Analysis of Impact of Climate change on Children's Health in Limpopo province, South Africa.

By

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INTRODUCTION

While Africa generally is a land of great contrasts, South Africa is a country of great diversity and inequalities both in terms of its geography, climate, peoples as well as socio-economic development. The several decades of apartheid policies and programmes have accentuated the unequal socio- economic and spatial development patterns, with the minority in small portion of the country generally better off than the majority in large expanse of land as in the northern Limpopo province, where varieties of climatic and extremes of weather conditions are experienced and the poorest of the poor are by sheer providence geographically confined. The population of Limpopo province though comprises of several ethnic groups distinguished by culture, language and race, the Black is by far the largest group comprising 97.3%, while the White, Coloured and Indian/Asian consist of 2.4%, 0.2% and 0.1% respectively (Stats SA 2007). The province is generally known to have the smallest percentage and number of white South

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Africans in the country and so, within the frameworks of apartheid policies and development programmes, had received the least attention in terms of socio-economic development.

According to UNICEF (2007), "throughout the world, children face significant threat to health from an array of environmental hazards. The protection of human, *particularly, children who are the most vulnerable* (emphasis ours) remains a fundamental objective of environmental policies to achieve sustainable development" Being the most vulnerable to vagaries of weather, the most exposed and the group with the least resistant ability, the risks children face are likely to be intensified by climate change. The health implication of this becomes more worrisome if we note that in any geopolitical entity, particularly in developing countries or its sub-regions, children constitute a very significant proportion of the population. While 11.3 % or 5.4million of the South Africa's population is found in the Limpopo province, about 2 million or 37.1% of this figure are children under the age of 14years (Stats SA, 2007). This is close to the national figure of similar groups in Bangladesh with 42 percent. Further it is observed that those children below 5 years in the Province constitute about 12.1% of the provincial population. This figure is higher than the estimated national figure for this group in developing countries. According to UNICEF (2007), the proportion of very highly vulnerable children (under five years) range between 10 and 20 percent of the population in countries (or areas of nations) with the least ability to cope with the health implications of climate change. Again, according to UNICEF, in high income countries, the proportion of under-five is about 4 or 5 percent (UNICEF 2007).

It has been observed that 34% of all childhood illness in the world and 36% of deaths in children under age 14 are due to modifiable environmental factors and that because of their physical, physiological and cognitive immaturity, children are more sensitive than adults to harm from environmental hazards (WHO, 1996). Although, overall death rates for young children continue to drop in most parts of the world due to improved nutrition, health care and immunization rates, as well as better environmental health, for many of the children in the developing countries who are most at risk from diarrhea diseases, respiratory illness, malaria, meningitis, cough, typhoid, measles, and malnutrition (the most significant causes of mortality for children), the situation is likely to worsen with some of the effects of climate change (UNICEF, 2007). The point is, climate change increases health hazards by worsening air quality, stimulating more extreme weather events, creating conditions that favour increases in food-water-and vector-borne infections, and enhancing heat stress condition.

It is hypothesized that, while children in different parts of the country face a lot of environmental health risks, a very significant proportion from the Limpopo province of South Africa, may indeed be living in a state of emergency. It is the health status of this significant proportion of the population in the province that is under focus in this study. This paper therefore examines the relationship between climate change and children's health, using data from five Municipalities in the Limpopo Province of South Africa.

AIM AND THE OBJECTIVES

Aim

The main purview of this study is to examine the relationship between climate change and children's health, using data from five Municipalities in the Limpopo Province of South Africa. The study seeks to analyse the incidence, prevalence rates, intracity, inter city and temporal variations of clinically diagnosed climate related diseases among children aged 0 to 13 years. Also the age and sex specific variations of these diseases as well as the relationships between critical climatic parameters of rainfall and temperature are examined.

Objectives

The objectives of the study are to;

- Examine the incidence, prevalence rates and trends of the diseases under consideration.
- Examine the intra-urban variation in incidence and prevalence of the diseases.
- Assess the variations in age and sex of the children with respect to prevalence of diseases and mortality rates.
- Examine the relationship between variations in climatic parameters and the diseases.
- Suggest adaptation / mitigation strategies.

ISSUES IN CLIMATE CHANGE AND CHILDREN'S HEALTH

Several conceptual issues are relevant in a study involving climate change and children's health. However, the key issues reviewed here are those of Climate change, Healthy city, environmental health and Children's health.

Climate Change

The phrase "Climate change" is often used interchangeably with "Global Warming". It is generally understood as changes in the variables or average state of the atmosphere over duration ranging from decade to millions of years. An assessment by the IPCC (2007) concluded that the Earth's climate would be 2-6^{0}C warmer than in the pre-industrial era by the end of the twenty-first century due to human-induced increases in greenhouse gases. The large-scale warming is expected to be accompanied by increased frequency and /or intensity of extreme events, such as heat waves, heavy rainfall, storms and flooding. Presently, climate change is the most pressing environmental, social and economic problem facing the planet because its consequences are global and of a long-term effect. The debate over whether climate change is a natural or human induced event seems to be over with the observation of IPCC (2007) to the effect that, global warming is occurring and increase in global temperature is a result of human activities.

According to IPCC, (2008), by 2100 global average temperatures would increase between 3.2-7.2 ^{0}F (1.8-5.0 ^{0}C), depending on a range of scenarios for greenhouse gas emissions, and stated that it was now 90 percent certain that most of the warming observed over the previous half century could be attributed to greenhouse gas emission produced by human activities (i.e., industrial processes and transportation).

The 1992 Earth Summit and the 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change attempted to address the issue of global warming, but in both cases the efforts were hindered by conflicting national economic agendas and disputes between developed and developing nations over the cost and consequences of reducing emissions of greenhouse gases.

Health, Healthy City and Environmental Health

The most popular definition of health is that provided by (WHO 1997) which defined health as a "state of complete physical, mental and social well-being and not merely absence of disease or infirmity". The world body also extended the conception of health to include "sense of well being and security". Elaborating on the concept, NISER (2002) defined health objectives to include the following:

1. To feel good and to be in good physical condition;
2. To be free from debilitating disease such as malaria;

3. To have good nourishment in order to maintain good health and;
4. To have access to good medical care.

A "Healthy City" has been defined as one that continually creates and improves physical and social environments. A "Healthy City" also continually expands community resources that enable its people to mutually support each other in performing all the functions of life and in developing to their maximum potential (WHO,2006). Some of the key characteristics of a "Healthy City" include:

- a clean, safe and sustainable environment;
- integration of health promotion and protection facilities, services and activities in specific settings such as schools, workplaces, healthcare institutions and the community;
- political commitment;
- working through innovation;
- inter sectoral collaboration; and
- Community participation.

