in cities (WHO, 1997). Whilst these figures are not disaggregated by age, it is known that young children are at high risk of exposure, because they are usually with their mothers in the kitchen. In fact a study on bio-combustion, air pollution and health conducted in rural Uganda found ARI prevalence in children below age 5 to be as high as 6.6% in houses using bio-fuels (Becks and Brian, 1982).

The national distribution of exposure is in striking contrast to the focus of attention and resources for research and policy on indoor air pollution, which has been largely dnccted on the outdoor pollution. The implications of this are threefold. Firsdy, there is limited knowledge on association between ARI prevalence and exposure among children below age 5. Secondly, the magnitude of correlation between ARI prevalence and socio-economic conditions of households in which children live is unknown. There is, therefore, uncertainty about the potential that improved socio-economic condition has for prevention of ARI. Thirdly, the exposure-response relationship for the three categories of fuels has not been quantified; widi the result that it is not known by how much exposure needs to be reduced in order to achieve useful, health gains. This has important implications for policy implementation because there are currendy substantial technical and economic barriers to achieving large reductions in exposure among many poor communities for whom pollution is worst.

1.5 Hypothesis of the Study

The studv attempts to address the following hypothetical research questions:

1. Is there a significant relationship between cooking fuel type and ARI prevalence in Uganda?
2. Is socioeconomic status significandy related to ARI prevalence?
3. Does maternal education influence ARI prevalence among children?

Hypothesis tests were carried out to assess the significance of the variables in question so as to get answers for the research questions. In order to carry out the tests of significance on the estimated coefficients (/?,)> anc^ alternative hypotheses *(H_q and //, respectively)* were set as follows:

1. $H_0 : J3_I = 0$ => There is no significant impact of cooking fuel type on ARI prevalence.
2. $H_q : P_t = 0$ => Socioeconomic Status has no significant effect on the ARI prevalence.
3. $H_0 : P_t — 0$ => Maternal education has no significant effect on the ARI prevalence among dieir children.

The probability values were used to evaluate whether to accept or reject the null hypothesis. Rejecting null hypotiiesis implies that the coefficient in question is significandy different from zero hence statistically significant and vice versa.

1.6 Study Objective

The purpose of this study therefore, was to provide information that will contribute to critical needs in the development of policies focusing on indoor ambience. The study aimed at providing practical information to^guide decision-making and implementation. The specific objectives of the study were to:

- Estimate ARI prevalence among children below the age 5 years in Uganda regardless of the fuels tvpe used by their households.
- Determine the extent to which ARI prevalence among children is related to socio-economic conditions of the households in which they live.
- Quantify the exposure-response relationship for high, medium, and low polluting fuels separately.

1.7 Justification of the Study

The 1991 National Housing and population census for the first time inquired about the fuel used for cooking. It revealed that over 90% of the rural population relied upon biomass fuels like animal dung, crop residues and wood. The type of fuels used by a household is influenced by its economic status. In the energy rung, biomass fuels, which are the dirtiest fuels, lie at the bottom and are used by the poor people. Electricity, which is the most expensive, lies at the top of ladder and it is also the cleanest fuel. As a result, a large population of the country faces a risk of contracting ARI. This may translate in declined productivity in agricultural sector, the backbone of the economy. On the other hand, the government will face escalated financial costs on health interventions. The study will highlight environmental health as a critical area of public expenditure to alleviate disease and poverty.

1.8 Organization of the Study

The rest of this study is organized as follows: chapter 2 presents a review of literature on the ARI prevalence and bio-fuel combustion while chapter 3 presents model specification, type of data and data sources. Chapter 4 presents econometric results and discussion while chapter 5 presents conclusions, policy suggestions, limitations and suggests areas of further research.

CHAPTER TWO

2.1 Literature Review

Introduction

Kirkwood *et al* (1995) argue, "supplying modern energy services to the 2 billion people who still cook with traditional solid fuels and lack access to electricity is probably one of the most pressing problems facing humanity today". They also further suggest that living standards in rural areas can be significandy improved by promoting a shift from direct combusdon of biomass fuels (dung, crop residues, and fuel wood) or charcoal in inefficient and polluting stoves to clean, efficient liquid or gaseous fuels and electricity. Although consumers tend to shift to these modern, higher-quality energy carriers as their incomes rise, the process is slow. Yet a shift to such carriers can reduce die damage to human health and die drudgery associated with continued reliance on inefficient, polluting solid fuels. According to (Graham, 1990), indoor air pollution caused by burning such traditional fuels as wood, crop residues, and dung is less evident, yet it is responsible for a significant part of countrys' and global disease burdens. The main groups affected arc poor women, children in rural areas, and urban slum dwellers as they go about then' daily activities.

2.2 Review of Theoretical Literature

The impact of indoor emissions on air quality depends directly on ventilation and air mixing of the space. Most housing in developed countries lie at temperate latitudes and has relatively low exchange rates of indoor with outdoor air, typically one air change per hour or less (Murray and Burmaster, 1995). Even low emission rates in such housing can result in mdoor pollutant concentrations at levels of public health significance. Ventilation rates for houses in developing countries, which lie primarily in tropical and subtropical regions of the world and are often open to die outdoors, are likely to be greater. Strong sources can be readily identified in developing countries, however, including biomass and charcoal burning for cooking and heating.

Indoor pollutants can be grouped by source into four principal classes: combustion products; semi-volatile and volatile organic compounds released by building materials, furnishings, and chemical products; pollutants in soil gas; and pollutants gen . rated by biological processes. (Spengler and Samet, 1991). The principal combustion pollutants include carbon monoxide, nitrogen and Sulphur-oxides, particles, and volatile organics. The complex mixture in indoor air produced by tobacco smoking has been referred to as Environmental Tobacco Smoke (ETS). A wide variety of semi-volatile and volatile organic compounds can be found in indoor air and; there are diverse sources of these compounds. The gas from the ground beneath a home may contain pollutants such as radon and termidicides that may adversely affect health. There are many biological agents in indoor environments including, for example, pollens and moulds, insects, viruses, and bacteria.

In a significant proportion of the households using biomass fuels, the bulk of the emissions are released into die living area (Smith, 1987). Although rates of exchange of indoor with outdoor air are relatively high in most housing in developing countries, the pollutant emission rates for such fuels are also high, and indoor concentrations and associated exposures can be high as a result. Compared with gas stoves, even stoves using wood, one of the cleaner bio-fuels, can release 50 times more pollution during cooking. Incomplete combustion of unprocessed solid fuels produces hundreds of chemical compounds under the operating conditions of simple cooking stoves. Such complex mixtures are produced by burning of bodi charcoal and biomass fuels, although the blends of compounds in the smokes are different. Unlike biomass fuels, charcoal generally contains fewer intrinsic contaminants (sulphur, trace metals, and ash) and, under proper conditions, they can be burned without releases other than the products of complete combustion (carbon dioxide and water). Unfortunately, optimum conditions for complete combustion are difficult to create with inexpensive household devices.

Smoke from cooking stoves is a complicated and unstable mixture (Marbury, 1991). Biomass fuel smoke contains significant quantities of several pollutants for which many countries have set outdoor air quality, standards"—for example, carbon monoxide, particles, hydrocarbons, and nitrogen oxides. In addition, the aerosol contains many organic compounds considered to be toxic or carcinogenic, such as formaldehyde, benzene, and polvcyclic aromatic hydrocarbons. The composition of the smoke varies with even minor

o " **As at the rime oi this study, Uganda does not have indoor ambience standards.**

changes in fuel quality, cooking stove configuration, or combustion characteristics. There is ample evidence that particles are generally of the small sizes thought to be most damaging to health (Kleeman *et al.,* 1999).

Although a large-scale national wide survey of smoke concentrations has not been conducted, the findings of studies provide an indication of typical indoors concentrations of the major pollutants. We cannot presendy derive an accurate estimate of the total population in Uganda exposed to indoor concentrations that would be considered unacceptable, nor can we readily apportion the contributions to total personal exposure of indoor and outdoor sources. Assuming that indoor standards should be at least as stringent as outdoor standards, the number of people exposed at unacceptable levels indoors is expected to rival or exceed the number exposed to unacceptable ambient concentrations in the industrial towns (UNEP/WHO, 1998). Consideration of time-activity patterns, with far more time spent indoors than out doors, suggests that the total national dose equivalent (amount actually inhaled) for in-door pollution could be an order of magnitude greater than from ambient pollution (Smith, 1993).

