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Research Article

Indoor Air-Pollution/Biomass Fuel as a Risk Factor of Opportunistic Respiratory Tract Infections in HIV Sero-Positive Patients of Western India

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Abstract

Background: It is well known that one third poor population of world use biomass fuel for cooking and heating. It is universally accepted fact that bio-mass fuel plays a significant role as predisposing factor of tuberculosis and acute respiratory tract infections even in non-immuno-suppressed (HIV sero-negative) individuals.

Aim: To study effects of biomass fuel on prevalence of RTI/tuberculosis on HIV-infected patients of Gujarat.

Materials and Methods: In the present study 961 HIV infected patients with RTI and 300 HIV infected patients with out RTI and 300 HIV-uninfected patients with RTI were surveyed for use of bio-mass fuel or clean fuel.

Result and Conclusion: It had been surveyed, statistically analysed and had been found even higher risk predisposing factor mainly for tuberculosis and other acute respiratory tract infections in immune-suppressed HIV-sero positive patients. It had been found that those who were HIV+ and using biomass fuel were found to have 2.3 times higher chance of contracting respiratory tract infection as compared to those negative for HIV. The 95% confidence interval not including the null value (OR = 1) indicates the significant association of the HIV status and the occurrence of RTI.

Keywords: *Biomass Fuel; Clean Fuel; RTI; TB; HIV*

Introduction and Methodology

The RTI are among the first opportunistic infections, observed in HIV patients and unlike HIV sero-negative persons some of the RTI even causes permanent damage to respiratory tract, thus affecting both quality and quantity of rest of their life. So, it is very important to prevent RTI in HIV patients by understanding risk factor for RTI in them. In this study we tried to understand the effect of biomass fuel (BMF) on opportunistic RTI in HIV patients.

Alison Morris., *et al*. [1], found that pneumocystic carinii pneumonia and bacterial pneumonia were associated with permanent decreases in FEV1, FVC, FEV1/FVC, and the diffusing capacity of carbon monoxide in HIV patients. Neither infection resulted in statistically significant changes in TLC. Alison Morris., *et al*. [1] concluded that PCP and BP resulted in expiratory airflow reductions that persist even after the acute infection resolves permanently in HIV patients.

Inefficient burning of BMF on an open fire or traditional stove generates large amounts of particulate matter as well as carbon monoxide, hydrocarbons, oxygenated organics, free radicals and chlorinated organics [2]. The particulate matter component of this smoke is classified according to its size, with inhalable material < 10 μm in aerodynamic diameter referred to as PM_{10}. The 24-h mean particulate matter levels set in the WHO guidelines for air quality are 50 $\mu g/m^3$ for PM_{10} and 25 $\mu g/m^3$ for $PM_{2.5}$ [3], but in many parts of the developing world the peak indoor concentration of PM_{10} often exceeds 2000 $\mu g/m^3$ [4,5]. Critically, there are age, gender and socioeconomic differences in levels of exposure and the consequent health effects [6]. Exposure to BMF has been estimated to have caused 0.5% of all deaths and 0.4% of all disability-adjusted life-years in South Africa in 2000 [7]. This review will examine the health effects on children and adults separately as well as distinguishing between respiratory and non-respiratory illness.

According to the Indian National Census (2001), 75% of households use solid fuels (primarily firewood and cow dung), with the prevalence of solid fuel use as high as 90% in rural areas. Currently about 70% of India's population lives in rural areas (estimated to decline to 55% by 2030). In India, an estimated 400,000 deaths from acute lower respiratory infection (ALRI) in children younger than five and 34,000 deaths from chronic obstructive pulmonary disease (COPD) in women are attributed annually to household solid fuel use, making this the third leading risk factor amongst all risk factors contributing to the national burden of disease and exceeding the burden attributable to outdoor air pollution [8-10].

	HIV+	**HIV-**	**Total**
RTI+	961	300	1261
RTI-	300	217	517
Total	1261	517	1778

Table 1: *Occurrence of RTI among those reporting to ART centre.*

OR = 2.317 and 95% CI = 1.86 to 2.88.

It can be seen that those who were detected as HIV+ had 2.3 times higher chance of contracting respiratory tract infection as compared to those detected negative for HIV. The 95% confidence interval not including the null value (OR = 1) indicates the significant association of the HIV status and the occurrence of RTI.

Results and Discussion

Globally, total number people living with HIV in 2012 are 35.3 million. In parts of the world where HIV infection is most common, BMF is the main energy source. In Malawi, for example, the incidence of HIV in pregnant women is 33%, and 70% of hospital admissions [11,12] and > 80% of households use BMF. However, the influence of BMF smoke on HIV-infected individuals has not been clarified.