Although urbanization has created opportunities for education, employment and socio-economic development, it has also given rise to health and environmental problems and issues, such as air and water pollution, crowded housing, traffic congestion and outbreaks of infectious diseases. This provided the impetus for the World Health Organization to develop the "Healthy Cities" approach to help countries cope with the adverse effects of urbanization. This approach encourages governments to incorporate health issues into all aspects of public policy, and to actively engage non-health sectors, such as environment, education, and urban planning, to integrate health protection and health promotion activities into all aspects of urban living.

Environmental Health

Environmental health, according to WHO, (2006), "…comprises those aspects of human development, health, disease and injury that are determined or influenced by factors in the environment". This includes the study of both the direct pathological effects of various chemical, physical and biological agents, as well as the effects on health of the broad physical and social environmental factors, which include housing and urban development, land use and transportation, industry and agriculture". The environment is a major factor that affects human health. Human exposures to hazardous agents in the air, water, soil and food and to physical hazards in the environment are major contributors to illness, disability and death worldwide (World Health Organization 2006). Furthermore, deterioration of environmental quality is estimated to be directly responsible for approximately 25% of all preventable ill health in the world, with diarrhea diseases and respiratory infections heading the list.

World Health Organization (2006) opined that Children are our future, numbering over 2.3 billion worldwide (aged 0-19) and representing bondless potential. Child survival and development hinge on basic needs to support life; among these, a safe, healthy and clean environment is fundamental. Children are exposed to serious health risks from environmental hazards. Over 40% of the global burden of disease attributed to environmental factor falls on children below five years of age, who account for only about 10% of the world's population. Environmental risk factors often act in concert, and their efforts are exacerbated by adverse social and economic conditions, particularly conflict, poverty and malnutrition. There is new knowledge about the special susceptibility of children to environmental risk: action needs to be taken to allow them to grow up and develop in good health, and to contribute to economic and social development. Pertinent observations by WHO, (2006) on the relationship between the environment and children's health are that:

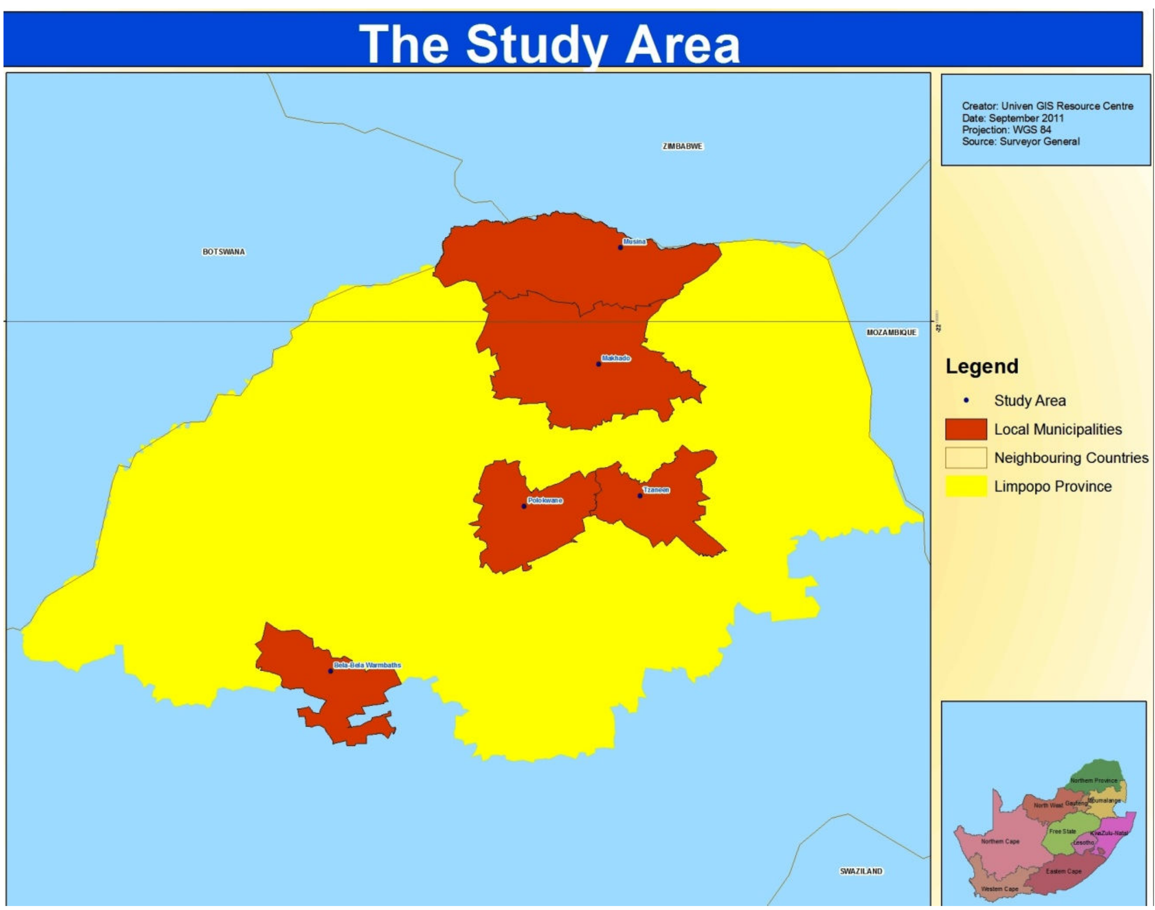
- Each year, at least three million children under the age of five die due to environment-related diseases.
- Acute respiratory infections annually kill an estimated two million children under the age of five. As much as 60 percent of acute respiratory infections worldwide are related to environmental conditions.
- Diarrhea diseases claim the lives of nearly two million children every year. Eighty to ninety percent of these diarrhea cases are related to environmental conditions in particular, contaminated water and inadequate sanitation.
- Nearly one million children under the age of five died of malaria in 1998. Up to 90 percent of malaria cases are attributed to environmental factors.

The incidence, prevalent rates and variations in these environment related disease in Limpopo Province is the subject of investigation here.

THE STUDY AREA

The study area of this research is the Limpopo province, the most northerly part of South Africa, with unique geographical location as it incorporates both tropical and subtropical climatic characteristics. The study covers five out of the nine Municipalities in the province. As shown in figure 1, while two of the selected Municipalities, namely Makhado and Musina municipality fall within the tropical region at the northern part of Limpopo, two others, the Capricorn District municipality with headquarters at Polokwane and the Greater Tzaneen Municipality fall around the tropic of Capricorn. Bela-bela City, the headquarters of its District municipality on the other hand, is the most southerly city of the province lying within the subtropical region. The District Municipality Hospital in each city was selected for study. These are government hospitals, with comprehensive health care programmes, and relatively longer history of, as well as better culture and method of record keeping.