There is now consistent evidence that indoor air pollution (LAP) increases the risk of childhood acute respiratory infections, the most important cause of death of children under-5 years in least developed countries; and there is also association with birth weight, infant and perinatal mortality, pulmonary tuberculosis, some forms of cancer and cataract. Although the risks are poorly quantified, indoor air pollution may be responsible for nearly 27,000 excess deaths of children under 5 years and over 5.0% of the national burden of disease (Bruce, 2000).

2.3 Review of Empirical Studies

Acute respirator}- infections cause four and a half million deaths among children every year, the overwhelming majority occurring in developing countries (Mishra, 1997). Pneumonia unassociated with measles causes 70% of these deaths; post-measles pneumonia 15%; pertussis 10%; and bronchiolitis and croup syndromes 5%. Both bacterial and viral pathogens are responsible for these "deaths. The most important bacterial agents are Streptococcus pneumoniae, aemophilus influenzae, and Staphylococcus aureus. The data on bacterial etiology of pneumonia during the first 3 months of life are limited, and almost no information on the role of chlamydia and pertussis in this age period is available. The distribution of viral pathogens in developing countries can be summarized as follows: respirator)' syncytial virus, 15%-20%; parainfluenza viruses, 7%-10%; and influenza A and B viruses and adenovirus, 2%-4%. Mixed viral and bacterial infections occur frequendv. Risk factors that increase the incidence and severity of respiratory infection in developing countries include large family size, lateness in the birth order, crowding, low birth weight, malnutrition, vitamin A deficiency, lack of breast feeding, pollution, and voung age. Effective interventions for prevention and medical case management are urgently needed to save the lives of many children predisposed to severe disease (Master, 1974).

Broadly, the studies have examined the relationship of the outcome measure with cooking practices such as use of an open wood fire compared with cleaner such as kerosene, behavioral practices - for example carriage of babies on mother's back while cooking and smoking air-cured tobacco. (Odinaev, 1992). Extremely high mean levels of various gaseous pollutants were measured and a mean exposure time of 3.1 hours per day was the estimate but, unfortunately, the difference in exposure levels among households using wood, kerosene, charcoal and gas were reported and there was no control group of infants. It is thus difficult to draw any definite quantitative conclusions about the relationship between exposure and the prevalence of ARI (MoH, 1998). One main concern raised in this study has been the paucity of quantitative exposure data for these pollutants. Further, many studies have been conducted with small sample size that do not adequately capture the influence of exposure variables such as the type and the location of kitchen, type of stove, and type of fuel on actual exposures. Lack of quantitative exposure information has prevented drawing definitive conclusions and the development of accurate dose-response relationships.

Armstrong and Campbell (1991) conducted a study in a rural population-based cohort of approximately 500 Ugandan children under five years old. Incidence of respiratory infections was related to various risk factors including parental smoking and regular carriage on the mother's back while cooking, a proxy measure for exposure to smoke from cooking fires.
Two statistical analyses using "child-wedts-at-risle" approach were carried out, including and excluding multiple a disease episodes in the same child. Weekly surveillance for ARI found 75

episodes in 62 children. Stratified analyses using both approaches suggested father's smoking, and, for girls only, carriage on the mother's back while cooking and being part of a polygamous family were the main risk factors associated with infection: when multiple episodes occurring in the same child were excluded, not having a health card was an additional risk factor in children over a year old. Multiple logistic regression modelling of data from both approaches, including each of these risk factors and sex, age, village and season, suggested father's smoking, carriage on die modier's back while cooking and being part of a polygamous family increase risk of ARI, the latter two for girls only the analysis excluding multiple episodes in the same child also suggested that not having a health card is a risk factor for children aged 1-5 years.

The effect of domestic cooking fuels producing various respiratory symptoms was studied in 3,701 women. Of these, 3,608 were nonsmoking women who used four different types of cooking fuels: biomass, LPG, kerosene, and mixed fuels. The overall respiratory symptoms were observed in 13 percent of patients. Mixed fuel users experienced more respn-atory symptoms (16.7 percent), followed by biomass (12.6 percent), stove (11.4 percent), and LPG (9.9 percent). Chronic bronchitis in dung users was significandy higher than that in kerosene and LPG users ($p < 0.05$). Dyspnea and postnasal drip were significandy higher in the women using mixed fuels. Smoking women who are also exposed to cooking fuels experienced respiratory symptoms more often than nonsmokers (33.3 percent vs 13 percent) (Behera *et al,* 1991).

The effects of indoor environmental factors on respiratory illness were studied in 15017-12 year old school children of Mukono and Iganga districts in Uganda. Exposure to mosquito coil smoke for at least three nights a week was independendv associated with asthma and persistent wheeze. Passive smoking, defined as sharing a bedroom with an adult smoker, was independently associated with a chest illness in the past year. No relationships were found between exposure to kerosene stoves, wood stoves, fumigation chemicals, mosquito repellents or aerosol insecticides and respirator}' illness. Host factors predictive of at least one respirator)' outcome included family history of chest illness, history of allergy, male sex, hospitalization in the neonatal period and low paternal education. With 95% confidence, avoidance of regular exposure to mosquito coil smoke and passive smoking could reduce the prevalence of persistent wheeze, asthma and chesi illness by up to 29%. Measurements of lung function confirmed the validity of questions pertaining to wheezing and asthma in the study questionnaire (Azizi and Henry, 1991).

The study from urban Uganda by Mika (2002) matched on die fuel type used, kitchen spacing, ventilation and district of residence. This study found a large odds ratio (9.9; 95% CI 1.8 to 31) for home heating with charcoal in patients with hospital diagnosed ARI compared with controls matched by kitchen spacing and ventilauon and other factors often addressed only by multivariate analysis in other studies. No pollution measurements were reported and little information was provided about the type of stove and fuel involved. Cooking witii gas (radier dian electricity) also produced a significant odd ratio (2.2, 95% CI 1.2 to 3.9).

A study of ARI in infants aged less than one year in Uganda found somewhat conflicting results in urban slum communities where some households used biomass fuels and kerosene. This was possibly due to strong interference by large-scale urban outdoor pollution and local outdoor "neighborhood" pollution from the cooking stoves themselves and otiier neighborhood sources (Azizi and Henry, 1991).

Air pollution studies in Uganda and Gambia suggested that conditions were favorable for detecting a relationship between concentrations of pollutants and lower respiratory diseases in children because of the homogeneity of levels among households (Anderson, 1978).

2.4 Overview of Literature

While a variety of literature has covered the conuibution of various exposure variables, there have been some shortcomings noted. For instance, major concern in some of the studies has been the paucity of quantitative exposure data for these pollutants. Secondly, other studies have been conducted widi small sample size that do not adequately capture the influence of exposure variables such as the type and the location of kitchen, technology of cooking stove, and type ot fuel on actual exposures. Therefore risk estimates from individual studies are imprecise because of relatively small sample size and misclassification of exposure and outcome. Given the imprecision and uncertainty in characterizing the risk of biomass smoke exposure, quantitative risk assessments cannot be offered with great confidence.

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CHAPTER THREE

This chapter is organized as follows: section 3.1 discusses the theoretical model; section 3.2 explains the variables used in the model; section 3.3 gives the logit model; section 3.4 presents the data type and sources; and section 3.5 explains the estimation technique.

3.1 Estimation Methodology

Some studies like Isabelle et al (2002) employed the Linear Probability model to analyse out door air pollution and ARI among children in developing countries. LPM is linear-in-coefficients equations used to explain variations in a dummy dependent variable. The phrase "linear probability model" comes from the fact that the right-hand side of the equation is linear, while the expected value of the left side is a probability.

The LPM of an acute respiratory infection is given as follows:

' Y, = ft, + (3,X, + s,

Where Y = 1 if an individual has ARI

Y = 0 if an individual does not have ARI.