The most important effect of HIV infection in Africa is to cause increased bacterial infections, pneumonia and TB. HIV infection is associated with mild airway obstruction and loss of gas transfer, with severe impairment occurring in the presence of *Pneumocystis jirovecii* infection [13]. HIV is also associated with the accelerated development of COPD [14] and it is likely, although not proven, that HIV infection is a significant contributor to airway disease in much of the adult population of Africa. Since both BMF use and HIV are associated with an increase in the incidence of pneumonia [9,15] and as particulate matter exposure and HIV result in increased pulmonary inflammation

[16,17], it is possible that by causing pulmonary inflammation the two major risk factors for pneumonia in African adults (HIV and BMF smoke) may actually demonstrate previously unrecognised synergy.

Tuberculosis is the second most common cause of death globally in adults attributable to a single infectious agent (WHO, 1998). Tuberculosis remains the leading cause of death due to infection in India, which bears nearly 30% of the global tuberculosis burden [18]. Each year, 2 million people in India develop tuberculosis and nearly 500,000 die from it, averaging more than 1000 TB deaths a day (WHO, 2000). India has the largest pool of people infected with tuberculosis (*Mycobacterium tuberculosis*) with an annual incidence 1.98 million, the largest number in any one country and catering to a fifth of the global burden of TB. It is estimated that more than half of India's adult population is infected with tuberculosis bacterium, *Mycobacterium tuberculosis*. Once a person is infected, any condition that weakens the immune system can trigger the development of active tuberculosis. Typically, 5 to 10% of these infected eventually become ill with active tuberculosis (ATS 1990). However, this percentage may be higher in the case of India, because of the ubiquity of the tuberculosis bacillus, high population density and poor socioeconomic and health conditions. Approximately 500,000 persons die from tuberculosis each year in India. In recent years, the growth of drug resistant tuberculosis and the rapid spread of human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) has contributed to the resurgence of tuberculosis in India and in other parts of the world (Raviglione MC, 1995; Piot P, 1997; Kochi A, 1994; WHO, 1992; Sawert H, 1996). NFHS recorded an overall active tuberculosis prevalence rate of 467 per 100,000 persons (IIPS, 1992) slightly higher than other estimates of the active (sputum positive) disease rate in India, which mostly range between 400 - 450 per 100,000 persons (WHO, 1992). Tuberculosis is a social disease with medical aspects and it has been described as a barometer of social welfare.

Risk factors associated with tuberculosis

Tuberculosis is a contagious airborne infection and a multifactorial disease in which the environment interacts with host-related factors to contribute to the overall clinical spectrum [19]. Despite the fact that the causative organism was discovered more than 100 years ago highly effective drugs and vaccines are available making tuberculosis a preventable and curable disease, it still remains a worldwide public health problem. Host-related and environment-related factors have been shown to play a role in the development of tuberculosis (TB), but few studies were carried out to identify their respective roles in resource-poor countries (Lienhardt, 2003).

Exposure to indoor air pollution especially particulate matter from combustion biofuels like wood, charcoal, agriculture residues and dung has been associated with respiratory diseases in less developed countries [8,20-22]. Cooking smoke has shown to increase the risk of acute respiratory infections chronic obstructive lung diseases (COPD), corpulmorale lung cancer and TB [19,23,24]. The mechanism by which cooking smoke can increase risk of respiratory diseases like tuberculosis is not well understood. It is plausible that cooking smoke increases the risk of tuberculosis by compromising the respiratory system's ability to resist infection by *M. tuberculosis* or resist development of active tuberculosis in already infected persons. Cooking smoke has been shown to compromise important pulmonary immune defence mechanism in animals [25] which results in increased susceptibility to infection and disease. Exposure to wood smoke may also impair the mucociliary defences of lung (Houtmryers E., *et al*. 1999) and decrease several antibacterial properties of lung macrophage, such as adherence to glass, phagocytic rate and the number of bacteria phagocytosed, thereby reducing resistance to lung infection. Chronic exposure to tobacco smoke also decreases cellular immunity, antibody production and bronchial immunity leading to increased susceptibility to infection and cancer (A Moniruzzaman 2006).

An analysis of data of 200000 Indian adults found an association between elf reported tuberculosis and exposure to wood smoke [19]. Persons living in households burning biomass fuel reported tuberculosis frequently than persons using clean fuels, with an odd ratio of 2.58 (1.98 - 3.37) after adjustment of socio-economic factors. Information of TB was gathered from National Family Health Survey data (NFHS, 1992-1993) that relied only on self-reported fuel and diseases. Blases associated with self reported TB and the lack of information on potential confounders such as smoking indicate the need of additional studies to examine association.

