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ACTION RESEARCH

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Climate Change and Health – Exploring Linkages

LEAD Pakistan

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It also establishes partnerships with organizations having similar mandates of taking the sustainable agenda forward.

Asia Pacific Network for Global Change Research (APN)

APN is a network that aims at promoting global change research in the region, increasing developing countries involvement in that research, and strengthening interactions between the science community and policy-makers.

It envisions to enable countries in the Asia-Pacific region to successfully address global change challenges through science-based adaptation strategies, effective science and policy linkages, and capacity development.

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Climate Change and Health
Exploring Linkages

APN
Asia-Pacific Network for Global Change Research

Acronyms

ANOVA	Analysis of Variance
API	Annual Parasitic Incidence
BHU	Basic Health Unit
CC	Climate Change
CDD	Centre for Diarrhoeal Diseases
Cum	Cumulative
DALYs	disability-adjusted life years
DCO	District Coordination Officer
DHMT	District Health Management Team
DHQ	District Headquarters
DSM	District Support Manager
EDO	Executive District Officer
FLCFs	First Level Care Facilities
FP	Family Planning
GHGs	Greenhouse Gases
GMT	Greenwich Mean Time
HMIS	Health Management Information System
IPCC	Intergovernmental Panel on Climate Change
IPD	In Patient Department
LEAD	Leadership for Environment & Development
LHWs	Lady Health Workers
MCHC	Mother & Child Health Care
MMRH	Mean Monthly Relative Humidity
MMT	Mean Monthly Temperature
MO	Medical Officer
MoH	Ministry of Health
NCHD	National Commission for Human Development
NGOs	Non Governmental Organizations
OPD	Out Patient Department
PHC	Primary Health Care
PMD	Pakistan Meteorological Department
PPHI	Peoples Primary Health Care Initiative
RHC	Rural Health Centre
SD	Standard Deviation
SEA	South East Asia
SES	Socio Economic Status
SNP	Single Nucleotide Polymorphism
SPSS	Statistical Package for Social Sciences
US	United States
WHO	World Health Organization

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Preface

It is a widely known and quite well understood fact that human health depends, essentially, on the conditions of social and natural environment. For it is the adequacy and flow of materials and services from the natural world that determines, the limits and characteristics, of the well being and health of a population.

Over the ages human societies have degraded or changed local ecosystems. Today, this burgeoning human impact on the environment has attained a global scale. Populations from around the world are now encountering unfamiliar human-induced changes in atmosphere, ozone depletion, land degradation, freshwater reduction and biodiversity loss.

While climate change affects multiple sectors, the effects on health are the only ones that pose a serious threat to long term sustainable development. In spite of this there has been little recognition among the practitioners of the various disciplines, of the relationships between environmental changes and human health.

Today, the challenge is not to understand how human health is linked with the planet's ecological, biological and geological systems; but rather to explore the manner in which large-scale changes in the same are influencing, even determining the health outcomes for whole communities and populations over a longer time frame.

Understanding the effects of climate change on human health is the first step towards taking effective action for keeping these to a minimum. The capacity to respond to the negative health effects of climate change relies on the generation of reliable, relevant, and up-to-date information pertaining to specific regions, countries, and localities, which is not yet available for developing countries.

In Pakistan, as in other developing countries, apart from a dedicated few, health professionals have not come to the climate change debate, and it is this status quo that LEAD Pakistan aims to change.

Over the last one year (2010-11) LEAD Pakistan has under its Leadership Development Programme and through financial assistance provided by Asia Pacific Network for Global Change Research (APN), brought together public health professionals from among the health related scientific community from around the country. Following a series of exercises directed at strengthening their capacities for undertaking research on health effects of climate change, this group of professionals embarked on the venture of exploring, analyzing and assessing climate related risks to health. The research papers published herewith are an evidence of the work carried out by the four cohort groups – Sindh, Capital, Punjab and Baluchistan – in the area.

The present work is however, only the first step. It is hoped that this cadre of health professionals will serve as an example and inspiration for other professionals to enter into this arena; and the research work carried out by them will prove to be the beginning of development of a scientific and research base on the subject.

Acknowledgements

This work would not have been possible without the active participation and keen involvement of LEAD Pakistan's partners at both the national and international level.

In this reference, we are particularly grateful to the role played by Pakistan Meteorological Department (PMD) in the provision of climate related data.

The supportive role of Health Management Information Systems (HMIS) – Provincial Office Hyderabad and National Office Islamabad; Centre for Diarrhoeal Diseases (CDD) Hyderabad; Provincial Malaria Control Programme, Department of Health, Government of Balochistan; Children Hospital Lahore; and members of District Health Management Team, District Gawadar, Balochistan, in the provision of health related data and information is duly appreciated.

We would also like to acknowledge the technical input provided by Global Change Impact Studies Centre (GCISC), Islamabad and UNU International Institute for Global Health (UNU-IIGH), Malaysia during the formulation of capacity building exercises.

The time and serious consideration given by LEAD Cohort 15 members, in undertaking the research work is also duly appreciated. The cohort's diligence towards overcoming barriers for collecting accurate and useful information; and its efforts in drawing together all facts and information into a research paper on climate change effects on health, merits mention.

Finally, we would like to acknowledge the support of Asia Pacific Network for Global Change Research (APN) for the first study of its kind in Pakistan on health effects of climate change.

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Association of Climate Change with Diarrhoea in Children

By:
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Background

There is now evidence which convincingly portrays that Greenhouse Gas Emissions (GHGs) caused due to human activities, such as fossil fuel burning, deforestation, marine pollution and the like, lead to ecological disturbances thereby acting as a key factor for climate change. This in turn affects human health and well-being.[1-5]

Over the past 100 years, Earth's climate has warmed on average by about 0.6°C.[6] This change in climate has led to increased frequency and intensity of heat waves, droughts, floods, and storms; altered agricultural productivity and food security; reduced water quantity and quality; and caused a spread in the geographic range and incidence of climate-sensitive infectious diseases, particularly certain vector, rodent, tick, water, and food borne diseases.[7] The World Health Organization (WHO) currently estimates that > 150,000 deaths and a burden of 5.5 million disability-adjusted life years (DALYs) can be attributed to climate change and climate variability each year.[9]

Apart from adults, climate change is also affecting children's health and is predicted to do so for the foreseeable future.[10] This is because many of the major diseases affecting children are climate sensitive.

It has been reported that in South Asia 100 children per 1000 live births die before they celebrate their 5th anniversary.[11] These high mortality rates are indicative of the poor socio-economic conditions and number of health problems faced by the communities.[12] Nevertheless proper hygiene and selective health planning have reduced infant mortality in many countries.[13]

In Pakistan, more than 20 million people fall under the age of five.[1] Out of total deaths in a year, almost 50% have been reported in under-five year old children. Similarly, of the total population who fall ill, a large proportion (nearly 60%) comprises of children.[14] It has been reported that about 550,000 children under five years die in Pakistan from preventable causes including pneumonia, diarrhoea, malnutrition, measles, and malaria. Although Pakistan has been able to reduce mortality rate for children by 15% since 1990; it still falls among countries with high child mortality rates.[15]

Worldwide, diarrheal diseases claim the lives of nearly two million children annually, with most of the deaths attributable to contaminated water, and inadequate sanitation and hygiene.[16]

Children are especially vulnerable to infections that cause diarrhoea because in part their immune system is less robust in fighting infections than that of older people.[17] Rotaviruses are the main pathogens responsible for diarrheal disease worldwide, especially in developing countries resulting in a large number of hospitalizations, and mortalities.[18] Studies in different countries have reported that prevalence of rotavirus infections in children requiring admission to hospitals ranges from 17.7% to 69%.[19-25] This pathogen is also found to be an important cause of childhood diarrhoea in Pakistan.[26-28]

Infectious diarrhoea, not causing cholera, is a condition that appears to be sensitive to temperature, precipitation, and extreme weather events. For example; hospital admissions for Peruvian children under 10 years varied with ambient temperature over a 5-year period.[29] Similarly, the number of non-cholera diarrhoea cases that included 70% children from birth to 14 years of age seen at the International Centre for Diarrhoeal Disease Research, Bangladesh Dhaka Hospital increased by 5.1% for every 10-mm increase in precipitation. An association of increased cases with higher temperature, especially among individuals of lower socioeconomic and sanitation status was found in that study.

Furthermore in developed countries, an approximately linear association between temperature and common forms of food-borne diseases such as salmonellosis were also found.[30] By 2030, it is estimated that climate change will have increased the risk of diarrhoeal disease in some regions by 10%.[31] This equates to an increase in the number of cases of diarrhoeal disease by 180 million per year and 95,000 more deaths.[32]

1 Pakistan lies in the temperate zone, with a climate generally characterized by hot, arid summers and cool or cold winters, and wide variations between extremes of temperature at given locations. Pakistan's largest city, Karachi, which is also the country's industrial centre, is more humid and gets less rain. On average more than twenty-five millimetres of rain in July and August with exceedingly dry remaining months. The temperature ranges from an average daily low of 13° C during winter evenings to an average daily high of 34° C on summer days. A high humidity prevails throughout the year.[8]

Rationale

In Pakistan, although numerous studies have reported association of diarrhoea with unsafe water and poor sanitation, coupled with poor food handling practices, [26, 33-35] none of the studies have documented any association with climate factors. The wide reported prevalence might be due to different climatic factors and environmental conditions. Therefore, surveillance for epidemiology of such infection and its precipitating factors especially in relation to climate change for Pakistan would help us to have a better understanding and control on acute gastroenteritis in young children. In the present study focus has been placed on children aged 1-4 years only, as their might be many associated factors beside climate change that can affect infants from 0-1 year and this will dilute the effect of environmental factors.

Aim

Overall the aim of this study is to find out the association of climate change with diarrhoeal diseases in children.

Objectives

The specific objectives are to:

- To find out the number of cases of diarrhoea among children aged 1 to 4 years in hospitals and First Level Care Facilities (FLCFs) of Karachi during last 10 years from 1999-2008.
- To find out the climatic trends occurring in Karachi during the above mentioned years.
- To determine the correlation of climatic changes and frequency of diarrhoea among children during the same years as mentioned above in Karachi.

Material and Methods

Study Population

All cases of diarrhoea reported and recorded in hospitals and First Level Care Facilities (FLCFs) of Karachi during last 10 years i.e. from 1999-2008.

Meteorological Data

Data regarding precipitation, humidity and temperature was taken from Pakistan Meteorological Office, Karachi for the same years as for the diarrhoeal cases.

Health Data

Data regarding diarrhoeal cases was taken from Centre for Diarrhoeal Diseases (CDD) and Health Management Information System (HMIS) Provincial Office situated in Hyderabad, Sindh.

Sample Size

Children 1-4 years who had diarrhoea and reported to OPD of hospitals and First Level Care Facilities (FLCFs) of Karachi during last 10 years from 1999-2008.

Time Period

January 1998 to December 2008

Sampling Technique

It was non probability purposive sampling and all the data of relevant towns of Karachi regarding diarrhoeal cases of 1-4 years children was collected and entered in SPSS software version 15. Data of only those 1-4 years children who reported to OPD of Hospitals and FLCFs was used to compare with climatic factors including temperature, humidity and precipitation.

Inclusion Criteria

All children 1 to 4 years irrespective of sex

Ethical Consideration

Confidentiality of individuals was maintained. The research was approved by the ethical committee of institutes from which the data was obtained.

Data Collection

Meteorological data was obtained from Meteorological Department, Karachi. The data about children suffering from diarrhoea was taken about hospitals and First Level Care Facilities (FLCFs) of Karachi from CDD and HMIS Provincial Office, Hyderabad. The hospitals and FLCF at Karachi were approached several times to obtain the relevant information but the officials expressed their inability to provide the same due to several reasons including failure of computers, crash of hard disk etc. Fortunately the information sent to provincial head quarter was preserved and after a lot of efforts and several appointments with officials at Hyderabad, the required information was obtained.

Data Analysis

Variables were coded for swift filling. After checking all forms, data was entered in SPSS version 15. Before data entry, forms were checked for mistakes and omission.

After entry, data was cleaned using frequency tables. Analysis was done on SPSS version 15 software package. Level of significance was set at 0.05 and â at 10% with the power of study at 90%.

Means and standard deviation of temperature, rainfall and humidity were determined. Student t-test was used for the comparison of means. ANOVA was used to compare difference over the time frame of 10 years. Correlation and regression models were used to determine association between number of diarrhoeal cases, temperature, humidity and precipitation.

Results

Results of the study depict that diarrhoeal data for 10 years was obtained from CDD and HMIS Provincial Office, located in Hyderabad. This data was compared with the Meteorological data obtained through net for Karachi city. Only the meteorological data for the month of February 2000 was missing.

Summary of statistics is presented in Table 1 which shows that the mean temperature from 1999 to 2008 was 27.06 with 28.9 as median and mode. Standard deviation was recorded as ±3. 96.

Mean, median and mode for humidity were 58.2, 58.6 and 43.7% respectively with ±11.02 as standard deviation.

Precipitation data shows mean as 17.29 with median and mode as 0 and standard deviation as ±49.63.

Mean median and mode for diarrhea were 2795, 2700 and 2302 respectively while the SD was ±999.8.

The histograms were plotted for the no of diarrhea cases, temperature, humidity and precipitation.

The data for temperature was negatively skewed with minimum of 17.7 and maximum of 31.8 Celsius - Figure 1.

The data for humidity was also slightly negatively skewed with minimum of 38 and maximum of 81.4% - Figure 2.

The data for precipitation was positively skewed with minimum of 0 and maximum of 283.7 - Figure 3.

The data for diarrhea was also positively skewed with minimum of 1062 and maximum of 6227 cases - Figure 4.

Line graph was plotted to find out the relationship of temperature with diarrhea. It is evident from the graph that maximum number of diarrhea cases for each year were observed in the months of higher average temperature. There was a highly significant relationship with r= 0.268 and p value less than.003 - Figure 5.

There was some relationship found between precipitation and diarrhea and maximum numbers of cases were observed when the precipitation was 271.

The value of r as calculated was 0.299 and p value as 0.001 - Figure 6.

There was no regular pattern observed for humidity and diarrhea. However maximum number of cases occurred when humidity was 75.5% and the value of was .330 with p value as .000 - Figure 7.

There was significant correlation observed between temperature, humidity, precipitation with number of diarrhea cases - Figure, 8, 9, 10 and 11.