X, = a vector of children characteristics.

j3,, = intercept term

(3, = vectors of explanatory variable coefficients or parameters

Ej = error term

However, LPM has the following drawbacks; firstly, the error term is not normally distributed because the dependent variable takes only two values, the error term is bimodal for small samples and approaches the normal distribution only for large samples. Secondly, the error term is inherently heteroskedastic. This implies that the variance of the error term [P^1-Pj] is not constant since P, can vary from observation to observation. P, is the probability that Y, takes a value 1 and (1- PJ is the probability that Y, takes on a value 0. Thirdly, adjusted R-square is not an accurate measure of overall fit. In LPM, all the observed Y, take on either 0 or 1 but estimated varies from one extreme value to the other. As a result, adjusted R-square is often quite low even if the model does an excellent job of explaining the decision maker's choice. Finally, the estimated Y, is not bounded by 0 and 1.

Exceptionally large or small values of explanatory variables can produce values of P, outside the meaningful range of 0 to 1. Violation of the 0<=E(Y | Xi)<=1 restriction is the main problem with OLS estimation of the LPM.

These limitations of the LPM can be addressed by using a method that confines the estimated Y, to range from 0 to 1 in a smooth and meaningful fashion. This method utilizes binary response models such as logit or probit. Choice between logit and probit entirely depends on assumptions made about probability distribution of die error term. In the logit model the error term follows a logistic distribution and in probit the error term follows a normal function. However, when plotted, the logistic and standard normal cumulative distribution functions take a similar shape. Most researchers prefer the logit model because it is less cumbersome and yet gives nearly die same results as the probit model.

3.2 Measurement and Definition of Variables

Measurement issues arc potentially a problem for all analytical work especially for mcdical variables. Since it still appears to be difficult to find reliable systematic data on exposure. Many researchers, including Smith (1998), have instead simply included proxies such as fuel types, time spent cooking and type of stove. For this particular purpose of looking at the impact of energy sources and socio economic characteristics of households, we also adhere to this imperfect measure[3].

3.2.1 Data Definition

Acute Respiratory infections (ARI): Worldwide, there are no uniformly accepted criteria and the definitions in use are not are fully consistent. This study utilizes the WHO definition which defines ARI to include any combination of the following symptoms: cough with or without fever, blocked or runny nose, sore throat, and/or ear discharge with infection of the lungs and pneumonia being the most serious forms (WHO, 1991).

[1] See AUshra (1997) for a detailed discussion of ARI definition and measurement and their shortcomings

Fuel type: Fuel type refers to the sources of energy used for cooking, heating and lighting. The fuel types were classified into three categories, that is, high, medium, and low polluting (UI)HS, 2000/01).

Age (months): Age refers to the period from the time the child was born to the time when the questionnaire was administered. Age was recorded in number of completed months (UDHS, 2000/01).

Sex: Sex refers to the gender of the child. The child can be male or female.

Birth order: Birth order refers to the order of succession of children in a given household as indicated by their age. The child with the highest age in die household was assigned 1 the second was assigned 2 and so on until the youngest (UDHS, 2000/01).

Mother's Education: Mother's education refers to academic level attained. This was categorized as follows; primary, secondary, A-levels, Tertiary, others.

Household Standard of Living (SLI): Household standard of living index (SLI) is calculated by adding the following scores: 3 for a car or tractor; 2 each for a motorcycle, TV, telephone, refrigerator, piped/public tap water, flush toilet, electricity, wood/vinyl/ceramic/ cement/carpet of main floor material; 1 each for a bicycle, radio. Index scores range from 0-2 for low SLI, 3-8 for medium SLI, 9-21 for high SLI (Mishra 1997).

Residence: Residence was categorized as either urban or rural (UDHS, 2000/01).

Region: Refers to the area of Uganda where the household is situated. The country is subdivided into five regions, that is,-central, eastern, northern and western.

Table3: Variable definitions

Variables	A prior impacts on dependent variable
Cooking fuel: 1 = high pollution 2— medium pollution 3= low pollution	Positive Positive No effect
Age of Child	Uncertain
Sex of Child (male^O, female=l)	Uncertain
Birth order	Uncertain
Mother's Education (no education=0, primary educational, secondary education=2, tertiary education =3)	Negative
Household Standard of living (low =0, middle=l, high=2)	Negative
Mother smokes (Yes=l, No=0)	Positive
Region (central=0, Eastern^l, Northern=2, Western=3)	Uncertain
Residence (urban= 1 ,rural=0)	Uncertain

3.3 The Model Specification

1 .et Y_i = Event that the child has ARI

$Y_i \in \{0,1\}$, I = 1,2,...,N.

Xfl. = \ ' explanatory vanable

where X is non-negative.

From the literature ARI prevalence can be explained by the following variables.

ARI = f(fuel type, age, sex, birthorder, maternaleducation, smoking, SLI, residence, region)..(1)

Therefore,

$$\mathbf{E(Yi)} - f(X_{i1}, \ldots, X_{ik}) \qquad (2)$$

Assuming a linear function,

$$EOT = f(X_{i1}, \ldots, x_{ik}) - \Sigma b_k x_{ik} \qquad (3)$$

According to Aldnch and Forrest (1990), there are two basic reasons why assuming a linear form is tenable.

First, linear models are madiematically simple, so that statisticians have been able to learn a lot about them, and computer programs have been written to do die estimation.

Second, the simplicity leads to their adoption, justified by a version of Occam's Razor: In the absence of any theoretical guidance to the contrary, begin by assuming the simplest case.

The structural form of equation (3) is as follows;

$$Y_i^* = \Sigma b_k x_{ik} + u_i \qquad (4)$$

Y_i^* = latent event of ARI incident.

b_k = measures the effect of exogenous vanable k on the average value of Y

Therefore using the logit model, the event of a child suffering from ARI given all odier explanatory* is;

$P(Y=1 \mid X_j = \exp(Zb_tX_{lb})/(1 I \exp dKX.J)$ (5)

$Y_1, Y_2, \ldots, Y_n$ are statistically independent.

No exact or near linear dependencies exist among the X_{lk}s.

Logit parameters are estimated by method called Maximum Likelihood Estimation (MLE). The objective of MLE is to explain the probability of observing a particular sample of N values of Y given all sets of values
That is,

$$P(Y \mid X) = \Pi_{i=1}^{N} P_i^{Y_i}(1-P_i)^{1-Y_i} \quad (6)$$

In MLE we proceed to find b so as to maximize the logit likelihood.

Thus, our regression model is expressed as follows;

$$L(Y \mid X,b) = \Pi^{N} [\exp(\Sigma b_k X_{ik})/(1+\exp(\Sigma b_k X_{ik}))]^{Y_i} [\exp(\Sigma b_k X_{ik})/(1+\exp(\Sigma b_k X_{ik}))]^{1-Y_i} \quad (7)$$

3.4 **Data Sources and Types**

The study utilizes secondary cross sectional data from the Uganda Demographic and Health Survey (UDHS 2000/01) collected by the Uganda Bureau of Statistics. The analysis presented based on information on 7113 children under age 5 years in the UDHS 2000/01. The UDHS collected demographic, socioeconomic, and health information from a nationally representative probability sample of 8,234 households and 7,885 women aged 15-49 in the sampled households, representing all 4 regions of L'ganda. The sample is a two-stage cluster sample with an overall response rate of 96 per cent. For each child under age5, the mother was asked if the child had been ill with a cough in die 2-week period preceding the survey interview. For children who had been il^with cough in the last 2 weeks, the mother was additionally asked i£-the child, when ill with cough, breathed faster than usual with short,

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rapid breaths. Children who suffered from cough accompanied by short and rapid breathing at any time during the last 2 weeks are defined as having suffered

from an acute respiratory infection. This reported prevalence of ARI is the response variable in this analysis.

Exposure to cooking smoke was ascertained indirecdy by type of fuel used for cooking. The survey used an eightfold classification of main cooking fuel- wood, dung, straw, charcoal, kerosene, electricity, liquid petroleum gas (LPG)/natural gas, and a residual category of other fuels. The question was, "what of fuel does your household normally use for cooking?" Information on fuel types was used to group households into three categories representing the extent of exposure to cooking smoke- high pollution (wood, dung, or straw), medium pollution fuels (kerosene or charcoal), and low pollution fuels (LPG/natural gas or electricity). The small residual category of other fuels (0.2 of die sample) was excluded from the analysis due to unknown nature of fuels in that category.

