



Respiratory Disease Incidences with different Indoor Lighting Designs at Gadamoji Area of Marsabit County, Kenya

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ABSTRACT

Respiratory disease incidence can be closely associated with designs of windows and lighting aspects in relation to some house structure dimensions. The aim was to compare the levels of respiratory disease incidences with the lighting designs at the study area, namely Gadamoji Division of the hilly Marsabit subcounty, an Arid and Semi-arid area, Kenya. To form a basis for comparison, rural appraisal tools were used to gather domestic health information from which, the position and extent of respiratory conditions were determined. Using similar tools for the same sampling units, data on housing design and lighting design were collected. Data were analysed using comparative techniques. The study categorized four major housing designs, four major designs of indoor lighting systems and three main sources of lighting fuels. Results showed that respiratory disease incidences were higher in traditional households and households which utilized wood fuel and kerosene in can lamps and lanterns respectively.

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Introduction

Presently, in total Africa consumes about 4 percent of total global energy resources, mostly concentrated in the urban areas (Akumu et al., 2004; U.S.D.E., 2009). The World Health Report 2000 had estimated that indoor air pollution from household use of solid fuels is the fourth leading health risk in developing countries with relatively high mortality rate of about 1.6 million deaths per annum (Raffensperger, 2007). However, a World Health Organisation bulletin published in April 2007 states that in 11 countries; Afghanistan, Angola, Bangladesh, Burkina Faso, China, the Democratic Republic of the Congo, Ethiopia, India, Nigeria, Pakistan and the United Republic of Tanzania, indoor air pollution is to blame for a total of 1.2 million deaths a year (WHO, 2007). The bulletin also states that globally, reliance on solid fuels is one of the 10 most important threats to public health.

Rural areas in developing countries face numerous development challenges, the greatest being access to modern sources of energy (Yevich and Logan, 2002). In African rural households (HHs), the use of fuels such as wood fuel and kerosene for cooking are identified as key contributors to atmospheric trace gases related to poor human health conditions (Sandra, 2001). These fuels have been reported to increase levels of indoor air pollution by particulate matter (PM) many times higher than international ambient air quality guidelines of 25 and 50 $\mu\text{g}/\text{m}^3$ per day for $\text{PM}_{2.5}$ and PM_{10} respectively allow for, exposing occupants to major health hazards (WHO, 2005). Schrinding (1999) links a wide range of poor health conditions, including tuberculosis, low birth weight, and visual impairments to direct exposures of emissions from burning fuel in indoor environments.

In Kenya, large proportions of modern fuels such as kerosene and Liquid Petroleum Gas (LPG), as well as electrical grid line power are consumed in urban houses. The Marsabit District Development Plan 2002 – 2008 (GoK, 2002) indicates that rural households consume comparatively larger proportions

of traditional fuels. The report estimates about 98% of these houses are not connected to the national electric energy grid. There is inadequate information on indoor lighting as apparently less research is being carried out into rate of energy consumption and indoor pollution from lighting sources. The study community is observed to be utilizing crude methods of indoor lighting. The study area was selected considering the cultural characteristics of housing designs and indoor lighting practices among other determinant surrogates.

Description of Gadamoji area of Marsabit, Moyale County

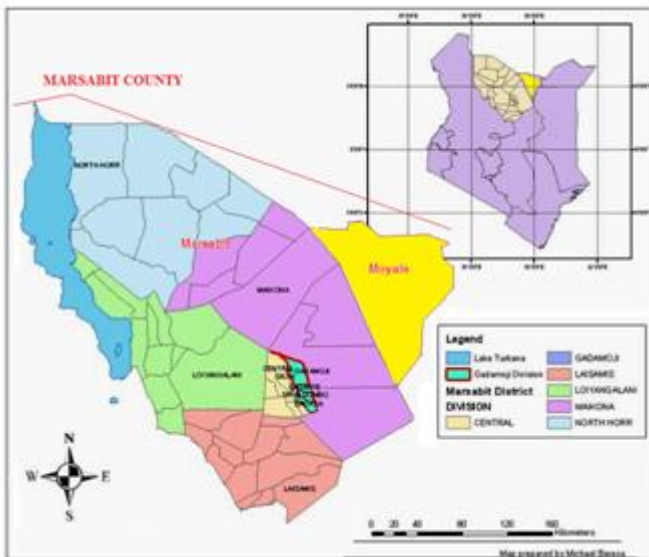
Marsabit is one of the former six districts that formed Eastern Province, Kenya before the introduction of county structures. It lies between latitude $01^{\circ} 15'$ North and $04^{\circ} 27'$ North and longitude $35^{\circ} 03'$ East and $38^{\circ} 59'$ East, covering an area of 66,000 km^2 . The specific study area is located within Gadamoji division, on the eastern slope of Mt. Marsabit, covering an area of 614 km^2 (GoK, 2002). The division is located between the peak of Mt. Marsabit through four strata represented by sub divisions, the last touching peripheries of the Chalbi Desert. Higher altitudes represent cooler weather with dense mountain forest. Vegetation cover and climate drastically transforms into the typical semi-arid nature at lowest altitudes of the study area.

