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Chapter 24

Indoor Air Quality and Risk Factors Associated with Respiratory Conditions in Nigeria

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Additional information is available at the end of the chapter

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1. Introduction

Clean air is a basic requirement for life and healthy living. The quality of air in homes, offices, schools, day care centres, public buildings, health care facilities and other private and public buildings where people spend over 80% (3/5) of their time daily is crucial for healthy living and people's well-being. The National Health and Medical Research Council (NHMRC) defines indoor air as 'air within a building occupied by people of varying states for a period of at least one hour' (NHMRC, 1996). Buildings covered by this definition include homes, schools, restaurants, public buildings, residential institutions, offices, etc. (www.arf.org.au)

Indoor Air Quality (IAQ) is an increasing concern in the world today. In fact, the mere presence of people in a building can significantly alter indoor air quality. Indoor air pollution is present in virtually every indoor space, with the exception of strictly controlled and sterile spaces in pharmaceutical, medical and research facilities. Indoor pollutants may originate from human activities, building materials and carpets; they may also penetrate from outdoor environments by forced ventilation, diffusion or infiltration [8]. Humans are inevitably exposed to these pollutants, considering the amount of time spent indoors, but the influence of the pollution on human health may vary, depending on age, sex, nutritional status, physiological conditions, and individual predisposition.

There is increasing evidence linking indoor air pollution to increased risk of respiratory tract infections, exacerbations of inflammatory lung conditions, development of chronic obstructive lung disease, cardiac events, stroke, eye disease, tuberculosis, cancer and hospital admissions especially in women and children who are the most exposed [40, 54, 59, 63].Acute Respiratory Infections (ARIs) are responsible for one-third of hospital admissions and 20%–30% of deaths among children under 5 years [19, 48] in developing countries.

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However, information regarding IAQ in Nigeria is scanty. Aside from the data collected by a few individuals and corporate organisations at scattered locations, there is no comprehensive and empirical database on the magnitude of the health risks and deleterious effects associated with exposure to poor IAQ by occupants in different built environments and the general population in Nigeria.

2. Brief profile of Nigeria

Nigeria is located in western Africa on the Gulf of Guinea and has a total area of 923,768 km^2. It shares a 4,047 km border with Benin (773 km), Niger (1497 km), Chad (87 km) and Cameroon (1690 km), with a coastline of at least 853 km. Nigeria lies between latitudes 4° and 14°N, and longitudes 2° and 15°E. Nigeria has about174 million inhabitants and is the most populous country in Africa and the seventh most populous country in the world. The country has over 500 ethnic groups, of which the three largest are the Hausa, Yoruba and Igbo. Nigeria is the 12th largest producer of petroleum in the world and the 8th largest exporter, and has the 10th largest proven reserves. Petroleum plays a large role in the Nigerian economy, accounting for 40% of GDP and 80% of Government earnings.

3. Indoor air pollution

Indoor air pollution refers to the amount of chemical, biological and physical contaminants in the air inside a building. There is a wide range of indoor air pollutant sources in houses including building materials, furniture, central heating and cooling systems, household cleaning products, paints, tobacco smoke, office machines and a variety of other products used in daily activities (EPA, 2009).

Nigeria, unlike the developed countries is faced with several environmental, social and economic challenges such as inadequate electric power supply, poor waste disposal system, air pollution, water pollution, noise pollution, unemployment, inadequate of water supply, etc. [67]. Most households in Nigerian cities operate small capacity fossil fuel electric power generators for electricity supply (ECN, 2009).

A study carried out by [67], revealed that small household generators in Nigeria operate an average of 6 h daily, while the average distance of generator away from building was 5.6 m. These alongside poor ventilation have influenced the quality of indoor air in the households [46].

Another major source of pollution in the indoor environment is household combustion of coal or biomass for cooking and heating. It is estimated that more than 50% of the world's population depends on animal dung, wood, crop waste or coal to meet their most basic energy needs (WHO, 2005). Firewood combustion for cooking is a common practice in most rural communities of developing nations including Nigeria. Its use as an energy source is widely reported