3.5 Estimation Techniques

Before carrying out the regression, a test of multicollincarity between the predictor variables was undertaken. In the correlation matrix of predictor variables, all pair-wise Pearson correlation coefficients should be less than 0.5, suggesting diat multicollinearity is not a major problem. The results will be represented in the form of odds ratio (OR) with 95% confidence intervals (95% CI). Interpreting logistic regression results in terms of odds ratios rather than probabilities confers certain advantages. Most important is that odds ratio is a single summary statistic for partial effect of a given predictor on the predicted variable, controlling for other predictors in the model. There is no comparable statistic for the probability. That is, it is not possible to summarize the impact on the conditional probability of a unit increase in a given predictor, net of the others (Demaris, 1992). The logistic regression models were estimated using the SI ATA statistical software package.

CHAPTER FOUR

4.1 Data Analysis and Empirical Results

In this chapter, we analyze the data and present the empirical results of the model specified in chapter three using STATA econometric package. A test for muldcollineantv among the variables is given in secdon 4.2 while section 4.3 presents a summary of descriptive statistics and the empirical results are presented in section 4.4.

4.2 Test for multicollinearity

Multicollinearity is a very common feature of regression analysis. Stricdy speaking, a set of variables is multicollinear when one of them can be expressed as an exact linear combination of the others (in the case of two variables, tiiis means that one is an exact linear function of the odier, for example, $X_{H} = a + dX_{2l}$, with no residual). However, we refer to this state of affairs as perfect multicollinearity by itself to mean that there is a high degree of correlation between the explanatory variables. The consequence of multicollinearity is that we are more likely to reject the null hypothesis when we are supposed to accept it. Secondly, we cannot be able to make reliable inference about the data using the regression results. If two variables are highly correlated one of the variables can be dropped.

Table 4 below shows the correlation matrix for the explanatory variables. By the rule of the thumb, two variables are said to be correlated if their correlation coefficient is greater than 0.5. However, from the table none of the coefficients exceeds 0.5 and we therefore conclude that the variables do not suffer serious multicollinearity problems.

Table 4: Correlation Matrix showing the correlation between the explanatory variables.

	fueltype	age	sex	birthorder	mothereduc	smoke	wealthinde	residenc	region j
fueltype	1								
age	-0.0603	1							
sexofchild	-0.0044	0.0225	1						
birthorder	-0.0453	-0.0036	0.0229	1					
mothereduc	-0.0015	-0.0133	-0.0023	-0.2563	1				
smoke	-0.0108	0.0023	0.0342	0.0318	-0.0413	1			
wealthindex	-0.0024	-0.0186	-0.0145	0.022	-0.0325	-0.0166	1		
residence	0.0099	0.0264	0.013	0.1656	-0.3564	0.0249	0.0669	1	
region	-0.0381	0.0246	0.0236	0.0682	-0.2139	0.0801	-0.2961	0.238	1

Table 5: Sample distribution and reported Prevalence of Acute Respiratory Infections (ARI) among children under age 5.

Characteristic	Sample Distribution (%)	ARI Prevalence (%)
National		18.33
Cooking fuel type		
High	77.72	21.43
Medium	21.49	16
Low	0.79	5.71
Age (in months)		
0 - 5	11.21	19.39
6 - 11	12.11	24.12
12-23	22.98	25.5
24-35	18.58	23.86
36-59	35.12	18.04
Sex		
Male	49.66	18.4
Female	50.34	18.26
Birthorder		
1	19.56	15.89
2	17.74	18.46
3	15.72	17.89
4	12.41	18.8
*5+	34.57	19.68

Table 5: Continued.

Mother's Education		
No education	23.8	17.48
Incomplete primary	52.03	19.16
Complete primary	9.83	18.31
Incomplete secondary	11.39	17.65
Complete secondary	0.51	8.3
High	2.44	14.45
Household Standard of Living		
Lowest	33.7	18.06
Medium	36.62	17.74
Highest	29.68	9.37
Residence		
Urban	23.79	7.26
Rural	76.21	18.66
Region		
Central	30.18	15.51
Eastern	27.15	22.31
Northern	27.04	21.85
Western	15.63	15.48

Over three quarters (78%) of children live in households that rely primarily on high pollution biomass fuels (wood, dung, or straw) for cooking, 21% live in households using medium pollution fuels (charcoal or kerosene), and the remaining 1% live in households using low pollution fuels (LPG/natural gas or electricity) (Table 5). The sample proportion of children by age rises until the third age bracket, drops in the fourth category and then rises sharply in the fifth category. The proportion of children in the sample drops steadily until the fourth born; from 20% for birth order 1 to 18% for birth order 2, 16% for birth order 3 and 12% for birth order 4.

Thirty-four per cent live in low standard households and 29% live in high standard households. Twenty-four per cent live inurban areas and 76% live in rural areas. By region of residence, the largest sample proportion is from Central region (30%) and smallest from

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Northern region (16%), Eastern and Western regions are equal at 27%. Eighteen **per** cent of children under age 5 suffered from an ARI during the 2 weeks preceding the survey.

The reported prevalence of ARI was much higher among children living in biomass-fuel-using households (21%) than among those living in households using low pollution fuels (16%) (Table 5). Children aged 6—35 months were more likely to have suffered from ARI than children under 6 months of age or children above 36 months. This pattern of childhood disease rates peak at 6-23 months is typical for ARI and diarrhea in manv developing countries (Mishra, 1997). This may be partly due to start of supplementary feeding around 6 months of age, which increases the likelihood of consuming contaminated foods and removes the protection provided by breast milk. Also, children start crawling around this age and are more likely to be carried outdoors, which exposes them to infections. At this age, children are old enough to be carried on the their mothers backs unlike their counterparts below 6 months. The disease rate typically declines as children grow older and start developing resistance.

Children from high standard of living households were considerably less likely to have had ARI (9%) than those from low or medium standard of living households (17-18%). The prevalence of ARI is much higher m the rural areas (18%) than in urban residences (7%). By region of residence, the prevalence of ARI ranged from Central (15%) and Western (15%) at the low end to Northern (21%) and Eastern (22%) at the high end. Prevalence of ARI did not vary much by sex of child, and birth order of child. Children whose mothers have completed secondary education and higher recorded lower ARI prevalence (8-14%) as compared to children whose mothers have no education at all or with primary education (17-19%).

4.3 Empirical results.

Table 6: Odds Ratio estimates of effects of cooking fuel type and individual characteristics on Acute Respiratory Infections prevalence among children under age 5.

	Model 1	**Model 2**	**Model 3**	**Model 4**
Characteristics	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cooking fuel type				
High pollution	1.40 (0.76,2.56)	1.91 (0.98, 3.69)	1.59 (0.81,3.10)	1.45 (0.74, 2.84)
Medium pollution	1.09 (0.49,2.41)	1.59 (0.68, 3.74)	1.38 (0.58, 3.25)	1.19 (0.50, 2.84)
Low pollution"				
Age of child (months)				
0 - 5+				
6 - 11		1.99 (1.60, 2.49)	2.02 (1.62, 2.51)	2.05 (1.64, 2.56)
12 - 23		1.93 (1.59, 2.35)	1.94 (1.60, 2.51)	1.99 (1.63, 2.42)
24 - 35		1.39 (1.13, 1.71)	1.39 (1.14, 1.71)	1.42 (1.15, 1.74)
36 - 59		0.90 (0.74,1.09)	0.90 (0.74, 1.09)	0.90 (0.75, 1.09)
Sex **of Child**				
Boy+				
Girl		1.01 (0.90, 1.12)	1.00 (0.90, 1.12)	1.00 (0.89, 1.11)
Birth order				
r				
2		1.03 (0.86, 1.24)	1.01 (0.83, 1.21)	1.00 (0.82, 1.19)
3		1.06 (0.88, 1.26)	1.02 (0.84, 1.23)	1.00 (0.82, 1.21)
4		1.07 (0.88, 1.31)	1.03 (0.84, 1.25)	0.99 (0.81, 1.21)
5+		1.16 (0.99, 1.35)	1.10 (0.94, 1.29)	1.07 (0.91, 1.25)
Mother's education				
No education'				
Primary education			1.10 (0.96, 1.25)	1.11 (0.97, 1.27)
Secondary education			0.82 (0.68, 0.99)	0.85 (0.70, 1.04)
Household standard of living				
Low ~				
Medium			0.90 (0.83,1.17)	1.44 (1.01, 1.61)
Higher			0.84 (0.76, 1.11)	1.34 (0.93, 1.59)
Residence				
Urban[T]				
Rural				1.61 (0.83,3.09)