The area has a population density of 30 persons per unit area, which is also the highest in the district (KRC, 2006). References from the Kenya Red Cross society (2006) statistics also show that there are about 17,500 inhabitants in the division. A household survey carried out by WFP (2006) shows that households were distributed in a ratio of 28% in Sagante, 23% in Dirib gombo, 29% in Qilta korma and 20% in Jeldesa. Lighting and housing design

The four most common indoor lighting sources in the study area (three stone firewood lighting, kerosene lantern, can kerosene lamp and electrical lighting) were investigated under the respective dominant housing types. The major types of housing structures include the dome shaped huts (*Dasee*), the

conical shaped huts (*Quuttule*), the rectangular structured house (*Arishi*) and the modern structured houses. Majority of the housing designs bear no ventilation spaces. Adequately ventilated houses are rarely met.

Figure 1. Location of Marsabit District in Kenya



(ARCGIS 10)

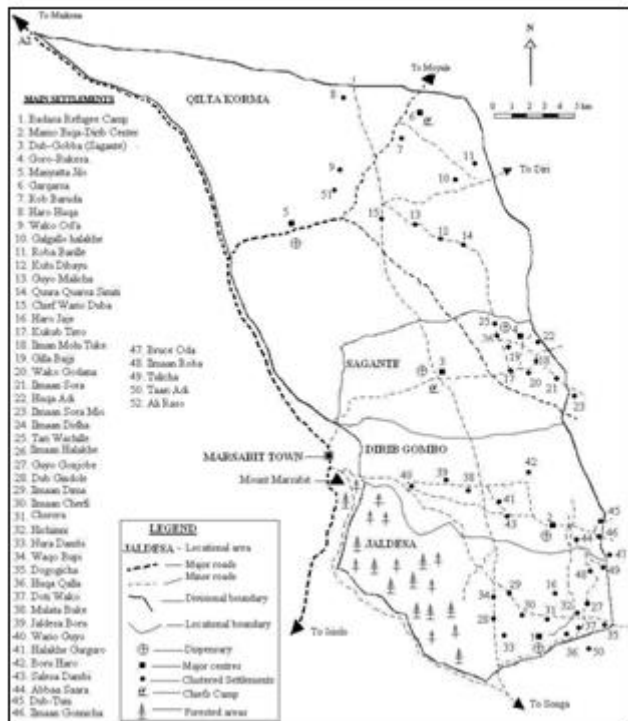


Figure 2. Map of Gadamoji division (Source: WFP, 2006)

Specific Objectives

- To determine the relationship between respiratory disease incidence and house lighting designs in the study area;
- To determine relationship between respiratory disease incidence and fuel sources in the study area;
- To determine the relationship between respiratory disease incidence and household demographic groups in the study area;

Methodology

Sampling methods

Sampling unit: Gadamoji division is divided into four locations, namely Qilta Korma, Sagante, Dirib Gombo and Jaldesa. There are about 3,000 households. Most houses are either semi-

permanent or permanent. These are in clusters within or around centres. The desired household sample size was calculated and placed at 100 housing units. Detailed information was provided through questionnaire sampling of residential household communities.

The research was carried out using both primary and secondary sources of data.

Simulation: Collection of data involved experimental measurements using prototype house structures and designs. Various lighting arrangements and sources were applied. This simulation process was done thrice (repetitively).