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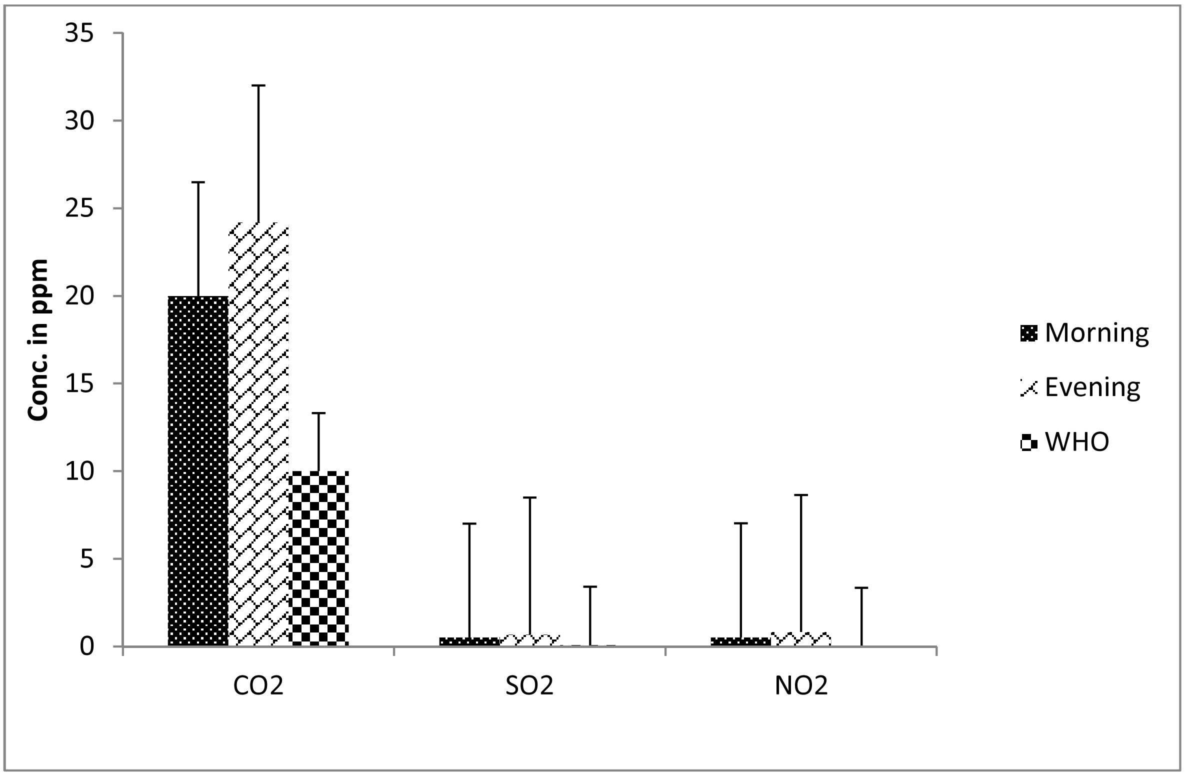
to impinge on the environment, particularly the quality of air and the health of populations especially women [5].

Based on a study designed to determine exposure to emissions from firewood cooking stove and the pulmonary health of women in Olorunda community in Ibadan, Nigeria, [5] found that the mean CO levels for fire wood stove emissions at six kitchen locations combined were 20.0±0.8 ppm (morning) and 24.2 ± 0.5 ppm (evening). These values were 2 and 2.4-folds higher, respectively, than the World Health Organization (WHO) limit of 10 ppm. The mean SO_2 levels for firewood stove emissions at the six locations were 0.505 ppm (morning) and 0.683 ppm (evening). These values were 6.3- and 8.5-folds higher, respectively, than the WHO limit of 0.08 ppm. The mean NO_2 levels for firewood stove emissions at the six locations were 0.517 ppm (morning) and 0.81 7 ppm (evening). These values were 25- and 41-fold higher, respectively, than the WHO limit of 0.02 ppm(Fig 1).

In this study, although the levels of NO_2 were low, there was a significant negative correlation between NO_2 and lung function (r = − 0.488), which indicated that chronic exposure to NO_2 is likely to impair lung functions (Ana *et al.*, 2012).



Source : Ana *et al.*, 2012

Figure 1. Mean morning and evening gaseous concentrations at six kitchen locations in comparison with WHO limits

4. Housing and indoor air quality

Housing is a place people spend most of their time and one of 'the main settings that affect human health' [12]. It is well established that housing is a 'key determinant of health' [62]. Good housing and good health go together [62]. Housing, as a neglected site for public health action, has been identified in a number of recent publications (Breysse *et al.,* 2005). Housing, however, encompasses a large range of factors, including biological (mould, cockroaches, dust mites, etc.), chemical (tobacco smoke, paints, etc.) and structural (moisture, heat ventilation, etc.).