There is strong evidence to support an association between solid fuel use and acute lower respiratory 4act infections (ALRI), chronic pulmonary obstructive diseases (COPD) and lung cancer (for coal only) [22,26,27]. Although there is epidemiological evidence to suggest an association with tuberculosis [19]. Few studies examining the association of TB and indoor air pollution have reported positive association [28] and few studies have even shown no association (Shetty, 2006; Crampkin 2004) in their studies with HIV-sero-negative patients. But we felt that in HIV sero-positive patients with suppressed immunity everyone would find a strong association between biomass fuel and RTI and TB.

Social factors include poor quality of life, poor housing and overcrowding, population explosion, under nutrition, lack of education, large families, early marriage, lack of awareness of cause of illness. Poverty, economic recession and malnutrition make population more vulnerable to TB. Recent increase in human migration has rapidly infected the uninfected communities. To make global situation worst, TB has formed a lethal combination with HIV. All these factors are interrelated and contribute to the occurrence and spread of tuberculosis (Park, 2005). Tuberculosis infection is more or less distributed uniformly in rural, semi-urban and urban population. Majority of cases come from rural and semi-urban region as more than 80% of population live in rural and semi-urban region. In urban India, most of the urban cases come from slum dwellers and low socioeconomic groups. The development of tuberculosis (TB) in man is a two-stage process in which a susceptible person exposed to an infectious TB case becomes infected and may later develop the disease, depending upon various factors. In a study conducted by Grzybowsk., *et al*. the risk of active disease among infected contacts also increased with closeness of contact (Ballard-Tremeer G, 1996) suggesting that the infecting dose may influence the risk of active tuberculosis as well as the risk of infection. In individuals infected with *Mycobacterium tuberculosis*, any condition modifying the balance established in the body between the host's immune defences and the tubercle bacilli can have an impact on the risk of developing the disease. Factors that have been shown to influence this balance have been investigated for a long time, and were reported to be both 'intrinsic' and 'extrinsic' to the host (Awasthi S, 1996). However, in most studies investigating risk factors for TB, host-related and environmental factors were usually investigated separately, using different.

Tuberculosis is a contagious airborne infection and a multifactorial disease in which the environment interacts with host-related factors to contribute to the overall clinical spectrum [19]. In India, tuberculosis is still one of the major cause of death from infectious diseases. Several researchers have suggested that poor living, socioeconomic conditions and several environmental factors are closely associated with TB transmission. Recent studies have focused on the influence of HIV on TB, but have not assessed other risk factors. However, there are limited studies showing this relationship between TB and the environment in India especially exposure to biomass fuel smoke. Hence this study was conducted to examine the relationship between biomass fuel and tuberculosis, RTI and HIV. In the present study strong association was found between type of fuel used and TB, RTI and HIV sero-positivity Out of five studies on indoor air pollution from biomass fuel combustion and risk of TB published at the time of the start of this study, three studies found positive association and two studies found no association. Moreover, biases associated with self reported TB and the lack of information on potential confounders such as smoking indicate the need for additional studies to examine the association between biomass smoke exposure and TB, RTI and HIV. Hence, this study was designed to address the role of indoor air pollution due to use of biomass fuel for cooking in development of tuberculosis, RTI in HIV patients. Since TB has a long latent period a cohort study would not be feasible and therefore a case control study design was chosen which has higher strength of evidence than a cross-sectional study design. This study showed strong association between cooking with biomass fuel and tuberculosis, RTI in HIV patients but did not reveal real association as the control and test did not match well in other factors like socio-economic condition, literacy and information about ventilation in home. This was consistent with the case-control studies conducted in Malawi by Crampin., *et al*. 2004 (OR = 0.6) and in South India by Shetty., *et al*. 2006 (OR = 0.9) as shown in table 2. A cross-sectional analysis of the NFHS household data for India conducted by Mishra., *et al*. 1999 found that use of biomass fuel increased the risk of self-reported pulmonary TB as compared to households reporting use of clean fuel (OR 2.58). Recent studies are also indicating mixed results, few showing association and few have found no association as shown in table 2. A recent study from Nepal (Pokrel, 2010) has shown 3.54 times higher risk in kerosene users, whereas the study has shown no association with use of biomass fuel for cooking. Another study conducted recently in a tertiary care hospital from North India [Behera, 2010] have found no association whereas study from South India (Kollapan, 2009) have shown 1.7 times higher risk in biomass users, where the study population had 87% males and 13% females. Study from Chandigarh found association with biomass fuel use whereas there was no association found for women who were life time biomass mass users (Lakshmi, 2010).

