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Use of Biomass Fuel in Households within Limpopo Province of South Africa and Its Association with Asthma among School Children Aged Thirteen and Fourteen Years of Age

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Abstract Biomass fuel is energy generated from burnt coal, wood, paraffin, dried animal dung and other agricultural waste. These substances when burnt produce toxic substances known to be detrimental to respiratory health. This cross sectional study determined the association of asthma and use of biomass fuel among 742 school children aged 13 and 14 years around Polokwane areas.The prevalence of asthma among the exposed group was 33%. The odds ratio for the association was 1.50, p 0.01 CI 1.09; 2. 10. The association was tested under different conditions using regression techniques. In all instances the exposure variable was resilient in predicting asthma, and this way support theories of air pollution and respiratory diseases. Findings of the study suggest complete electrification of areas in Limpopo Province to prevent use of alternative unclean energy sources in order to minimize or eliminate exposure to energy-related respiratory disease agents. For purposes of control, asthma should be made a priority disease and an asthma surveillance system be established in Limpopo Province.

Keywords Biomass Fuel, Environment, Asthma, Children, Rural

1. Introduction

Burning paraffin, gas, coal, wood and agricultural waste produce toxic gases and particulate matterlike nitrogen oxides, carbon monoxide, carbon dioxide, smoke, methane, sulphur dioxide, nitrogen oxides,PM 1.0 and 2.5,all known to be detrimental to respiratory health. These substances trigger or exacerbate asthma and other allergic diseases. Household environments likepoor ventilation; and host characteristics such as presence of other diseases (asthma, chronic obstructive diseases, pneumonia, diabetes[1] and age[2] are predisposing factors. Many studies were conducted to test the effects of indoor combustion on the pathogenesis, trigger or exacerbation of asthma and other allergic diseases. The majority of the studies were observational (descriptive with an analytical component) rather than experimental. Most studies used proxies of exposure rather than quantitatively -measured exposures, except for the one study by Breysse et al[3] which measured the concentration of particulate matter 1.0, 2.5, nitrogen oxide and ozone. Since proxies rather than measured toxicants were the exposures, causal factors such as concentrations, duration of exposure and doses could not be determinedhence causal inferences could not be made.

Use of gas stoves, coal stoves, wood stoves, paraffin stoves, open wood or coal fires, gas and paraffin heaters, kerosene heaters were the exposures. In one study[4] researchers simply used "indoor air quality" as the exposure without making reference to sources of the air quality indoors. Methodological diversities implied here may account for inconsistencies in findings of the studies. Thorn et al[5], Kilpelainen et al[6], Eisner et al[7], and Noona et al[8] investigated woodstove and respiratory diseases. Only Thorn et al observed a positive association, odds ratio 1.7 95% CI 1.2-2.5.

Wong TW et al[9] investigated household cooking gas, passive smoking, outdoor pollution, and respiratory illness in children. A dose –response relationship of frequency of cooking with gas and respiratory illness was observed.Phoa et al[10] investigated effects of gas and other fume-emitting heaters on the development of asthma during childhood. These researchers observed that exposure to fume –emitting heaters in early years of life was associated with respiratory illnesses.

The current study investigated the association of asthma and

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use of biomass fuel.As used here biomass fuel refers to energy generated from burnt coal, wood, paraffin, dried animal dung and agricultural waste. It is believed that this study being done in a different contextwill support or negate what is currently known about the effects of air pollution on respiratory health. Energy sources mentioned above, singly or in combination, produce toxic substances, some of them adverse enough to be classified under the Environmental Protection Agency's (EPA) list of criteria pollutants. Table 1 lists air pollutants and their concentrations emitted from biomass fuel, and known to be detrimental to respiratory health.

This study used a sample of 742 children drawn from ten schools in five education districts in the province of Limpopo in South Africa. Children are known to be highly susceptible to asthma and other respiratory illnesses because of the level of their bio-physical development[2].The age group of 13-14 was selected in accordance with the research protocol of the International Study of Asthma and Allergies among Children (ISAAC) that typicallyuses two age groups, the 6-7 years age group and the 13-14 year age group. In this study the older age group was selected in order to keep the cost of the study low, as the younger age group would have necessitated a follow-up into communities to interview their parents or custodians.

The National Heart, Lung and Blood Institute[11] defines Asthma as 'a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role in particular, mast cells, eosinophil, T lymphocytes, macrophages, neutrophils, and epithelial cells. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, coughing, and abundant mucous production, particularly at night or in early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The inflammation also causes an associated increase in anexisting bronchial hyper-responsiveness to a variety of stimuli.

