DISCUSSION PAPERS ON CHILD HEALTH

WHO/FCH/CAH/05.06

Situation Analysis of Household Energy Use and Indoor Air Pollution in Pakistan

Department of Child and Adolescent Health and Development
World Health Organization

INDOOR AIR POLLUTION

CAH

Acknowledgements

WHO/CAH wishes to thank Dr. Zafar Fatmi; Dr. M. Masood Kadir, Dr. Waqar Ahmed and Dr. Ambreen Kazi of the Department of Community Health Sciences, The Aga Khan University, Karachi, Pakistan for undertaking this review.

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Preface

More than two billion of the world's poorest people in developing countries rely on solid fuels including biomass for household energy needs, particularly for cooking and heating. These fuels lead to indoor air pollution (IAP) levels many times higher than developed countries. IAP exposure increases the risk of diseases, including pneumonia, chronic respiratory diseases and lung cancer, and accounts for a substantial burden of diseases in developing countries. Women and children in developing countries are the worst sufferers due primarily to their indoor involvement.

Pakistan is a predominantly rural society where biomass fuel is the major source for cooking and heating. Women are primarily involved in biomass collection and combustion, therefore also inhale most of the poisonous chemicals present in the smoke.

Biomass meets about 86% of total domestic energy requirements. Ninety per cent of the rural and 50% of the urban population depend on biomass fuels. Information regarding IAP and its health effects is lacking in Pakistan. However, information regarding the amount of wood consumed by an average household is available. Small-scale endeavours to control IAP are being carried out by various agencies in Pakistan.

In conclusion, more information regarding use of biomass and other fuels, behavioural studies and housing details regarding conditions of indoor air in Pakistan is required. Further, numbers of interventions are available and have been tried on a smaller scale at low cost by government, NGOs and academic institutions to address the impact of indoor air pollution. Intervention studies need to be conducted on a larger scale to know the impact clearly. These may relate to the intervention at source such as improved stoves, use of cleaner fuels; improving living environment such as better ventilation and working to improve user behaviours, such as keeping children away from smoke during cooking times. Furthermore, a meeting of government, NGOs and academic institutions working on environmental health is needed to develop a plan of action on IAP for the future.

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Summary

Indoor air is defined as *"air within a building occupied for a period of at least one hour, by people of varying states of health"*. According to *The World Health Report 2002* indoor air pollution (IAP) is responsible for 2.7% of the global burden of disease and nearly 2.5 million people die due to air pollution, mainly (65%) because of indoor air pollution. Biomass fuel is the major source of IAP and it is burned for cooking, heating and lighting homes. *Biomass fuel* refers to any plant- or animal-based material deliberately burned by humans. Biomass is the energy source of the poor in developing countries. Use of biomass leading to a high level of indoor air pollution, particulate matters and chemicals, is a serious potential health hazard.

The Department of Community Health Sciences, Aga Khan University has undertaken the task to review the situation of household energy use and indoor air pollution in Pakistan with the support of the Department of Child and Adolescent Health and Development of the World Health Organization, Geneva. A review of sources of published and non-published literature was conducted to assess the situation of IAP. In addition, data from governmental and non-governmental agencies working on IAP in Pakistan were collated.

The Pakistan Household Energy Strategy Study (HESS) undertaken in 1992 showed that biomass fuels account for about 86% of total household energy consumption in Pakistan, while wood fuel alone accounts for 54% of total. Therefore, biomass is the major cooking and heating energy in Pakistan. Wood, crop residues and animal dung are the major sources among the biomass. Biomass is mostly burned in inefficient three-stone stoves leading to incomplete combustion and high levels of indoor air concentration of smoke. IAP due to burning of biomass fuel is posing a serious threat, particularly to women and children in Pakistan. During peak hours of cooking the concentration of indoor air pollution may be many times higher than safe levels.

Less published evidence is available regarding the indoor air concentrations of particles and chemicals due to biomass fuel burning in Pakistan. Most studies have been conducted to estimate the amount of emissions due to biomass combustion. Only a few studies have been conducted in Pakistan to relate IAP to health effects. Furthermore, few studies have been conducted to learn the behaviour of the population regarding the use of stoves. Besides urban-rural differences in use of type of fuel, there are expected cultural differences in household cooking practices. Therefore, in turn the exposure levels and adverse health effects may also vary in different ethnic and cultural regions of Pakistan. Also given the climatic variations in different regions in Pakistan, in comparing the colder northern part, where houses are relatively closed, with the southern part of the country which is warm and houses are open to the outside environment would give different exposure levels among the population. Therefore, it is expected that there would be more adverse health effects due to IAP in northern areas of Pakistan.

IAP is not a recognized environmental hazard at policy level, therefore, generally less efforts have been made in this regard so far in Pakistan. No legislation governs the indoor air concentrations of hazardous substances at household level in Pakistan A few governmental, non-governmental and academic institutions are working to improve IAP, however on a small scale. Intervention studies such as on improved stoves were introduced on a small scale which indicates positive results. Also there is a network of institutions working on renewable energy technology, again on a small scale.

The situation in Pakistan regarding IAP warrants urgent attention. This requires a meeting of the stakeholders to define a policy and agenda of action to develop future strategies. Studies gathering evidence of effect of intervention through improved cooking stoves or other technologies on IAP are required. The studies conducted so far are on a small scale, therefore, there is a need to conduct studies on a larger scale. This will have a favourable impact on the population in general and especially on the health of women and children in Pakistan.

Introduction

INDOOR AIR POLLUTION

Air pollution is an atmospheric condition in which certain substances like gases, particulate matter, radioactive materials etc. are present in such a condition that they can produce undesirable effects on mankind and his environment. The National Health and Medical Research Council (NHMRC) defines *indoor air* as *"air within a building occupied for a period of at least one hour by people of varying states of health".* Covered by the definition are buildings such as homes, schools, restaurants, public buildings, residential institutions, hospitals and offices. Workplaces covered by occupational health standards such as industry, etc. are not included in this definition. *Indoor air quality* can be defined as the totality of attributes of indoor air that affect a person's health and well-being (1).