A large number of the population in Nigeria resides in houses with poor housing conditions (as shown in Figure 2.). Provision of adequate housing has been a problem in developing countries like Nigeria. Shortage of decent accommodation, particularly in cities, has resulted in individuals occupying bungalows or rooms above specified capacity. More so, in the quest to provide themselves with urgent accommodation, people have resorted to building houses outside required specifications and/or at indecent locations. Because of this problem, there is no available information on the indoor air quality of living homes in the country.

5. Indoor air environment

Indoor environments are fundamental environmental factors capable of impacting health [16, 32]. Air quality of indoor environments is one of the main factors affecting the health, well-being and productivity of people. The effect on health rises as exposure to and density of air pollution increases [35, 42].

In indoor air environments (non-industrial), the most important source of airborne bacteria is the presence of humans (Kim and Kim, 2007). Major indoor activities such as talking, sneezing, coughing, etc. can concentrate airborne biological particulate matter in the indoor environment. House dust, pets and their bedding material, wood materials and furniture stuffing could serve as reservoir from which spores of *Alternaria, Aspergillus, Botrytis, Cladosporium, Penicillium, Scopulariopsis* spp. and yeast cells are occasionally released into the indoor air [17].

6. Bioaerosols in the indoor air environment

Bioaerosols consist of aerosols containing microorganisms (bacteria, fungi, viruses) or organic compounds derived from microorganisms (endotoxins, metabolites, toxins and other microbial fragments) (Heikkienenet *et al.,* 2005). Aerosols of biological origin form a significant portion of the total atmospheric aerosols, sometimes reaching up to 50% of all aerosol particles [37].

Bioaerosols vary in size (20 nm to >100 nm) and composition depending on the source, aerosolisation mechanisms and environmental conditions prevailing at the site [53]. The

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inhalable fraction ($PM_{2.5}$) is of primary concern because it is the most susceptible portion of the bioaerosols to reach the deeper parts of the respiratory system (Pope *et al.,* 1995).

(a) (b)

(c) (d)

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Plate 1. Typical housing structure in urban (a and b) and rural (c and d) settings in Nigeria

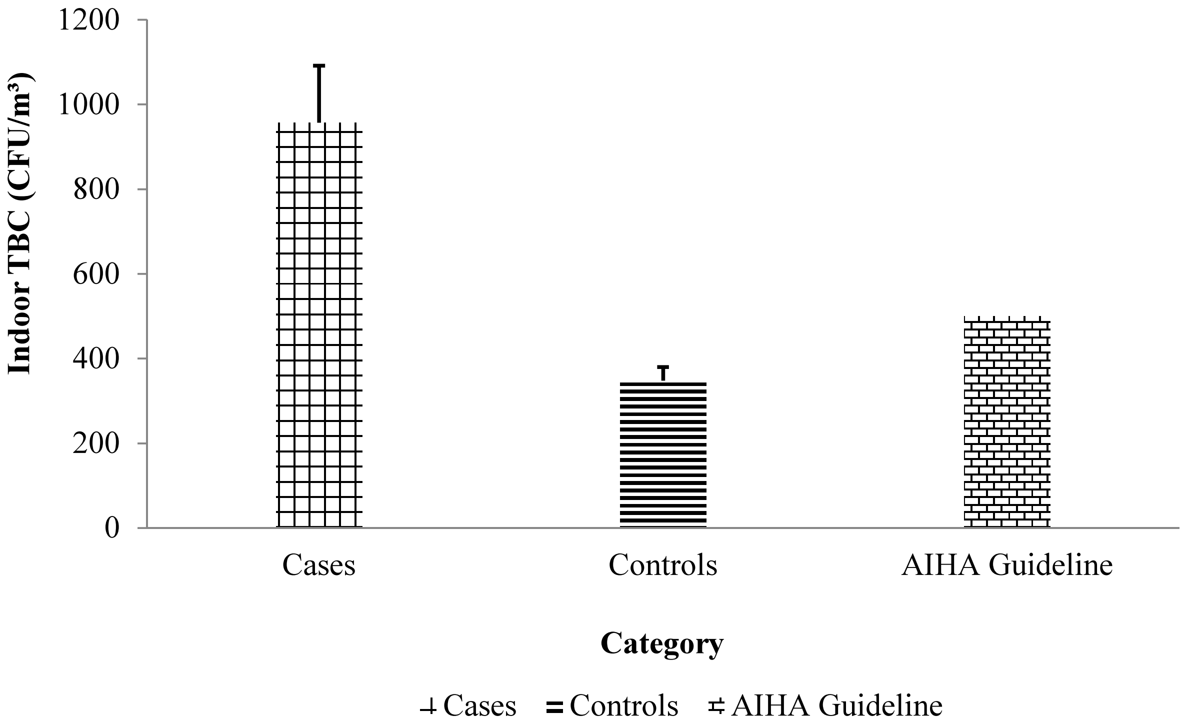
Indoor air contains a complex mixture of bioaerosols such as fungi, bacteria and allergens along with non-biological particles (e.g., dust, smoke, particles generated by cooking, organic and inorganic gases) [33]. Airborne microorganisms might pose an environmental hazard when present in high concentrations in indoor environments resulting in health problems [68].