Table 1
Distribution of Statistics of Diarrhoea and Meteorological Factors of Karachi City from 1999 to 2008

		Temperature	Humidity	Precipitation	Diarrhoea
N	Valid	119	119	119	120
	Missing	1	1	1	0
Mean		27.059	58.205	17.296	2795.67
Std. Error of Mean		.3635	1.0101	4.5497	91.269
Median		28.900	58.600	.000	2700.00
Mode		28.9	43.7(a)*	.0	2302(a)
Std. Deviation		3.9654	11.0191	49.6310	999.801
Variance		15.725	121.419	2463.241	999601.266
Skewness		-.828	-.018	4.036	.628
Std. Error of Skewness		.222	.222	.222	.221
Kurtosis		-.677	-1.319	16.920	.641
Std. Error of Kurtosis		.440	.440	.440	.438
Range		14.1	43.4	283.7	5165
Minimum		17.7	38.0	.0	1062
Maximum		31.8	81.4	283.7	6227

* *Multiple modes exist. The smallest value is shown.*

Figure 1
Histogram showing Temperature Distribution of the Studied Population

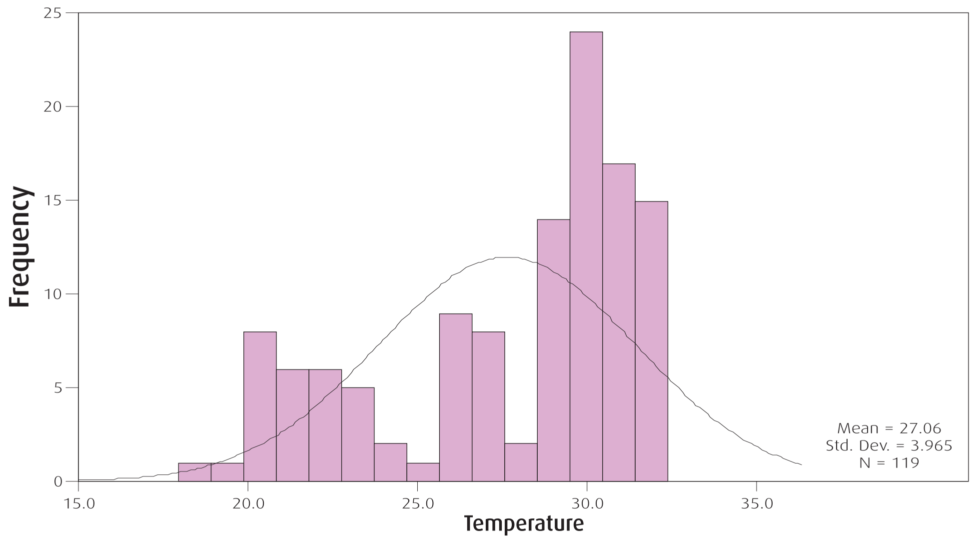


Figure 2
Histogram showing Humidity
Distribution of the Studied Population

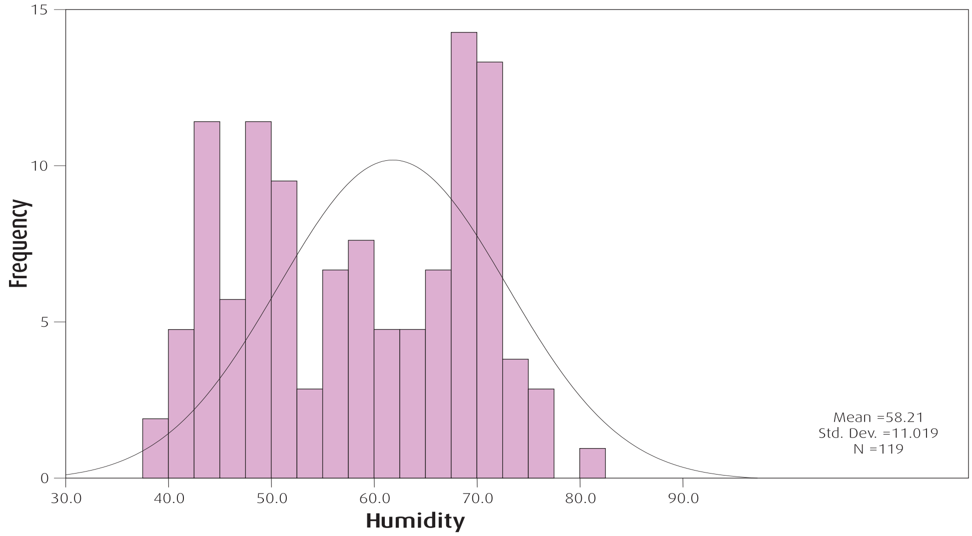


Figure 3
Histogram showing Precipitation
Distribution of the Studied Population

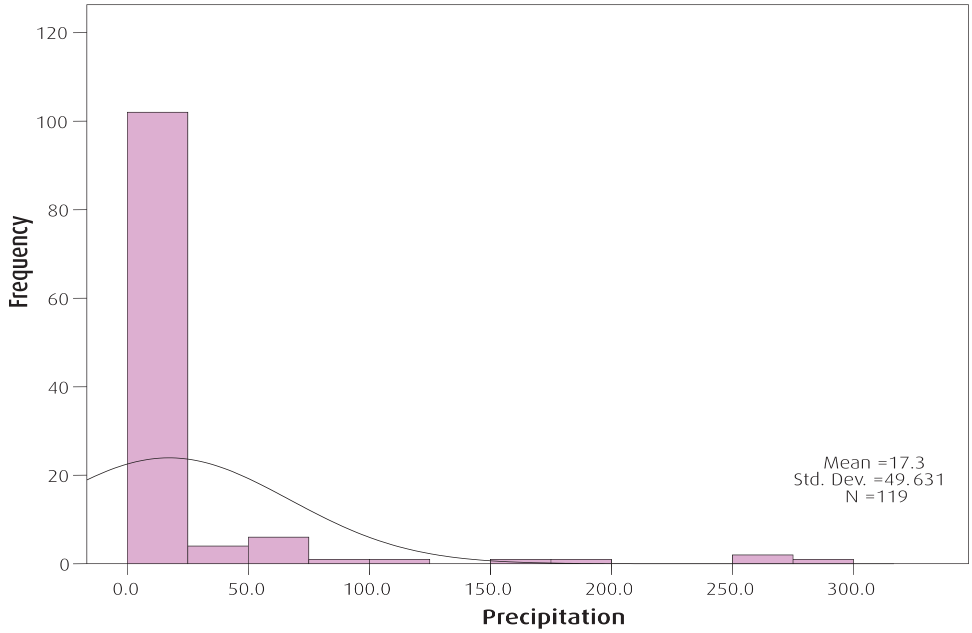


Figure 4
Histogram showing Diarrhoea Distribution of the Studied Population

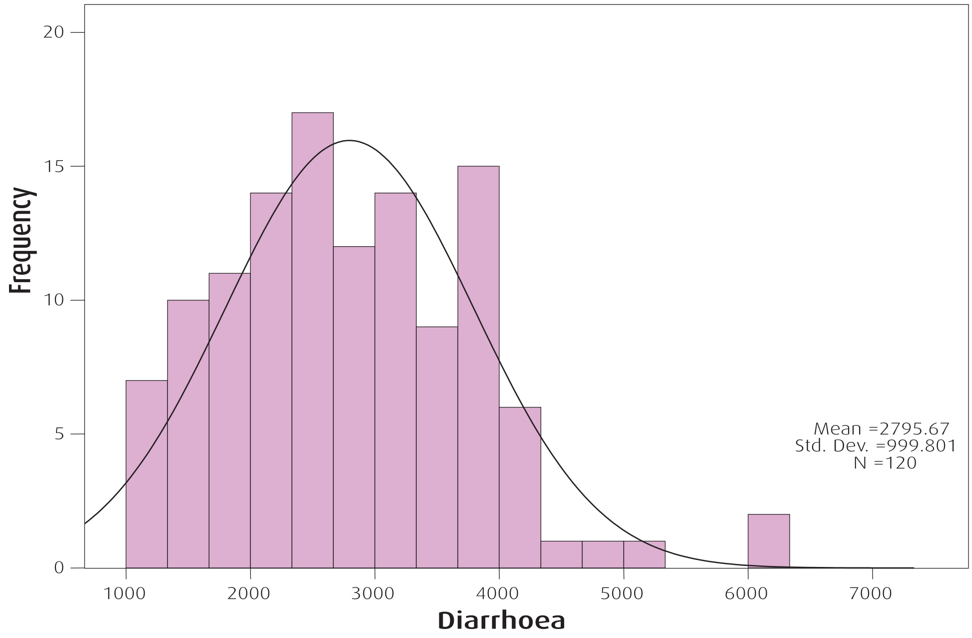
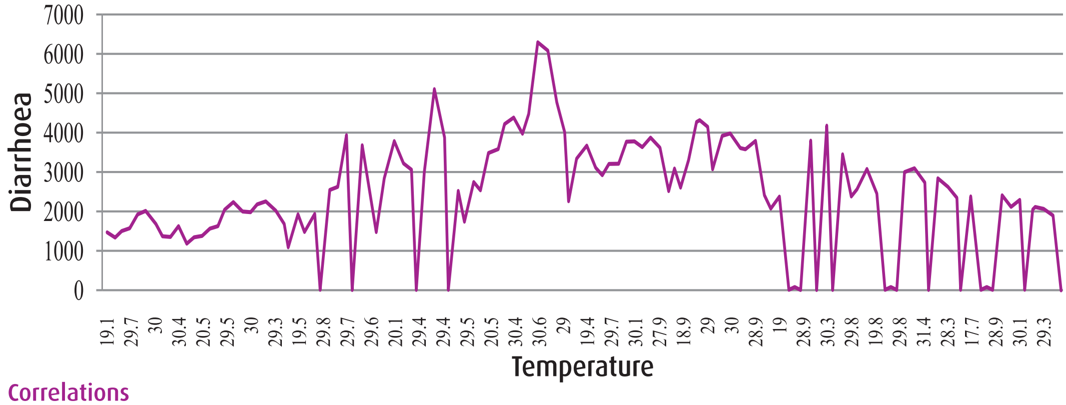


Figure 5
Distribution of Diarrhoea with Temperature from 1999-2008

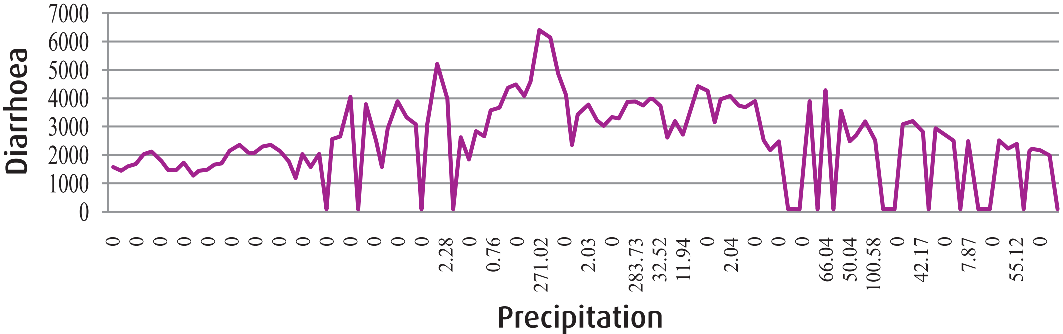


Correlations

		Temperature	Diarrhoea
Temperature	Pearson Correlation	1	.268(**)
	Sig. (2-tailed)		.003
	N	119	119
Diarrhoea	Pearson Correlation	.268(**)	1
	Sig. (2-tailed)	.003	
	N	119	120

** Correlation is significant at the 0.01 level (2-tailed).

Figure 6
Distribution of Diarrhoea with Precipitation from 1999-2008

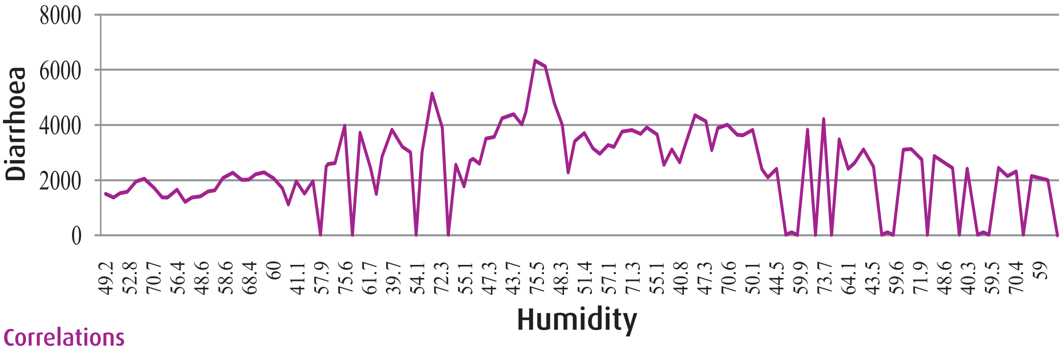


Correlations

		Diarrhoea	Precipitation
Diarrhoea	Pearson Correlation	1	.299(**)
	Sig. (2-tailed)		.001
	N	120	119
Precipitation	Pearson Correlation	.299(**)	1
	Sig. (2-tailed)	.001	
	N	119	119

** Correlation is significant at the 0.01 level (2-tailed).

Figure 7
Distribution of Diarrhoea with Humidity from 1999-2008



Correlations

		Diarrhoea	Humidity
Diarrhoea	Pearson Correlation	1	.330(**)
	Sig. (2-tailed)		.000
	N	120	119
Humidity	Pearson Correlation	.330(**)	1
	Sig. (2-tailed)	.000	
	N	119	119

** Correlation is significant at the 0.01 level (2-tailed).

Figure 8
Correlation between Temperature and Diarrhoea

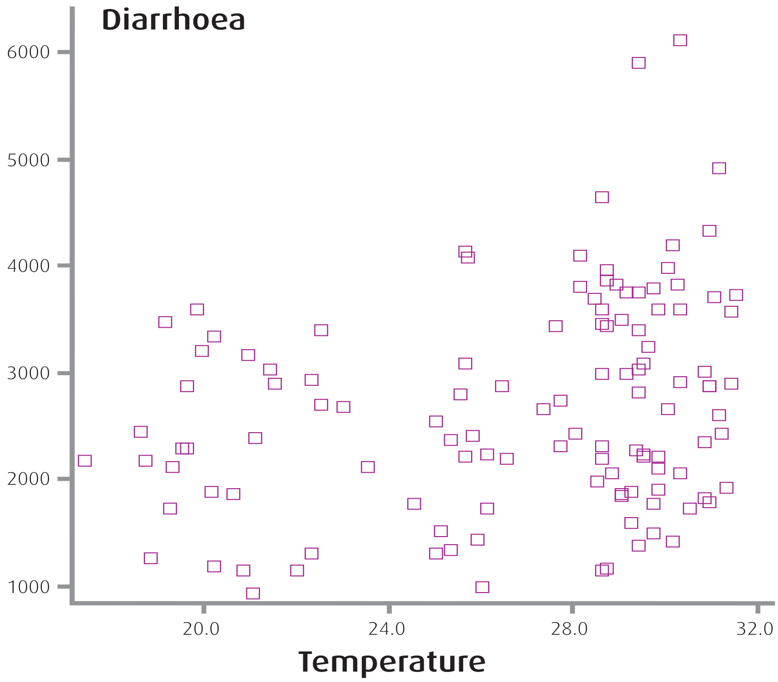
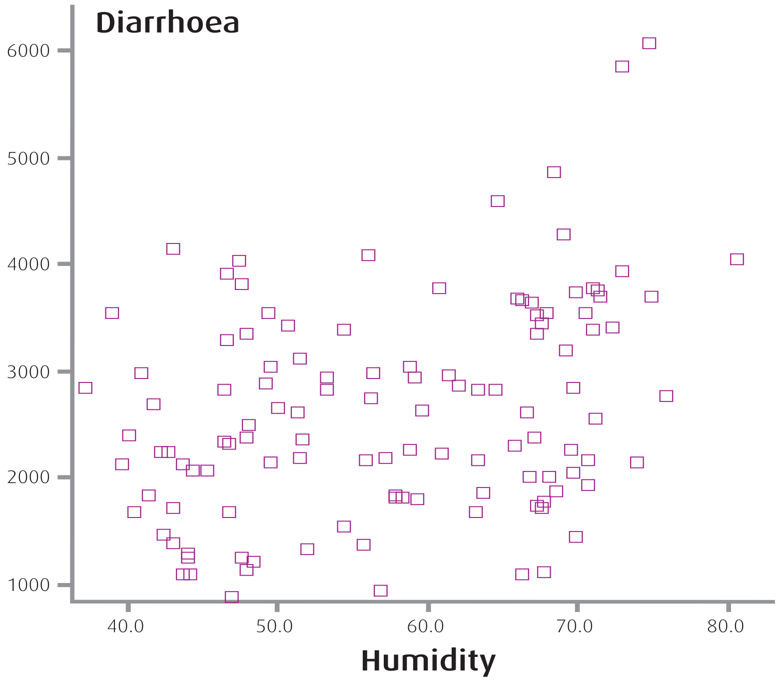