Reversibility of airflow limitation may be incomplete in some patients with asthma'.

According to this definition, asthma results from the interaction of inflamed airways, obstructed air flow, and bronchial hyperresponsivesness to many stimuli; and that theseinteractions determine clinical expression of asthma such as wheezing, tight chest and cough[11].

In this study asthma was measured using theAsthma Core Questionnaire of the ISAAC protocol. The questionnaire uses presence of selected symptoms to diagnose presence of the disease.

A question that listed types of indoor energy sources to which the respondents answered "Yes" or "No" was used to measure the predictor variable.

Asthma is associated with factors broadlyclassifiedinto host and environmental factors. Host factors include age, sex, atopy and genetics. Environmental factors include air pollution emitted from a wide variety of sources such as smoking, use of biomass fuel, automobile transport emissions, emissions from power generation etc. Environmental factors are defined as triggers, suggesting that inherited potential to develop asthma is a necessary condition. Inherent susceptibility of individuals to asthma explains why people evenly exposed to environmental triggers do not simultaneouslydevelop asthma.

Table 1. Types of air pollutants and their concentrations emitted from biomass fuel and classified as Criteria pollutantsbythe Environmental Protection Agency.

Pollutant	Concentration
Carbon Monoxide	25-50 Mg/ M3
Nitrogen Dioxide	0.01 – 5mg/M3
Sulphur Dioxide	1-3 Mg /M3
Total Particulate Matter	0, 1-4.2mg/ M3

Source:A.P.S. Terblancheet al. 1996[12].

2. Objectives of the Study are to

1. Determine the Association of Asthma and Use of Biomass Fuel among School –Based Children in Limpopo Province of South Africa.
2. Estimate the Prevalence of Asthma among Children Exposed to Toxic Emissions from Use of Biomass Fuel.
3. Estimate Prevalence of Asthma among the Different Demographic Groups
4. Estimate Measures of Association of Asthma and Exposure to Use of Biomass Fuel.
5. Estimate potential Effects of Other Variables on the Primary Associations of the Study.

3. Methods

3.1. The Study Area

Limpopo Province is one of the poorest provinces of South Africa[13]. It is predominantly rural. Rural villages and agricultural farming communities comprise the bulk of the provincial land and these are areas where the larger population proportion lives. Table 2 gives details of the rural- urban distribution of the population of Limpopo province.

The study area lies within the District Municipality of Capricorn, within a radius of 60 kilometres around the capital City of Polokwane.The sampled areas are ten schools in five education districts. Schools and districts are distributed variably within a 60 kilometre radius, the majority being located in rural villages. Informal/ traditional housing structures, absence of waterborne sanitation systems, absence of bulk water supplies, lack of proper road infrastructures and absence of bulk electricity supplies characterize rural villages of Limpopo. This is more so as one move further away from the City of Polokwane.

Table 2. The population counts and proportions Limpopo Province by secondary or small towns and rural areas.

Area	Population in Counts	Percentages
Secondary/small towns	733, 748	13.20
Rural areas	4 830 215	86.81
Total	5 563 963	100.00

Source: PROVIDE Project 2005[14].

Table 3 gives details of proportions of various uses of electricity within Limpopo Province compared to South Africa as a whole.

Table 3 shows that since 1996 up to and including 2007 (year of study), Limpopo Province had lower rates of electricity use in both absolute, and in comparative terms with South Africa as a whole.

Children whom, during the study year (2007), were aged 14 and 13 were born in 1993 and 1994 respectively. At the time of the 1996 Census (when the first survey on electricity was done), they were aged 3 and 2 respectively. It is therefore likely that study children could have been in the group that was exposed to indoor use of biomass fuels at early ages of three and two, when the risk of respiratory diseases in children could have been higher due to incomplete biological development as suggested[2].