Data Tools: Questionnaires, Oral interview schedules and observation sheets: These techniques were used to collect information concerning social status, health, fuel consumption and housing within the study area. The questionnaires were designated to respondents from the health practitioners, community and household representatives. These were designed to give both qualitative and quantitative data, which were essential when producing scores and when making conclusions of the analysed results. Details filled in the observation sheet included the types and dimensions of housing.

Results and discussion

Housing: Information about household structures in the study area was used to control simulation parameters.

Table 1. Distribution of housing structures

Type of houses	%
Dome shaped hut (Dasee)	41
Conical shaped hut (Quuttule)	40
Rectangular shaped house (Arishi)	14
Modified rectangular house (Min-D'kha)	5

From the field work, it is noted that the most common type of houses were the dome shaped huts which recorded 41% of the total and the conical shaped hut representing 40%. Moderately few at 14% represented rectangular shaped houses, while only 5% were the modified rectangular shaped houses.

Household volume: The experimental phase was carried in the study area inside test house structures simulating average housing structures in the division. Their sizes were categorized in three volumes of 20, 30 and 40 cubic metres since only a limited number of experiments could be carried out. The simulation volumes were obtained by 1) arranging the study area house volumes in an array from the maximum to minimum range, 2) stratifying the range into three equal sub-range-groups, and then 3) determining the mean of each group. The answer given to the nearest ten whole digits were used as the simulation house volumes.

Ventilation: The mean window area to floor area ratio is the parameter used for observing the deviation from the recommended WHO recommended standard of 0.1 (Habib *et al.*, 2009). The concentration of pollutants depends upon rates of production and removal, the source, and their dilution by ventilation (Lowry, 1989). The exchange between indoor and outdoor air profoundly affects contaminant levels in a dwelling (Esmen, 1985).

Table 2. Mean window size distribution

Type of houses	Mean Window area : Floor area ratio	HHs
Dome shaped hut	None	None
Conical shaped hut	0.0006	3
Rectangular shaped house	0.0028	9
Modified rectangular house	0.0611	5

Most sampled houses bear no windows, but only 12 units consisting of the conical shaped hut and the rectangular shaped house had small provisions with a mean ratio of 0.0006 and 0.0028 respectively of window to floor area, hence poor lighting and ventilation. Moreover, they are usually very dark that in darker days, indoor lighting periods are extensively long. Only 5 of the modified houses were built with provisions for window spaces averaging a mean window to floor area of 0.0611.

In a recent research carried out to determine the size of traditional "Tukul" house structures by altitudinal zone in rural communities, Abera and Yemane (2002) indicate that the World Health Organization recommends a minimum ratio of 0.1 of window to floor area to provide adequate ventilation. No relevance has been given to door structures and sizes, but in the study area, most of the door ways are rather short and narrow. Sisal woven mats or clothing materials were used to separate the interior from exterior environments.

Lighting sources:

57% of surveyed households depend on firewood. 25% depend on kerosene can lamps. 12% of households in the division lit their living area using lanterns. Only 6% of surveyed households relied on solar energy. As earlier mentioned, no household was connected to the national electricity grid in the study area.

Respiratory disease occurrence in the study area

Among the total 1,500 disease incidences recorded, respiratory diseases known to be caused by or related to particulate matter from lighting fuels represents 29.3%. Other diseases such as malaria, diarrhoea, and diabetes represent 70.7% of the total incidences. These findings are not far from those recorded at Marsabit district hospital for the year 2004 as indicated by Roba and Post (2005). The records indicate that 26.3 % of particulate related diseases were related to respiratory diseases.

The study recorded a total of 440 respiratory diseases linked to indoor air pollutant concentrates through household interviews, inquiries and observations. Figure 3 shows the distribution between upper and lower respiratory infections derived from the study area.