Figure 9
Correlation between Humidity and Diarrhoea



Regression Analysis

Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	tempera(a)	.	Enter

a All requested variables entered.
b Dependent Variable: diarrhea

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.268(a)	.072	.064	964.423

a Predictors: (Constant), tempera
b Dependent Variable: diarhoea

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8397181.694	1	8397181.694	9.028	.003(a)
	Residual	108823086.171	117	930111.848		
	Total	117220267.866	118			

a Predictors: (Constant), tempera
b Dependent Variable: diarrhea

Coefficients(a)

Model		Un-standardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta	Lower Bound	Upper Bound	B	Std. Error
1	(Constant)	986.375	612.239		1.611	.110	-226.132	2198.882
	tempera	67.272	22.389	.268	3.005	.003	22.932	111.613

Figure 10

Normal P-P Plot of Regression Standardized Residual

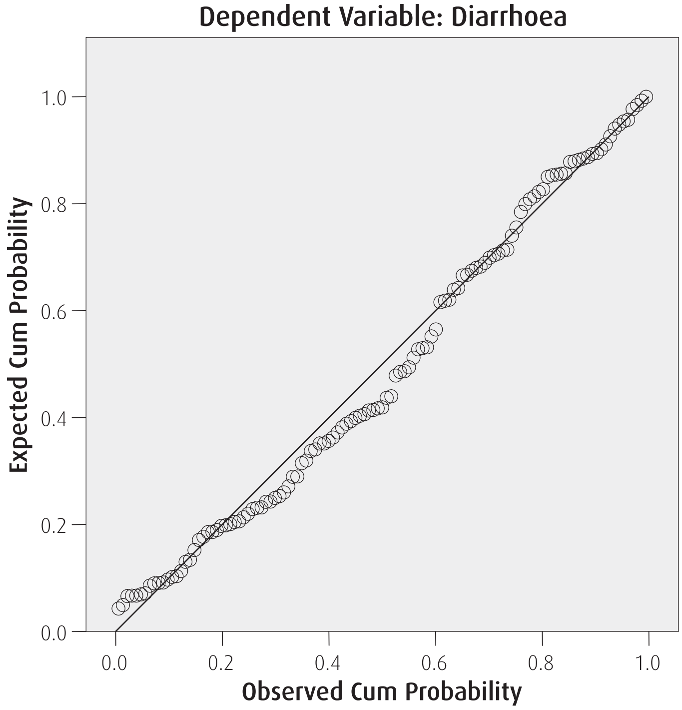
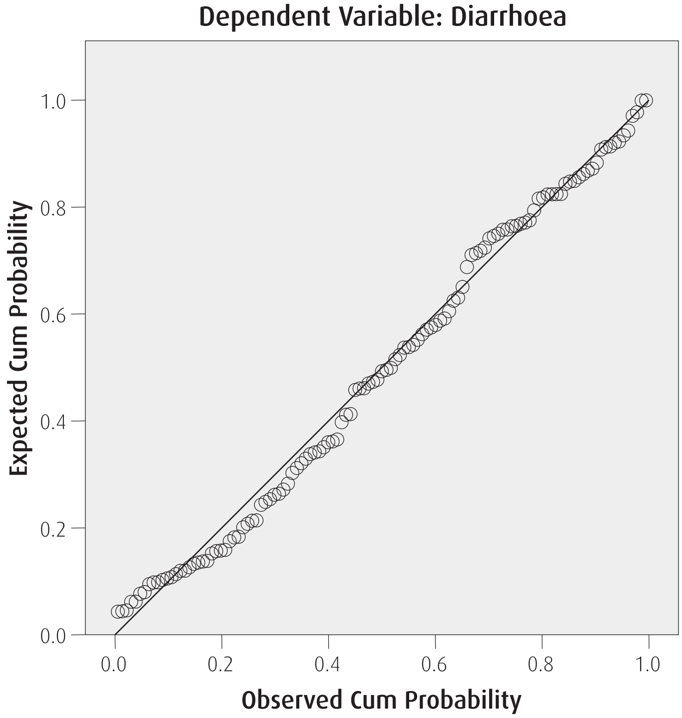


Figure 11

Normal P-P Plot of Regression Standardized Residual



Discussion

Health information is lacking in our country and though there are certain agencies responsible for data collection yet a lack of commitment questions the validity of data. Looking at the data for the period of 10 years, from 1999 there was significant relationship observed between number of diarrhoeal diseases and temperature, humidity and precipitation. Though the confounding factors could not be ruled out as data was secondary in nature and information about variables like, socioeconomic status, preterm birth, low birth weight, malnourishment and parity were missing yet the peak of diarrhoeal cases during increased temperature, increased humidity and increased precipitation depict the strong correlation with a p value as low as 0.003.

There are therefore, persuasive reasons to believe that in future, diarrhoea prevalence especially in South Asia will vary in line with climatic changes. Our result match with another study conducted in Dhaka, Bangladesh where, non-cholera diarrhoeal cases per week increased by 6% per 1°C increase in temperature.[36] Moreover, a non-linear increase in diarrhoea was also observed in Peru during 1997-98 El Nino episode (higher than normal sea surface temperatures) that had a strong effect on weather and the temperature rose up to 5 °C above normal.[29]

Significant regional differences for climate change and potential diseases were found in studies having varied population and habits. Karachi is the largest cosmopolitan city of Pakistan having an expansive area of 3530 square kilometres with a variable socio-economic, cultural and ethnic background, still we were able to find a strong relationship between the various climatic factors including temperature, humidity and precipitation and diarrhoea. Another study conducted to explore the potential relationship between climate variability and the incidence of diarrhoea in the Pacific Islands during 1978 to 1998, found positive association between annual average temperature and the rate of diarrhoea, except on two of its islands (Nauru and Niue).[37] However a recent meta study found negative correlation between temperature and rotavirus in the tropics, but with large differences between the sites.[38] The mean cases of reported diarrhoea were found to be 2795 cases per year.

In addition, there was no available information for the probable causes and kinds of diarrhoea. Due to the lack of spatially referenced cause for diarrhoea and with only geophysical or population data it seems to be substantially low in number for this mega city to be evident. A recent study in Japan found that the weekly number of infectious gastroenteritis cases increased by 8% for every 1°C increase in the average temperature.[39-40] Similarly a regression analysis done in a Chinese study found increase of 11% to 16 % in the number of cases of bacillary dysentery for each 1°C temperature rise.[41]

Apart from temperature, climatic factors such as precipitation and humidity that might contribute in diarrhoea incidence were also considered in the present study. The extent of these is highly dependent on the pathogen mix and water and sanitation infrastructure. Although the exact causal mechanism are unclear, these variables may have an impact on the replication rate of certain microorganisms, both bacteria and protozoa.[42] They may also have an impact on survival of different viruses. The results of association of humidity and precipitation in the present study were found to be linear with diarrhoea and significant relationships were observed. A few papers have examined the relationship between other climatic factors and diarrhoea, and the results are inconsistent. Zhang et al (2007) found that rainfall does not affect transmission of specific diarrheal pathogens, whereas another study found that low levels of rainfall are associated with high incidences of diarrhoea.[37, 41]

Evidential reports on climate change and its impact on global burden attributable to diarrhoea (mortality and morbidity) is unequivocal and is considered to be largest along with malnutrition in South and Southeast Asian countries including Pakistan.[43] Multivariate analysis shows that all three climatic factors are strongly correlated with the number of diarrheal cases in children from age 1-4. However there was no significant temperature change, observed between the mean temperature in the year 1999 and year 2008. There was some increased number of diarrheal cases in year 2004 with the increase of climatic factor but in 2008 again the number of diarrhoeal cases regressed to the figure of 1999 along with climatic factors.

In this context, it needs to be highlighted that climatic variability can be witnessed over a minimum period of 3 decades or 30 years. Data spanning over a period of

10 years can only reflect short term variations in temperature, humidity or precipitation; but cannot highlight long term or consistent changes in climatic conditions.

As the present study depicts strong relationship between increase in temperature, humidity and precipitation, it can be safely said that increase in annual average temperature, humidity and precipitation in Karachi would in all likelihood lead to an increased prevalence of diarrhoea, especially in children aged 1-4 years.

In view of the above it might also be more appropriate to study impacts from changes to extreme values of daily mean temperatures rather than impacts from changes to monthly mean temperatures as in the present study. It might help in building empirical data set for developing correlation models for temperature impacts on diarrhoea. A prospective study could be more important in this regard.

Conclusion

- It is concluded that there was strong positive association found between temperature, humidity and precipitation with number of diarrhoea cases in children less than 5 year of age.
- There was no significant difference found between mean climatic factors from year 1999 to 2008.
- There is evidence from other studies as well that the climatic factors have significant positive association with increased number of diarrheal cases.
- There is an urgent need to keep check on environmental factors specially temperature to prevent future epidemics of diarrhoea and other related health illnesses.

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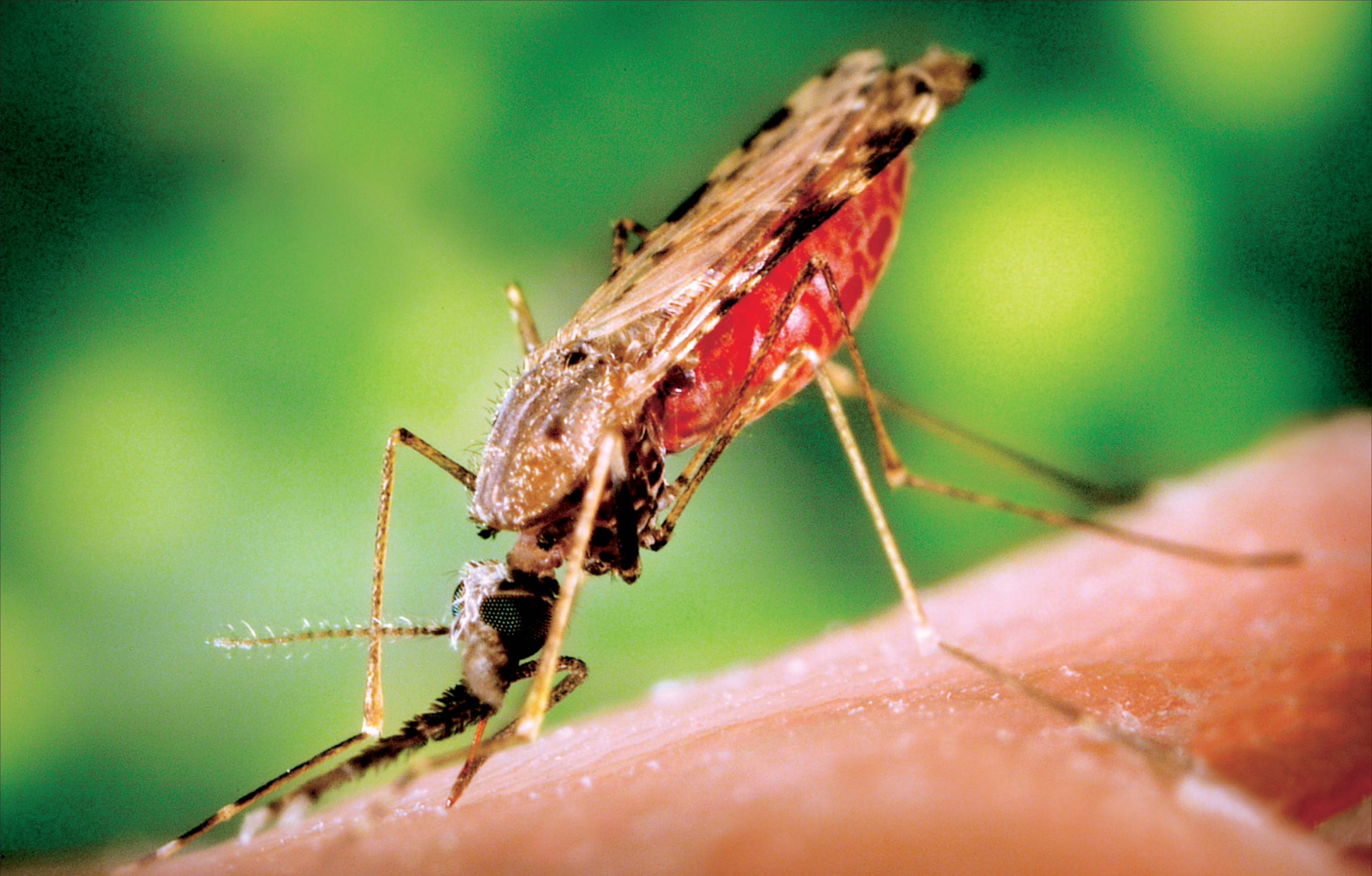


http://www.curepharmaceutical.com/wp-content/uploads/2010/10/Anopheles_mosquito.jpg

Association of Climate Change with Magnitude and Trends of Malaria

By:
LEAD Cohort-15 - Capital Group

- Dr. Samina Mohsin Khan (Group Leader)
- Brgd. Dr. Maqsood-ul-Hassan
- Dr. Komel Zulfiqur
- Dr. Farah Rashid Siddiqui

Background

Climate change is a new emerging threat of global proportions. During the 20th century, world average surface temp increased by approximately 0.6°C.[1] The Third Assessment Report of the Intergovernmental Panel on Climate Change [2] (IPCC, 2001) has highlighted that by 2100 the global temperature would increase by 1.8-5.8°C.