In developing countries biomass fuel is the major source of indoor air pollution (IAP). *Biomass fuel* refers to any plant or animal-based material deliberately burned by humans. Biomass fuels are burned for cooking, heating and lighting homes and are the energy source for the poor. Frequently, these biomass fuels are burned on an open fire or in poorly functioning stoves (three-stone stoves) for cooking or in open hearth for heating and drying food. In addition to the smoke produced within one household, smoke which is produced outside could be a major contributor for an individual household, especially for developing countries in temperate climates where houses are open to the outside environment. These include smoke from nearby houses, burning of forests, agricultural land and household waste, use of kerosene lamps, industrial and vehicle pollution. Therefore, to decrease IAP, intervention at the community level is also required alongside the household level.

Indoor smoke contains a range of health-damaging pollutants, such as small particles and carbon monoxide and particulate matters, etc.. Concentration of IAP levels vary greatly depending on the time of day, season and place of measurement, especially for inhalable particles (Particulate matters <10 microns) and carbon monoxide (CO) levels. Pollution levels may be 20 times higher than accepted standards (2).

According to the *World Health Report 2002* indoor air pollution is responsible for 2.7% of the global burden of disease. The health burden from IAP is greater in high altitude rural areas because the houses are small and closed due to the cold climate. Women and young children of developing countries are at greatest risk because of their gender roles and household responsibilities and behaviours – cooking and spending a lot of time indoors – result in high exposure to IAP. As an estimate on the impact of IAP on women and children, 85% of all global particulate exposure occurs indoors (2).

More than two billion people in the world and 75% of households in India, China and nearby countries, and 50-75% of people in parts of South America and Africa still use solid fuels which include dung, wood, agricultural residues or coal. Nearly 2.5 million people die each year from air pollution. The burden is greater due to indoor air (65%) than ambient air pollution. More than 90% of this exposure occurs in developing countries, often in rural or peri-urban areas, because of the use of biomass as the main source of energy. The total amount of pollution released from domestic fuels is not high relative to fossil fuels used in industry, therefore, there may be less harmful effects on environment; however human exposure to IAP is much higher, leading to increased adverse health effects. This is because (i) people tend to spend more time indoors than outdoors, and (ii) the concentration of air pollutants indoors is much higher due to limited ventilation, compared to outdoors where pollutants quickly become diluted. Therefore, developing countries account for 77% of all global particulate exposure. Numerous studies have found that IAP levels are typically many times higher in developing countries than developed world standards for ambient air quality (3).

Poor environmental conditions are associated with high infant and child mortality (4). More than two million children die annually in developing countries from respiratory infections (2). Agents and factors responsible for respiratory diseases are mainly transmitted through the air. Domestic smoke and inadequate ventilation are significant risk factors for acute respiratory infections. Distribution of global attributable deaths according to age group by risk of indoor smoke from biomass fuels are as follows: 0-4 years is 56%, 5-14 years is 0%, 15-59 years is 5%, 60+ years is 38%. The distribution among females is 59%, more compared to males which is 41%. Distribution of attributable disability adjusted life years (DALYs) due to indoor smoke from solid fuels according to age group is as follows: 0-4 years is 83%, 5-14 years is 0%, 15-59 years is 8% and 60+ years is 9% in the year 2000. These figures point to the fact that children and women suffer the worst from IAP (2).

Adverse health effects due to IAP

The incomplete combustion of biomass fuels in simple stoves releases a host of complex chemicals. Pollutants include suspended particulate matters, carbon monoxide, formaldehyde, nitrogen dioxide, ozone and polycyclic aromatic hydrocarbons (see table below).

Indoor air pollutants and their potential health effects

Pollutant	Mechanism	Potential health effects
Particulate matters (PM-10/2.5)	▪ Bronchial irritation ▪ Reduced mucocilliary clearance	▪ Respiratory infections ▪ COPD and exacerbation ▪ Wheezing, asthma ▪ Excess mortality including CVD
Carbon monoxide (CO)	▪ Binding with Hb (reduced Oxygen delivery)	▪ Low birth weight ▪ Increased perinatal deaths
Benzopyrene	▪ Carcinogenic	▪ Lung cancer ▪ Cancer of mouth, pharynx, larynx
Formaldehyde	▪ Nasopharyngeal and airway irritation	▪ Increased infections (?) ▪ May lead to asthma (?)
Nitrogen oxides (NOx)	▪ Acute: bronchial reactivity ▪ Chronic: infections	▪ Wheezing ▪ Respiratory infections and reduced lung functions
Sulphur oxides (SOx)	▪ Acute: bronchial reactivity ▪ Chronic: particulate effects	▪ Wheezing, asthma ▪ COPD, CVD
Smoke	▪ Absorption of toxin into lens, leading to oxidative changes	▪ Cataract

Source: WHO 2002. The health effects of indoor air pollution exposure in developing countries

Smith et al. have classified the link between health outcome and IAP exposure as (i) strong evidence (Acute Respiratory Infections, Chronic Obstructive Pulmonary Disease and lung cancer), (ii) moderate evidence (cataract, tuberculosis), (iii) limited evidence (asthma) and (iv) insufficient evidence (low birth weight and peri-natal deaths, heart disease) (5). The health effects due to each of the major constituents of IAP with its mechanism are given in the table.

Exposure assessment of IAP

'Intake fraction' is the integrated incremental intake of a pollutant released from a source and summed over all exposed individuals during a given exposure time, per unit of emitted pollutant. Therefore, it is not the concentration of IAP but the dose that determines the health effects (i.e. exposure level). Exposure refers to the concentration of pollution in the immediate breathing environment over a specified time interval (pollution level X time). It is measured as person-hour of exposure and measured directly through personal monitoring and indirectly through information on *pollutant concentration* and *activity pattern* (6).

Women and children at special risk due to IAP in developing countries

In most of the rural areas of developing countries collection of wood and cooking is the responsibility of women. Women cook meals for the whole family and this exposes them to high levels of indoor pollution generated during the cooking process.

Children are particularly vulnerable to a contaminated and unsafe physical environment including IAP. Metabolic pathways, especially in the first months after birth, are immature and children are not able to eliminate completely IAP compounds. Children drink, eat and breathe more in relation to their body weight and they have more years of life ahead than the adults. Therefore, the health consequences due to IAP are also more likely for children as compared to adults (7). However, it is not just the biology of growth and development that leads to special impact of environmental threats but varieties of social and psychological factors influence their exposure. Children under-5 remain confined with their mother in-doors, which leads to increased exposure to IAP.