Table 3. A comparison of proportions of households using electricity as a source of energy for lighting, cooking and heating in Limpopo Province and in South Africa

Uses	Census/Community Survey	Limpopo Proportions	South Africa Proportions
Lighting	1996	38.7	57.6
	2001	62.9	69.7
	CS 2007	81.0	80.0
Cooking	1996	20.5	47.1
	2001	25.3	51.4
	CS 2007	40.2	66.5
Heating	1996	19.7	44.5
	2001	27.4	49.0
	CS 2007	36.8	58.8

Sources: Community Survey Report 2007 and General Household Survey 2002-2009, 2010[13]

3.2. Study Design

Author used a cross sectional design with a weighted andprobability sample of students selected in the study without due regard to exposure or disease status. A multi-stage cluster sampling technique was used for selecting eligible children from the population of study. First, eligible educational districts within the Capricorn District Municipality were selected as long as they were within the 60 kilometre radius around the capital city of Polokwane. Second, eligible schools within selected districts were chosen based on maximum variability and for having the required age group of 13-14. Third, eligible classrooms within eligible schools were selected on the basis of the presence of the required age group. Finally, eligible students taken from eligible classrooms were selected using the probability proportional to sample (PPS) technique. At each classroom, children who met the criteria for inclusion, namely being aged 13 or 14 years, of unknown exposure status and free from the disease,were selected. Children in the sample were mostly in Grades 7 and 8.Schools for children with special needs were excluded from sampling, so were those whose parents refused to give informed consent.

3.3. Data Collection

The Research and Ethics Committee of the University of Pretoria on the 30th November 2006 gave permission for the study, as did the department of Education in Limpopo by allowing access to different schools. In each school, children aged 13 and 14 were called into the school hall where the study was explained to them. Consent forms attached to questionnaires were given to each child to obtain consent to participate in the study from parents or legal guardians. After parental consent was obtained, assent was obtained from the children. Children who did not return the forms to school were considered to have been refused to participate in the study. Before interviews commenced, consent and assent forms were separated from the questionnaire to remove all identifiers.

Research assistants interviewed the participants and recorded the data using structured questionnaires. The completed questionnaires were collected at the various schools, serially numbered and captured. Data validation and verification were done in collaboration with interviewers at the various schools prior to data analysis.

3.4. Data Analysis

The objective of the analysis was to determine the association of asthma and use of biomass fuel within households. Exposure to smoke emitted from burnt biomass is one among important predictors of asthma in this study. Others were absence of a waterborne toilet, persistent cough and (to a moderate extent), exposure to hyper allergenic diets.

Pearson’s Chi-square tests of association, binary logistic regression and multi-level analyses were used for data analysis. Multilevel analysis used for quantifying variability of asthma at the levels of districts and schools will not be explored in this paper. Data entry and analysis were performed using the statistical package, Stata version 10.

4. Results

Table 4 presents demographic and other characteristics of children in the study.

Table 4. Demographic and other characteristics of children in the study (n=742)

Variable	Frequency	Percentage
Sex		
Male	326	43.94
Female	416	56.06
Age Category		
14 years	486	65.50
13 years	256	34.50
Residence Category		
Non-village	21	2.83
Village	721	97.17
Presence of a smoker at home		
Present	202	27.22
Absent	540	72.78
Having tap water at home		
Present	398	53.64
Absent	344	43.36
Waterborne toilet		
Present	181	24.39
Absent	561	75.61
Pet ownership		
Present	276	37.20
Absent	466	62.60
Perceived dust in the living area		
Yes	499	62.25
No	243	32.75
Use of biomass fuel at home		
Yes	270	36.39
No	472	63.61
Consume milk		
Yes	677	91.24
No	65	8.76
Consume eggs		
Yes	669	90.16
No	73	9.84
Consume peanuts		
Yes	680	91.64
No	62	8.36
Consume fish		
Yes	709	95.55
No	33	4.45
Family history of asthma		
Yes	96	12.94
No	646	87.06
Family history of allergies		
Yes	287	38.68
No	455	61.32
Asthmatic		
Yes	205	27.63
No	537	72.37
Having a persistent cough		
Yes	227	30.59
No	515	69.41
Exposed to chemicals indoors		
Yes	275	37.06
No	467	62.94
Socioeconomic status		
Otherwise	203	27.36
Low	539	72.64
Exposure to allergenic diets		
Yes	479	64.56
No	263	35.44

Prevalence of asthma in the sample (n=742)
Asthmatics were 205/742 or 27.63%

Fifty-six per cent (56.06%) or 416 children in the study were females. Sixty-five per cent (65%) or 486 were aged 14 years. The overwhelming majority of the sample, 97.17% came from villages, but residence did not significantly predict asthma in this study.

The prevalence of asthma in the sample was 27.63%. This is more than what was previously observed in the same area[15]. Mankweng district which is semi-urban had the lowest prevalence of 17%. Maraba being the farthest and more rural had higher prevalence of 35%.