Climate change affects multiple sectors like agriculture, forestry, water resources, air quality, ecosystems, biodiversity, etc. However, of these the effects of climate change on health are the only ones that pose a serious threat to long term sustainable development. In terms of its effects on health, one of the consequence highlighted by the Fourth Assessment Report of IPCC (2007), is the possible increase in vector-borne diseases spatially and temporally. The fact that an increasing number of malaria epidemics have recently been documented throughout the world bears testament to the observation.[3]

The major reasons for such epidemics are climatic factors such as abnormal rains, long periods of increased humidity and temperature and/or more permanent climatic changes as a result of irrigation, agriculture or tree plantations. Military conflicts and civil unrest, along with unfavorable ecological changes have greatly contributed to malaria epidemics, as large number of unprotected and non-immune refugees move into malarious areas.[4]

The social, cultural and economic dimensions, in terms of disproportionate impact on the poor, associated loss of wages and productivity both at the micro and macro levels, are enormous. The disease is deeply rooted in the poor communities affecting national development and taking away major share of health budgets.

The malaria situation remains highly dynamic and evolving, and is likely to be further aggravated by climate change. Since there is evidence that warming of the earth's temperature and increasing precipitation will hasten maturation of the parasite in mosquitoes, increase the biting frequency and create conditions more conducive to mosquito breeding.[5] Climate change is expected to worsen in the future, both in frequency and intensity, and so are the related health consequences.[6] This will disproportionately affect the poor and marginalized sections of society, particularly those living in remote areas such as tribal populations.

Malaria causes about 2,414 deaths per day, over 90% of which are in Sub-Saharan Africa. It is both a disease of poverty and a cause of poverty slowing economic growth by 1.3% per year in endemic areas. WHO estimates that globally 33.96 million Disability Adjusted Life Years (DALYs) are lost due to malaria in which South East Asian Region contributes around 1.34 million.[7]

Malaria is an enormous health and developmental problem in South East Asia as 1,256 million people are at risk for malaria, with more than 120,000 deaths occurring each year.[8]

A total of 50.6 million people are at risk of malaria in Bangladesh, where more than 95% of all cases are reported from its 11 highly endemic districts. About 1.5 million cases were reported in India in 2008 alone.[9] Whereas in Pakistan in the same year the total number of reported cases were 4.5 million, of which 60% were from the province of Balochistan which has the highest incidence and prevalence of malaria in the country.[1]

There is a strong likelihood that with changes in climate a consequent change in trends and magnitude of malaria will also be observed.

1 Program Brief, Malaria Control Program, Department of Health, Government of Balochistan, 2010

Rationale

Malaria has high morbidity and mortality in most countries of the world including Pakistan. In order to overcome the malaria challenge, there is an urgent need for concerted efforts by the formal and informal health sectors, including the international community.

The study will explore the frequency of malaria with the changing trend in climate over last decade. Further it will explore the frequency of malaria cases in known endemic areas and non-endemic areas.

Objectives

- To determine different trends of malaria in Pakistan with respect to:
  - Geographical distribution;
  - Seasonal frequency;
  - Magnitude.
- To correlate it with temperature change in Pakistan, irrespective of age, gender and socio-economic status in last 09 years i.e. from 2001 to 2009.

Methodology

It was a cross sectional study based on secondary data.

Due to short time duration, limited resources and other logistical issues it was not possible to cover whole of Pakistan. In view of the same, focus was placed on Baluchistan because of it having the highest incidence and prevalence of malaria in the country.

The 30 districts of Balochistan were divided into two categories, endemic and non-endemic. From these two strata, two endemic and two non-endemic districts were randomly selected by lottery method.

Study population was the reported malaria cases in the selected districts. Secondary data for malaria for the last 9 years was collected from 'Provincial Malaria Control Programme, Department of Health, Government of Balochistan' whereas climate related data was obtained from 'Pakistan Meteorological Department, Government of Pakistan' with the help of 'LEAD Pakistan'.

Data was analyzed using SPSS 13 whereby appropriate statistical tests were applied, including linear logistic regression models.

Results

Table1
Selected Districts

S. No	Endemicity	District	Population
1.	High	Zhob	327,657
2.	High	Khuzdar	497,184
3.	Low	Quetta	940,815
4.	Low	Chaghi	155,662

Annual Parasitic Incidence (API)

Table 2
Mean Annual Parasitic Incidence

S. No	Endemicity	District	Population	Mean API
1.	High	Zhob	327,657	15.9 ± 8.1
2.	High	Khuzdar	497,184	14.9 ± 8.3
3.	Low	Quetta	940,815	0.013 ± 0.012
4.	Low	Chaghi	155,662	0.22 ± 0.20

Table 3
Mean Monthly API Differences between
High and Low Endemic Districts from 2001 to 2009

Months	Monthly API - High Endemic Districts	Monthly API - Low Endemic District
Jan	2.1	0.06
Feb	2.5	0.10
Mar	4.4	0.11
Apr	6.1	0.13
May	8.1	0.08
Jun	22.3	0.19
Jul	31.0	0.13
Aug	19.8	0.16
Sep	41.8	0.18
Oct	28.0	0.17
Nov	21.2	0.11
Dec	10.6	0.03

Table 4

Mean Monthly API Difference by Districts from 2001 to 2009

Months	Zhob	Quetta	Khuzdar	Chaghai
Jan	2.450	0.003	1.744	0.122
Feb	2.783	0.003	2.257	0.200
Mar	4.898	0.006	3.967	0.222
Apr	6.717	0.010	5.444	0.248
May	8.717	0.009	7.389	0.146
Jun	23.080	0.015	21.611	0.374
Jul	32.249	0.026	29.756	0.226
Aug	20.508	0.039	19.018	0.273
Sep	43.515	0.024	40.107	0.331
Oct	29.156	0.011	26.906	0.322
Nov	22.537	0.006	19.812	0.210
Dec	11.747	0.002	9.537	0.049

Temperature

The mean monthly temperature in high and low endemic districts was 20.8±7.8 and 20.6±9.1 degrees Celsius, respectively.

It is to be noted that during the peak summer months of June, July and August, the mean temperature was found to be low in high endemic districts as compared to low endemic districts. There was a 0.24 degrees Celsius difference in June, increasing to 2.56 degrees Celsius in July to 1.94 degrees Celsius in August. Before and after that the high endemic districts remained slightly warmer than the low endemic districts.

Figure 1

Mean Monthly Temperature of High and Low Endemic District 2001 - 2009

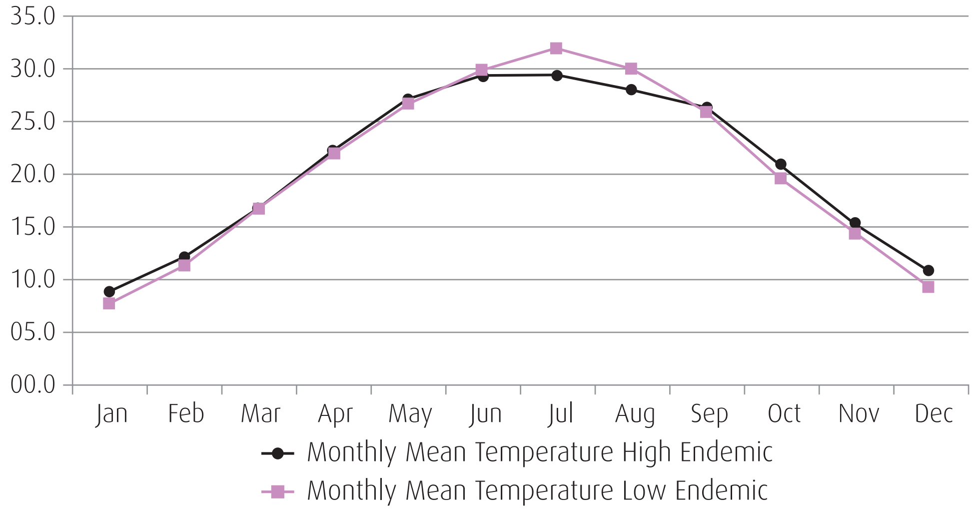


Table 5
Mean Monthly Temperature Differences between High and Low Endemic Districts from 2001 to 2009

Months	Monthly Temp High Endemic Districts	Monthly Temp Low Endemic District	Temperature Difference between Low Endemic and High Endemic
Jan	8.8	7.59	-1.21
Feb	12.2	11.19	-1.01
Mar	17	16.79	-0.21
Apr	22.5	22.12	-0.38
May	27.5	26.96	-0.54
Jun	30.1	30.34	0.24
Jul	29.9	32.46	2.56
Aug	28.5	30.44	1.94
Sep	26.6	26.26	-0.34
Oct	21.2	19.78	-1.42
Nov	15.4	14.43	-0.97
Dec	10.8	9.19	-1.61

Table 6
Mean Monthly Temperature difference by Districts from 2001 to 2009

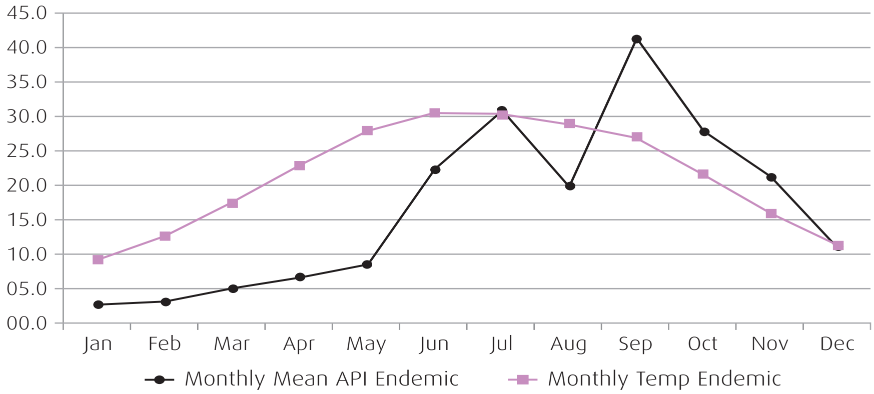
Months	Zhob	Quetta	Khuzdar	Chaghi
Jan	7.5	4.7	13.0	10.5
Feb	8.8	7.7	16.3	14.6
Mar	14.0	13.1	22.0	20.5
Apr	19.9	18.5	27.5	25.8
May	24.7	23.7	32.3	30.2
Jun	27.9	27.3	33.9	33.4
Jul	28.7	29.4	32.8	35.5
Aug	27.3	27.6	31.8	33.3
Sep	26.2	22.7	28.4	29.8
Oct	20.7	16.3	23.5	23.2
Nov	15.0	11.9	18.2	17.0
Dec	9.5	6.6	14.1	11.8

Monthly Temperature and API

An attempt was made to establish correlation between effects of monthly temperature on API over nine years i.e. from 2001 to 2009 in the high and low endemic districts.

In high endemic districts, it appeared that with rise in temperature, there was a rise in API. However, during the month of August, there was a decrease in API, followed by an increase in API in September. Beyond September, both temperature and API continued to decrease (Figure 2).

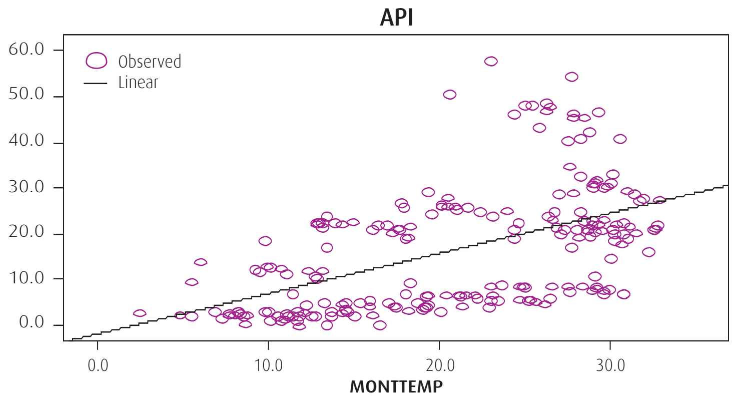
Figure 2
Effect of Temperature on API by months over 9 years 2001 - 2009 in High Endemic Districts



However, when the same was attempted in the low endemic districts, there was no apparent correlation.

A linear regression model was applied on the effects of monthly temperature on the API. Among the high endemic district, there was a strong linear relationship, $p<0.001$, $F=81.14$ (Figure 3). This implies that with the increase in temperature there is a linear increase in the API.

Figure 3
Liner Regression Model depicting relationship between Monthly Temperature and API in High Endemic Districts



On the contrary, the same model of association did not show any significant co-relationship in the low endemic districts.

Annual Temperature and API

When the Annual API was correlated with Annual Temperature in the high endemic districts, it showed zero co-relationship, depicting no effect of annual temperature on annual parasite incidence rate (Figure 4).