PAKISTAN

Geography

Pakistan lies between 23°-35' to 37°- 05' north latitude and 60°-50' to 77°- 50' east longitude. The total land area is 796,095 km^2. It has four provinces viz. Sindh, Punjab, North West Frontier Province (NWFP) and Balochistan. The land consists of varied regions as: (i) part of Himalayas which cover its northern and north-eastern parts; (ii) the Balochistan plateau; (iii) the Potohar Plateau and salt range; and (iv) the Indus plain, the most fertile and densely populated area of the country. The country has an agricultural economy with a network of canals irrigating major parts of its cultivated land. The northern high mountainous ranges are extremely cold in winter while the summer months are pleasant. The plains of the Indus valley are extremely hot in summer with cold and dry weather in winter. The coastal southern strip alongside the Arabian Sea has a moderate climate. In order to conserve heat the houses are kept closed in the northern part which may raise the IAP level several-fold compared to the southern part of the country where the houses are mostly open due to the temperate climate.

Population and environment

The major driving force for environmental health degradation in Pakistan is its growing population. Pakistan ranks seventh in the world's most populous states with a population of 134.8 million. It ranks 135th on the United Nations Human Development Index. Doubling time is estimated at 27 years. Per capita gross national product (GNP) (US$ 1998-99) for Pakistan is 470. The following table depicts trends of some indicators of development for Pakistan.

Trends of indicators of development for Pakistan

Years	Population with access to safe water (%)	Population with access to sanitation (%)	Population with access to health care (%)	Population with access to essential drugs (%)	Underweight children (under 5) (%)
1988-91	56	24	90	--	42
1990-96	74	47	55	--	38
2000	88	61	--	50-79	38

Source: World Development Indicators, 2001

Health indicators of Pakistan

The health indicators of Pakistan are gloomy compared to other low-income countries with a similar GNP. Infant mortality is 77 per 1000 live births, and maternal mortality is 340 per 100,000 live births (median estimates). Pakistan faces the double burden of disease i.e. a rapidly increasing incidence of noncommunicable diseases and injuries alongside the burden of endemic communicable diseases (8).

Health Indicators of Pakistan, 2001

Life Expectancy	
Male	64
Female	66
Crude death rate	7.2
Population growth rate	2.06

Source: Pakistan Demographic Survey 2001, Federal Bureau of Statistics, Government of Pakistan

Two-thirds of the population live in rural areas. Average household size is estimated at 6.8 persons. As 38% of households consist of a single room with kitchen, these households have a greater concentration of IAP which leads to high exposure (8).

Health of women and children

Reproductive health problems are a significant cause of premature death and disability among women. Because of excess mortality of young girls and women of childbearing age, Pakistan is one of the few countries in the world where men outnumber women.

Pakistan's population of under-5-year-old children is 23.8 million and those of under-18 years consist of 73.7 million, literally half the population. More than 5.5 million children are born every year (larger than the entire population of New Zealand). Every year 700,000 children die, mostly due to common preventable problems. Pakistan ranks 157th in the world for Infant Mortality Rate (IMR), but appears to be doing better on the Child

Mortality Rate (CMR) (under-5 years) where it ranks 39. A disproportionate amount of child mortality falls within the neonatal period. The contrast between the IMR and CMR suggests that if a child has survived the first year of life in Pakistan, its future prospects of survival are much higher (9).

Various studies and surveys reveal that acute respiratory infections, diarrhoea, malnutrition and vaccine preventable diseases are the main factors for high infant and child mortality in Pakistan. Acute Respiratory Infections (ARI) account for 160,000 deaths per year. Mortality due to diarrhoea is decreasing while mortality due to ARI is surfacing as the number one killer of under-5-year-old children in Pakistan (9).

Causes of deaths among under-5 years old, 2001, Pakistan

Neonatal	12.48%
Pneumonia	4.35%
Typhoid	4.22%
Diarrhoea	2.99%
Born weak	2.99%

Source: Pakistan Demographic Survey 2001, Federal Bureau of Statistics, Government of Pakistan

Terms of reference of review

The Department of Child and Adolescent Health and Development (CAH), World Health Organization (WHO) invited the Department of Community Health Sciences (CHS), Aga Khan University (AKU), to undertake a situation analysis regarding indoor air pollution and the possible effects on the health of the women and children in Pakistan. Hence, the purpose of this report was to review available scientific literature and develop a situation analysis. This document reviews the available information on household energy use and possible health effects due to indoor air pollution in Pakistan. Based on the findings, the report also makes recommendations for improvement of the situation of indoor air pollution in Pakistan.

Methods and sources of information

A literature search was conducted through published sources. In the first attempt Medline and internet sources were searched using MeSH words “indoor air pollution”, “developing countries and indoor air pollution”, “indoor air pollution and Pakistan”. Next, an attempt was made to access information from local governmental and non-governmental agencies (NGOs) working in Pakistan.

Initially the Pakistan Environmental Protection Agency (EPA) and the World Conservation Union (IUCN) offices were contacted to identify agencies and institutions working on environment and indoor air pollution in Pakistan. A list of agencies and organizations working on environmental health that had undertaken or have the potential to undertake work on indoor air pollution is attached at the end of the report (see appendix).

A literature search at the libraries of EPA and IUCN was conducted. Published or unpublished reports regarding the work done on IAP in Pakistan were gathered.

Household energy use and indoor air pollution in Pakistan

In 1996, the Streamline Greenhouse Gas (GHG) Inventory Methodology study identified the procedures prescribed by the Intergovernmental Panel for Climate Change (IPCC) for estimating national GHG emissions in source categories, i.e. total energy, industrial processes, solvents and other uses such as agriculture and livestock, forestry and land use change, and waste.