Author	Study type and location	OR
Gupta., *et al*. (1997)	Case-control, North India	2.54 (1.07 - 6.04)
Mishra., *et al*. (1999) NFHS	Cross sectional	2.58 (1.98 - 3.37)
Padilla., *et al*. (2001)	Case-control, Mexico	2.20 (1.10 - 4.20)
Crampkin., *et al*. (2004)	Case-control, Malawi	0.60 (0.30 - 1.10)
Shetty., *et al*. (2006)	Matched case-control, South India	0.90 (0.46 - 1.76)
Kollapan (2009)	Matched case-control, Tamilnadu	1.7 (1 - 2.9)
Behera (2010)	Matched case control, North India	0.60 (0.22 - 1.63)
Pokhrel (2010)	Matched case control, Nepal	1.21 (0.48 - 3.05)
Lakshmi., *et al*. (2010)	Matched case control, North India	3.14 (1.15 - 8.56)

Table 2: *Studies which have evaluated the association of indoor air pollution and tuberculosis.*

Authors study type and location OR (95% CI)

- Padilla., *et al*. (2001) Case-control, Mexico 2.20 (1.10 - 4.20)
- Crampkin., *et al*. (2004) Case-control, Malawi 0.60 (0.30 - 1.10)
- Shetty., *et al*. (2006) Matched case-control, South India 0.90 (0.46 - 1.76)
- Present Study Case-Control, Gujarat
- Kollapan (2009) Matched Case control, Tamilnadu 1.7 (1 - 2.9)
- Behera (2010) Matched case control, North India 0.60 (0.22 - 1.63)
- Pokhrel (2010) Matched case control, Nepal 1.21 (0.48 - 3.05)
- Lakshmi., *et al*. (2010) Matched case control, North India 3.14 (1.15 - 8.56)
- Present Study (2.317 odd ratio).

The significant association in our study may be because the Gujarat, Indian households tend to be least ventilated and are at the higher end of spectrum among biomass users worldwide (Typical particulate levels of 500 - 2000 μg/m^3, South Indian households; Gujarat, India: 6800 μg/m^3; Garhwal, India: 4500 μg/m^3; Kenya: 1000 to 4800 μg/m^3; Guatemala: 1100 - 1900 μg/m^3). Moreover, cooking fuel is used only for cooking purposes, unlike North India where it is also used for space heating purposes and cooking is done predominantly outdoors in this study region as the temperature is warm for almost entire year except during monsoon. Time spent by the cooks close to the stove while cooking is also comparatively more in Western India due to the type of food cooked. In this study, majority used biomass and the clean fuel users of this study were not life time clean fuel users. They also switch to biomass usage frequently. Around 50% used clean fuels in Nepal, Chandigarh study as the study population was from both urban and rural areas. Assessment of risk factor such as exposure to biomass cooking fuels needs to be further explored. Risk of Tuberculosis was higher in women living in households with history of TB in one of the family member. It is well known that the risk of infection with *Mycobacterium tuberculosis* depends on closeness of contact with an index case (Ballard-Tremeer G, 1996; Fine PEM, 1994; Andersen S, 1960; Roelsgaard E, 1964; GrzybowskiS, 1975; Saiman L, 2001; Lockman S, 1999). In this study, positive association was found for TB in patients with poor literacy status which was consistent with the studies conducted by Shetty., *et al*. and an age- and sex-matched case control study from South Africa. This could be attributed to the increased awareness among the literates. The risk of acquiring TB is higher in women staying indoors especially in households with a known case of TB as they are likely to be infected within the home due to corresponding higher infectious dose. The number of persons per room was used as a measure of overcrowding and found that it was a significant risk factor for TB. As TB is an air-borne disease, the risk of an uninfected person becoming infected is strongly associated with the probability of coming into contact with an infectious TB case (Chapman JS, 1964). For this reason, crowding has been traditionally associated with the risk of TB infection, as a greater degree of shared airspace increase the exposure to *M. tuberculosis*. In Guinea- Bisssau study, adult overcrowding was a risk factor for TB (Campbell H, 1997) [29,30].

Conclusion

In conclusion, although this study has shown strong association of TB with biomass fuel use, this study has highlighted the role of other risk factors for TB in non-smoking rural women. The information generated in this study can also be used by researchers in this area, policy makers and other community workers for implementing awareness programs, interventions to reduce incidence of TB in this region which is still a major infectious disease contributing to the national burden in India. The burden of disease attributable to environmental factors has only been recently recognized as an important contributor to health policy decisions in India. Although the study has been designed to be a pilot effort to study this potential association, it is hoped that this study will provide the necessary insights for larger scale assessments that could be aimed at design of interventions to reduce the exposure and possibly the risk of tuberculosis.

Air pollution studies have shown that simple classification by fuel or stove type results in substantial misclassification of true exposure. This would reduce the chance of finding an effect. Supplementary indoor air quality measurements can be undertaken in future which may allow refinement of the exposure metric. Additional studies on HIV sero-positive patients are required to further elucidate the relationship between biomass and disease with long latency such as TB as reduction of biomass use or exposure to biomass smoke can provide substantial co-benefits to the community by reducing the other host and environment risk factors. I personally felt that this study would be more significant in North India, where besides cooking even biomass fuel is even extensively used for indoor heating purpose.

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