Bioaersosols contribute to about 5%--34% of indoor air pollution [66]. The source of bioaerosols in indoor air includes furnishing and building materials, microbiological contamination within the walls and ceilings and floor activities. The outdoor environments are oftentimes major sources of indoor bioaerosols as particles are transferred indoor through openings of the building envelope (windows, doors). However, one of the most important factors affecting indoor air quality is how the building is heated, ventilated, air-conditioned and its occupancy [9].

6.1. Bacteria in indoor air environment

Airborne bacteria are major issues in indoor environments. The potential health risks resulting from exposure to airborne bacteria can occur at workplaces and residential locations [28]. A study conducted in Nigeria by [7] in day care centres, reported that the genera of bacteria isolated from the indoor environment included *Pseudomonas, Staphylococcus* and *Bacillus* spp., in both wet and dry seasons.

Elsewhere, the most important bacterial strains found in an indoor atmosphere are representatives of the genera *Bacillus, Micrococcus, Kocuria and Staphylococcus, Streptomyces albus, Pantoea agglomerans, Pseudomonas chlororaphis, Arthrobacter globiformis, Thermoactinomyces vulgaris and Corynebacterium* spp.[23].



Source: Ana et al., 2013

Figure 2. Mean Indoor TBC among cases and controls as compared with AIHA Guideline

Also, in a study designed to determine the burden of airborne microbes in indoor environment that predispose children under the age of 5 to acute respiratory infections, the indoor airborne bacterial load among cases ($9.6x10^2 cfu/m^3$) was higher than the acceptable limit

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(≤5.0x10^{2}cfu/m^3) proposed by the American Industrial Hygiene Association (AIHA, 2001) for residential locations compared to controls (3.5x10^{2}cfu/m^3) [7] (Fig. 2).

Like fungi, bacterial growth takes place in the presence of sufficient moisture. In the indoor environments, sources of required moisture for microbial growth include drip pans of air-cooling devices, freezers or refrigerator, humidifiers and wet surfaces of bathrooms and kitchen [45]. Water may also originate from leaks in plumbing or roof, or be a result of condensation or harsh rain or snowing [65]. Standing water is a potential source of bacteria, and once disturbed, bacteria may become airborne [65].

6.2. Fungi in indoor air environments

The building-associated fungi consist of filamentous microfungi (moulds) and yeasts. The most common fungal genera occurring in indoor environments are *Penicillium*, *Aspergillus*, *Cladosporium*, *Alternaria* and yeasts [36].

In the same study carried out by [6] they showed that genera of fungi isolated in indoor environment of day care centres included *Aspergillus, Penicillum, Geotricum, Fusarium* and *Candida* spp., and in the dry season *Aspergillus, Penicillum, Geotricum* and *Fusarium* spp.,

Their presence in indoor air is as a result of transportation from outside environment via building materials, carpets, furniture, wallpapers, etc. Ventilation and air-conditioning systems are another common way of penetraton of fungi into the buildings. The rate of further growth, spreading and multiplication depends exclusively on moisture content in indoor air, regardless of the type of surface [30].

Natural food source for fungi vary from plant, animal and human particles in house dust, to fragments of construction materials such as floor and wall textile coverings, furniture, residue of cooking traces, food storage and paper materials. Since these materials occur in good quantity in every building, and considering that optimal temperature for fungi growth ranges from 10–35 ºC, the only limiting factor for development of fungi and mould contamination is dampness [31].