Pakistan National Greenhouse Gas Emissions Inventory, 1989-90 (in 1000 t)

Greenhouse Gas Source Categories	CO_2 Emissions	CH_4	N_2O
Total energy (Fuel Combustion + Fugitive)	62625	323	0,11
Industrial Processes	3733	0	0
Agriculture	0	2146	0,05
Land Use Change and Forestry	15361	0	0
Waste	0	220	0
Total National Emissions	**81720**	**2689**	**0,16**

IPCC has proposed the following equations for estimation of carbon dioxide emissions from biomass consumption for energy purpose:

- *Emission from fuelwood*
  Wood consumed (000tonnes) * carbon content (27%) * amount oxidized (90%)

- *Emission from Charcoal*
  Charcoal consumption (000tonnes) * carbon content (87%) * amount oxidized (90%)

- *Emissions from bagasse and agriculture wastes*
  Agricultural waste (000tonnes) * carbon content (22.6%) * amount oxidized (90%)

Fuelwood consumption for Pakistan is estimated at 10,611, 000 tonnes of Oil Equivalent (TOE). Using the equation of IPCC for fuelwood, the carbon is estimated at 10.68 Tg which corresponds to 39.19 Tg of CO_2 emissions. Charcoal consumption for Pakistan is estimated at 170,000 tonnes, for which carbon is estimated at 0.133 Tg that corresponds to 0.488 Tg of CO_2 emissions. Similarly, bagasse/agricultural waste consumption is estimated at 8,120,000 TOE, for which carbon is estimated at 8.04 Tg which corresponds to 29.48 Tg of CO_2 emissions (10).

Although Pakistan is among the low-carbon-emission countries, energy consumption per capita tripled in Pakistan since 1970 due to economic growth and industrialization. Biomass is a major source of cooking fuel in Pakistan. The average CO_2 emission for the year 1999 is estimated to be 102.3 million metric tones (11). According to Ninth Five-Year Plan, it is estimated that 90% of rural households and 60% of urban households meet their needs through using biomass, including wood. However, no reference has been made regarding its source of information (12).

The only source of authentic data on consumption of wood (including fuelwood) comes from the Pakistan Household Energy Strategy Study (HESS) conducted in 1992. HESS showed that biomass fuels account for 86% of total household energy consumption in Pakistan and fuelwood accounts for 54% of the total. Most (90%) of the biomass is being consumed in homes. Biofuels are used in traditional stoves for cooking, domestic and water heating. Biofuels account for 94% of energy used by households in rural areas and 58% in urban areas. Cooking consumes 82.1%, domestic heating 7.3% and water heating 9.8% of total fuelwood used in domestic sector (13).

Biomass energy consumption in Pakistan, 1993-94 (kilo tonnes oil equivalent)

	Fuelwood	Other biomass	Total biomass energy
Production	12,219	9,154	21,373
Transport losses	-313	-448	-761
Final consumption	11,906	8,706	20,612
Residential	11,675	6,848	18,523 (89.89)
Commercial	225		225 (1.09)
Industry	6	1,858	1,864 (9.0)

Source: Asian Energy News, Asian Institute of Technology, Vol. 5, No. 11, November 1995

Cooking is the major end use of fuelwood, crop residues, dung, natural gas and liquid petroleum gas (LPG). HESS 1992 estimates give the share of fuelwood in domestic sector of 53.8% (including charcoal), dung 18.1%, agricultural waste 14.1%, natural gas 7.1%, kerosene and LPG 2.7%, and electricity 4.3%. The average annual household use of fuel according to various types of biomass and energy sources is shown in the table below, which shows that biomass is the major source of energy for the household sector. Therefore, the total amount of IAP produced due to biomass is much greater than fossil fuel use in the domestic sector. A household usually uses mixed types of fuel, however it is estimated that an average biofuel-using household consumes the following amount of biomass shown in the table below. Natural gas would by far be the cheapest fuel for cooking (14).

It is evident that millions of poor households in Pakistan rely on traditional biomass fuels for cooking and domestic heating. These households suffer a disproportionately high burden of ill health from exposure to indoor smoke. Lack of public awareness, insufficient knowledge of effective interventions, and inadequate attention given to policies and technological solutions to improve access of poor households to cleaner forms of energy complicate the situation.

Average annual household fuel consumption, 1991

Biomass fuel	Quantity
Fuelwood	2,324 kg
Dung	1,477 kg
Crop residues	1,161 kg
Charcoal	115 kg
Other fuels	
Electricity	1,238 kwh
Natural gas	40,220 ft^3
Kerosene	41 kg
LPG	122 kg

Source: Pakistan Household Energy Strategy Study, Government of Pakistan, under the UNDP, World Bank Energy Sector Management Assistance Programme (1994)

The World Health Organization (WHO) has divided the countries of the world into six different regions. Geographically, Pakistan falls in the WHO Eastern Mediterranean Region. "D" signifies that there is 'high child and adult mortality' in this region. Among high mortality developing countries including EMR-D, out of 10 selected risk factors for indoor smoke, biomass fuels account for 3.7% of DALYs and are the fourth most common risk factor. In EMR-D, 55% of households used biomass fuels and therefore were at risk of exposure to indoor smoke in 2000. Chronic obstructive pulmonary disease (COPD) among females and lower respiratory infections among children attributes to 45% and 41% of DALYs due to indoor smoke from biomass fuels, respectively. There is also a slight increased risk of cancers (tracheal/bronchial/lung cancers) among females compared to males in this region (15).

SOCIO-ECONOMIC FACTORS INFLUENCING IAP IN PAKISTAN

The choice of fuel type used by a household is influenced by its income level. Households with a higher income level use either gas or liquefied petroleum gas (LPG). The major factors affecting firewood consumption are location, income level, household size and availability of types of fuels. According to one estimate, in Pakistan, households that have 16 or more members consume only 2.2 times more than those having fewer than five members (3687 and 1785 kg/year, respectively) (14).

In Pakistan, availability of firewood and other alternative fuels and the availability of labour resources for collection purposes are important determinants of consumption. Whereas urban households purchase 86% of their fuelwood needs, over 69% of the total consumption is collected free, mostly by women and children, in rural areas. Rural households that collect firewood consume larger quantities compared to those who purchase it: 7.1 compared to 6.0 kg/day. This may be because collected firewood is of lower quality. Or it may be because the expense of purchasing firewood presents a greater incentive to conserve wood than does the efforts required to collect it (14).