Figure 4
Liner Regression Model depicting relationship between Annual Temperature and API in High Endemic Districts

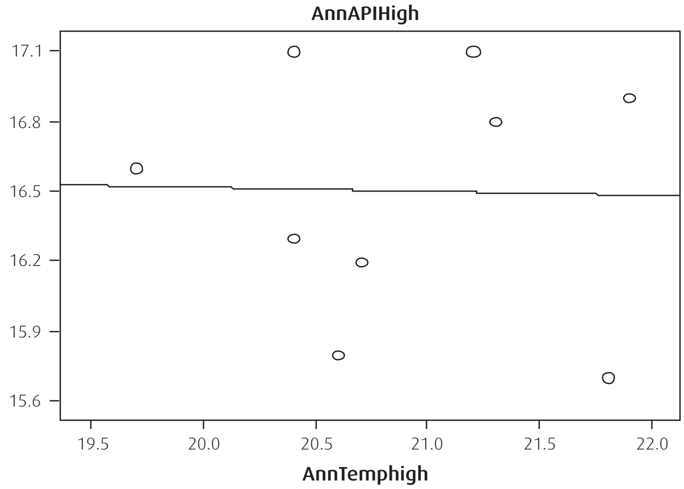


Figure 5
District Zhob Annual Temperature & Annual API 2001-2009

Figure 6

District Quetta Annual Temperature & Annual API 2001-2009

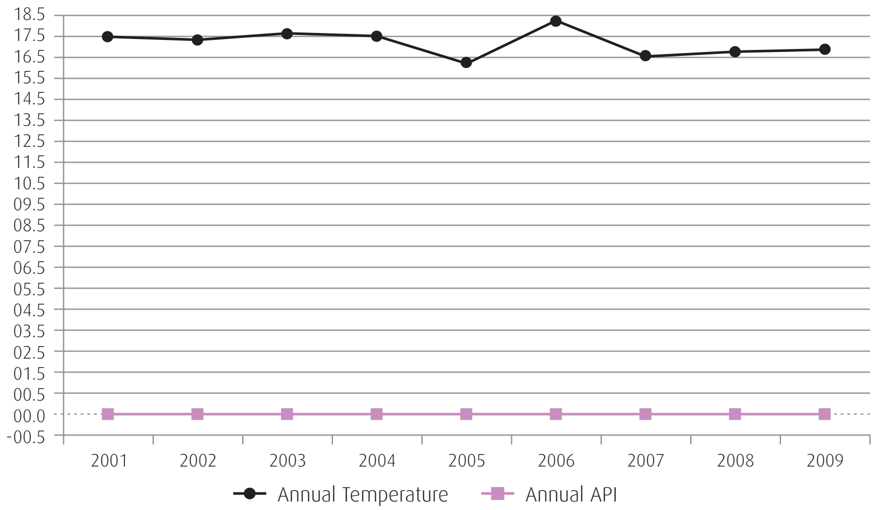


Figure 7

District Khuzdar Annual Temperature & Annual API 2001-2009

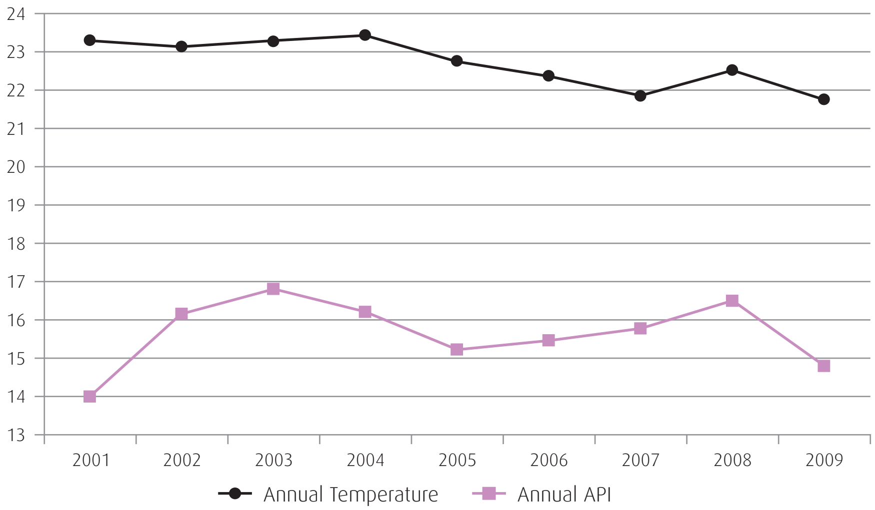
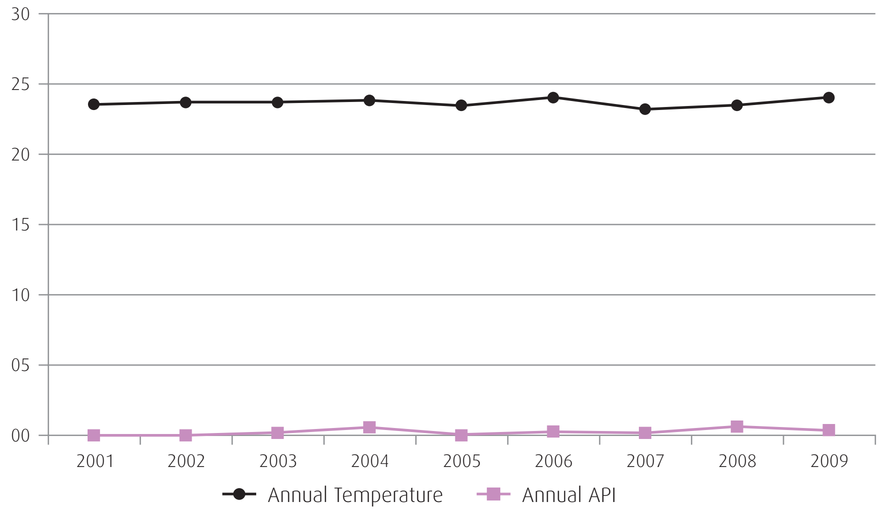


Figure 8
District Chaghi Annual Temperature & Annual API 2001-2009



Discussion

There appeared no statistical relation between Annual Temperature and Annual Parasitic Incidence (API) during the last nine year i.e. from 2001 to 2009. However there is an apparent rise in Annual Parasitic Incidence (API) corresponding to the monthly temperature during each year over the last nine years in the high endemic districts. This may be attributed to the favourable temperature required for the breeding of the anopheles mosquito (responsible for carrying malarial parasite).

During the month of August, the peak season for Monsoon rains, temperature decreases along with the API. However, there is a rise in API following rains, despite the fact that the temperature continues to decrease. Malaria spreads due to multi-factorial reasons including temperature. The stagnant water in which the mosquito breeds could be one of the important factors highly prevalent in that season.

In addition, the metrological data in our study does not show any significant change in the rise of temperature. This finding is consistent with other studies in which a set of well-maintained meteorological records show no rise in temperature over recent decades.[10] Other factors such as drug and pesticide resistance, changing land use patterns and human migration may also play roles; and temperature may not be the only major factor driving the increase in malaria. However, as it could be one of the many factors therefore it should be taken into consideration.[11]

Future climatic changes may alter the prevalence and incidence of the disease, but obsessive emphasis on "global warming" as a dominant parameter is weak; the principal determinants are linked to ecological and societal change, politics and economics.[12] Medical problems involve multiple factors in which the socio-economic environment plays important role in determining the vulnerability of subjects.

Limitations

- There is under reporting of malarial cases and the reliability of data could be uncertain;
- API has been calculated with the same denominator, whereas over period of time the denominator must have changed due to change in demographic indicators.
- The non-availability of malaria data for more than 10 years is also a limitation.

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Association of Climate Change with Asthma in Children

By:
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- Dr. Saira Afzal

Background

The causes of asthma are still not well understood. There are several recognized factors that may increase the risk of developing the condition or trigger asthma symptoms in those who already have the condition. Risk factors for asthma may be broadly classified into:

- Constitutional factors which predispose to the development of asthma or particular outcomes of asthma. The presence of family members with asthma, certain genetic mutations, sex, age group, the presence of an atopic (allergic) disposition are all examples of such factors that serve to identify at-risk individuals and also to generate hypotheses about the underlying mechanisms of the disease. As they cannot be modified by intervention, surveillance of these factors is of limited value.
- Environmental exposures or other factors which are associated with an increased risk of acquiring asthma or having certain adverse outcomes of the disease. These exposures serve as potential targets for interventions to (a) affect the risk of acquiring asthma; or (b) prevent the development of asthma; or (c) change/improve the course of the disease, because exposure to such factors can be modified and monitored. Hence, surveillance of these factors may be valuable and informative.

There is a wide range of environmental factors that trigger symptoms in people with asthma, including exercise, viral infections, irritants (including smoking, indoor and outdoor air pollutants), specific allergens (for example, house dust mites and mould spores), and certain ingested food preservatives. In most cases, apart from viral infections and air pollutants, avoidance of exposure to these environmental causes of asthma has been extensively investigated and reviewed. The subject remains controversial with conflicting evidence on the effects of, exposure to pollutants and other allergen sources; protective effects of breast-feeding; overweight and obesity; and the role of infections in childhood. A number of randomized controlled trials evaluating the effects of specific interventions for the prevention of asthma are currently underway. Without clear evidence of an important, avoidable causal role in asthma, these factors are not suitable targets for surveillance [1].

Exposure to allergens has been conclusively linked both to the development of asthma, de novo, and to progression of the disease. Since this is a potentially avoidable cause of asthma, exposure to environmental allergens and the occurrence of asthma are important targets for research.

Existing Scenario

The increased emission of Green House Gases (GHG) has led to climate change and its adverse effects. Increased frequency and intensity of extreme weather events like heat and cold waves, floods, storms and cyclones have caused loss of life, injury, psychological distress and greater frequency of communicable diseases, especially among vulnerable groups such as children, old people and impoverished communities.

Climate change has also been responsible for increase in air pollution leading to a rise in respiratory and eye diseases. There is increased concentration of ground level ozone leading to difficulty in breathing and a higher frequency of asthma, acute bronchitis, acute rhinitis and pneumonia. Moreover, extrinsic factors for the attack of asthma like, increased pollen grains, chemical droplets and harmful gases, have also increased. The significant increase in the occurrence of asthma between the 1960s and 2008[2], owes itself to some extent to the rapid climatic shift occurring across the globe.

According to the World Health Organization (WHO) around 9% of US children had asthma in 2001, compared with just 3.6% in 1980 whereas, around 10% of the Swiss population suffers from asthma today compared with just 2% some 25 years ago[3].

The range of environmental factors that trigger symptoms in those having asthma have been the focus of a number of research endeavours however, none of the studies have documented any association with climate factors. As climatic conditions may prove be to a critical causal factor in the recorded increase in asthma cases therefore; exploration of the same seems only prudent. This is especially important for a developing country like Pakistan which due to its limited resources is especially vulnerable to the effects of climate change.

The present study is therefore being conducted with a view of creating a better understanding of the association between climatic conditions and asthma.

Rationale

The research will inform the policy makers about climate change possible effects on increased occurrence of asthma cases, especially in vulnerable populations. This information may in turn, serve the basis for (a) specific actions or strategies to control and/or decrease the harmful effects of climate change; (b) sustainable prevention and control programs that will help in adaptive measures, especially in more vulnerable groups; and (c) setting up of effective surveillance systems and public health training programs for reducing and/or adapting to the harmful effects of climate change on the development of asthma.

Aim and Objectives

Aim:

To find out the association between climate change and asthma in children under five years of age.

Objectives:

- To find out the number of cases of asthma among children aged 1 to 4 years in tertiary care hospitals of Lahore during last 06 years i.e. from 2004-09;
- To find out the temperature and humidity records occurring in Lahore during the above mentioned years;
- To determine the correlation of climatic changes and frequency of asthma among children during the same years as mentioned above in Lahore.

Methodology

Study Design:

Cross-Sectional

Study Duration:

The study covered a time duration of 06 years i.e. from 2004-09.

Study Population:

All the children (1-4 years) who were brought to Children Hospital Lahore due to an attack of asthma during last 06 years i.e. from 2004-09.

The reason for focusing on this age group is because factors other than climatic conditions may affect infants from 0- 1 year and this will dilute the effects.

Sampling Technique:

Non probability purposive sampling was used to collect data of only those children aged 1-4 years who were diagnosed by Children Hospital Lahore as having asthma.

Sample Size:

All cases of asthma reported and recorded at Children Hospital Lahore during last 06 years.

Inclusion Criteria:

Children aged 1-4 years who, according to hospital records, were diagnosed as having asthma.

Exclusion Criteria:

Children who, according to hospital records, had pneumonia, malnutrition, any congenital malformations like cleft palate.

Sources of Data Collection:

- Data regarding temperature and humidity was obtained from Pakistan Meteorological

- Department, Government of Pakistan through LEAD Pakistan;
- Data regarding asthma cases was obtained from computerized hospital records in Children Hospital Lahore.

Ethical Consideration:

The data was obtained from the concerned departments after obtaining due approval from those in charge. Moreover during the course of this study confidentiality of individuals has been maintained.

Results

During the six year period, i.e. from 2004 to 2009, a total of 7,620 children aged 1-4 years visited the asthma clinic at Children Hospital Lahore. 165 patients visited asthma clinic in the year 2004 while 2,332 visited in the year 2009. The frequency shows a fourteen fold increase. This increasing trend in frequency of asthmatic patients less than 5 years of age in 6 years is statistically significant (P<0.05).

56% of patients (4,298 out of 7,620) visited asthma clinic in the months from August to December (Table 1). A monthly frequency distribution indicates that highest number of patients in all six years was reported in the month of December whereas; lowest number was reported in January. On the other hand, Mean Monthly Temperature (MMT) was highest in June and lowest in January while, Mean Monthly Relative Humidity (MMRH)[1] was highest in August and lowest in April (Table 1).

Table 2 shows the correlation between Monthly Number of Patients, and MMT and MMRH. Generally there was a negative correlation between Monthly Number of Patients and MMT, but it was not significant. However, in the year 2007 there was a significant positive correlation between Monthly Number of Patients and MMT (p value 0.022).

In general there was a positive correlation between monthly number of patients and MMRH, but it was significant for the year 2006 only (p value 0.007).

The correlation analysis shows that with rise in temperature there is a decrease in frequency of asthma in patients less than 5 years of age. It means more under 5 patients reported to have asthma in cold weather than hot weather. It was also noted that occurrence of asthma in patients under 5 increases with a rise in humidity. In the year 2006 in particular the relationship between the two factors is statistically significant.

Table 1

Number of Patients, Temperature and Humidity Levels In Years 2004-09

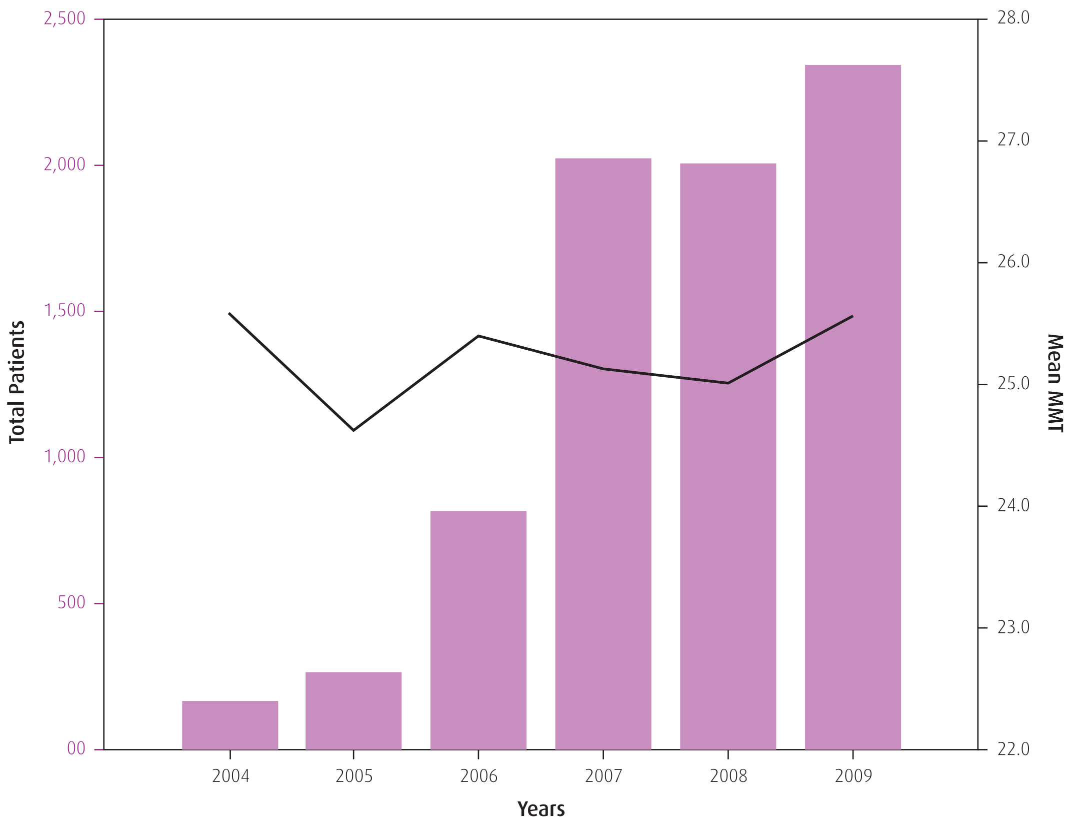
Month	Number of Patients in an Year						Total Patients	Mean of Patients	%age of Patients	Mean MMT	Mean MMRH
	2004	2005	2006	2007	2008	2009	2004-09	2004-09	2004-09	2004-09	2004-09
Jan	18	22	26	107	71	100	344	57.33	4.51	13.77	52.00
Feb	9	20	29	144	170	194	566	94.33	7.43	17.18	50.00
Mar	13	19	33	91	153	153	462	77.00	6.06	22.75	41.17
Apr	11	43	29	117	136	185	521	86.83	6.84	28.63	24.33
May	12	25	21	182	72	89	401	66.83	5.26	32.30	25.17
Jun	10	22	38	250	112	122	554	92.33	7.27	33.07	36.00
Jul	9	21	90	201	78	75	474	79.00	6.22	31.48	58.50
Aug	12	23	106	214	197	228	780	130.00	10.24	30.97	63.67
Sep	24	21	99	143	270	295	852	142.00	11.18	29.90	54.67
Oct	24	22	58	180	320	340	944	157.33	12.39	26.30	42.33
Nov	8	17	142	210	180	196	753	125.50	9.88	20.87	48.67
Dec	25	19	146	177	247	355	969	161.50	12.72	15.52	51.83