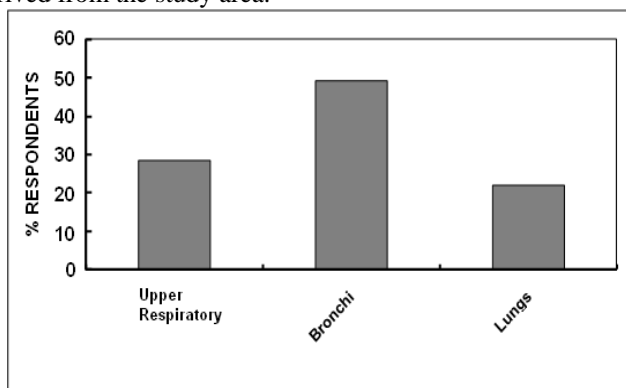


Figure 3. Respiratory infections from sampled incidences

According to the charts, diseases of the upper respiratory tract appeared in about 27% of the total particulate diseases. Diseases of the lower respiratory system were found to be to about 72% of the total incidences. A further break-down of the latter fraction shows that 22% were related to the lungs while bronchial diseases constituted about 50%.

The most frequently used indicator for suspended particulates in the air has been PM10 as a single indicator range with the diversity of effects ranging between the upper and lower respiratory systems (WHO, 2005). Recent studies on particulate matter emitted from indoor fuels have now linked

upper respiratory diseases to PM10-2.5, and lower respiratory diseases to PM2.5 (Schirnding et al., 2001; Lebowitz, 1996). The studies have identified characteristics of particulate matter from wood and kerosene, while others have linked their effects on the human body to various known health conditions. Particulates in inhaled air are deposited selectively on walls of the respiratory tract in the order of their size. The effects are said to mainly produce inflammatory responses, exacerbation of existing airways diseases or impairment of pulmonary defense mechanisms. Inhaled PM may increase the production of antigen-specific immunoglobulin, alter airway reactivity to antigens or affect the ability of the lungs to handle bacteria, suggesting that particulate exposure may result in enhanced susceptibility to microbial infections (WHO 2006).

The figure below shows how upper and lower respiratory diseases were distributed among main household groups of male adults, female adults and children.

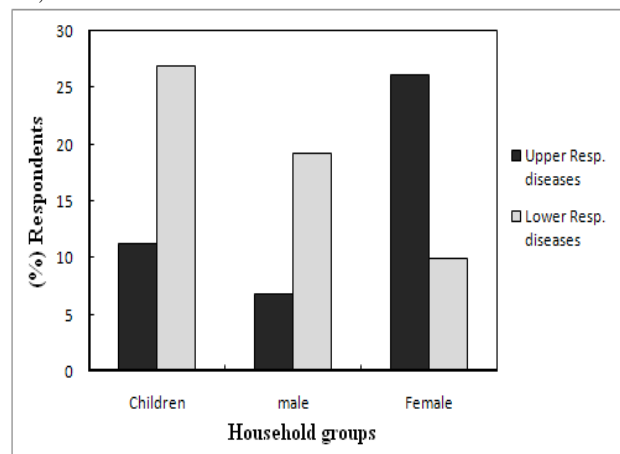


Figure 4. Respiratory disease occurrences among study household groups

The groups consisting of children and women recorded the highest incidences of respiratory diseases. Lower respiratory diseases were higher among children (26%) while women recorded highest levels of upper respiratory diseases (26%). Among men, lower respiratory disease incidences were recorded at 20% while upper respiratory disease incidences were recorded at 7%. Men were affected by 20% of lower respiratory disease incidence and 7% of upper respiratory disease incidence.

The high levels of disease incidences witnessed among women and children may have been influenced by exposure characteristics related to evening time spent indoors and nature of indoor activities. Infants and young children run increased risks because they tend to be cared for in the home close to where their mother is working. In addition, infants and young children have heightened vulnerability due to their immature respiratory systems and physiological susceptibility (Cairncross et al. 2003).

In order to find out how respiratory diseases related to particulate matter were distributed among Gadamoji population, the study analyzed the frequency of their occurrence among age groups. Figure 5 below shows the outcome of results. Children below 3 years consist of about 9% of the sample population, which was affected by almost 15% of total disease incidences within the study area. The population in the age-group between >3 to ≤18 years was modal (about 54%) while corresponding disease incidences recorded relatively low levels (about 25%). The demographic group >18 to ≤50 also registered high levels of respiratory disease incidences at about 54%, with a drop of population level at about 32%.