Various sources confirm that in rural areas, income levels are not an important determinant of overall energy consumption. In these situations, the availability of the firewood and other biomass and the availability of labour resources (women and children) for collection purposes are more important determinants of consumption than are income levels (15).

Sources of fuelwood for urban and rural households – Pakistan 1992

Rural	**Low income**	**Medium income**	**High income**	**Total**
Buy only	22.5%	29.8%	40.2%	28.8%
Collect only	69.1%	58.5%	50.8%	60.9%
Buy and collect	8.3%	5.7%	9.1%	10.3%
Urban	**Low income**	**Medium income**	**High income**	**Total**
Buy only	78.4%	85.0%	91.6%	84.3%
Collect only	18.8%	9.4%	5.8%	11.5%
Buy and collect	2.1%	5.8%	2.3%	4.2%

Source: Siddiqui KM

In urban areas, about 86% of households purchase firewood and over 70% of these belong to medium-low or low income households with an average expenditure of less than Rs. 2000 per month, making them more sensitive than rural households to relative price changes in the cost of wood. When it comes to combined consumption, (almost) half the people purchase it and other half procure it free through collection (15).

Fuelwood consumption in rural and urban areas of Pakistan

	Rural		Urban		Total	
	Buy	Collect	Buy	Collect	Buy	Collect
Pakistan	25.8	74.2	73.4	26.6	49.6	50.4

Source: Siddiqui KM

A survey of households in Peshawar city carried out in 1992 showed that income level influences choice of fuel type used by the household. The poorer the household, the likelihood of biomass fuel use is more. The pattern is similar to other developing countries and is called 'energy ladder'. Also there is evidence that as the household size increases, the household per capita energy consumption decreases, therefore, the average per capita consumption also decreases. The household size and annual per capita energy consumption are negatively correlated (17).

Households in Balochistan consume the most fuelwood per household, probably due to lack of alternate fuels. Punjab has the highest consumption of crop residues and lowest consumption of firewood per household, because it has the largest farm area (18). On the other hand, Sindh has the highest consumption of electricity due to the high level of urbanization (19).

Per capita woodfuel consumption is estimated to be 0.27 tonnes in Pakistan. Per capita consumption of wood energy is higher in rural areas and lower in urban areas, where it decreases as the size of the city increases. The consumption of wood stays relatively constant as income levels increase in rural areas but decreases markedly with increase in income in urban areas. The transition of biomass to fossil fuel is driven by the urbanization process. The urban household switches to modern fuels, the availability of which generally increases with the size of the urban settlement (19).

Cooking fuel	Percent of households in Peshawar city
Wood	13.4
Charcoal	-
Kerosene	33.8
LPG	7.8
Gas	38.7
Dung	6.3
Total	**100**
Household size	**Average annual per capita energy consumption (million kj)**
1-3	8.12
4-6	6.13
7-9	5.47
10-12	4.23
13+	4.16

Source: Siddiqui KM, 1997

In Pakistan, total energy consumption in the household sector grew about 74% from 9.46 million TOE in 1980-81 to 16.44 million TOE in 1994-95 (17). Moreover, there occurred a shift in favor of greater use of commercial fuels in households; this increased from 10% to 27.5% over the same 15-year period. However, during 1994-95, the total energy consumption in the country showed a growth rate of 3.6% per annum which is not very high if population growth rate of almost 3% is taken into account (20).

Another interesting study found that traditional energy use patterns delay the demographic transition from patterns of high mortality-high fertility to low mortality-low fertility, thereby impeding economic growth. These findings have important implications for the development of strategies to improve the quality of rural life and alleviate poverty among developing countries (21).

Fuel type used	Annual household fuel expenditure	
	Rs	US $
Wood	4636	185
Kerosene oil	4065	163
LPG	1198	48
Gas	3591	144
Dung	755	30
Weighted average	3526	141
1 US $ = 25 Pak rupees (1991)		

The study conducted in Peshawar city found that the average annual household fuel expenditure (excluding electricity) was 3526 rupees. However, it varies with the type of fuel used by the household.

It is evident from the above data in the table that kerosene and gas are the predominant fuels used by the people of Peshawar city and account for 80% of total estimated consumption. Woodfuels account for 15.7% of total consumption. The remaining 4% is accounted for by LPG and cow-dung. It may be emphasized here that consumption is measured in terms of delivered energy. Since burning efficiency of different fuels varies between 0.2-0.7, the net energy consumption will be less than the delivered energy (16).

BIOMASS OTHER THAN WOOD

Woodfuels dominate the household sector and account for 53.3%, and charcoal a further 0.6% of total household energy consumption. However, there are other biomass besides woodfuels which are commonly used in Pakistan, the details of which are as follows:

Dung: It is estimated that about 60% of the households use, on average, 3.2 kg of dung per day. The Baltistan Energy Survey Expedition in 1988 found that 68.3% of sampled households used dung cakes with an average of 2 kg/day. HESS showed that 56.3% of households use dung as fuel, consuming 13.3 million tons in 1991; one third of the total dung production of 39.4 million tons. More than 85% of dung used as fuel is consumed by rural households. Dung cake is the cheapest fuel in financial terms. The average market price of dung cake is Rs. 0.50 per kg. whereas firewood prices are almost 174% higher. Dung is still cheaper at Rs. 0.28/MJ compared to Rs. 0.62/MJ for firewood.

Crop residues: Crop residues supply the largest amount of energy to the household sector after firewood and dung, and account for 8.3 million tons, equivalent to 2.82 M TOE. Large quantities of fuelwood substitutes are also being used in Pakistan and are estimated to be over 8 million tons annually (14).

Total consumption of biofuels of selected crop residues (thousand tons/year)		
Biomass types	**Consumption**	**Percentages**
Cotton sticks	5,148	64.0
Local biomass	1,678	20.9
Bagasse (sugar-cane)	298	3.7
Kahi grass	293	3.6
Rice straw/husks	211	2.6
Corn husks/stalks	201	2.5
Wheat straw	159	1.9
Tobacco husks	29	0.4
Coconut shells	29	0.4
Total	**8046**	**100.0**

Source: Ouerghi and Heaps, 1993

ENVIRONMENTAL TOBACCO SMOKE (ETS)

Pakistan faces the increasing threat of tobacco-related health and economic hazards. People smoke in confined spaces such as inside homes, offices and public transport (23). People smoke in public places because of ineffective legislation and there is little political will to control smoking (24).