Fungi may be extremely harmful for human health, but may also destroy the building itself (Figure 4.), particularly wooden parts, such as roofs and other materials. Some fungi species produce strong allergens, which initiate immune reaction type I (IgE mediated). For example, the indoor contamination with *Alternaria, Penicillium, Aspergillus* and *Cladosporium* spp., is related to asthma and other allergic respiratory diseases. Some of these species, such as *Penicillium* and *Aspergillus* can also induce type III allergy (IgG mediated), while at high concentrations, may also initiate combined type III and IV reaction manifested as hypersensitivity pneumonitis. Major fungal allergens are isolated and identified (such as Cla h I from *Cladosporium herbarum*, Alt a I and Alt a II from *Alternaria alternata* and Asp f I and Asp f III from *Aspergillus fumigatus*) [22].

Fungi mycotoxins have strong genotoxic, carcinogenic and immunotoxic potential. The carcinogenic effects of aflatoxin (mycotoxin produced by *Aspergillus flavus* and *Aspergillus parasiticus*) are well known. The most important mycotoxins related to indoor air contamination are trichothecenes, generated by fungi *Stachybotrys chartarum* (macrocyclic trichothecenes, trichodermin, sterigmatocystin and satratoxin G) [10].

Plate 2. Fungi on the wall and ceiling of a typical indoor environment

6.3. Viruses in indoor environment

Viruses are small (20-400 nm), obligate intracellular parasites. They represent a common cause of infectious disease acquired indoors, as they are easily transmitted especially in crowded, poorly ventilated environments [72].

Airborne transmission of viral agents occurs when viruses travel on relatively large respiratory droplets (> 10 μm) that people sneeze, cough or exhale during conversation or breathing (primary aerosolisation). A single cough can release hundreds of droplets while a single sneeze can release about 40 000 droplets at speeds of up to 50--200 miles per hour with each droplet containing millions of viral particles. Aerosol droplets travel only short distances (1-2 meters) before settlings on surfaces, where viruses can remain infectious for hours or days.

Poorly ventilated and crowded indoor environments are favourable conditions for viral transmission. Hospitals, in particular, are environments where viral aerosols can be particularly hazardous, since patients tend to be especially prone to infection due to pre-existing illness. Elderly patients, children, cancer patients, immunocompromised or immunosuppressed patients are most at risk.

6.4. Protozoa in indoor environment

Protozoa may also be present in indoor air in damp buildings. [77] detected amoebae in 22% of the 124 samples of various materials collected from buildings with evident moisture damage. Field studies on the presence and concentrations of protozoa in indoor air, as well as health aspects of these microorganisms in given conditions, are still lacking, with

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the exception of one in vitro study conducted by the same authors, who suggested that amoebae act synergistically with certain bacteria, enhancing their cytotoxic and pro-inflammatory potential [78].

7. Prevalence of respiratory problems in Nigeria

Acute respiratory infections are a major cause of morbidity and mortality among Nigerian children. It was estimated that pneumonia accounted for 20% of deaths in children under the age of 5 years in Nigeria between the year 2000 and 2003 (WHO, 2007).

A prospective cohort study in Ilorin, Nigeria, reported that the rate of acute respiratory infection was three episodes per child per year with pneumonia being responsible for 1.3 episodes per child per year [27]. In another hospital-based study in Ibadan, 28.4% of children admitted to the hospital with acute lower respiratory tract infection had acute bronchiolitis with respiratory syncytial virus being the most common viral aetiologic agent [39].

There is scanty data on the bacterial aetiology of pneumonia in Nigerian children.According to WHO, (2002), about 20% of all deaths in children under 5 years are due to Acute Lower Respiratory Infections (ALRIs - pneumonia, bronchiolitis and bronchitis); 90% of these deaths are due to pneumonia. There is a seasonal variation in acute respiratory infections in Nigerian children with more episodes occurring during the rainy season [5, 27, 39].

8. Indoor environmental risk factors for respiratory conditions

8.1. Overcrowding

Many children are exposed to very crowded conditions at home, schools (Figure 5.) etc., and this increases risk of transmission of illness. Most studies in developing countries have found that the average area of habitable space per person is well below the WHO recommendation of $12m^2$ [15].

According to a study by [7], the mean number of occupancy among children under the age of 5 admitted in a tertiary health facility for ARIs was 6.0±1.5 as compared to 4.0±1.0 among controls. A positive association was found between the level of occupancy and indoor total bacterial count. A similar study by [70] recorded the highest bacterial burden in an over-crowded environment. This suggests that the number of persons in the household is directly proportional to the level of bacteria build-up in the indoor environment.

8.2. Environmental tobacco smoke among parents

More than 150 published studies have shown a significant relationship between Environmental Tobacco Smoke (ETS) and respiratory illness in children. Meta-analyses revealed a strong evidence for associations between both prenatal maternal smoking and postnatal ETS exposure and risk of ARI in children [21].