1 At 1200 UTC (UTC=GMT: Greenwich Mean Time)

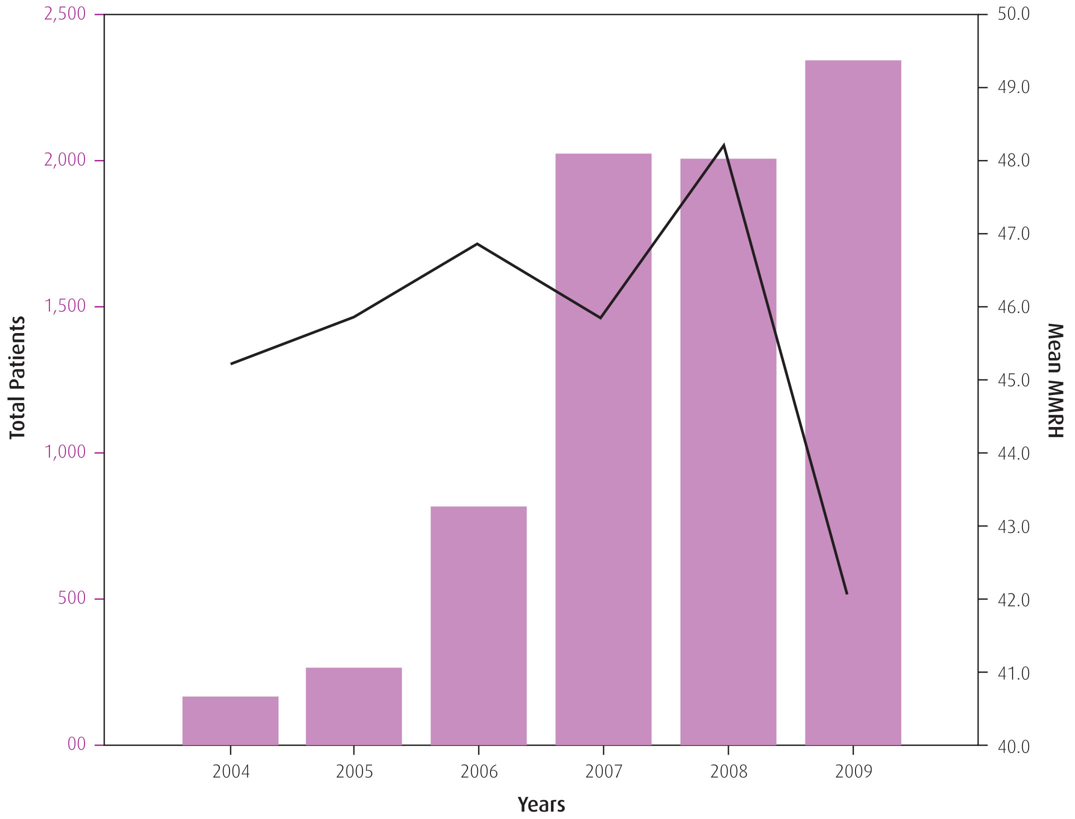
Table 2
Correlation between Monthly Number of Patients and MMT and MMRH

Year	MMT		MMRH	
	Correlation Coefficient	P Value	Correlation Coefficient	P Value
2004	-0.246	0.441	0.060	0.853
2005	0.537	0.072	-0.416	0.179
2006	-0.144	0.656	0.729	0.007
2007	0.650	0.022	0.189	0.557
2008	-0.175	0.586	0.365	0.243
2009	-0.371	0.236	0.161	0.617
2004-09	-0.017	0.890	0.087	0.469

Graph 1
Total No. of Patients & Mean Monthly Temperature (MMT)



Graph 2
Total No. of Patients & Mean Monthly Relative Humidity (MMRH)



Discussion

In Pakistan, asthma is one of the most common reasons for children seeking health care. The 14-fold increase in the frequency of asthma cases over a six-year period, brought forward in the present study, bears testament to the fact.

During the time period covered in the study, an association between shifts in temperature and humidity patterns and trends in health care utilization by asthmatic patients under 5 years of age was observed. The data obtained was therefore indicative that extreme seasonal patterns especially cold spells and increase in humidity trigger asthma symptoms.

This may be due to the fact that plant-derived allergens are affected by meteorological variations, in terms of plant growth and pollen production and transport. Other aeroallergens, such as those derived from mites and fungi, are also influenced by certain meteorological conditions [6].

An increase in various air pollutants has also been related to meteorological conditions [7]. Increased levels of pollutants have been repeatedly found to be associated with asthma attacks, and some air pollution related episodes of asthma exacerbation are due to meteorological factors that favor the accumulation of air pollutants at ground level [8]. In addition to this, the seasonality of viral infections, rapid proliferation of germs due to climate changes, resistance and mutations in pathogens for survival in low temperature and increased humidity conditions, has also been repeatedly documented [9,10].

Childhood asthma research studies have also shown that environmental changes modulate the immune system to increase the magnitude of airway inflammatory response to allergens and irritants [19-21]. The change in humidity and temperature, observed in the present study, could therefore also help us to potentially explain the association of seasonality of asthma admissions with specific meteorological variables.

An analysis of the results has brought forward the existence of an association between occurrence of asthma in children under 5 years of age and higher humidity levels. Similarly it has come forward that a decrease in temperature gives rise to an increase in asthma cases in children under 5. However, in both cases the correlation although present was not found to be statistically significant.

At present the study bears testament to an already known relationship i.e. certain weather conditions trigger asthma symptoms. To explore if over time there has been an increase in the intensity and frequency of such weather conditions; and to assess if this has led to a corresponding increase in occurrence of asthma in children what is required is data for a minimum period of 30 years.

Climatic variability can only be witnessed over a minimum period of 3 decades or 30 years. Therefore, any reasonably significant assessment about the existence of association between climate variables and asthma would require analysis of data, about the relevant climatic conditions and asthma cases, for a period of time far longer than the six years as in the present study.

In Pakistan availability of accurate climate data for any variable for the said time frame poses no problems. However, when it comes to health related data the situation is entirely different. The availability of consolidated, accurate, computerized data for any disease and in particular climate sensitive diseases is nothing short of a distant dream. The situation gets even worse when the data required pertains to the country's rural area.

Moreover as the present study relied on analysis of secondary data, confounding factors could not be ruled out. In this reference, an important extraneous variable was the fact that in late 2006 the Government of Punjab announced provision of free medicines as mandatory. A ruling that led to a sudden increase in hospital admissions in the ensuing years thereby, clouding the existence of relationship between climatic conditions and occurrence of asthma.

The analysis of available data hints at the existence of a relationship between the two variables variability in certain climatic conditions, namely humidity and temperature, and occurrence of asthma in children under 5. This should be considered as the first step. The relationship has to be explored further depending of course on the availability of required health and climate related data for a longer time frame so as to arrive at more significant conclusions.

Recommendations

Further research for exploring and analyzing the role of meteorological variables in morbidity of asthmatic children is required. In this reference studies on the relationship of the following with asthma are advised: the genetic trait, CD14 single nucleotide polymorphism (SNP) C-159T; exposure to endotoxins; and gene-environment interaction.

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Response of Public Health Infrastructure to Extreme Weather Events – A Case Study of District Gawadar's Encounter with Cyclone Phet

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Background

Extreme events have received increased attention in the last few years, due to the often large loss of human life and exponentially increasing costs associated with them. These primarily refer to extremes based on simple climate statistics, such as very low or very high temperatures and event driven extremes such as floods, storms, cyclones, droughts or hurricanes. These may also be defined by the impact an event has on society. That impact may involve excessive loss of life, excessive economic or monetary losses, or both[1].

The most commonly used definition of extreme event is based on an event's climatological distribution. Extreme events occur only 5 percent or less of the time. They are, by definition, rare[2,3].

An extreme event then, is a significant departure from the normal state of the climate, irrespective of its actual impact on life or any other aspect of the Earth's ecology. When a climate extreme has an adverse impact on human welfare, it becomes a climatic disaster[4].

Natural variability in the climate often produces extremes in the weather. An important question which scientists are trying to answer is whether mankind's interference with the global climate through the enhancement of the natural greenhouse effect will increase the frequency or magnitude of extreme weather events[4].

Table 1
Human Influence on Trends for Extreme Events[5]

Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*	*Likely*	*Virtually certain*
Warmer and more frequent hot days and nights over most land areas	*Very likely*	*Likely (nights)*	*Virtually certain*
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)	*Likely*	*More likely than not*	*Likely*

Several diverse extreme events are occurring concurrently around the world, giving rise to an unprecedented loss of human life and property. Pakistan, unfortunately, is no exception.

Pakistan lies in the temperate zone with generally arid climate, characterized by hot summer and cool or cold winters and they are wide variation between extreme of temperatures[6]. The weather extremes in the country include high and low temperatures, heavy rainfall and flooding. Over the decades a vast proportion of the country's population has been affected by these disasters.

Figure 1
Percentage of Pakistan Population Affected by Extreme Weather events during 1920-2010 [7]

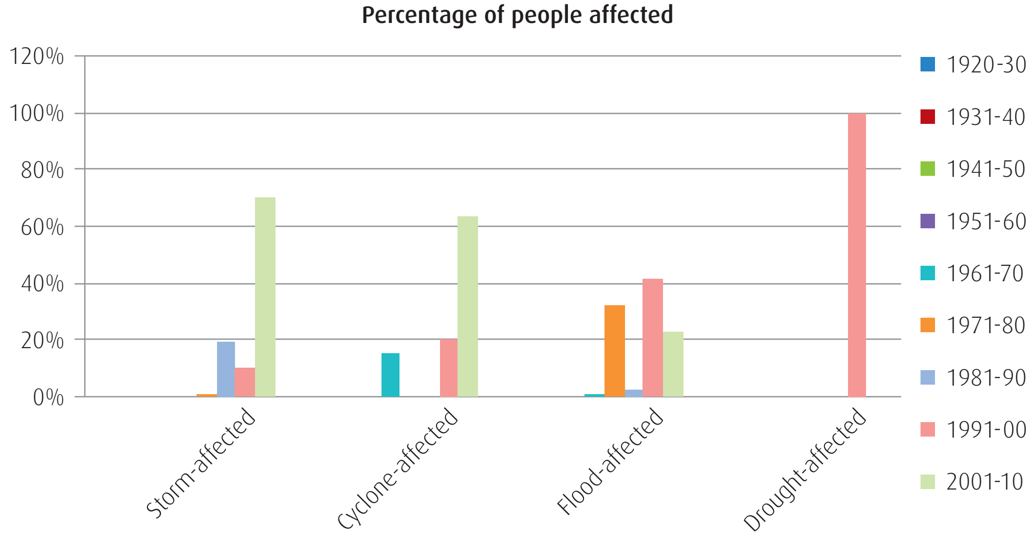
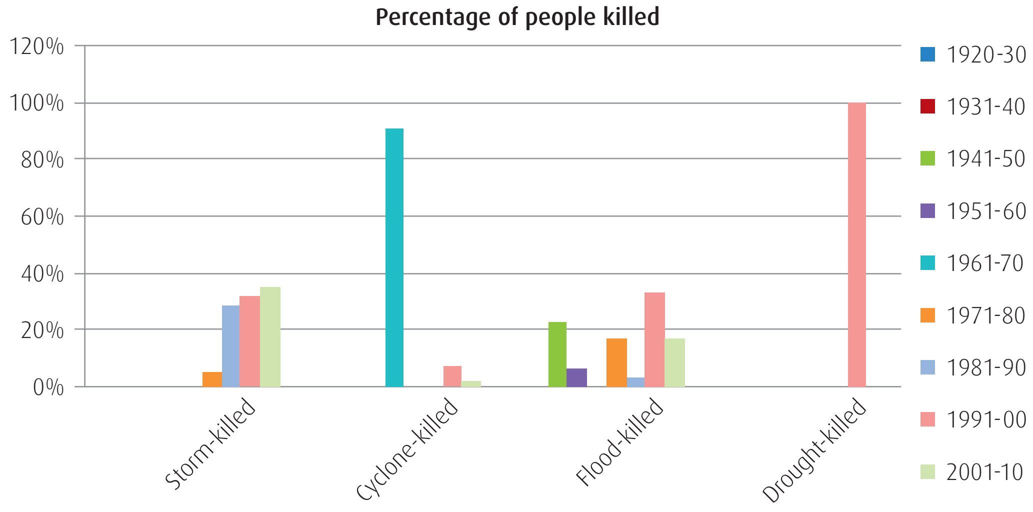


Figure 2
Percentage of Pakistan Population Killed by Extreme Weather events during 1920-2010



It has been estimated that in the coming years the intensity and frequency of such events will increase as a result of climate change[8].