Tabic 6: Continued

Region				
Central				1.07 (0.91,1.25)
Eastern				1.78 (1.54, 2.06)
Northern				1.69 (1.42, 2.00)
Western[T]				
Number of Children	7113	5888	5888	5888

From the survey data, 77.72 per cent of the children lived in households high polluting fuels. Out those, 21.43 per cent had suffered from ARI within two weeks prior to die interview. On die other hand, only 21.49 per cent of the children in the sample lived in medium pollution using households and of which 16 per cent had suffered from ARI within two weeks prior to the survey. Similarly, less than 1 per cent of the children lived in low pollution households and only 5.71 per cent suffered from ARI. Perhaps this represents the percentage of ARI attributable to factors other than those considered in this study.

Holding other factors constant, the unadjusted odds ratio of having suffered from ARI for children living in households using biomass fuels is 0.40 higher than those living in households using electricity or natural gas. Similarly, children from households using charcoal or kerosene had 0.09 higher odds of having suffered from ARI than those using electricity/natural gas (Table 6, Model 1).

Model 2 incorporates the effects of age of the child, sex of the child, and birth order in addition to die fuel types. The odds of children having suffered from ARI increased to 0.91 and 0.59 for biomass and charcoal/kerosene respectively others factors equal. Children in the second and third age category have over 0.90 higher odds of having suffered from ARI other factors equal. The odds drop to 0.39 in the forth category. The results show systematic reduction in ARI prevalence as the children develop. This phenomenon could be a result of increased resistance to infection as the child develops. Sex and birth order of the child do
[1] not significandy affect odds of infection.

When mother's education and household living standard are additionally controlled in Model 3, the effect of cooking with biomass fuels drops substantially although it remains large and statistically significant. The analysis shows that standard of living was negatively related to ARI prevalence. This implies that children from high socioeconomic status (SES) had 0.16 lower odds of having from ARI compared to children from the low SES holding other factors constant. Similarly, other factors equal, belonging to middle SES decreased the odds of a child suffering from ARI bv 0.1. However, results show that maternal education level did not significantly affect the odds of ARI prevalence among children. These findings arc contrary to existing literature and expected results. However, such unexpected findings may occur in cases where a sizable number of mothers with primary or no education do not have medical or any other form records in which case they can easily forget previous episodes of ARI among theu* children. Secondly, there may be under estimation of ARI cases among mothers with no education since some children may have already died from severe ARI. Thirdly, there is a reasonable number of educated mothers who are employed and therefore have to find maids to look after their young children. In most cases these maids have primary or no education and this may have the same effect as having mothers with primary or no education.

In the full model (Model 4), the effect of fuel type, age of child, region and residence were significantly different from zero. These results clearly indicate that the variables were the most influential in determining the ARI prevalence among Children in Uganda.

Table 7: Logit Estimates for ARI prevalence among children in Uganda, by selected variables.

Logit estimates Number of obs =5888
LR chi2(19) = 275.84
Prob > chi2 = 0.0000
Log likelihood = -3758.3866 Pseudo R2
0.0354

	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]	Generated Prob.
highpollut~n	0.3066653	0.3438744	0.89	0.373	-0.3673162	0.9806468	0.2641
mediumpoll~n	0.1600645	0.4425616	0.36	0.718	-0.7073402	1.0274690	0.1479
Age_1	0.7174820	0.1138780	6.30	0.000	0.4942852	0.9406788	0.5120
Age_2	0.6848796	0.1012327	6.77	0.000	0.4864672	0.8832920	0.4958
Age_3	0.3477924	0.1054523	3.30	0.001	0.1411097	0.5544751	0.2937
Age_4	-0.1056926	0.0978952	-1.08	0.280	-0.2975637	0.0861785	-0.1114
sexofchild	-0.0045516	0.0552417	-0.08	0.934	-0.1128234	0.1037201	-0.0045
secondborn	-0.0184951	0.0939833	-0.20	0.844	-0.2026990	0.1657088	-0.0186
thirdborn	-0.0118761	0.0966214	-0.12	0.902	-0.2012504	0.1774983	-0.0119
fourthborn	-0.0219299	0.1023219	-0.21	0.830	-0.2224770	0.1786173	-0.0221
fifthbo, n	0.0485742	0.0825493	0.59	0.556	-0.1132194	0.2103677	0.0474
pr_educ	0.1083065	0.0685800	1.58	0.114	-0.0261079	0.2427209	0.1026
abovepr_educ	-0.0992817	0.1031581	-0.96	0.336	-0.3014679	0.1029045	-0.1043
medium_sli	-0.1121189	0.0673305	1.67	0.096	-0.0198464	0.2440841	-0.1060
I Iigh_sli	-0.0936207	0.0755641	0.71	0.478	-0.0944823	0.2017236	-0.0981
central	0.1059037	0.0826481	1.28	0.200	-0.0560835	0.2678910	0.1004
eastern	0.5908751	0.0753041	7.85	0.000	0.4432819	0.7384683	0.4461
northern	0.5307088	0.0875486	6.06	0.000	0.3591167	0.7023009	0.4118
residence	0.1819083	0.0733884	2.48	0.013	0.0380698	0.3257469	0.1663
_cons	-1.8222210	0.3807974	-4.79	0.000	-2.5685710	-1.0758720	-5.1855

Using low pollution fuel as the base category, the results reveal that children living in medium and high pollution were more likely to.suffer from ARI. Specifically, medium pollution fuels increased the probability of ARI among children by 0.1479[4] whereas high pollution fuels increased the probability of infection by 0.2641. Just like in the logistic results, die sources of cooking fuels were not significant in the ARI prevalence. This could be due to two reasons; fust, a significant number of households in Uganda use more than one cooking fuel falling in different categories and therefore we cannot make definite conclusions about the effect of certain fuel. Secondly, there ajnumber of confounding factors such as exhaust

[1] **Probabilities were calculated using the expression; 1-£x7>-(coef.).**

gas from automobiles, atmospheric dust and industrial gases that may expose children to tracheal infections and yet they have not been captured in this particular study. Murray and Lopez (1996) argue that rapid urbanization and the uncontrolled growth of urban slums also create a "double burden" for the urban and semi-urban poor. Furthermore, they are increasingly exposed to "transition risk"- one portion of that risk is from dirty cooking fuels, primitive stoves, and crowding, while the other is a result of modern transport and industrial pollution.

Children between the ages 6-35 months were more likely to catch ARI compared to their counterparts between the ages 0-5 months. On other than, children above 36 months were least likely to suffer from ARI compared to all other age categories. These results are consistent with the results obtained from logistic regression. A shift from the first category (0-5 months) to the second age category increases the probability of catching ARI by 0.5120. Compared to the first age category. Children in the third age category stood a 0.4958 higher probability of contracting ARI Similarly, a child in the forth age category had a 0.2938 higher probability of contracting ARI. On other hand, being in the fifth category decreased the probability of a child contracting ARI by 0.1115.

Sex of the child, birth order and maternal education levels were not significantly related to the prevalence of ARI among the children in Uganda. Sex of child may not have been significant because children below 5 years are not differentiated in the household chores, which may influence chances of infection. Standard of living was a significant variable in the prevalence of ARI. Households at high level of living standards had 0.0981 less cases of ARI compared to the households in low living standards, other things equal. Similarly, middle-income households had 0.1060 less cases of ARI as opposed to low-income households, holding other factors constant. Further analysis also shows that there were less cases of ARI among children in middle-income rather than in high-income. Mishra (1997) attributes this contradiction to the fact that children from high-income households are predominantly exposed to modern hazards such as industrial waste gases, paints and fumigation more often than children from middle-income households.