4.1. Prevalence Estimates and Estimates of Associations in Various Demographic Groups.

4.1.1. Age Category

In the sub-group of children aged 13 years (n=256) the prevalence of asthma was 25.39% or 65/256. In the sub-group aged 14 years (n=486) prevalence was 29% or 140/486. The asthma odds ratio for the two groups was 0.84, p = 0.32, CI 0.60; 1.19. This findings show that older age was protective of asthma.

4.1.2. Sex

In a sub-group of males (n=326), 80 were diagnosed with asthma and the prevalence was 25.0%. Among the sub-group of females (n=416) 125 were diagnosed with asthma and the prevalence was 30.0%. The male- female odds ratio was 1.32, p = 0.06, CI 0.98; 1.99. The finding shows that females were 1.32 times more likely to have asthma than males.

4.1.3. Category of Residence

In the sub-group coming from rural villages (n=721) 196 or 27.18 were diagnosed with asthma. In the sub-group coming from suburbs, townships and inner city (n=21) 9 were diagnosed with asthma making a prevalence of 43%. Though numerically smaller, prevalence in this latter group was very high indicating the likelihood of exposure to higher concentrations of multiple, particularly environmental agents.

However if we take the total number of asthmatics (n=205) in the whole sample (n=742), only 9 (9/205) or 0.0439% lived in other areas other than villages. But the majority 196/205 (96%) lived in rural villages indicating effects of village life on asthma occurrence. The odds ratio for the two groups was 0.51 showing that not coming from rural villages was protective of asthma.

Prevalence among children who did not live in villages was 0.012%. The odds ratio for the two groups was 0.50 p 0.12 CI 0.21, 1.20. This finding suggests asthma was negatively associated with residential category.

The prevalence of asthma was higher in a group that lived in the area since birth i.e. 47.80% followed by the group that lived in the area from three years onwards with 31%. This finding supports the theory that duration of exposure to air pollutants of certain concentrations is effective in causing asthma asKlepeis[16] suggests in his exposure model.

4.1.4. Use of biomass fuel

In the total sample (n=742) 270 used biomass fuel for energy within their homes, making a prevalence of 36.40%.The prevalence of asthma in this subgroup (n=270) was 32.96% or 89/270.

Among the 205 subjects with asthma in the whole sample (n=742) 89 or 43.40 % were exposed to use of biomass fuel within their homes.

4.2. Determining Associations through LogisticRegressionanalyses

4.2.1. Use of biomass fuel and asthma

To test whether asthma was associated with use of biomass fuel, a logistic regression analysis was done. This analysis revealed that use of biomass fuel significantly predicted asthma, with odds ratio 1.50 p 0.01 CI 1.09; 2.10, suggesting thatchildren who came from a household using biomass fuel for energy were 1.50 times more likely to have asthma than those who came from households not using biomass fuel for energy.

4.2.2. Testing the Influence of the Magnitude of Other Odds Ratios in the Model on the Odds Ratio of the Primary Model.

Theory suggests that the magnitude of the odds ratio of the predictor and outcome variable depends upon the prevalenceof the magnitudes of other variables in the model. Author tested the magnitude of the odds ratio of asthma and biomass fuel in two models. The one model was a saturated model with many predictors irrespective of their significance status (Table 5). The other model was a model with only significant predictors (Table 6).

To test the effects of other predictors on the magnitude of the odds ratio of asthma and use of biomass fuel, a logistic regression analysis was done. Results are shown in Table 5.

Results in Table 5 show that the main predictor retained its resilience in the presence of other predictors. In a model of asthma and use of biomass fuel, the odds ratio was 1.50, p value 0.01, CI 1.09; 2.10. In a model with other predictors the odds ratio was 1.49 p 0.04 CI 1.02; 2.18. The difference between the two odds ratios is small showing that the variables in Table 5 did not affect the magnitude of the odds ratio of the primary exposure variable. Thus indicating its resilience.

Results of Table 6 above shows that other significant predictors affected the magnitude of the odds ratio of the primary predictor and the outcome variable, 1.43, p 0.05 CI 1.00, 2.04 as against 1.50 p 0.014, CI 1.08, 2.09.The differences between the two odds ratios are small indicating the resilience of the primary exposure variable in predicting asthma.