Fig.1: The Study Area



RESEARCH METHODOLOGY

Two types of secondary data were required for this study. The first on climate related diseases and the second on climatic parameters. The first data type relates to the incidence of such diseases as: malaria; typhoid; asthma; skin cancer; diarrhea; measles, and meningitis. The children covered are those aged 0 to 13 years. Although the study aimed to cover 20 years hospital record from 1990 to 2010, however, the earliest period for which data could be obtained was for 11 years period spanning 1999 to 2010. The period covered is the ten year period between 1999 and 2009. Our observation is that there is a relationship between age of record and data accuracy and completeness. Record keeping in retrievable format is a recent development (in most cases, not more than 10years old). In most of the hospitals, older records either do not exist, or had been destroyed or dumped as a heap of documents in inaccessible manner in a "dungeon". The information gathered include, age, sex, location of patient as shown by residential address, as well as the clinically diagnosed diseases with associated complications. These data types were collected from the medical records section of each of the five hospitals.

The method of collection in each hospital involved a review of case notes of clinically diagnosed diseases. Relevant cases, bearing in mind, age and disease type, were identified and recorded in a structured questionnaire. A total of 7869 relevant cases were encountered in the five hospitals during the period covered by the research.

The second type of secondary data is the 21 years meteorological data covering the period 1999 to 2010. This relates to mean maximum and minimum temperatures and mean annual rainfall. The climatic parameters were supplied by the South African weather services, Pretoria.

The data collected was subjected to cross tabulation so as to examine the variations in critical variables of interest, while Chi-Square test was specified to test the significance of relationships. Pearson correlation was used to test the relationship between incidence, years of temperature and rainfalls. Regression analysis was employed to examine the relationship between climatic parameters and the incidence of diseases. Hence climatic parameters are the independent variables while incidences of disease are dependent variables.

RESULT AND DISCUSSION

Evidences of climate change

In order to establish whether or not there is climate change in the province, 21 years data on temperature and rainfall were analysed. As shown in figure 2a, while expectedly there are fluctuations in maximum temperature during the period, the trend shows an overall increase for the four municipalities for which the data type was available. Temperature data was not available for Makhado Municipalities. The R coefficient of variations for each of the cities are 0.50, 0.56, 0.48, and 0.02 respectively for Bela-Bela, Tzaneen, Mussina and Polokwane. The corresponding R coefficients for minimum temperature are 0.004,-0.383, -0.004 and 0.135. The above shows that, while maximum temperature tends to increase during the 21 years period, minimum temperature shows a decrease over the same period, thereby indicating that there is climate change in the direction of local warming in the province. Maximum temperature in the most tropical location, Mussina was the highest ranging from 29 ^{0}C to 32.2^{0}C, giving an annual increase of 0.15^{0}C while for BelaBela, the most subtropical of the locations maximum temperature ranged from 25.5^{0}C to 29.6^{0}C, also giving an annual increase of 0.19^{0}C.

Some studies had it that the world's average temperature has increased by 0.5^{0}C in the past 300 to 400 years (Ogundipe, 2006). The warming of the Earth as it were is a common physical problem. The accumulation of the heat trapping gases in the atmosphere establishes a new higher temperature for the equilibrium between the incoming solar radiations from the earth into the blackness of space. More energy is made available for the heating of the land and evaporating water when the temperature increases. The evidence from the past century suggests that in the middle and higher latitudes, the warming may proceed at a rate of 0.3^{0}C to as much as 1^{0}C per decade throughout the next decades and that if no steps are taken to reduce the accumulation of heat-trapping gases, the warming can be expected to accelerate (Houghton, Jenkins and Ephraums, 1990; Leggett, 1990).