[6] in their study indicated that parental smoking or any other smoker in the house as a risk factor for ARIs in children under the age of 5 (OR = 4.7; CI = 0.9-2.17, $p<0.05$). This could be due to the accumulation of emissions from cigarette smoking in the indoor environment as a result of inadequate ventilation [13].

8.3. Household biomass fuel

Biomass fuel is any material derived from plants or animals which is deliberately burnt by humans. Firewood combustion for cooking is a common practice in most rural communities of developing nations including Nigeria [4]. Majority of the households burn biomass fuels in open fireplaces, consisting of simple arrangements as three rocks (Figure 7.), a U-shaped hole in a block of clay, a pit in the ground or in poorly functioning earth or metal stoves. The process of combustion in most of these stoves is incomplete, resulting in substantial emissions which, in the presence of poor ventilation, produce very high levels of indoor pollution (WHO, 2000).

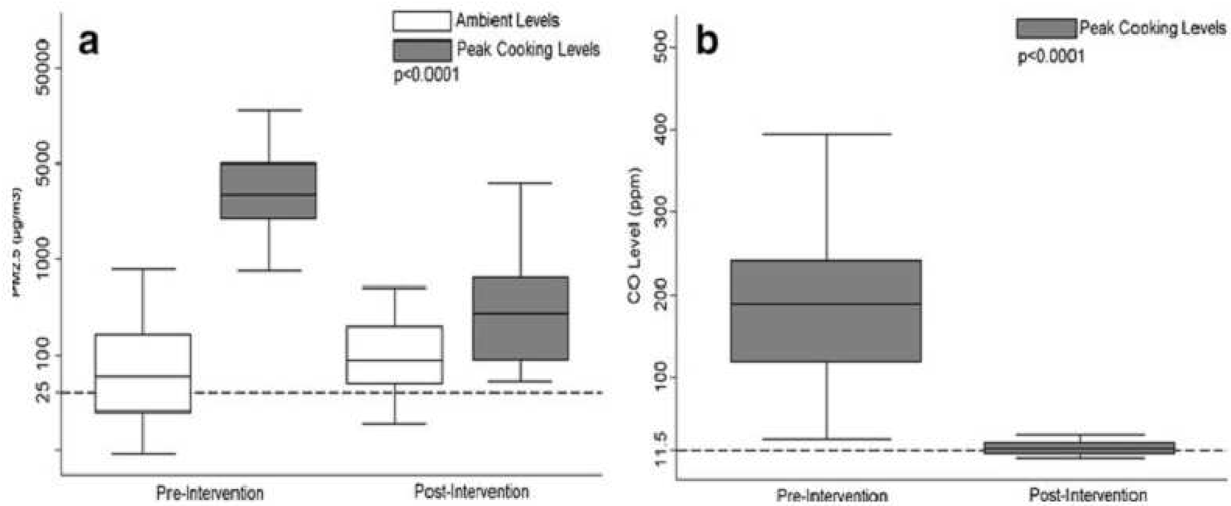
Plate 3. Overcrowding condition in a typical school setting

Many of the substances in biomass smoke have adverse health effects. The most important ones are carbon monoxide, nitrous oxides, sulphur oxides, formaldehyde and polycyclic organic matter, including carcinogens such as benzo[a]pyrene. Particles with diameters <10 microns (PM_{10}), and particularly those <2.5 microns in diameter ($PM_{2.5}$), can penetrate deeply into the lungs (USEPA, 1997).

A Nigerian study on the concentration of indoor air pollutants due to the use of firewood for cooking and its effects on the lung function of women living in the selected homes found that the concentration of PM_{10} and gaseous emissions such as CO and NO_2 significantly exceeded the WHO limits by several folds. Chronic exposure to high level of the indoor air pollutants particularly the respirable particulate matter could possibly compromise the lung function status of women [4].

[47] in their study of the effects of stove intervention on household air pollution and the respiratory health of women and children in rural Nigeria, demonstrated an association between cooking with biomass fuel, increased prevalence of respiratory symptoms and presence of obstructive lung disease. The high frequency of respirator y and other exposure-related symptoms seen in mothers and children at baseline (pre-intervention) were substantially reduced a year later following replacement of the traditional stoves with low-emission stoves (Fig.3). This observation is consistent with the report of higher frequency of respiratory symptoms, especially cough in women exposed to biomass smoke in Mozambique [24], Nepal [60], Pakistan [61], Mexico [56] and Guatemala [20, 64].