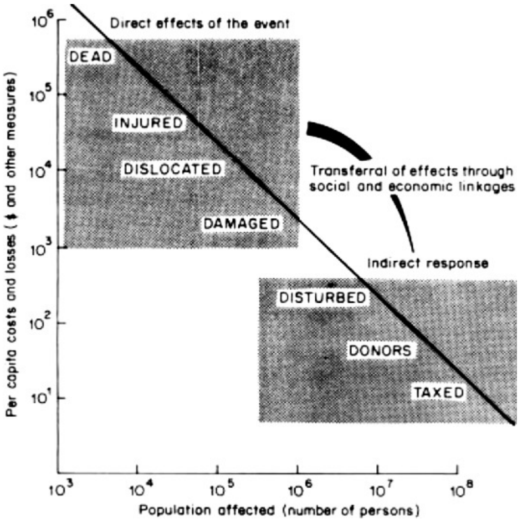
In terms of the spatial relationship between extreme events and their impacts, most evidence suggests that the area over which the event occurs tends to be smaller than the area over which the impact of that event is felt. In part this may result from the type of event. The blocking of a vital road or rail route by flood will result in societal costs far beyond the area of the flood itself through delays in transport and rerouting of materials or passengers.

Research has suggested that most extreme events produce a `cascade' of impactsin bureaucratic societies by sharing some of the economic costs among all taxpayers, and in less bureaucratic societies by sharing losses among relatives and kinsfolk. In simplistic terms, therefore, in addition to the directly affected population devastated by storm, flood or drought, we must recognize those indirectly affected through increased voluntary charitable donations, involuntary taxation, or social responsibilities for kinsfolk.

In terms of time-scale a similar relationship between the duration of the event and its impact can be suggested. The destruction during an event, whether of life or property, usually occurs over a shorter period than the post-event impact. Injured victims die long after the tornado has struck, flood-damaged structures take time to be repaired, grazing herds may take up to ten years to reach pre-drought levels and, for some victims, the psychological traumas of the event may remain throughout their lifetimes.

For immediate victims who have survived the disaster, the impact is clear enough–deaths and injuries, property damages and food shortages. Their experiences provide sources for three different types of interpretation of the disaster. First, the experience becomes part of the collective societal experience of the environment, expressed perhaps as folklore, poetry, aphorisms or preferred sequences of activities such as the timing of crop plantings. Second, the experience becomes the source for research by academics or government officials enquiring into the disaster, and finally the experience, as translated through the media, becomes the basis for the general public's view of the event.

Figure 3
The cascade of disaster



For general public, its view of the disaster impact is constrained by media coverage of the event and to some extent by the official response to the potential `cascade' of effects from the disaster Apart from their varied ability to cover the disaster, the news media (newspapers, radio and television news services) have their own biased policies on the reporting and presentation of news items, stemming from their ownership and capacity to search out and relay information. Thus the immediate, short-term, spectacular impacts may be reported, but the longer-term post-event impacts may be overlooked.

Extreme Events & Human Health

The linkages between climate change and health are complex, and interact with many other influences. For example, the main concern regarding climate change is that it has the potential to worsen existing health challenges, such as control of water- and vector-borne diseases, particularly for the poorest populations. However, factors such as socioeconomic status, access to health services, and local capacity to cope with weather-related hazards, all determine the level of health vulnerability to climate change, and must be taken into account when assessing risks or planning adaptation measures[9].

Evaluation requires robust surveillance capacity, a well-trained public health workforce, and established, efficient, reliable systems for sharing information among different levels of government and parts of the health sector. It also requires a periodic inventory of available services and assessment of the degree to which those services are accessible to the most vulnerable populations they are designed to serve.

As climate change has become a certainty, so has the need for public health action to anticipate, manage, and meliorate the health burdens it will impose. The standard framework for public health action are the 10 Essential Services of Public Health. These services, with examples pertinent to climate change, appear in table (adapted from the US Health Services model).

Table 2
Ten Essential Services with Climate Change Examples

Service	Climate Change Example
1. **Monitor** health status to identify and solve community health problems.	Tracking of diseases and trends related to climate change
2. **Diagnose and investigate** health problems and health hazards in the community.	Investigation of infectious water, food , and vector-borne disease outbreaks
3. **Inform, educate, and empower people** about health issues. Climate change issues.	Informing the public and policymakers about health impacts of climate change
4. **Mobilize community partnerships** and action identify and solve health problems.	Public health partnerships with industry, other professional groups, faith community, and others, to craft and implement solutions
5. **Develop policies and plans** that support individual and community health efforts.	Municipal heat-wave preparedness plans
6. **Enforce laws and regulations** that protect health and ensure safety.	(Little role for public health in climate related emergency situation management)
7. **Link people** to need ed personal health services and ensure the provision of health care when otherwise unavailable.	Health care service provision following disasters
8. **Ensure** competent public and personal health care workforce.	Training of health care providers on health a spects of climate change.
9. **Evaluate effectiveness, accessibility, and quality** of personal and population -based health services.	Program assessment of preparedness efforts such as heat-wave plans
10. Research for new insights and innovative solutions to health problems.	Research on health effects of climate change, including innovative techniques such as modeling, and research on optimal adaptation strategies.

In developing and implementing services to address climate change, public health professionals will need to confront several practical realities. First, the effects of climate change will vary considerably by region. Second, they will vary by population group; not all people are equally susceptible. Third, these effects are highly complex, and planning and action will need to be multidimensional[10].

Government public health departments are responsible for creating and maintaining conditions that keep people healthy. At the local level, the governmental public health presence, or "local health department," can take many forms. Furthermore, each community has a unique "public health system" comprising individuals and public and private entities that are engaged in activities that affect the public's health. Regardless of its governance or structure, regardless of where specific authorities are vested or where particular services are delivered, everyone, no matter where they live, should reasonably expect the local health department to meet certain standards, which for a functional local health department, under the overall oversight and operational policy of the respective public health agency, would include:

- Understands the specific health issues confronting the community, and how physical, behavioral, environmental, social, and economic conditions affect them.

- Investigates health problems and health threats.
- Prevents, minimizes, and contains adverse health effects from communicable diseases, disease outbreaks from unsafe food and water, chronic diseases, environmental hazards, injuries, and risky health behaviors.
- Leads planning and response activities for public health emergencies.
- Collaborates with other local responders and with state and federal agencies to intervene in other emergencies with public health significance (e.g., natural disasters)[11].

In theory, and in the significant part of reality also, the constitution of Pakistan provides Health as a fundamental right, therefore, for the average citizen healthcare MUST be provided by the Government, thus the health burden on the Government is huge. Meeting emergency and disaster mitigation needs is invariably a primary function of the Government. However, deficiencies are rampant and public in the major part are dissatisfied with the standard of services provided. Strong private sector healthcare services are available, but their impact is not as significant as it could have been, given the socioeconomic situation of the country. The same is true for the province of Balochistan Pakistan's largest province in terms of land mass.

The health characteristics of Balochistan are a typical example of the national situation, with low life expectancy, widespread communicable diseases, a high maternal and child mortality, similar to many developing countries and regions. However, Balochistan has a reasonable availability of health infrastructure. The problem primarily relates to their utilization, management, the capacity of health human resources and institutions to ensure the policy objectives.

Table 3
Public Health Infrastructure (services) in Balochistan [12]

S.#	Facilities	Nos.	Beds	Ambul;	District Gawadar	Beds
1	Tertiary and Teaching Hospitals	04	1739	12		
2	District Hospital	27	1437	47	01	34
3	Civil Hospitals	12	334	18	01	28
4	Rural Health Centers	75	1050	77	02	24
5	Basic Health Units	515		17	17	
6	Civil Dispensaries	595			24	
7	MCH Centers	84			03	
9	TB Clinics	21			01	
10	Leprosy Centers	11	34		01	
11	College/Institution	03				
12	Nursing Schools	04				
13	Public Health Schools	9				
14	DHDC	05				
15	PHDC	01				
16	National Programs	07				
17	Private Hospitals	37	870		1	16

In the given scenario a need was felt for assessing the effectiveness and efficacy of Baluchistan's health care systems in coping with climate related disasters. For the purpose the destruction caused by cyclone PHET 2010 in District Gawadar, Baluchistan was taken as a case in point.

Objectives of the Study

The following objectives were adopted for this study:

1. To assess the effects of Cyclone PHET on health system and health Infrastructures in District Gawadar;
2. To assess the capacity of the Gawadar's Health system to cope with an extreme event;
3. To develop recommendations for future action particularly for the province of Balochistan, Pakistan and the entire region at large.

Methodology

Geographical Focus

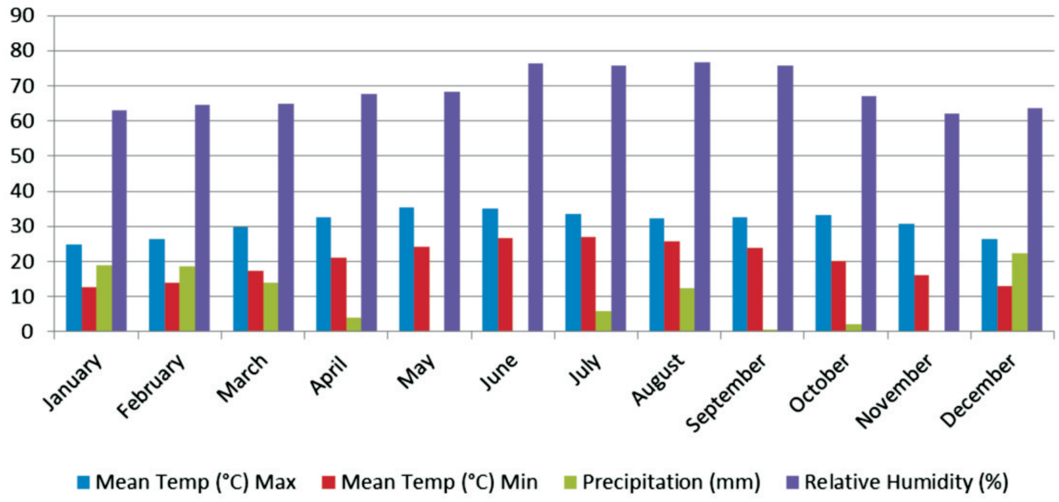
The province of **Balochistan** is largest in area, 347190 sq.km (44% land mass), and yet the least populated of the total country, about 8.4 million (5%) of the total 161.1 million, population density 23/sqkm[13].

Gawadar is one of the two districts of the province of Balochistan forming Pakistan's shoreline on the Arabian Sea. The main towns are Gawadar, Pasni and Jiwani. Area-15216 sq.km; Population-0.246million; Females are 47.3%, males 52.7%. The urban-rural distribution is 54%:46% (in contrast to national ratio of 32%:68% and provincial ratio of 23%:76%[13,14,15].

Gwadar is located at 0 meters (0 ft)300 meters (984 ft) meters above sea level, climate is dry and hot arid. The oceanic influence keeps the temperature lower in the summers, higher in winters. Mean temperature in the hottest month of June remains between 31°C(88°F)-32°C(90°F), while in the coldest month of January varies between 18°C(64°F)-19°C(66°F). This uniformity of temperature is a unique characteristic of the coastal region in Balochistan. Occasionally, winds moving down the Balochistan plateau bring cold spells, otherwise winter is pleasant and shorter than summers. The weather is identical to that of Middle-East as most rains occur from December till January.[16].

Figure 4

Mean Climate District Gawadar[17]



Universe

The universe adopted for this study comprised of the District Health System (Infrastructure, Human Resource and Logistics), District Administration, and Population affected by the Cyclone PHET in June 2010, in District Gawadar, Balochistan Province, Pakistan.

Design

The study was an exploratory category of research with observational design. Mixed method[18], approach was utilized as the major sources of information to be collected were in the 'qualitative' category.

a) The data collection modalities adopted were:
   - Desk Top Data Collection: The main modalities involved were internet search, relevant reports from the Government, NGOs, Media, and articles on Gawadar, and reviews.
   - In-depth interviews with the concerned management and operational staff, who were involved with the mitigation activities for PHET, or who were present in the affected areas during PHET and its aftermath in Gawadar district.
   - Survey of Health infrastructure affected by PHET.

b) 'Check Lists' and 'Interview Guides' incorporating the information requirements , were the primary instruments utilized, these were developed as a part of the study protocol.

c) Personal observation by the research team were also recorded and made part of analysis.

d) No sampling was required for this study.

e) To reach a fair assessment on the subject, it was decided to collect information about the following areas:
   - The damage caused by Cyclone PHET to life, property, and health infrastructure in Gawadar i.e. the situation after PHET.
   - The situation before PHET.
   - The mitigation planning and plan implementation.
   - State of Rehabilitation and Reconstruction of the damages in general and to the health system in particular.
   - Information on weather of Gawadar with future projections.

Variables and Indicators

To achieve the information understood to be minimally required for the study under the subject areas indicated above, the following variables and indicators were determined necessary for data collection.

- Age and Sex distribution of deaths, injured, disease outbreaks
- Damage and Impact Indicators from records and observation
- Mitigation and Rehabilitation activities carried out
- Climate variables from records
- Bottle necks and gaps identified

List of Interviews Conducted

The following were interviewed for this study:

- District Coordination Officer (DCO) Gawadar
- Executive District Officer (EDO) Health
- District Support Manager (DSM) Peoples Primary Health Care Initiative (PPHI)
- District Coordinator National Programs for Family Planning (FP) and Primary Health Care (PHC)
- District Coordinator District Information System and Disease Early Warn System
- District Coordinator, Tuberculosis (TB) Dots Control Program
- Public Health Specialist, National Maternal & Child Health Program
- Medical Officer (MO) In-charge Basic Health Unit (BHU) x 2
- In-charge Mother & Child Health Care (MCH) Centre
- In-charge Rural Health Centre (RHC)
- Medical Superintendant (MS) District Headquarter Hospital (DHQH)
- Lady Health Worders (LHW) from the Affected Community

Data Analysis and Reporting

The procedure for data analysis was guided by the type of data which was primarily qualitative in nature. Quantitative data has been collected for the survey of health infrastructure, health services performance, morbidity and mortality data.

Simple statistical frequencies were used to describe the important characteristic of the themes, although a generalization is not possible. Here it should be noted that the data obtained in such a study, which is primarily exploratory is not necessarily representative of the general population.

Observations & Findings

Devastation Caused by Cyclone Phet 2010

Cyclone Phet marched through the Arabian Sea from May 31 to June 6, 2010. The heaviest rainfall from the cyclone (600 or more millimetres / 23.6 or more inches) occurred over open waters of the Arabian Sea. One area of northeast Oman received as much as 450 millimeters (17.7 inches), while Pakistan received between 150-300 millimeters/ 5.9-11.8 inches as Phet made landfall there. Tropical Cyclone Phet brought not just strong winds but also heavy rains to the Arabian Sea, the Arabian Peninsula, and the coast of Pakistan in late May and early June. Phet reached its greatest intensity off the coast of Oman on June 3. After making landfall in Oman, Phet dissipated somewhat, but remained organized enough to move back over the Arabian Sea towards Pakistan. Tropical Cyclone Phet made its second and final landfall on Sunday, June 6 along coastal Pakistan bringing heavy rainfall, floods, and damages. By June 7, NASA satellite imagery confirmed that the remnants of Phet were still raining over inland areas of Pakistan and India.