Fig. 2a Trend in maximum temperature 1990 to 2010

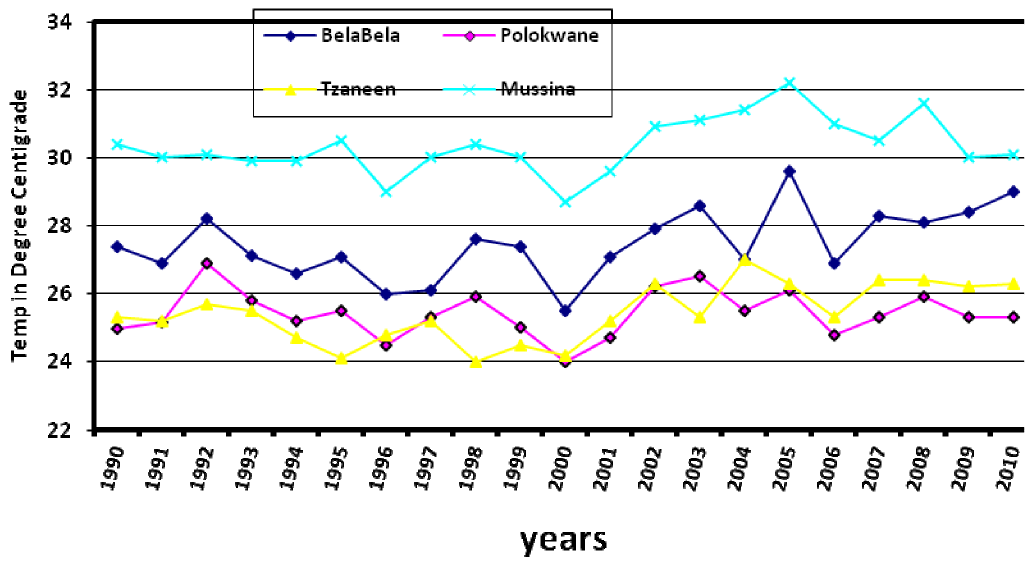


Fig 2b: Trend in minimum temperature 1990 to 2010

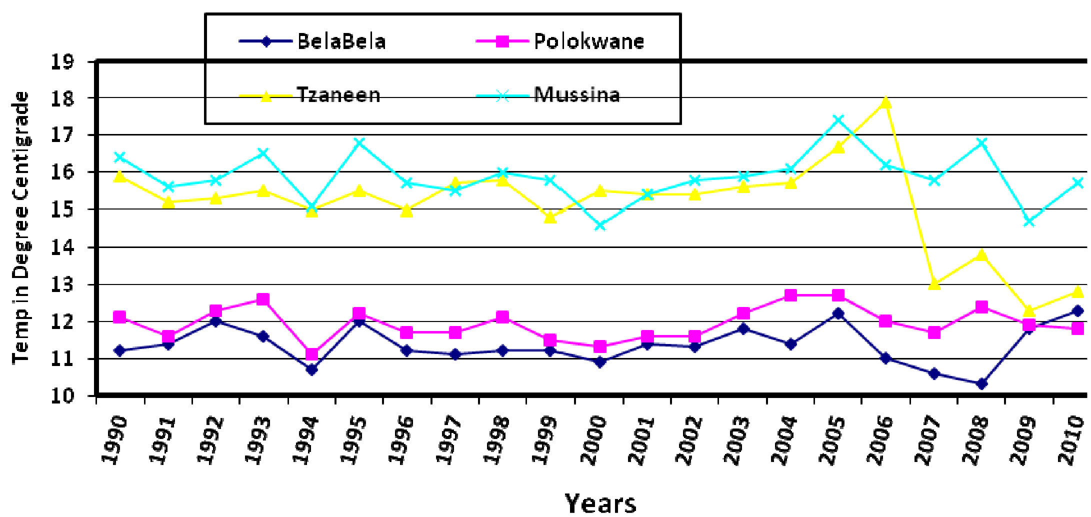
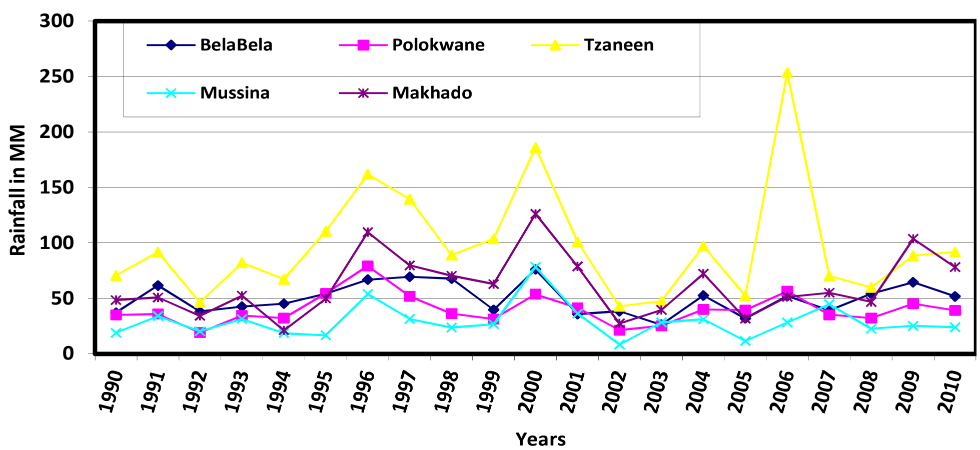


Figure 3 shows that average annual rainfall though fluctuates but is generally low in the various municipalities during the 21 years period. Tzaneen, a subtropical location had the highest values ranging from 43mm in 2002 to 254mm in 2006. The relationship between annual rainfall and years was analysed using Pearson correlation. The results show positive but very low coefficients of 0.027, 0.063, 0.020 and 0.188 respectively for Polokwane, Tzaneen, Mussina and Makhado and negative coefficient for BelaBela the most subtropical location with R = -0.022.

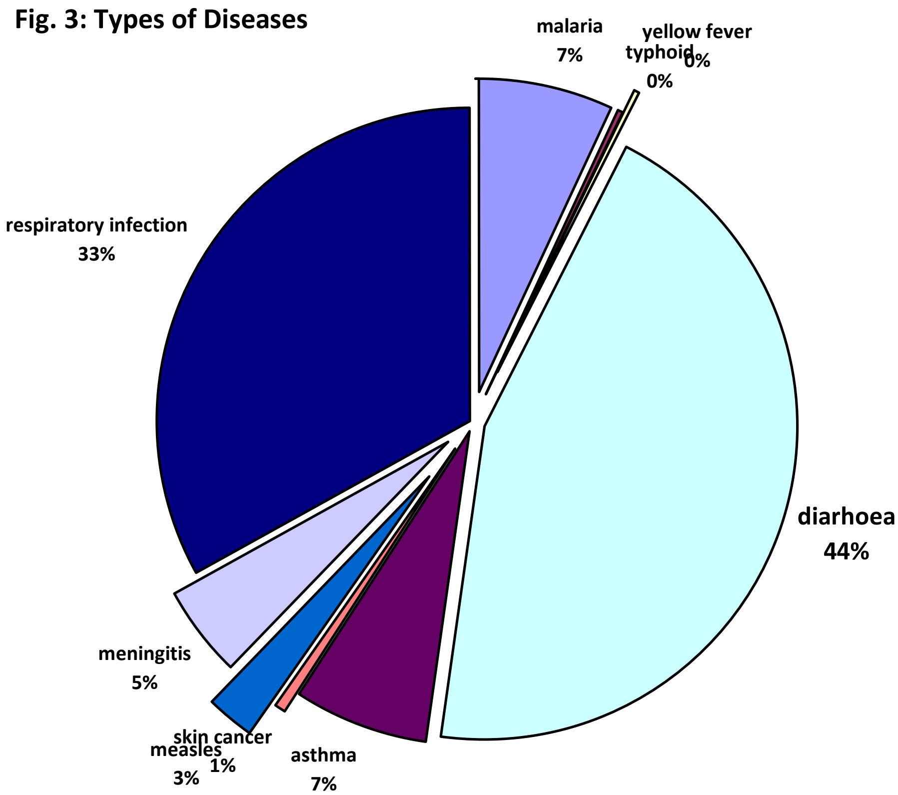
It is concluded that with increasing maximum temperature, decreasing minimum temperature and low and decreasing average annual rainfall, there are evidences of local warming in the province. The health implication of climate change featuring local warming and the specific relationships between climatic parameters and incidence of climate change related diseases are some of the issues investigated in the following sections.

Fig.2c Rainfall trend 1990 to 2010



INCIDENCE AND PREVALENCE RATES OF DISEASES

As shown in figure 3, the most prevalent disease in the study area are: diarrhea (42.4%); respiratory infection (31.3%), asthma (6.6%) malaria(6.5%) and meningitis(4.5%). There is also significant presence of measles (2.4%).



Further result shows that 99.4% of all incidence of disease affected the black race. While the Coloured, Indians and White race had 0.3%, 0.2% and 0.1% respectively. This variation however reflects more of the general pattern of population distribution in the province, as noted earlier in this report.