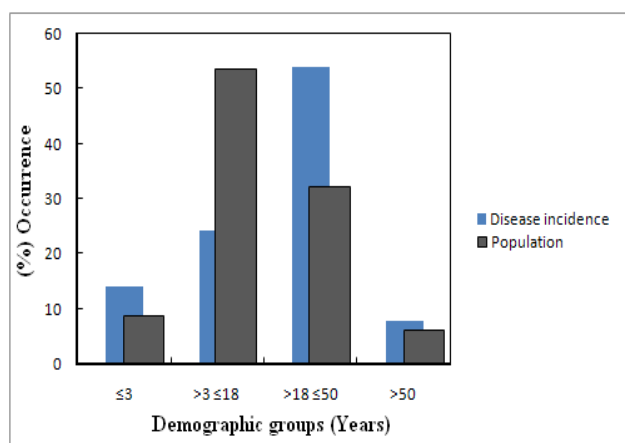


Figure 5. Respiratory health response within age groups

Further reduction of population, hence disease incidences were witnessed as age advanced. In this respect, the group consisting of the elderly above 50 years showed low population levels at about 6%, with respiratory disease incidences at about 7%.

From the graph it was evident that there was a drastic drop of population between demographic groups of >18 to ≤50 and that >50 years. Some households consisted of elderly members (above 51 years) spending most of their time indoors. WHO (2006) states that in general cases, the increases in mortality associated with particulate air pollution are greatest among the elderly. The prevalence of Chronic Obstructive Pulmonary Diseases (COPD) and other chronic respiratory diseases increases with age. However, many physiological changes associated with aging may increase susceptibility to particle effects. Virtually all components of the respiratory system are affected by aging. In addition, maximal oxygen uptake and maximal cardiac output decline with age. The elderly are more susceptible to respiratory infections, partly because of an age-related decline in specific immune responsiveness. The elderly may be more susceptible to particle exposure because of lifetime exposure to environmental agents, including particulate air pollution, as well as previous respiratory infections (WHO, 2006).

The chart also shows high disease incidences among the demographic group below 3 years. Children are particularly susceptible to acute respiratory infections, which are the most common cause of death in developing countries. Evidence from a variety of studies suggests that exposure to air pollution increases the risk of acute respiratory illnesses in children, including pneumonia, and admission to hospital for respiratory illness and death among children below the age of 5 in developing countries (Schirnding *et al.* 2001). In one of the huts in the study area, a 3 day old baby was among a large family living in a shelter lit using wood fuel. It was also noted that some conditions affecting elder children may not seem to be considered as serious according to household managers, where as they could bear serious negative implications over long term exposure basis. Examples of such conditions are running noses, reddening of the eyes, dermal irritations, nasal inflammations, nose bleeding and light coughs.

During the questionnaire administration session, it was revealed that attitude towards the connection between domestic smoke and health was least considered by household managers in most cases. In fact, most household members did not seem to be disturbed by the same wood smoke concentrations which disrupted the interviewers comfort while administering the questionnaire.

Exposure surrogates as determinants of health outcome

The broad array of health effects associated with air pollution is partly explained by differential susceptibilities to pollutants, depending on host and environmental factors such as exposure characteristics as well as the individual's housing and neighbourhood conditions. The health outcome used for this analysis is the respiratory disease frequency of occurrences observed within the study area. Figure 5 below shows health outcome based on prominent household lighting fuels as a determining surrogate.