The rural residences had higher cases of ARI reported than the urban residences. The results reveal that Staying in the rural area increased the probability of infection by 0.1663. It must be also noted that the highest percentage of rural residents use biomass fuels and belong to low and middle-income status. Therefore, the higher and significant prevalence of ARI in rural residences could be attributed to a combination of the foregoing factors. Also, using the western region as the base region, residing in die Central region does not significandy affect the probability of ARI prevalence. However, the probability of infections increases by 0.4462 in the Eastern region and 0.4118 in the Northern region. However, it should be noted that Eastern and Northern regions have got lower populations compared to Central and Western regions. Therefore, a constant number of ARI cases expressed as a percentage of the regional populations would appear larger in Eastern and Northern. Secondly, unlike Eastern and Northern, the Central and Western regions are situated in mountainous areas and lakeshores where air currents are abundant. Regular air currents mean that the air exchange between in door and out door will more rapid.

The analysis shows that biomass gready increases die probability of contracting ARI compared to natural gas, LPG and electricity. On one hand, the logistic results show that exposure to cooking smoke from biomass combustion is significantly associated with ARI prevalence in young children, independent of child's age, maternal education, household living standard, and other factors. These results are consistent with the earlier hospital-based case-control study of young Uganda children (Collings, 1990) and provide further evidence that cooking with high pollution unprocessed biomass fuels can increase the risk of ARI in young children. The mechanism by which cooking smoke can increase the risk of ARI is not fully described here. However, Mishra (1997) argues that exposure to biomass smoke has been associated with compromised pulmonary immune defense mechanisms. Of the specific pollutants in biomass smoke, exposure to respirable particulate matter (PM_{10}) has been shown to induce a systemic inflammatory response that includes stimulation of the bone marrow, which can contribute to the pathogenesis of die cardiorespiratory morbidity (Tan, 2000).

Other evidence indicates tl at exposure to polycyclic aromatic hydrocarbons (PAH)—especially benzo-[a]pvrene (B[a]P), which is found in large quantities in biomass smoke—can causc immune suppression and can increase the risk of infection and disease(Kong, 1994; Moreover, acute and long-term exposures to oxides of nitrogen, commonly found in biomass smoke, can increase bronchial reactivity and susceptibility to bacterial and viral infections (Samet, 1990). It is, therefore, possible that extended exposure to high levels of cooking smoke can impair the pulmonary defense mechamsms, compromise the lung function, and render children more susceptible to ARI.

From the logit results we found that living standard of the household was significant at 90 per cent confidence interval. This implies that children from poorer households stood higher probability of contracting ARI compared to middle income households. Similarly, children from households with very high standard of living stood low probability of contracting ARI. Wealth index was used to represent the socioeconomic status of household. It was also the main distinguishing component of this particular study from the previous studies that have been carried in Uganda in the recent past. Socioeconomic status was found to be a significandy related to ARI prevalence among children at 90 per cent CI. This meant that children from poorer households suffered more from ARI than those from middle-income households.

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CHAPTER FIVE

This chapter presents the main conclusions of the study in section 5.1; and the policy implications in section 5.2. The limitations of the study are presented in section 5.3 and suggested area of further research in section 5.4.

5.1 Conclusions

The objecuves of this study were; to estimate ARI prevalence among children below the age 5 years, determine the extent to which ARI prevalence among children is related to socio-economic status of the households in which children live, and to quantify the exposure-response relationship for high, medium and low polluting fuels.

The data were collected from die Uganda Demographic and Health Survey. This data set captured the demographic characteristics, health and socioeconomic status of the children and the mothers. There are some maternal variables that had bearing on the child's healdi such as the level of education and whether or not the mother smokes. The multi-collinearity test was performed on die explanatory to ensure that die variables were not perfectiy correlated. This was done using the correlation matrix in STATA statistical package. The analysis utilized both the logistic and the logit regressions and in both cases the results were consistent.

Acute respiratory infections are a serious problem in Uganda. The study findings showed that the prevalence of ARI among children below 5 years is 18.33%. Three quarters of the ARI cases were found in die rural. This predominance can be explained by the fact that most rural residents use biomass fuels in poorly ventilated housing. The other factors that are related to ARI prevalence included; age of the child, socio-economic status, and region of residence. The sample distribution showed that ARI prevalence increased in children development unul 23 months, dien dropped until 35 months and picked up after 35 mondis. Logit results showed that Nordie'rn and Eastern regions had the highest cases of ARI and western district had the lowest. From^oth the logit and logistic results, we do not have evidence to reject the null hypothesis. Therefore, we fail to reject to the null hypothesis at 10 percent level of significnncc and conclude that maternal education is not related to ARI prevalence among theix children.

Socioeconomic ' status was found to be significandy related to ARI prevalence among children at 90 per cent CI. As expected socioeconomic status was negatively related to acute respiratory infection. This meant that children from poorer households suffered more from ARI than middle-income households, which in turn suffered more from ARI than the high-income households. We can therefore reject the null hypothesis that socio-economic status is not related to ARI prevalence at 10 percent level of significance and conclude that socio-economic status is negatively related to the ARI.

The highest cases of ARI were observed among children living in homes using biomass. This showed that the exposure-response for biomass, which is highly polluting is the highest among all the fuel types. This was followed by charcoal/kerosene and electricity/natural gas.

5.2 Policy Suggestions

5.2.1 General Policy Suggestions

An important implication is that public health programs aiming to reduce the negative impacts of indoor air pollution in Uganda should focus then* attention on measures that result in larger reductions in pollution, especially those that bring average exposure below 2,000ng/m\

Technology innovation programs and public health initiatives provide a variety of benefits in developing nations. Widi more than 2 billion people worldwide relying on biomass as dien-primary source of energy, efforts to introduce new energy technologies should also include detailed attention to health outcomes. A long record of national, multilateral, and private donor efforts to promote irproved (high-efficiency and low emissions) stoves exists. Ma'nv of these programs, although lowering average emissions, may not have reduced exposure below the 2,000ug/m' level that may provide important health benefits.

The results of this analysis, for example, indicate that although improved wood stoves substannally reduce exposure, in many cases they offer smaller health benefits than a transition to charcoal, which can reduce exposure to very low levels.

5.2.2 Specific Policy Suggestions

Improved stoves

The most vulnerable group is the rural poor who predominandy use biomass for long hours in poorly ventilated shelter. Even with biomass, using improved stoves could minimize exposure to carbon monoxide and improve efficiency. Efficient stoves use less biomass to obtain the required amount of energy and reduce the quantities of particulate matter emitted. Programs to popularize the use of improved stoves have already been implemented in Kenya and iMalawi by non-governmental organization in conjunction with the concerned governmental departments. The same program will mitigate health risk arising from indoor biomass combustion.

Improved Ventilation

Besides indoor combustion, improved ventilation of kitchens or houses goes a long way to allow free air exchange to reduce the concentration of particulate matter indoors.

Community Awareness

Children below 5 years have very immunity to respiratory infection. As a way of protecting this age group, mothers should be sensitive about the potential dangers of poor indoor ambience. This can be done through women social clubs and basic health care programs.

Fiscal measures

The ministry of health should lobby for tax relief or even tax exemption on natural gas since the health cost imposed on die economy due to biomass utilization is enormous. In fact, tax exemption on natural gas, which according to our analysis was found to be of low pollution, could be over compensation tax increase on charcoal.

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Improve Socioe-conomic status

The government should design program to improve the socio-economic standards of the poor especially in the rural areas. Improved standards of living have been shown to be negatively related to ARI. Higher incomes mean diat households can afford improved stoves and better cooking fuels.

5.3 Limitations

Several measurement constraints should be kept in mind when considering the findings of this study. First, many households in Uganda typically use a combination of cooking fuels, whereas we have information only on the primary cooking fuel. Our estimated effects are attenuated to the extent diat a mix of biomass fuels and cleaner fuels is actually used by many households instead of biomass fuels alone.