As shown in Table 1, the profile of the municipalities on disease incidence varies. For instance, more than half (59.4%) of disease incidence in the most tropical location, Mussina was diarhoea which was the most prevalence disease in the province. The proportion was over fourty percent in Polokwane (43.7%), BelaBela (42.1%) and Tzaneen (40.7%), which also had the highest concentration of the second most prevalent disease, respiratory infection with 48.9 per cent, followed by Makhado(25.7%) and Mussina(12%). The observed intercity variations in disease incidence is statistically significant with a p-value of 0.00

Table 1: City variations in incidence of disease

	NR	malaria	Dengue	Typhoid	Y.fever	Diarhoea	Asthma	S.Cancer	Measle	‘Gitis	Resinfectn	Others	Total
Mussina	56 3.9 (51.4)	140 9.6 27.6	7 0.5 38.9	0 0.0 (0.0)	0 0.0 (0.0)	863 59.4 (26.1)	78 5.4 (15.3)	0 0.0 (0.0)	115 7.9 (60.8)	16 1.1 (4.6)	175 12.0 (7.2)	4 0.3 (1.3)	1454 18.7
Makhado	4 0.4 (3.7)	183 19.0 (36.0)	1 0.1 5.6	29 3.0 (85.3)	0 0.0 (0.0)	229 23.8 (6.9)	147 15.3 (28.8)	0 0.0 (0.0)	5 0.5 (2.6)	77 8.0 (22.2)	247 25.7 (10.1)	40 4.2 (12.7)	962 12.4
Polokwane	6 1.3 5.5	5 1.1 (1.0)	1 0.2 (5.6)	0 0.0 (0.0)	0 0.0 (0.0)	205 43.4 (6.2)	30 6.4 (5.9)	0 0.0 (0.0)	7 1.5 (3.7)	89 18.9 (25.6)	29 6.1 (1.2)	100 21.2 (31.6)	472 6.1
Tzaneen	21 0.5 (19.3)	102 2.6 (20.1	4 0.1 (22.2)	5 0.1 (5.6)	1 0 (10.0)	1598 40.7 (48.4)	164 4.2 (32.2)	0 0.0 (0.0)	8 0.2 (4.2)	94 2.4 (27.1)	1918 48.9 78.8	9 0.2 (2.8)	3924 50.4
Belabela	22 2.3 20.2	78 8.1 (15.4)	5 0.5 (27.8)	0 0.0 (0.0)	9 0.9 (0.1)	407 42.1 (12.3)	91 9.4 (17.8)	1 0.1 (100)	54 5.6 (28.6)	71 7.3 20.5	66 6.8 (2.7)	163 16.9 (51.6)	967 12.4
TOT	109 1.4	508 6.5	18 0.2	34 0.4	10 0.1	3295 (42.4)	510 6.6	1 0.0	189 2.4	347 4.5	2435 31.3	316 4.1	7780 100

$X^2 = 0.000$ * figures in bracket represent column percentages

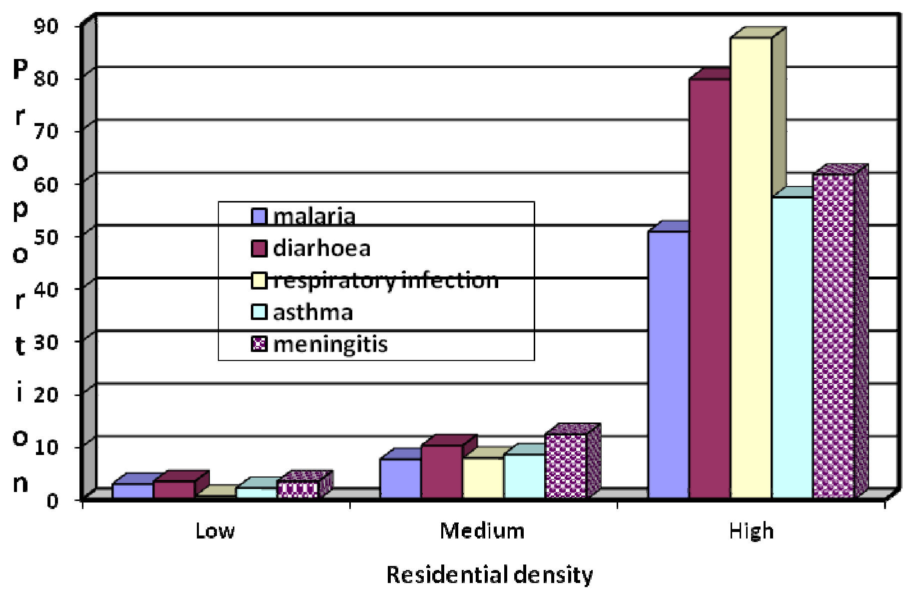
Table 2: Incidence of disease by residential density

	NR	malaria	Dengue	Typhoid	Y.fever	Diarhoea	Asthma	S.cancer	Measle	Gitis	Resinfectn	Others	Total
NR	9 1.0 (8.3)	196 22.1 (38.6)	2 0.2 (11.1)	26 2.9 (76.5)	2 0.2 (20.0)	214 24.1 (6.5)	163 18.4 (32.0)	0 0.0 (0.0)	21 2.4 11.1	78 8.8 22.5	94 10.6 (3.9)	83 9.3 (26.3)	888 11.4
LOW	7 3.6 (6.4)	15 7.8 (3.0)	0 0.0 (0.0)	0 0.0 (0.0)	0 0.0 (0.0)	115 59.9 (3.5)	11 5.7 (2.2)	0 0.0 (0.0)	1 0.5 (0.5)	12 6.3 (3.5)	18 9.4 (0.7)	13 6.8 (4.1)	192 2.5
MED	23 3.2 (21.1)	39 5.3 (7.7)	6 0.8 (33.3)	0 0.0 (0.0)	3 0.4 (30.0)	341 46.7 (10.3)	44 6.0 (8.6)	0 0.0 (0.0)	7 1.0 (3.7)	43 5.9 (12.4)	192 26.3 (7.9)	32 4.4 (10.1)	730 9.4
HIGH	70 1.2 (64.2)	258 4.3 (50.8)	10 0.2 (55.6)	8 0.1 (23.5)	5 0.1 (50)	2625 44.1 (79.7)	292 4.9 (57.3)	1 0.0 0.0	160 2.7 (84.7)	213 3.6 (61.6)	2129 35.7 (87.5)	188 3.2 (59.5)	5959 76.7
TOT	109 1.4	508 6.5	18 0.2	34 0.4	10 0.1	3295 42.4	510 6.6	1 0.0	189 2.4	346 4.5	2433 31.3	316 4.1	7769 100

$X^2 = 0.000$ * figures in bracket represent column percentages

Further analysis reveals that the incidence of disease also varies within residential areas, with the high density neighbourhood recording the overall highest proportion of 76.7 per cent followed at a distant by the medium and low density areas respectively with 9.4 and 2.5 per cent. The observed intracity variation is statistically significant with a p-value of 0.00. Figure4 illustrates the profile of the density areas on the five most prevalent diseases. The high density areas had the highest proportion of diarhoea (79.7%), respiratory infection (87.5%), asthma (57.3%) malaria (50.8%). In each of these cases, the medium and low density areas had the lower and least proportion respectively.