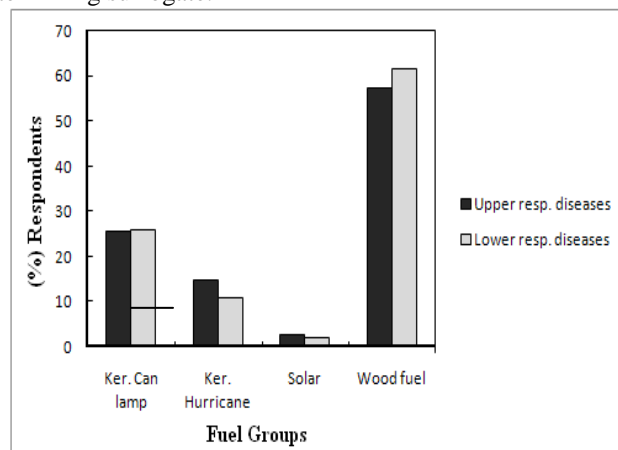


Figure 6. Health outcomes based on sources of lighting fuels

Reading from the charts, households which utilized wood as the main lighting fuel recorded the highest levels of both upper and lower respiratory diseases incidences (58 and 61% respectively). Kerosene can lamps which characteristically expose unshielded flames recorded almost half of these levels at 26% for upper and 26% for lower respiratory disease incidences. Further lower levels were recorded by lanterns at about 14% for upper and 12% for lower respiratory system. Significantly lower incidences of respiratory diseases were shown by solar at about 2% for upper and 1% for lower respiratory disease incidences.

The health status respond to the sources of lighting fuel utilized by the community, who mainly depend heavily on wood fuel sources for indoor lighting. Households which were consistently lit using wood or kerosene fuel in can lamps were diagnosed with higher respiratory disease incidences as compared to those who lit using kerosene lanterns. Solar lighting sources, which are considered to be pollution free, recorded the lowest respiratory disease incidence. It was therefore evident that health quality is determined by the various modes of indoor lighting.

From the above results, kerosene in lanterns as a lighting fuel is important for the poor in rural areas and has in some cases served as a substitute for wood fuel (GoK, 2006). Hence, any efforts to increase kerosene consumption will undoubtedly relieve pressure on wood use. Extending views from the GoK (2006) document, indeed, the government has often used tax reduction or non-increase for kerosene for this purpose and also as a poverty mitigation measure. Key emerging concerns in this regard are the impact of kerosene on the levels of indoor air pollution and the consequent health impacts on the poor.

The main types of shelters in the study area are the dome shaped and conical shaped huts, rectangular shaped houses and the modified rectangular houses as earlier discussed. Health outcomes based on types of houses within the study area was also analyzed.

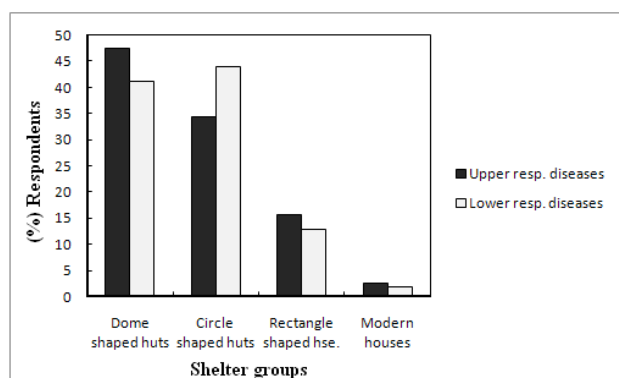


Figure 7. Health outcomes based on types of houses

The dome shaped houses recorded the highest ratios of disease incidences at about 48% of upper and 41% lower respiratory disease incidences. Relative to these levels, the conical shaped houses recorded slightly lower levels of about 34% for upper and 44% of lower respiratory diseases. Respiratory disease incidence levels were recorded among rectangular shaped houses at about 15% for upper and 13% for lower respiratory diseases. The least levels were recorded among modified rectangular houses, whereby 3% were recorded for upper respiratory diseases while 2% were recorded for lower respiratory diseases.

Wealth plays a major role in determining type of houses, access to reliable health services and therefore, life quality standards within families. The socioeconomic status (SES) of a household plays a major role in both the health status of the individuals in a household and in the quality of their housing situation. Research has established that people with low SES in a society tend to be less healthy and to die earlier than people with a high SES (Hwang et al., 1999). In the case of Gadamoji area, the dome shaped huts which were earlier found to bear the least value recorded the highest disease incidences. Increase in household value recorded relative decreases of respiratory disease incidences. Modern house structures require a lot of unreachable monetary inputs to construct. Only the wealthier families with easy access to housing development services in Marsabit town could construct these structures.

Conclusions

The study found that households utilizing wood fuel bear greatest health burden from respiratory diseases. Further analysis reveals that traditional forms of housing structures (the dome and circle shaped huts) housed families bearing greatest impacts from respiratory diseases. In general, age groups between 18-50 years and children below the age of 3 suffered most from respiratory diseases.

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