BIOMASS USE IN 'RURAL INDUSTRIES' AND 'VILLAGE APPLICATIONS'

Biomass is also used in 'rural industries' and 'village applications'. In the context of Pakistan, a 'rural industry' can be defined as an enterprise established in rural areas to pursue commercial interests such as curing tobacco and making bricks, pottery and ceramics etc. 'Village applications' include popcorn making, social ceremonies and other services like *hammams* (hot baths), etc. (25). The total quantity of fuel used for both 'rural industries' and 'village applications' in the above mentioned activities comes to over 12 million tons (4.29 million TOE) of fuelwood and its substitutes. This illustrates the magnitude of the use of fuelwood in 'rural industries' and 'village applications' (25).

Methods to control IAP

POLICY FORMULATION

Indoor air pollution is not considered a public health problem among the population and scientific community in Pakistan. Therefore, little direct evidence of adverse effects of indoor air pollution on health is available.

There is a general lack of information on the availability and effectiveness of the types of intervention for reducing indoor smoke. Intervention studies conducted to date are small- scale and inconclusive.

Addressing IAP effectively will require multiple actions to be taken including raising awareness among government decision-makers and the population in general. In addition, interventions in areas such as the petroleum sector, small business development, improved stove programmes, rural poverty alleviation strategies and health education are required.

IMPROVED COOKING STOVES

Interventions to alleviate IAP in developing countries have tended to focus overtly on improved cooking stoves, although the potential for other interventions such as smoke hoods, cleaner fuels (fossil fuel, electricity, etc.), modified kitchens or designing of ventilated houses are also available.

Less work has been done to establish the necessary reductions in the pollution levels for alleviating the health impacts of IAP. However, significant work has been done and advocated in the context of fuel-efficient stoves in Pakistan.

A fuel-efficient cooking technology project (providing improved stoves) funded by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) of Germany was launched successfully and implemented throughout Pakistan. Due to encouraging results, another programme (Fuel Saving Technology) was initiated by the Government. The programme also provided incentives to NGOs and community-based organizations, with the result that NGOs and the private sector improved the quality and efficiency of cooking stoves to such a level that cooking stoves are now being exported to Afghanistan and Central Asian States (26).

In northern areas of Pakistan, the Aga Khan Planning and Building Services, Pakistan (AKPBS,P) project showed that on an average, a single house consumes approximately 5.9 tons of wood each year, making fuelwood as one of the major expenses for individual households. After food, it accounts for 11% of all household expenditures and 23% of all non-food household expenses (1998-2000) (27). In a pilot project implemented by AKPBS,P in rural Sindh in which smoke-free stoves (SFS) with smoke-hoods were built, the cost of a smoke-hood was 90 rupees and was provided free of charge by AKPBS,P, while stoves made of clay for 25 rupees were bought by the users. The project was evaluated by Aga Khan University, Community Health Sciences (AKU-CHS) at the request of AKPBS,P. AKU-CHS assessed the smoke-free stoves (SFS) for acceptance in the communities, the social and health impact on the lives of the women, appropriateness of stoves as technology and technical efficiency and environmental impact (28). SFSs are made of clay and husk and are a technology of the Pakistan Council for Renewable Energy Technology (PCRET) which was adopted by the Building and Construction Improvement

Programme (BACIP), an AKPBS,P programme. The SFSs were compared with traditional three-stone stoves (TS). A quantitative survey and focus group discussions (FGDs) with women and village development organizations (VDOs) were conducted, and carbon monoxide (CO) levels in kitchens were measured, comparing the results of SFS with TS users. Overall, 45 intervention (SFS) and 114 non-intervention (TS) households were compared. The following were the key findings of the evaluation:

- Most of the households were using wood (97% in SFS and 89% in TS) in these villages. About 19% of the households still used TS alongside SFS.
- The majority of the households using SFS thought that the stove produced less smoke compared to those who were using TS.
- Some of the women thought that it was convenient and quick to cook on SFS, because it had space for two pots to be cooked simultaneously.
- There appeared to be no significant perceived economic efficiency of SFS compared to TS for communities (fuel-efficiency). Most women did not know whether the stove consumed less or more fuel. This may be because the easy availability of wood in that area rendered it difficult to ascertain the difference and therefore was of little concern for individual households.
- In rural Sindh, mothers usually do not keep children with them in the kitchen; therefore there is less chance of exposure of children to smoke.
- Women who were using TS complained of more difficulty in breathing, heat, cough and tears while cooking (TWC).
- In the multivariate analysis, adjusting for socioeconomic variables, we found that symptoms of dry cough (AOR = 0.61; 95% CI0.26-1.41), sneezing (AOR = 0.54; 95% CI 0.22-1.30) and tears while cooking (TWC) (AOR =0.51; 95% CI 0.21-1.21) were less likely to occur in those women that were using SFS compared to TS. However, the results were not significant statistically, probably due to the small sample size.
- Regarding CO measurements, the results showed a mean lowering of 10 ppm of CO in the ambient air of SFS compared to TS kitchens. Although, the SFS had not achieved a safe level of CO (8 pmm or below), it had made an improvement.

RENEWABLE ENERGY RESOURCES

Renewable energy resources are the resource of energy that is replaced rapidly by natural processes such as sunlight, hydropower etc., and includes solar, wind or biogas plants. Renewable energy use is a new concept in Pakistan and its role is negligible in total energy. Use of renewable energy could play a major role in reducing IAP and could be a good alternative to biomass.

There is a potential for using biogas as rural energy throughout the country by a network of community biogas plants. The Government of Pakistan started a comprehensive biogas scheme in 1974 and commissioned 4550 biogas units by 1990 throughout the country. The units were designed to provide 3000 to 5000 cubic feet of biogas per day for cooking and lighting. The programme was developed in three phases. During the first phase, 100 demonstration units were installed under grant by the Government. During the second phase, the cost of the biogas was shared between beneficiaries and the Government. Later on for the third phase, the Government withdrew financial support, however, technical support continued to be provided free of charge. Unfortunately, after the withdrawal of the government financial support, the project did not progress any further (26).