Although the incidence of some respiratory symptoms may be lower in children compared to mothers, it is evident that the children are also exposed to the same $PM_{2.5}$ and CO levels, as 94.1% of the mothers always have their children with them during cooking [47]. Studies have also suggested that children exposed to household air pollution early in life may have impaired lung development, indicating that the impact of exposure to biomass smoke may continue into adulthood [2].



Source: Oluwole et al., 2013

Figure 3. Comparison of household particulate matter (a) and carbon monoxide (b) concentration levels before and 1 year after distribution and monitored use of low-emission stoves. The dotted lines represent WHO recommended levels. It has been highlighted to show that cooking time concentrations of $PM_{2.5}$ and CO in all households sampled were significantly above the recommended levels before distribution and monitored use of low-emission cooking stoves

Over 40 % of the participating mothers and children in our study had mild to moderate obstructive defects. This impaired lung function is likely caused by particulate matter (PM) in firewood smoke, which is believed to induce oxidative injury through its ability to carry adherent metals into the lungs and cause inflammation [57].

Source: Oluwole et al., 2013

Plate 4. Simple arrangement of three stones where biomass burns in an indoor environment

Exposure to these pollutants is reported to be higher in women and children (Figure 8.) [1, 11]. It has been shown that exposure to biomass fuel smoke is responsible for a number of respiratory diseases such as Acute Respiratory Infections (ARI), Chronic Obstructive Pulmonary Disease (COPD), Tuberculosis and Asthma; Low Birth Weight; Cataract and Blindness [14]. The adverse effects on respiratory health of products of incomplete solid-fuel combustion are summarized in Table 1.

Compound	Potential Health Effect
Breathable particulate matter	Wheezing, exacerbation of asthma, respiratory infections, chronic bronchitis and chronic obstructive pulmonary disease.
Carbon monoxide	Low birth weight, increase in perinatal deaths.
Polycyclic aromatic hydrocarbons	Lung cancer, cancer of mouth, nasopharynx and larynx.
Nitrogen oxides	Wheezing, exacerbation of asthma, respiratory infections, reduced lung function in children.
Sulphur oxides	Wheezing, exacerbation of asthma, exacerbation of chronic obstructive pulmonary disease, cardiovascular disease.

Source: Perez et al., 2011

Table 1. Adverse effects on respiratory health associated with indoor air pollution

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Source: Oluwole et al., 2013

Plate 5. Mother and child exposed to biomass emissions in an indoor environment

8.4. Dampness in indoor environments

Numerous studies have examined the potential association between damp housing conditions and respiratory ailments among occupants. It was discovered that increase humidity leads to increase mould growth and exposure, which could result in asthma and other respiratory conditions. The presence of home dampness has been reported to affect about 38% of Canadian homes [18]. A Canadian study found that children living in damp or mouldy homes were 32% more likely to have bronchitis [18] (secure.cihi.ca). Substantial problems have been identified in some First Nations communities due to a combination of inappropriate housing design, poor construction, inadequate maintenance and poor ventilation [41].

8.5. House dust mites and cockroaches in indoor environments

House Dust Mites (HDMs) thrive in the dust of homes, particularly in the presence of high indoor relative humidity (secure.cihi.ca). In order to survive and multiply they require a relative humidity in excess of 45%–50%, but their activity, including feeding and maturation is more rapid at higher rates of relative humidity, which was confirmed in field studies [79].

Cockroaches are implicated as a major cause of asthma among inner city children in the U.S., resulting in increased hospital admissions, school absenteeism, and unscheduled medical visits for asthma [58].