Second, there is a possibility of sample selection due to ARI-related mortality.
This implies diat children living in poorer biomass-fuel-using households are more likely to die from ARI; our estimates of effect of cooking smoke on ARI are lower than the actual. However, given high prevalence of ARI and relatively small number of deaths in the sample, the impact of this bias on our estimated effect is likely to be negligible.

Third, there is also a possibility of underreporting of ARI due to lack of awareness that the child had the disease during the 2-week reference period. To the extent that underreporting due to lack of awareness is greater among those living in households using biomass fuels, it would contribute to underestimation of the effect of cooking smoke on die prevalence of ARI.

Fourth, we were unable to control direcdv for crowding in the household because die UDHS did not collect data on number of rooms in the household. Indoor crowding tends to be correlated with biomass fuel use and may affect the risk of ARI.
Finally, we were also not able to coatrol direcdy for extent of use of medical sendees, because the survey did not collect any information on diis subject. However, our set of control variables includes measures of SES, which are correlated with access to and use of

mcclical services. As mentioned earlier, information on ARI is based on mothers' responses and no clinical measurements were undertaken. Moreov **it**, smoke exposure was ascertained from type of fuel used for cooking. Although die symptomatic definition used here is intended to measure acute lower respiratory infections (ALRI) in children, some acute upper respiratory illness may have been included in the reported prevalence. Because it is not possible to separate ALRI from these data, we use the term ARI in this study, not ALRI. In developing countries such as Uganda, where clinical data on ARI are usually not available or very weak, the symptomatic definition of illness used here has been shown to provide a fairly accurate assessment of ARI in the population. (Stanek, 1994). Moreover, indoor air pollution measurements in several developing countries have shown fuel type to be the best single indn-ect indicator of household pollution levels. Despite these problems in the measurement of smoke exposure and ARI, the consistency in the size of crude and adjusted effects of biomass fuel use on childhood ARI suggests a possible 'exposure-response' relationship.

5.3 Areas of Further Research

A number of cofactors play a role in determining ARI risk in children. Although the effects of some factors, such as maternal education, passive smoking, income category, have been covered here, die link with indoor air pollution needs further investigation to conclusively support the association. Because risk factors are often correlated, it can be difficult to evaluate their individual effects. Poor children frequently have nutritional deficiencies, live in crowded areas, and are exposed to high levels of environmental pollutants. Potential biases from confounding and also effect modifications are therefore major issues in interpreting the epidemiological evidence. In addition, most of the current studies lack a standardized definition for ARI. Future studies should be conducted prospectively to evaluate individual risk factors and better classify exposures, as well as to characterize synergistic effects on well-defined ARI. New studies should incorporate exposure assessment strategies that the consequences of unavoidable measurement error, minimize misclassification and include validation studies to address

APPENDIX1: Summary Statistics for the Covariates

Variable	Obs	Mean	Std. Dev.	Min	Max
Ari (Not infected=0, mfected^l)	7113	0.183326	0.386961	0	1
Fueltype (Electricity =1, LPG=2, Biogas=3 Kerosene=4, Coal=5, Charcoal=6, Firewood=7 Dung=8, other=99).	7113	10.8185	18.84621	1	99
Age of child	5888	27.30129	17.14088	0	59
Sex of cliild (male=l, female=2)	7113	1.503444	0.500023	1	2
Birthorder (first=1 ,second=2,third=3 (fourth = 4, fifth = 5)	7113	3.247013	1.551107	1	5
Mothereduc (no education = 0, primary =1 Secondary = 2, Higher = 3, N/A = 9)	7113	1.201603	1.093165	0	9
Wealth index (Low = 1, Middle =2, Higher =3)	7113	1.959792	0.795136	1	
Residence (Urban = 1, Rural = 2)	7113	1.762126	0.425812	1	2
Region (Central = 1, Eastern = 2 Northern = 3 Western = 4)	7113	2.397441	1.177416	1	4
Smoke (No = 0, Yes = 1 N/A = 9)	7113	0.017855	0.218882	0	9

APPENDIX 2: Logit Estimates for ARI prevalence among children in Uganda

Logit estimates Number of obs = 5888
LR chi2(19) = 275.84
Prob > chi2 = 0.0000
Log likelihood = -3758.3866 Pseudo R2 = 0.0354

	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
highpollut~n	0.3066653	0.3438744	0.89	0.373	-0.3673162	0.9806468
mediumpoll~n	0.1600645	0.4425616	0.36	0.718	-0.7073402	1.0274690
age_1	**0.7174820**	**0.1138780**	**6.30**	0.000	**0.4942852**	**0.9406788**
age_2	**0.6848796**	**0.1012327**	**6.77**	0.000	**0.4864672**	**0.8832920**
age_3	**0.3477924**	**0.1054523**	**3.30**	0.001	**0.1411097**	**0.5544751**
age_4	-0.1056926	0.0978952	-1.08	0.280	-0.2975637	0.08617b5
sexofchild	-0.0045516	0.0552417	-0.08	0.934	-0.1128234	0.1037201
secondborn	-0.0184951	0.0939833	-0.20	0.844	-0.2026990	0.1657088
thirdborn	-0.0118761	0.0966214	-0.12	0.902	-0.2012504	0.1774983
fourthborn	-0.0219299	0.1023219	-0.21	0.830	-0.2224770	0.1786173
fifthbom	0.0485742	0.0825493	0.59	0.556	-0.1132194	0.2103677
pr_educ	0.1083065	0.0685800	1.58	0.114	-0.0261079	0.2427209
abovepr_educ	-0.0992817	0.1031581	-0.96	0.336	-0.3014679	0.1029045
medium_sli	**-0.1121189**	**0.0673305**	**2.07**	**0.096**	**-0.0198464**	**0.2440841**
high_sli	**-0.0936207**	**0.0755641**	**2.13**	**0.078**	**-0.0944823**	**0.2017236**
central	0.1059037	0.0826481	1.28	0.200	-0.0560835	0.2678910
eastern	**0.5908751**	**0.0753041**	**7.85**	0.000	**0.4432819**	**0.7384683**
northern	**0.5307088**	**0.0875486**	**6.06**	0.000	**0.3591167**	**0.7023009**
residence	**0.1819083**	**0.0733884**	**2.48**	**0.013**	**0.0380698**	**0.3257469**
_cons	**-1.8222210**	**0.3807974**	**-4.79**	0.000	**-2.5685710**	**-1.0758720**

v

References:

Aldrich, J.H., & Forrest, D.N. (1998). "Linear Probability, Logit and Probit Models" Sage Publications.

Anderson, H. R. (1979). "Respirator}' abnormalities, Smoking habits and Ventilatory capacity in a highland community in Papua New Guinea: prevalence and effect on mortality." *Internationaljournal of Epidemiology* Vol.8 No.2, pp. 127-35.

Armstrong, J. R., & Campbell, H. (1991). "Indoor air pollution exposure and lower respiratory infections in young Gambian children." *International Journal of Epidemiology* Vol.20, No.2, pp.424-9.

Azizi, B.H., Henry R.L. (1991). "The effects of indoor environmental factors on respiratory illness in primary school children in developing countries." *International Journal of Epidemiology,* Vol. 20, pp. 144-50.

Barnes, D.F., Openshaw, K., Smith, ICR., & Van der Plas, R. (1994). "What makes people cook widi improved biomass stoves?" *A. Comparative International Review of Stove Programs,* The World Bank: Washington, DC.

Becks, B.D.,& Brian, j.D. (1982). "Prediction of pulmonary toxicity of respirable combustion products from residential wood and coal stoves". Proceedings of the Residential Wood and Coal Combustion Special Conference. Air Pollution Control Association, Pittsburg.

Behera, D., Jindal,S.K., & Malhotra, H.S. (1991). *Thorax,* Vol. 46 No.5 pp.344.

Blair, A., Saracci, I., Stewart, P.A., Hayes, R. &: Shy, C. (1990). "Epidemiologic evidence of the relationship between formaldehyde exposure and cancer." *Scandinivian Journal on Work, Environment and Wealth.* Vol.16, pp.381.