Pakistan produces enough animal waste for the production of biogas. Currently all such animal waste is burned in dry form as a domestic source of energy. The same can be used for producing biogas at the community level (29).

ENHANCING ACCESS TO MODERN FUELS

Although overall most households in Pakistan rely on biomass, natural gas is the fuel of choice of urban residents. The price of natural gas is considerably lower than any other energy source. Forty-five percent of urban households, and over 80% of all households, however, do not use natural gas. Facilitating the uptake of natural gas among urban households through gas pipeline expansion is an option. But the expansion of gas to rural areas as an option should be looked at carefully to ascertain whether those less well off would be able to afford the connection charges which would be required initially (30).

HOUSING INTERVENTIONS

Housing intervention is another possibility to reduce IAP. However, very little attention has been paid in this regard so far in Pakistan. A study to measure health effects of housing interventions was conducted in (Northern Areas) Pakistan both by Aga Khan Health Service, Pakistan (AKHS,P) and Aga Khan Planning and Building Service, Pakistan (AKPBS,P). This pilot study was proposed to collect data on the implications of selected housing improvements, specifically in relation to health. The study was to determine whether there is a correlation between better lighting, ventilation and warmth inside the house with fewer illnesses and improved health in general. The data was collected in two sets of houses – intervention and non-intervention houses. Fifty study and 100 control houses were selected for the study. The intervention houses were selected on the basis that: (1) they have installed at least one improvement that addresses the issues of ventilation and/or warmth, namely roof hatch window, wall insulation, and double-glazed window; and (2) households with improvements installed at least one year prior to the study. The control houses were carefully chosen on the basis of their similarity to the intervention houses in terms of the following socioeconomic characteristics: age structure, education, income, and housing characteristics. The study revealed that there is a relationship between better housing conditions and disease burden in general. That there were fewer illnesses when a house is warm, well ventilated and well lit. Although, the studies were not controlled for many confounders, houses with interventions (installed at least one ventilation or warmth structure in the house such as roof hatch window, wall insulation, and double-glazed window) showed significantly lower illnesses (4.3%) than where interventions were not done (9.0%). Wall insulation reduces ventilation, roof hatch windows are likely to increase ventilation, and double- glazed windows could either increase or decrease ventilation, depending on how people use them. Therefore, the results and conclusions of this study are questionable (31).

FUELWOOD CONVERSION SYSTEM

In the United States, Austria and Northern Europe, biomass is used for the production of electricity and running heating systems. In Brazil, it is used in the production of steel. Sugarcane bagasse-based electricity production accounts for about 10% on the island state of Mauritius. Conversion of dung into biogas is common in many South Asian countries like India, China and Nepal, etc. This option has not been explored much in Pakistan as yet (32).

ORGANIZATIONAL CAPABILITIES IN PAKISTAN

There are several governmental and nongovernmental (NGOs) organizations working in renewable energy technology projects throughout the country particularly in rural areas. NGOs, however, are not involved in national policy-making. In Pakistan, almost all the research and development work is carried out by public sector organizations (33). The activities of all those who are wholly or partly involved in research in the field of renewable energy technologies and their applications are given below:

The National Institute of Silicon Technology (NIST)

The National Institute of Silicon Technology (NIST) was established under the Ministry of Science and Technology and was devoted to research, development and popularization of solar energy in general and photovoltaic cells in particular in the country. The Institute concentrates mainly on the complete spectrum of monocrystalline silicon solar cell technologies. It has the facilities for growing the silicon single crystals, sawing ingots into wafers, processing wafers to fabricate solar cells, laminating photovoltaic modules and making different types of tests and measurements of cells, modules and systems. Current research interests are on the development of low-cost processes by using comparatively cheaper and indigenously available materials. The Institute has also developed systems such as solar lanterns, street and garden solar lights, cells and battery chargers, light home systems, etc. (34).

NIST is also working actively on the development of low cost and efficient solar thermal appliances such as solar water heaters, solar cookers, solar dryers, solar desalination plants, etc. This makes the centre unique and provides an opportunity to see a large number of different but closely related solar technologies in one place. The Institute has earned an international reputation and has developed linkages with a number of international organizations. The Institute also acts as headquarters of the Inter Islamic Network on Renewable Energy Source – one of many networks of the Organization of Islamic Conference (OIC) Standing Committee on Scientific and Technological Cooperation (COMSTECH). COMSTECH aims at assessing human and material resources and building indigenous capabilities in the fields of science and technology. It is working for the promotion, continuing cooperation and coordination in scientific and technological areas with its member states and creation of an effective institutional structure for planning research, development and monitoring of scientific and technological activities (35).

Solar Energy Research Center

Solar Energy Research Center, Hyderabad is part of the Pakistan Council of Scientific and Industrial Research (PCSIR) under the Ministry of Science and Technology. Its research and development programme aims to utilize adoptive and adaptive methodology to exploit solar energy sources. The special fields of interest include solar thermal applications, including power generation, solar desalination, solar air-conditioning and heating. Their work is still at the experimental level (36).

Pakistan Council of Appropriate Technology (PCAT)

The Council was established in Islamabad with the main objective to implement appropriate technologies in the country. Major areas in which PCAT has been involved pertain to food, energy, health and habitation including potable water, sanitation and income-generating trades at the grass roots level. PCAT has worked in the field of renewable energy, i.e. installation of mini-hydropower plants, biogas plants, solar cookers, harnessing wind energy for water lifting and energy efficient cooking stoves.

The offices of PCAT are established in all provinces with staff trained in energy fuel saving technologies and biomass. These establishments train the master trainers of NGOs/CBOs. NGOs, in turn, identify the problems encountered in the field for these technologies and rectify them (26).

Universities

A number of university departments are also actively involved in research in the field of solar thermal activities. The National University of Science and Technology (NUST) is active in solar thermal power generation, starling engine, and indoor heating / cooling. The Institute of Environmental Studies Technologies of Ghulam Ishaq Khan (GIK) Institute are involved in solar thermal device testing, and the Mechanical Engineering Department of the University of Engineering and Technology, Lahore, in solar radiation and other solar thermal activities.