Table 5. Results of logistic regression analysis of asthma and all predictors

Predictor	Odds Ratios	P Value	Confidence Intervals
Biomasss fuel	1.49	0.038	1.02; 2.18
Gender	1.40	0.06	0.98; 2.00
Age category	0.80	0.24	0.55; 1.16
Smoker at home	1.31	1.17	0.89; 1.92
Running water	1.16	0.46	0.78; 1.72
Waterborne toilet	0.53	0.00	0.34; .84
Pet ownership	1.00	0.99	0.69; 1.43
Dusty environment	0.97	0.87	0.65;1.42
Consumes milk	2.03	0.02	1.12; 4.74
Consumes eggs	1.86	0.08	0.92; 3.70
Consumes cheese	2.04	0.04	1.05; 3.99
Consumes fish	0.88	0.77	0.38; 2.06
Consumes peanuts	1.36	0.39	0. 67; 2.79
Family history of asthma	0.82	0.46	0.48;1.38
Family history of allergies	1.19	0.34	0.83; 1.71
Persistent cough	4.15	0.00	2.89; 5.96
Exposure to hyper allergenic diets	0.31	0.00	0.15;0.64

Table 6. Results of logistic regression analysis of asthma and the main predictor and other significant predictors

Variable	Odds ratio	P value	Confidence Interval
Use of biomass fuel	1.43	0.05	1.00; 2.04
Waterborne toilet	0.576	0.00	0.39;0.85
Persistent cough	3.96	0.00	2.80; 5.61
Exposure to allergenic diets	0.73	0.08	0.52; 1.03

4.2.3. Adjustment for Confounding

A review of literature shows that variables such as age, gender, place of residence are potential confounding variables[17]. As a result a logistic regression to test for confounding was done. Table 7 gives details.

Table 7. Results of adjustment for confounding

Asthma	Odds Ratio	P value	Confidence Intervals
Smoke	1.61	0 .00	1.15, 2.25
Age cat	0.82	0.27	.58, 1.16
Gender	1.33	0.09	.953, 1.85
Residence	1.36	0.03	1.03, 1.80

The results of table 7 showed that the adjusted odds ratio is moderately larger than the unadjusted odds ratio 1.61 vs. 1.50 suggesting that the variables age, gender and place of residence, were confounders of the association of asthma and use of biomass fuel for energy.

However results in Table 5 and 6 showed the resilience of the primary factorin predicting asthma.

5. Discussions

The prevalence of asthma in the sample was 27.63 or 205/742. The findings on age, sex and use of biomass fuel, as far as they relate to susceptibility to asthma, support what is currently known.

5.1. Age and Asthma

Sixty five per cent of the sample was aged 14 years. The odds ratio of 0.84 suggests that higher age was protective of asthma. This finding supports several theories of children's susceptibility to asthma. One such theory suggests that incomplete biological development of small children(particularly their undeveloped immune defence systems and developing lungs) increase their susceptibility to asthma and other respiratory diseases[2, 18].Another theory suggests exposure to inspirable toxic pollutants in early years of life leads to atopy and sensitization of the respiratory system[19]. Theories of asthma development also suggest that airway inflammation, whether inherited or acquired from the environment, if it happens before the age of three years, sets the stage for development of asthma by 6 years of age or later[11].Author is of the opinion that most 13 and 14 year old children in the study were exposed to toxic air pollutants during their early years and that this exposure may have been due to lower rates of electrification in Limpopo province as shown in Table 3.

5.2. Gender and Asthma

Fifty six per cent (56.06%) or 416/742 respondents were females. The prevalence of asthma within this group was 30% or 125/416.Female asthmatics comprised 61% or 125/205 of the sub-sample of all asthmatics in the study. The odds ratio of female-male asthma was1.32, p 0.06, CI 0.98; 1.99. The finding shows that girls were 1.32 times more likely to have asthma than boys.

This finding is not consistent with the generally held perspective that boys aremore susceptible to asthma than girls. The National Heart, Lung and Blood Institute[11] suggested that at younger ages males are more at risk than females. Harwood[20] also suggested boys are susceptible to asthma before the age of 14 years. Some studies also showed rates of asthma, wheezing, and rhinitis and hay fever symptoms to be higher in boys than girls in cities with high humidity and in cities with low humidity[21].Another theory suggested that lungs of boys are smaller during younger ages when compared with those of girls at same ages, making boys more susceptible to asthma at younger ages[22].

5.3. Use of Biomass Fuel and Asthma

Thirty six per cent or 270/742 of the sample used biomass fuel for energy within their homes. The prevalence of asthma within this group was 32.96% (or 89/270).