Fig.4: Intracity variations in incidence of most prevalent Diseases



Sex and Age variations in incidence of disease

Figure 5 shows that more than half of the children who suffered from climate change related disease were males (54.7%). Also on the five most prevalent diseases, male children had higher proportion with 52.8%, 54.6%, 55.9%, 54.9% and 62% respectively for diarrhea, respiratory infection and malaria. The observed sex variation in incidence of disease is statistically significant with a p-value of 0.00. This implies that male children are more susceptible to climate change related disease than their female counterpart. This is perhaps as result of the fact that male children particularly from ages 3 upward are more active in and interactive with the environment and consequently more exposed to vagaries of whether. The relationship between ages and disease incidence is investigated next.

Fig.5: Sex variations in incidence of disease

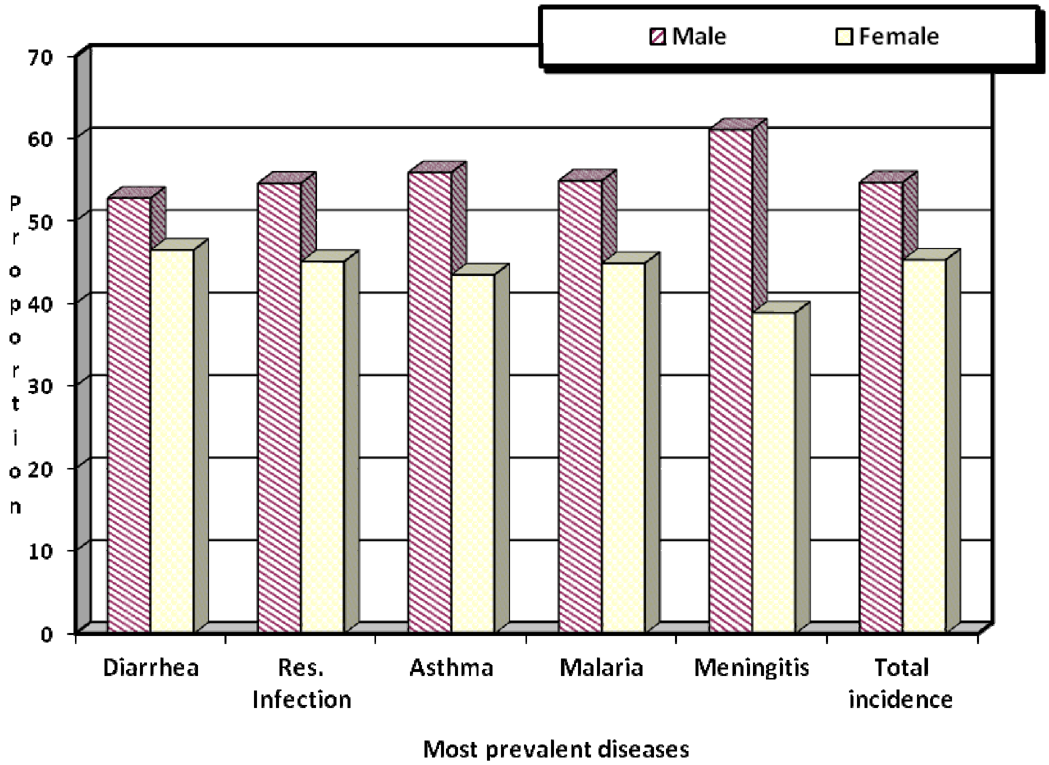
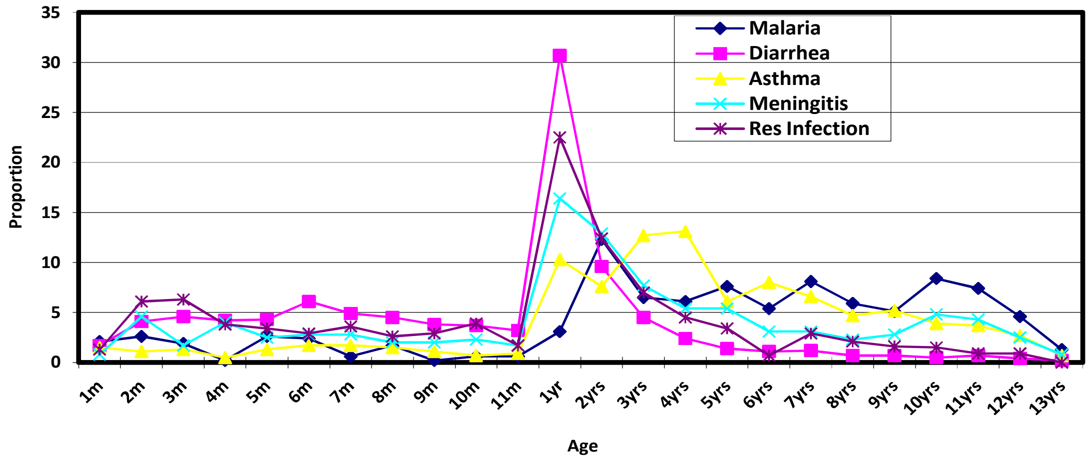


Figure 6 shows the age specific incidence of five most prevalent diseases among the children. It is crystal clear that ages 1 to 2 years were more susceptible than other ages in all the five most prevalent cases. Thus this age group is considered very critical as far as climate change related diseases particularly diarrhea, respiratory infection, meningitis and malaria. However, the result of Pearson correlation between the ages and incidence of the five disease shows that, malaria, asthma and meningitis respectively with r = 0.537, 0.364 and 0.073 are positively correlated with age. This implies that the older a child is, the more susceptible it is to malaria, asthma and meningitis. This is to be expected since older children spend more time than the younger children, outside the home environment in the street or neighbourhood for play and other outdoor activities and are thus exposed to vagaries of whether. On the other hand, diarrhea and respiratory infection each with r = -0.245 and -0.205 have negative correlation with age. In the case of diarrhea, this is to be expected since older children tend to show greater sense of responsibility in the area of environmental hygiene than the younger ones, while higher incidence of respiratory infection among the younger children may be due to lower immunity against airborne pathogens which causes the infection.