Bruce, N., Neufeld, L., Boy, E., & West, C. (1998). "Indoor bio-fuel air pollution and respiratory health: die role of confounding factors among women in Highland Guatemala." *International Journal ofEpidemiology.*Vol.27, pp.454.

Collings, D.A., Sidiole, S.D., & Martin, &.S., (1990). "Indoor woodsmoke pollunon causing lower respiratory disease in children." *Tropical Doctor* Vol.20, pp. 151-55.

Den v.m.s, A. (1992). "Logit Modelling: Practical Application" Sage Publications, London.

Dutt,D. (1996). "Effect of Indoor Air Pollution on the respiratory system of women using different fuels for cooking in an urban slum of Pondicherry." *National Medical Journal of India,* Vol.9, pp.113.

Graham, N.M.H. (1990). "The Epidemiology of Acute Respiratory Infections in children and adults: a global perspective." *Epidemiological Review Vol* 27 pp 149-178.

Global Environment Monitoring System. Assessment of Urban Air Quality. United Nations Environment Programme/World Health Organization, 1998. Unpublished document cited in Chen BH, Hong CJ.

Isabelle, R., Jonathan, M.S., Kirk, R.S.,& Nigel, B. (2002). "Outdoor Air Pollution and Acute Respiratory Infections Among Children in Developing Countries." *journal of Occupational and Environmental Medicine.* Vol. 44, pp. 640-49.

Kirkwood, B.R., Gove, S., Rogers, S., Lob-Levyt., Artthur, P., & Campbell, H. (1995). "Potential Interventions for the Prevention of Childhood Pneumonia in Developing Countries: A Systematic Review." *bulletin of World Health Organisation.* Pp. 793-98

Kleeman, M.J., Schauer, J.J., & Cass, G.ll. (1999). "Size and Composition distribution of five particulate matter emitted from wood burning, meat charbroiling, and cigarettes." *Environmental Science and Technology.* Vol.33, pp3516-23.

Kong, L.Y., Luster, M.I., Dixon, O'Grady, J., & Rosenthal, G.J. (1994). "Inhibition of lung immunity after intratracheal instillation of benzo(a)pyrene." *American journal of Respiratory Critical Care Medicine* Vol.150, pp.1123—29.

Mar bury', M. (1991). "Woods Smoke". In: Samet, J., Spengler, J., eds "In door air pollution: a health perspective." Baltimore: Johns Hopkins University Press, pp 209-22.

Master, K.M. (1974). "Air pollution in New Guinea." Cause of chronic pulmonary disease among stone-age natives in the highlands, *journal of American Medical Association* Vol.228, ppl635.

Mika L, (2002). "Addressing health and household energy problem in Zimbabwe." Paper presented at the 9Ifl international conference on indoor Air Quality and Climate, Monterey, California.

Ministry of Health (MOH) [Uganda].nd. National Health Policy 1998. Kampala, Uganda: MOH.

Mishra, V., Retherford, R. (1997). *National Family ITeath Survey bulletin* No.8.

Mishra, V., Rctherford, D., & Smith, R. (1997). "Effects of cooking smoke on prevalence of blindness in India", Working Paper Population Series # 91, East West Centre.

Mishra, V.K., Retherford, R.D. & Smith, ICR. (1999). "Biomass cooking fuels and prevalence of tuberculosis in India." *International journal of Infectious Diseases.* Vol.119.

Murray, C., & A. Lopez. (1996). "The Global Burden of Disease." Cambridge, M.A:Harvard University Press.

Murray, D.M., & Burmaster, D.E. (1995). "Residential air exchange rates in the United States: empirical and estimated parametric distributions by seasons and climatic region". *Risk Analysis.* Vol.15, pp.459-65.

Odinaev, F.I. (1992). "The characteristics of development and course of pneumoconiosis under the conditions of a mountain climate". *International Journal of Epidemiology,* Vol. 7, pp. 13.

Padmavati, S. and Joshi, B. (1964). "Incidence and etiology of chronic cor pulmonale in Delhi: A necropsy study." *International journal of Epidemiology.* Vol. 46, pp. 457.

Pasternack, MS. (1998). "Pneumonia in childhood." In: Fishman A, ed. *Irishman's pulmonary diseases and disorders.* 3rd *edition.* New York: McGraw-Hill.

Patel, T.S and Raiyani, C.V (1995). "Indoor air quality: Problems and perspectives. In: Energy Strategies and Green House Gas Mitigation. Ed. P.R Shukla. Allied Publishers. New Delhi, pp.72.

Samet, J.M., & Utell, M.J. (1990). "The risk of nitrogen dioxide: What have we learned from
i
epidemiological and clinical studies?" *Toxicol Industrial Health Vol.6f* pp247-62.

Smith ICR, & Liu Y. (1994). "In door air pollution in developing countries". In: Samet JM (ed). Epidemiology of lung Cancer, Lung Biology in Healdi and Disease Vol. 74, pp.151-84.

Smith, ICR. (1993). "Fuel combustion, air pollution exposure and health: the situation in developing countries." *Annual Review of Environment and Energy.* Vol.18, pp529-66.

Smith, ICR. (1987). "Biofuels, air pollution and health: A global review." Plenum Press, New York.

Smith, K. R., Aggarwal A.L., & Dave,R.M. (1983). "Atmosphere and Environment." pp. 2343.

a

Smith,IC,Apte, M.G., Yuqing, M.,WongSekiarttirat,W., & Kulkarni,A. (1994). "Energy" Vol.19, No.5, pp. 587.

v

Splengcr, J.D. and Samet, **J**.M. **(1991). "A** perspective on indoor and outdoor air pollution." In Samet J, Splengler J, eds *Indoor air pollution: a health perspective*" Baltimore:Johns Hopkins University Press, **ppl-29.**

Stanek, E.J III., Wafula, E.M., Onyango, F.E., & Musia J. (1994). "Characteristics related to the incidence and prevalence of acute respiratory tract infection in young children in Kenya." *Clinical Infectious Diseases.* Vol.18, pp.639—647.

Sxvenberg, J.A., Kerns, W.D., Mitchell, **R.I.,** Gralla, E.J & Parkov, K.L. (1980). "Induction of Squamous cell carcinomas of the rat nasal cavity by inhalation exposure to formaldehyde vapour." *Internationaljournalfor Health.* Vol.40, pp.3398.

Tan, W.C., Qiu D., & Liam, B.L. (2000). "The human bone marrow response to acute air pollution caused by forest fires." *Journal of Respiratory Critical Care Medicines.* Vol.16, pp.1213—17.

Uganda Bureau of Statistics (UBOS) and ORC Macro. (2001). "Uganda Demographic and Health Survey 2000-2001." Calverton, Maryland, USA: UBOS and ORC Macro.

Uganda Bureau of Statistics (UBOS) and ORC Macro. (2001). "Uganda National Household Survey 1999/2000: Report on the Socio-Economic Survey." Entebbe, Uganda: UBOS.

Viau, C., Hakizimana. G., & Bouchard M. (2000). "Indoor exposure to polycyclic aromatic hydrocarbons and carbon monoxide in traditional houses in Burundi." *International Archives for Occupational and Environmental Health* Vol. 73, No.5 pp.331-8.

World Health Organisation. (2001). World Health Report (2001). Geneva: WHO.

World Bank, Africa Technical Department, Review of Policies, Strategies, and Programmes m the Traditional Energy Sector, Proceedings of Workshop 1, Ouagadougou, Burkina Faso, February 21-25, 1994 (Working-level translation from French), pp. 28, 48, 77.

World Health Organization. *World Health Report 200 /.* Geneva: WHO, 2001.

World Health Organization, (1999). Air quality Guidelines.

World Health Report (1997). "Health systems: improving performance." WHO. http://www.who.int/whr/

World Health Organization (WHO), (1991). *Technical bases for the WHO recommendations on themanagement ofpneumonia-in children at first-level health facilities.* Geneva: WHO.

World Resources Institute and World ftank. (1998-99). "World Resources: A Guide to the Global Environmental." Oxford University Press, Oxford.

Wyiulci, E.L. horum: (1979). Workshop on carbon monoxide and cardiovascular diseases. Prevention and Medicines Vol.8, pp.261.