A logistic regression of asthma and use of biomass fuel yielded an odds ratio of 1.50, p 0.014 CI 1.86; 2.97 suggesting that use of biomass fuel significantly predicted asthma in this sample.

When adjusted by age, gender, residence, the odds ratio for use of biomass fuel and asthmawas 1.61 , p 0.00, CI 1.15; 2.25 suggesting that the crude and adjusted odds ratio did not differ much (1.50vs. 1.61).

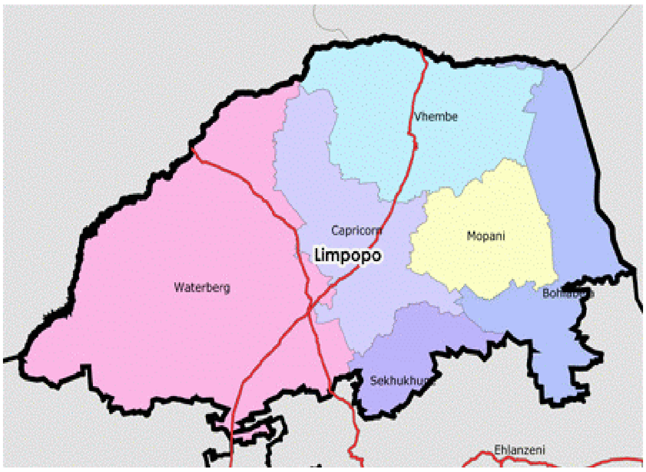
Looking at the data above, it is clear that the main study variable predicted asthma significantly and that potential confounders age, gender and residence did not significantly affect the relationship of asthma and use of biomass fuel.

This finding supported what is already known about the effect of burnt biomass on respiratory health: Burnt wood, coal, paraffin, gas, dried animal waste and agricultural waste produce toxic substances. Burnt paraffin and wood emit methane, nitrogen dioxide, nitric acid; carbon monoxide and carbon dioxide are emitted as cooking fumes[23]. Burnt coal emits carbon dioxide and carbon monoxide, dozens of polycyclic hydrocarbons and particulate matter[24].Household cooking stoves with or without ventilation, produce enough pollutants to significantly affect local neighbourhoods[25]. Nitrogen oxide combines with water to form acids that damage lung tissue. It also combines with sulphur dioxide to form inspirable particulate matter (sulphates and nitrates)[26]. Nitrogen dioxide exacerbates asthma and causes death among asthmatics[27]. Sulphur dioxide irritates respiratory tracts and causes airways to close and disrupt lung function[28]. Ozone damages the lungs, causes coughing, and in asthmatic patients, causes exacerbations. It also compromises the immune system and causes shortness of breath and painful breathing[29]. Fossil and biomass fuel[wood and coal] inflame airways and cause them to constrict resulting in breathing difficulties[30]. Fine and ultra-fine inspirable particulate (PM 1.0, 2.5) lodge deeper into lungs and incur damage to lungs[31]. A mixture of toxic pollutants can cause allergic sensitization to healthy individuals and to those who have chronic obstructive diseases[32]. When inhaled, carbon monoxide reduces the ability of the blood to bring oxygen to body cells and tissues[33]. Carbon dioxide inflames airways and causes them to become constricted resulting in breathing difficulties. It also irritates respiratory mucosa and increases sensitization to allergens[34].

The evidence presented in this study suggests that if rural children continue to be exposed to substances that burnt biomass produces, the risk of asthma in Limpopo province will remain high. Given that sick children become sick adults, Limpopo province may confront a phenomenon of insufficient healthy manpower to carry out development tasks.

6. Conclusions

If findings of this study and that of Maritz[15], both having been done in the District Municipality of Capricorn, are taken together; and given that The District Municipality of Capricorn which contains Polokwane, the capital city of Limpopo, is relatively developed and urbanized compared to the remaining 4 district municipalities of Vhembe, Waterberg, Mopani and Sekhukhune (Figure 1) below, it can be concluded that the risk of asthma in Limpopo is significantly high. This makes asthma a major public health issue that should be prioritized for prevention and control. Such measures should include establishment of an asthma surveillance system and that the disease be made notifiable. Under such circumstances it will be possible for Limpopo government to identify the risk factors for asthma among children. Inadequate electrification leading to use of biomass fuel for energy (one of the major risk factors), will be highlighted and targeted for intervention.



Source: Demarcation Board (www.demarcation.org.za) in PROVIDE Project[5]

Figure 1. Map of Limpopo Province showing all District Municipalities

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