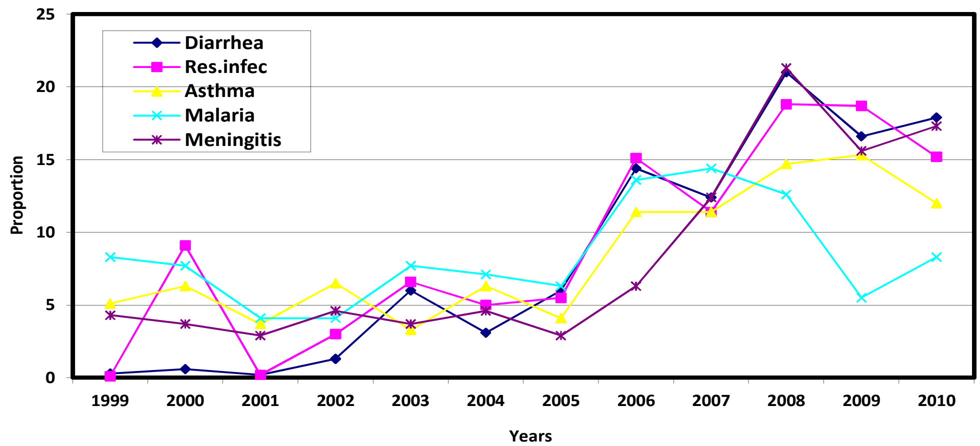
Fig.6: Relationsh between age and incidence of disease



TREND IN INCIDENCE OF DISEASE

Figure 7 shows the trend in the five most prevalent diseases. That there was increasing incidence of the five most prevalent diseases is indicated by the result of Pearson correlation which are 0.928, 0.930, 0.813, 0.392 and 0.818 respectively for diarrhea, respiratory infection, asthma, malaria and meningitis. While all cases were below 10 per cent up till 2005, there was upsurge thereafter, with diarrhea and meningitis reaching epidemic proportion in 2008, before showing slight decrease in 2009 and a tendency to rise again in 2010. The observed upsurge in incidence may be due to increase in local temperature as observed earlier. The ineffectiveness of the existing health care policy is however indicated, signaling a dire consequence on the health of the children. It is these consequences that are investigated next.

Fig.6 Trend in incidence of most prevalent diseases

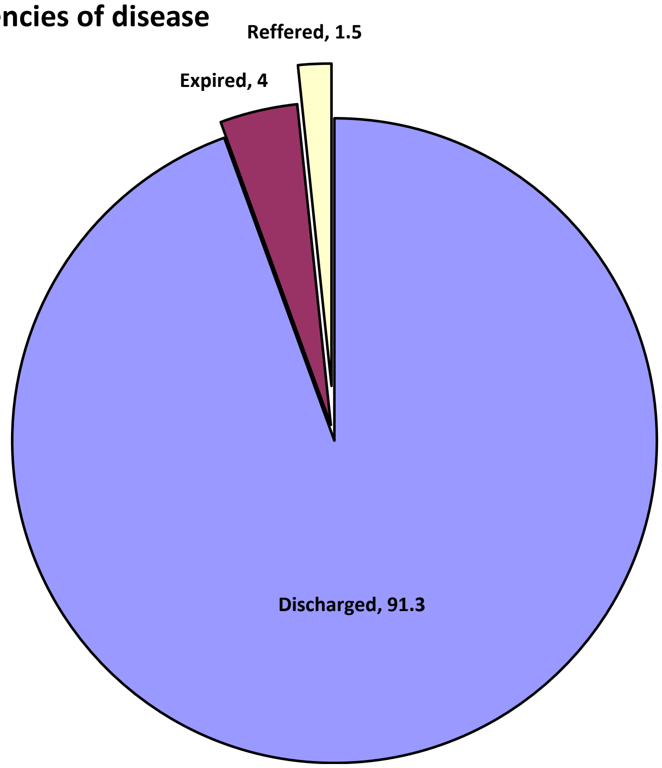


CONSEQUENCES OF DISEASES ON CHILDREN.

Result of analysis as summarized in figure 8 shows that out of the children admitted for climate change related diseases, 91.3 per cent were successfully treated and discharged, while a significant proportion 4.0% died of the various diseases. Another 1.5 per cent were referred to other hospitals or had to be discharged based on request of parents. Result of further analysis as summarized in table 4 reveals that of those children that died, 54.2% were males while 44.9% were females. (sex of remaining 0.7% not indicated). The observed sex variations in mortality rates is significant with p-value of 0.00

In line with earlier observation, 98.1 per cent of the deaths occurred among the black children, while most of the deaths 96.7% resulted from dehydration associated with diarrhea, the most prevalent disease in the study area. The finding here is in line with UNICEF 2007, which identified diarrhea and respiratory infection as the most important and leading causes of mortality among children.

Fig. 6: Consequencies of disease



RELATIONSHIP BETWEEN INCIDENCE AND CLIMATIC PARAMETERS

In order to examine the relationship between climatic parameters and climate related diseases, the incidence of each of the five most prevalent diseases, diarrhea, respiratory Infection, asthma, malaria and meningitis, between 1999 and 2010 was subjected to multiple regression analysis. As a prelude, the data on incidence of diseases was first factor analysed, using the principal component analysis method. This was done to first extract the communalities of the diseases, their variances (measurement of relative importance or prevalence rate) of each disease in the area and then, the derivation of a linear composite factor or component factor- "disease factor", which is then used as a dependent variable Y1, as an input into a general linear regression model expressed symbolically as $Y_1 = b_1x_1 + b_2x_2$, with x_1, x_2 being average temperature and average rainfall respectively are independent variables. The relationship between incidence of disease and climatic parameters of rainfall and temperature is thus examined to test the hypothesized relationship that there is a linear relationship between temperature and rainfall on the one hand and, incidence of diarrhea, respiratory infection, asthma malaria and meningitis.

Result of the factor analysis reveals that there is only one linear composite, which reliably extracts 81.21% variance from the data set. Table 3 shows the composite factor and the loading of the diseases. In the explanation of the relationship between the diseases and climatic parameters, the most important disease as also noted in earlier discussion of prevalent rates of diseases is, diarrhea (.979), followed by respiratory infection (.963), asthma (.951), meningitis (.928) and malaria (.639). The result of regression model as shown in Table 4a reveals that while the coefficient of joint correlation R, between the composite diseases and climatic parameters is .616, the coefficient of determination R^2 is .379. This implies that 37.9% of incidence of disease may be attributable to climatic parameters. However, Table 4b shows that with F ratio of 2.751 and p = .117, the observed relationship is not statistically significant at 95% confidence level. The point to note here is that, temperature and rainfall are major closely associative factors with incidence of disease. Since about 40 percent of disease incidence is accounted for by climatic parameters, if these vital parameters are controlled, close to half of incidence will be under control.

Table 3: Communalities explained by each disease.

	Component score
Diarrhea	.979
Respiratory Infection	.963
Asthma	.951
Malaria	.639
Meningitis	.928

Extraction method: Principal Component Analysis

Thus calibrating the predictive model in Table 4c, y = a + bx + e , where y = the linear composite of the diseases (diarrhea, respiratory infection, asthma, meningitis and malaria in order of importance), y = – 38.681 + 1.329 (maxtemp) + 0.41 (avrain) + e

The result implies that, if all the climatic parameters are kept constant, a unit increase in temperature will produce 1.329 (more that 100%) increase in the incidence of the five major diseases. Given the fact that local temperature is increasing this observation portends great danger for the children in the province. Perhaps it is not out of place to say that the children in the area may be living in a state of emergency as any further increase in temperature, a very certain occurrence would spell further doom on the children's health. The importance of a healthy children population cannot be overemphasized, being the hope of the nation, the soul and vigour of the subregion.