Conclusions and recommendations

The document attempts to present and assimilate available information on indoor air pollution in Pakistan. Environmental health is a comparatively new area of research, therefore, information on environmental statistics, especially in relation to environmental health, is rudimentary in Pakistan. Sporadic efforts are being carried out on environmental health throughout Pakistan, therefore, there is great need to document such activities.

Regarding air pollution, data is generally available about ambient air quality focusing on outdoor air such as concentrations of SOx, NOx, CO, PM_{10} and ozone, these key air pollutants being reported at selected urban locations only. As IAP has not been recognized as a hazard as yet, data is very sparse and not available in Pakistan. There is very little published literature available regarding IAP.

Published literature and reports either do not have direct evidence from the data or it does not count IAP as an environmental health issue for Pakistan. Most of the documentation available is focused on the ecological environment. Therefore, the scope of human health has been neglected throughout. The information gathered in these documents is from random sources and there are very few well-conducted studies available. Also it seems that data has been collected for two purposes: from the government perspective to show progress in their field, namely forestry and woodfuel conservation, or from independent sources which attempt a situation analysis taking into account various sources and analyses.

Data regarding household energy use are comparatively better-documented than those on the effects of IAP on health. Household energy-use data is collected in the context of forest conservation and woodfuel energy management and preservation. However, the recommendations made for woodfuel conservation at times, favour the reduction of IAP in Pakistan. For example, burning of dung has been considered as draining the agricultural potential of the country and has been advocated to be utilized for agricultural purposes. In this respect, many reports have advocated the promotion of fuel-efficient cooking stoves. Sporadically, in these reports, there is some emphasis on gender role in wood collection and the relation of women's health to energy use in Pakistan. Nonetheless, the focuses of these reports are more to do with the effect of wood collection, rather than IAP on women's health.

Contributing factors for IAP such as population increase and overcrowding are evident from the household energy-use data. This situation is exposing an increasing number of the population to indoor physical and biological hazards as well as depleting forests (deforestation) at an alarming rate. The current state of affairs is that most households are utilizing biomass as their main source of energy. Besides depleting forests, this is leading to a high level of IAP exposure and health consequences in Pakistan. Women and children, who live mostly indoors, due to less involvement in outdoor work, and school enrollment ratios, are primarily exposed to IAP in Pakistan. Poverty leading to fuelwood shortage forces women to use less preferred smoke-generating lower quality fuels, dung and agriculture residues, leading to health problems in rural women. Besides that due to wood shortage, women are obliged to walk long distances to collect wood carrying heavy loads.

There is also potential to join efforts with organizations working on gender and their involvement to protect the lives of women from the hazards of wood collection and its improper utilization. Studies should be conducted on gender participation at all stages of fuelwood production, flow and utilization to identify the extent of the role of women. Policy-makers should not ignore the central role of women in the rural energy system in designing interventions, to enhance rural development. Studies on the behaviour of the population regarding IAP are also required.

The situation warrants formulation of a policy regarding IAP in Pakistan, namely recognizing it as a major hazard for the population, especially women and children; setting pragmatic and achievable standards regarding indoor air; directing the attention of stakeholders towards developing interventions to decrease IAP in Pakistan. Development of national standards by environmental protection agencies (EPA) regarding indoor air pollution would also expedite the process. At the moment, there is no regulation which gives guidelines on levels of IAP in Pakistan.

In this regard, a meeting should be arranged between community-based development organizations which are working to improve the rural and urban environment, ministries of health and forest, national environmental protection agencies, international organizations and bilateral and multilateral agencies working on environmental health aiming to improve the environment in Pakistan (see appendix).

The data are sparse regarding health consequences due to IAP in Pakistan. However, there may be less need for accumulation of the direct collection of evidence of health impact of IAP in Pakistan, because the attributable risk associated with IAP is well-established through the global comparative risk assessment. In this respect, well-conducted studies of effective interventions for reducing IAP and fuel consumption and its beneficial impact are needed. These interventions should be practical, acceptable by the users, and required to be sustainable, cost-effective and fuel-efficient. Pilot studies of various interventions have been carried out at various places within Pakistan. These efforts need expedition and collaboration to enhance their impact.

One of the available and practical options to improve the situation of indoor air includes development and adoption of fuel-efficient and smoke-free stoves for the population at large. This will have a 'double impact' of improving the environment and health, primarily of women and children and saving energy. Deficiencies have been identified in the implementation of such smaller-scale interventions therefore, these could be addressed in future interventions. Development and dissemination of improved cooking stoves to improve kitchen hygiene and women's health on a large scale could have a major impact. Also research on efficient utilization of fuelwood should be strengthened and promoted.

Besides improved stoves, other technologies already developed by the Pakistan Council of Appropriate Technology (PCAT) should be introduced in the market on a mass scale.

LIMITATIONS OF REVIEW

This review attempts to carry out a situation analysis of IAP, based on a review of documents, published and unpublished reports from various agencies and organizations working in Pakistan. These documents at many points felt incomplete in their information and analysis. The reported studies are observational and very few measure exposure directly, instead relying on proxy indicators such as fuel type, stove type or time spent near the fire. The main purpose is to communicate essential facts and deficiencies in the available information on IAP in Pakistan. These documents have been synthesized in the text to give an overview of IAP. Apart from recent documents that included information on IAP, previous documents on environment did not consider IAP as a threat to health and therefore lack information in this regard. Also, despite mounting evidence that biomass smoke exposure increases the risk of a range of diseases, there is very little well-designed intervention being done so far in Pakistan.

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32.	Enercon, Islamabad	Shamsi, S.S.
33.	Hydrocabon Develoment Inst. of Pakistan, Karachi	Sarwar, S.N.
34.	National Physical and Standards Laboratory, Islamabad	Z. A. Khan
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Dr. Ambreen Kazi is a senior resident, a post-graduate trainee for fellowship, in Community Medicine (FCPS). She is qualified in Family Medicine (MCPS). She has an interest in environmental burden on women in Pakistan. In this regard she is developing 'stress scale for pregnant women', assessing the social environmental burden on women in Pakistan.

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