8.6. Sanitation and housing quality

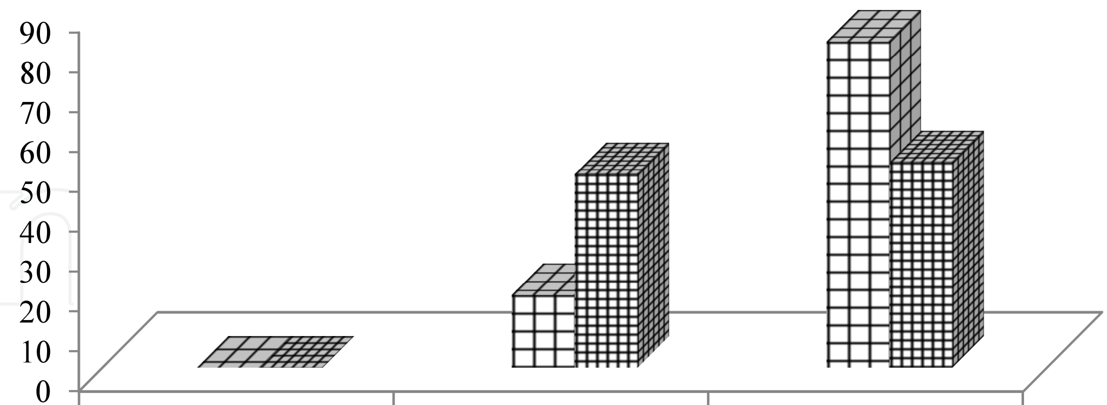
[15] found that children with respiratory illness come from houses with poorer sanitation than controls, while in developed countries promotion of hand washing has been associated with reduced incidence of respiratory illness.

8.7. Indoor air meteorological conditions

A case-control study carried out in Ibadan among houses of children under the age of 5 revealed that a higher proportion of houses visited among cases and controls recorded indoor relative humidity (RH) values above the comfort level (30%–60%)(Fig. 4). The high RH (above comfort level) observed among a large proportion of houses among cases could be as a result of high moisture content. The mean indoor and outdoor air RH among cases (69.6 ± 4.7; 67.2 ± 5.0) was found to be higher than among controls (63.1 ± 6.5; 66.1 ± 7.1) [7]. With such high relative humidity levels, microorganisms such as fungi and bacteria can survive on non-living materials including dusts (Choa *et al.,* 2002). High relative humidity above 70% also tends to favour the survival of viruses that infect the membrane of the respiratory tract.

8.8. Inhalable particulate matter burden

Particulate matter (PM) has been recognized in recent years as the most dangerous and widely spread air pollutant [43] affecting more people than any other pollutant and contributing to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer. PM_{10} is associated with increased mortality and morbidity in many cities worldwide and the risk is greatly pronounced among susceptible populations, including the elderly, children and people with pre-existing health conditions [55].



	Low	Comfort	High
Case	0	18.2	81.8
Control	0	48.5	51.5

Key: Low = <30%, Comfort = 30 – 60%, High = >60%
Source: Ana et al, 2013

Figure 4. Indoor relative humidity for houses among cases and controls

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[6] in their study of inhalable particulate matter burden in selected day care centres in Ibadan, Nigeria, observed that the mean indoor PM_{10} readings for wet season (73.4 ± 54.4μg/m³) and dry season (296.3 ± 61.6μg/m³) significantly exceeded the WHO guideline limit of 50μg/m³ (Table 2).The indoor/outdoor PM_{10} ratio was 1.38 ± 0.97 and being greater than 1 indicated a possible indoor source of pollution. High particulate matter concentration observed was indicative of the poor indoor air quality condition in the day care centres.

Parameter	**Season**	**Mean ± Standard deviation**	**p-value**
Indoor condition			
Particulate Matter (PM_{10})	Wet	88.6 ± 55.6	<0.001
	Dry	299.8 ± 62.9	
Source: Ana and Umar, 2013			

Table 2. Indoor particulate matter concentration in the wet and dry seasons

9. Conclusion

Everyone has the right to a good standard of living, adequate for the health and well-being of his family. Over the years, man has built houses to protect himself from environmental hazards. Buildings do not always protect their occupants from pollution. The quality of housing conditions plays a decisive role in the health status of the residents. The bioaerosols, dust and gaseous pollutants trapped or growing on the inside may well exceed those outdoors and therefore exacerbate health problems.

A polluted indoor air is a risk factor for human health globally. The magnitude of the health risks and risks factors associated with exposure to poor indoor air quality especially among children under the age of 5 are evident in Nigeria. Overcrowding, the use of generators and biomass fuel have been identified as the critical environmental problems which increases the likelihood of respiratory symptoms and/or obstruction in those exposed on a regular basis in Nigeria.

Health policy changes regarding construction of homes with better ventilated kitchens and use of environmentally friendly, low-emission and energy-efficient cooking stoves, aimed at mitigating the deleterious effects of exposure to indoor air pollutants in mothers and children will significantly improve indoor air quality and reduce the risk of respiratory symptoms.

Indoor Air Quality will continue to be an essential field in environmental health studies and interventions because exposure to varied indoor substances will likely increase in the coming years. Research on the molecular characterisation of indoor bioaerosols, genetic susceptibility to indoor pollutants and their carcinogenic effect are required.

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