Table 4a: Summary of regression model

R	R square	Adjusted R Square	Std. error of the estimate
0.616[a]	0.379	0.241	0.87092738

A. Predictors: (constant), Av Rainfall, Max Temp

Table 4b ANOVA

ANOVA[b]

Model	Sum of Squares	Df	Mean Squares	F	Sig.
1 Regression	4.173	2	2.087	2.751	.117[a]
Residual	6.827	9	.759		
Total	11.000	11			

Table 4c: Regression coefficients

Coefficients[a]

Model	Unstandardised Coefficients		Standardized Coefficients	T	Sig
	B	Std. Error	Beta		
1 (constant)	-38.681	16.546		-2.338	.044
Max. Temp	1.329	.571	1.039	2.329	.045
Av. rainfall	.041	.020	.914	2.048	.071

[a]. Dependent Variable: REGR factor score 1 for analysis 1

SUMMARY RECOMMENDATIONS AND CONCLUSION

Summary

From the analysis and discussion in this paper, the most prevalent climate change related diseases in the study area were diarrhea, respiratory infection, asthma and malaria. The total incidence varied within city, with the high density areas recording the highest proportion of, followed by the medium and low residential density areas. Also the most tropical location, Mussina had the highest incidence of most prevalent disease, diarrhea followed by the most subtropical location, Bela-Bela. Mortality rate was higher for males than female children. Analysis of 21 years temperature and rainfall data for the municipalities show that maximum temperature is positively correlated with years, while rainfall decreases overtime, thereby indicating local warming in different municipalities. Incidence of disease tends to increase with temperature while showing a very low correlation with rainfall. Result of multiple regression shows that that 37.9% of incidence of disease may be attributable to climatic parameters. In particular, the most important climatic parameter that greatly influences incidence of disease is temperature, which unit increase would result in over 100 per cent increase in incidence of diarrhea, respiratory infection, asthma, meningitis and malaria, which according to UNICEF(2007) are the leading causes of death in children. There is however the need for further research on the varying levels of awareness of climate change and the health implications in the province.

Recommendations for mitigation/adaption strategies

The analysis and discussion in this paper point to the fact that there is climate change in Limpopo province and that this change is in the direction of local warming featuring, increasing maximum temperature and decreasing rainfall. It is also clear that temperature is significantly associated with incidence of diseases. Consequently climate change has significant influence on children's health.

- Mitigation and adaptation strategies or primary and secondary preventive measures are generally suggested strategies in pediatric health care to address the effects of climate change on children. While mitigation involves reducing Green House Gas (GHG) concentrations in the atmosphere with the goal of reducing climate change, adaptation involves developing public health strategies to minimize and in some cases eliminate local and regional adverse health outcomes that are anticipated from climate change. We suggest both immediate, medium and long term strategies to address climate change related illnesses in children, and that different levels of responses identified here, are to be involved so as to ensure sustainable responses to threats of climate change on children's health in the province. These levels of responses are: the family circle, the community, local municipality, NGOs and International Agencies.
- Of immediate concern at the primary family circle level is recognition of the fact that parents have the responsibility of ensuring that their children are not exposed to contaminated environment where their children live or play. It is observed in this study that children under 5 years age are the most affected compared to the older age groups. There is therefore the need to embark on enlightenment campaign on care for this age group. This should be a consciously formulated programme of action packaged for health care providers and administered through existing health care networks at the community level with special attention on the high density areas. This effort can be complemented by activities of NGOs and other International agencies in different communities in the province.
- Also there is need to improve the children's level of health within the family circle. This implies improvement in family's socio-economic status and by logical extension capacity to cope with adverse effects of whether on their children, improvement in health care services particularly those aspects affecting children.

- As shown in this study, the bulk of the people affected by the disease are mainly the poor in the high density residential neighbourhoods. Consequently, there is the need for the formulation of a massive support for sustainable job creation while the existing ones can be made more sustainable. This can be a sustainable pathway for the eradication of poverty. The role of NGOs and International agencies here is of utmost importance.
- Communities on the other hand should be organized through the various traditional leaders/authority and with the assistance of local and district municipalities and NGOs to embark on good environmental practices such as regular environmental sanitation. The Municipalities should provide the necessary legislative and administrative frameworks, while logistic and infrastructural support be provided by the NGOs. In order to inculcate desirable culture of clean in-house and neighbourhood environment, there should be the creation of sanitary inspectorate division or unit at each municipality. The inspectors are to pay regular visits to homes and neighbourhoods to enforce clean environment policies. No doubt, a clean environment would not give room for disease vectors to breed.
- As a medium and long term measure is the need to control pattern of human settlement developments such that developments on mountains, hill sides, alongside the valleys and other areas prone to erosion are avoided. The current pattern of settlement developments in many parts of the province particularly in such parts of Makhado Municipality as Tshakhuma and Tsianda, will obviously accelerate soil erosion and deforestation. Also there is the need to focus policies and programmes on improving the physical environmental conditions of those in the high density areas, where over 90 per cent of incidence are recorded. Perhaps there is the need to declare the high density areas, as disaster risk areas and target them for health improvement plans and actions.
- Closely related to the above is the need for environmental education aimed at minimizing or the prevention of wild veld fires and deforestation. Given the fact that several communities in the Limpopo province still have areas in which people embark on indiscriminate cutting-down of trees as they generally rely on fuel wood for domestic purposes. There is therefore the need to pursue tree planting campaign more vigorously at the grassroots through traditional authorities.

- Of both medium and long term strategies is the need for awareness regarding issues of implications of climate change. Communities, local municipalities and indeed the general public should be aware of the impact that climate change has on their health and on the environment in which they reside. Creation of awareness of climate change can be done if the general public itself is allowed to participate together with government in the discussions of coming up with strategies that can curb the impacts of climate change. Specifically, there is the need to involve women and children, particularly those in the primary school in decision making and programmes aimed at improving children's health. This will ensure that relevant stakeholders in children's health, mothers in particular are not only informed but are involved in responding to the challenges that affect their lives.
- A major research direction is the investigation of the varying levels of awareness of climate change issues and household response patterns in the province.

Conclusion

The observed change in climate in the province calls for attention. The temperature is getting warmer and rainfall is decreasing. Climate change is a reality in the province. This in itself has very wide implications not only for human health but also for agriculture as the area is generally known as a major food basket of the nation. With specific reference to health, increasing dryness will increase the incidence of air borne and communicable diseases. Children will be the worst off as they are the most exposed and most vulnerable and the least equipped to cope with the health hazards, given their rather weak socio-economic background. There is therefore the need to focus policy and programme attention on children in the province, particularly those of them in the low class but high density residential areas.

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