Phet affected thousands of people living along coastal areas of Pakistan when it made landfall. Gwadar, on the southwestern coast of Pakistan reported torrential rainfall, flooding and damages. The coastal highway in Balochistan was washed away from flooding. Reports of damage indicated up to three feet of standing water, power outages and destroyed boats[19].

Cyclones that instigate in Arabian sea, usually did not make landfall in Gwadar before Phet 2010, since Gwadar is located on the extreme western coast of Pakistan. The majority of the interviewees stated that they had no experience of such cyclone in their life. Even there was no folk lore or stories of any such high intensity of winds with continuous heavy rains from their grandfathers or great grandfathers. The impact of the cyclone was devastating to put it simply.

The majority of the houses and buildings which were built with stone and mud, were severely destroyed by the cyclone. Large numbers of inhabitants were injured and had to be rescued. The people were shifted in to relief camps and to other safe locations. In Gawadar and Jiwani towns, large number of houses, water supplies, drainage system, costal highway and internal roads were damaged. The coastal belt was hit by cyclone with heavy rains with winds destroyed the infrastructure, boats and fishing equipment. The fishermen became jobless as it was the main income source of the district population.

Impact of PHET 2010 on District Health System

The major damage observed was:

- BHU Shadoband was damaged and remained closed for a month, delivery of services were shifted to be delivered from a medical camp. The building developed cracks and remained in water for period of 1 month. Logistics and supplies were damaged. The BHU Surbandar boundary wall collapsed.
- In RHC Jiwani the building was severely damaged; the beds, logistics, equipment, furniture, infrastructure were destroyed.
- In District HQ hospital, X-Ray unit roof collapsed, the X-ray machine and its accessories were damaged.
- Overall 3 RHCs, 20 BHUs, 10 CDs and 1 TB clinic, with their residential colonies, were severely affected by cyclone, these need major repairs and renovation work.

Cost Estimates of PHET Damages

According to the District Health Management and District Administration, the following is the cost estimates of damages due to PHET 2010[20].

Construction of BHUs at Shadoband, Basool, & Mojo	Rs. 13.5 million
Major Repairs 0f 7 BHUs	Rs. 10.5 million
Minor Repair and renovations of 3 BHUs	Rs. 01.5 million
Major Repair in RHC Jiwani with residential colony	Rs. 05.7 million
Minor Repair in RHC Pasani and residential colony	Rs. 02.5 million
Construction of X-Ray unit in D/H Quarter Hospital	Rs. 01.0 million
Repair and renovation D/H Quarter Hospital	Rs. 01.5 million
Construction 03 civil dispensaries	Rs. 04.5 million
Major repair of 12 civil dispensaries	Rs. 04.8 million
Total	**Rs. 45.5 million**

Trauma during PHET

- Deaths - 7
- Major injuries 30
- Minor injuries 1245
- Villages destroyed 45
- Houses washes away - about 5000
- Houses damaged - 10,000
- Houses partially affected 20,000
- Fishing launches damaged 5
- Fishing Boats damaged 60[21]

Epidemics

Chances of an outbreak are real in cases of devastation by a cyclone, particularly if it is of such a high intensity as PHET was. Episode of Diarrheas were reported in BHU Surbander and RHC Jiwani. These epedemics were reported on June 7-8, 2010 in village Surbander and Jiwani. The diarrhea cases were 23 in under five years and 61 in above 5 years, in the same area Malaria also effected 11 children under five and 34 adults. Fortunately there was no mortality reported during this outbreak. These episodes were controlled within 2 days.

Pattern of Disease Before and After PHET

The pattern of diseases Before and After Cyclone PHET 2010 in BHU Shado-Band, Surbander, RHC Jiwani, and District HQ Hospital was observed. A significant increase is noted. Particularly the number of 15-49 age female cases increased after cyclone. The figures below show this pattern facility wise.

Figure 5
Pattern of Disease Before and After PHET BHU Shadoband

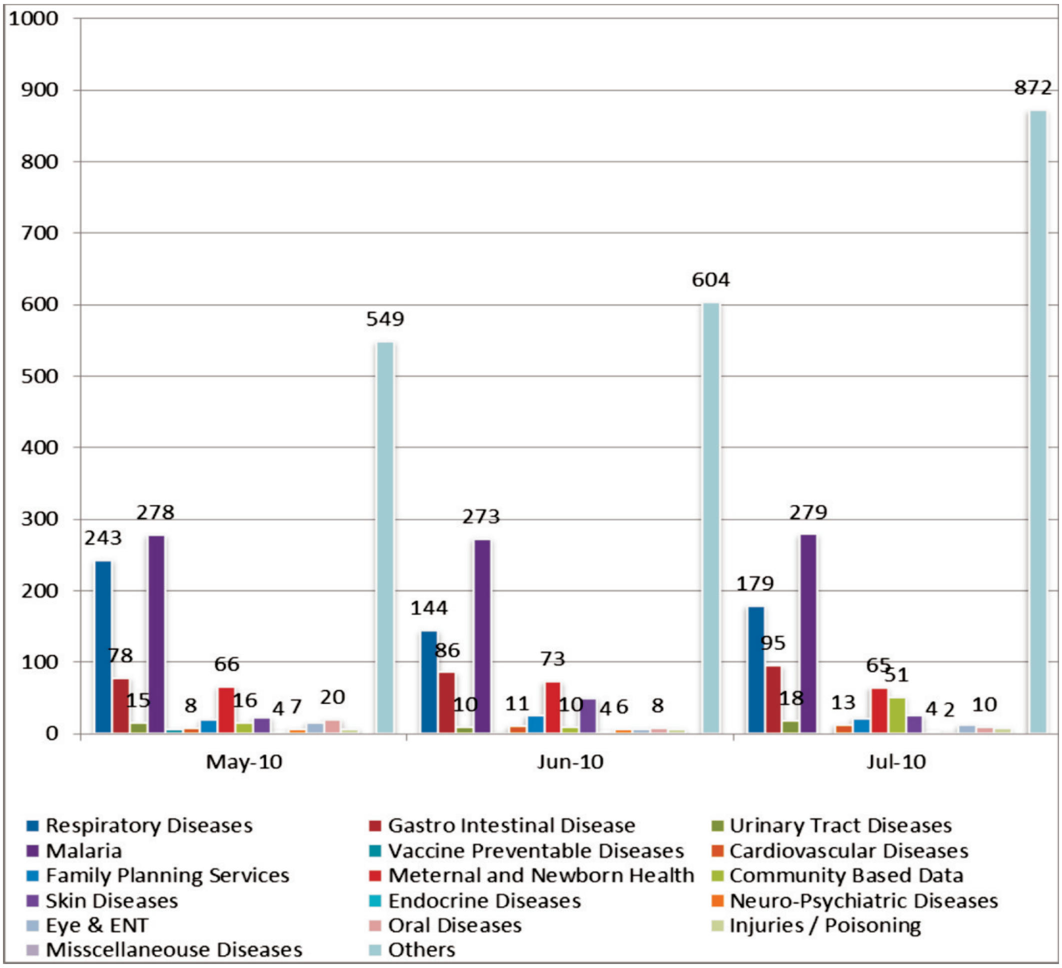


Figure 6

Pattern of Disease Before & After PHET BHU Surbandar

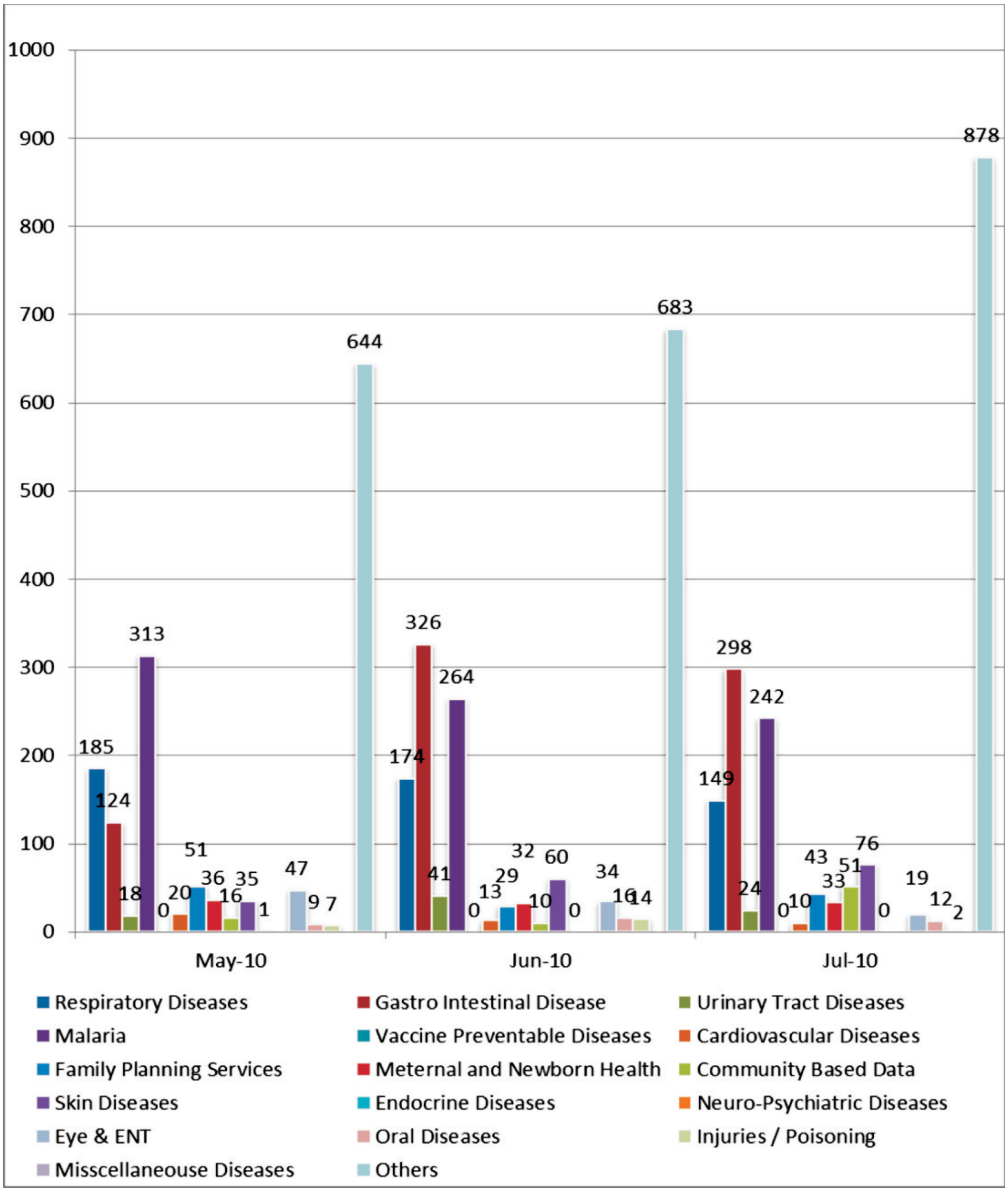


Figure 7
Pattern of Disease Before & After PHET - RHC Jiwani

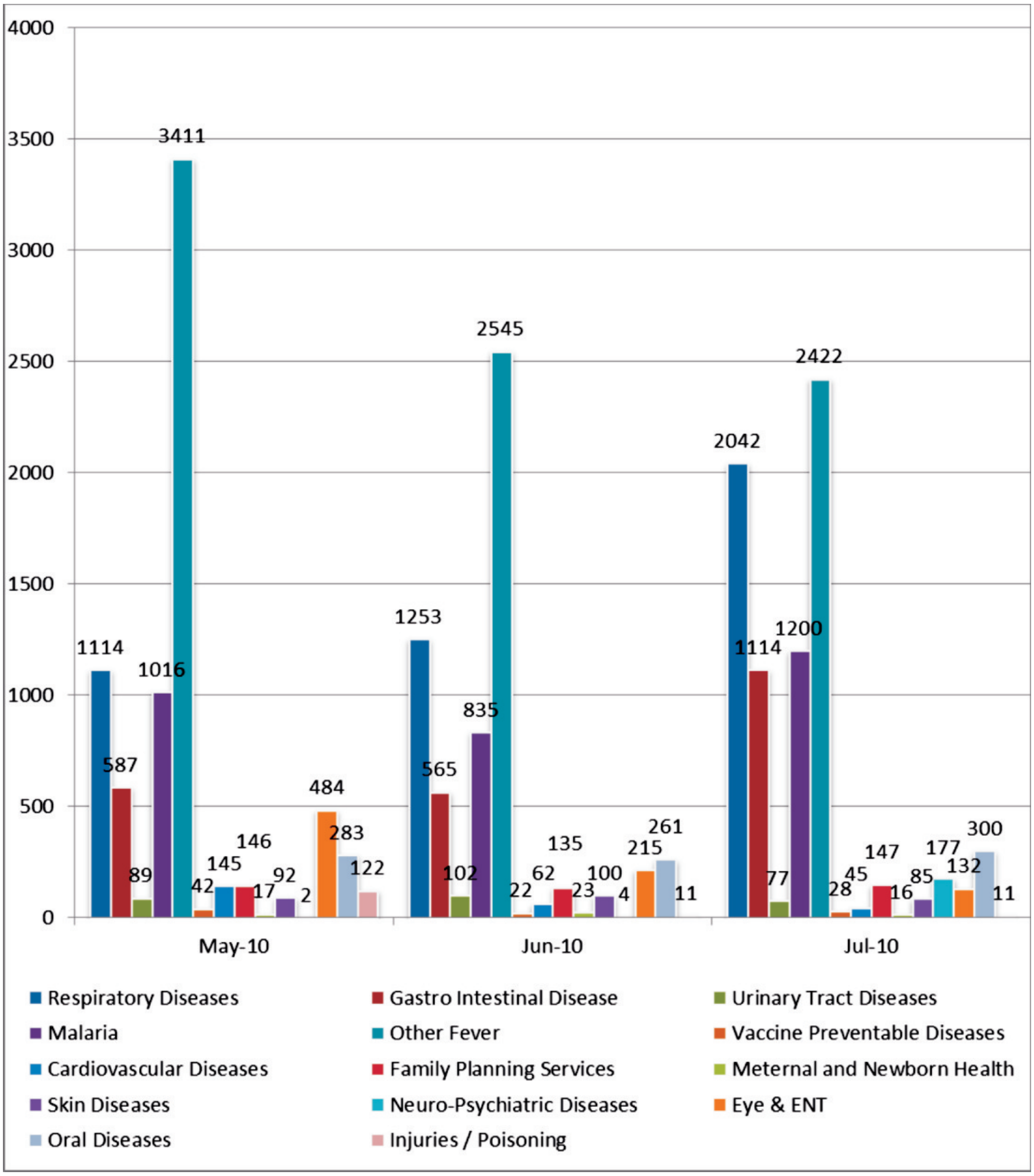


Figure 8
Pattern of Disease Before and After PHET DHQ Hospital

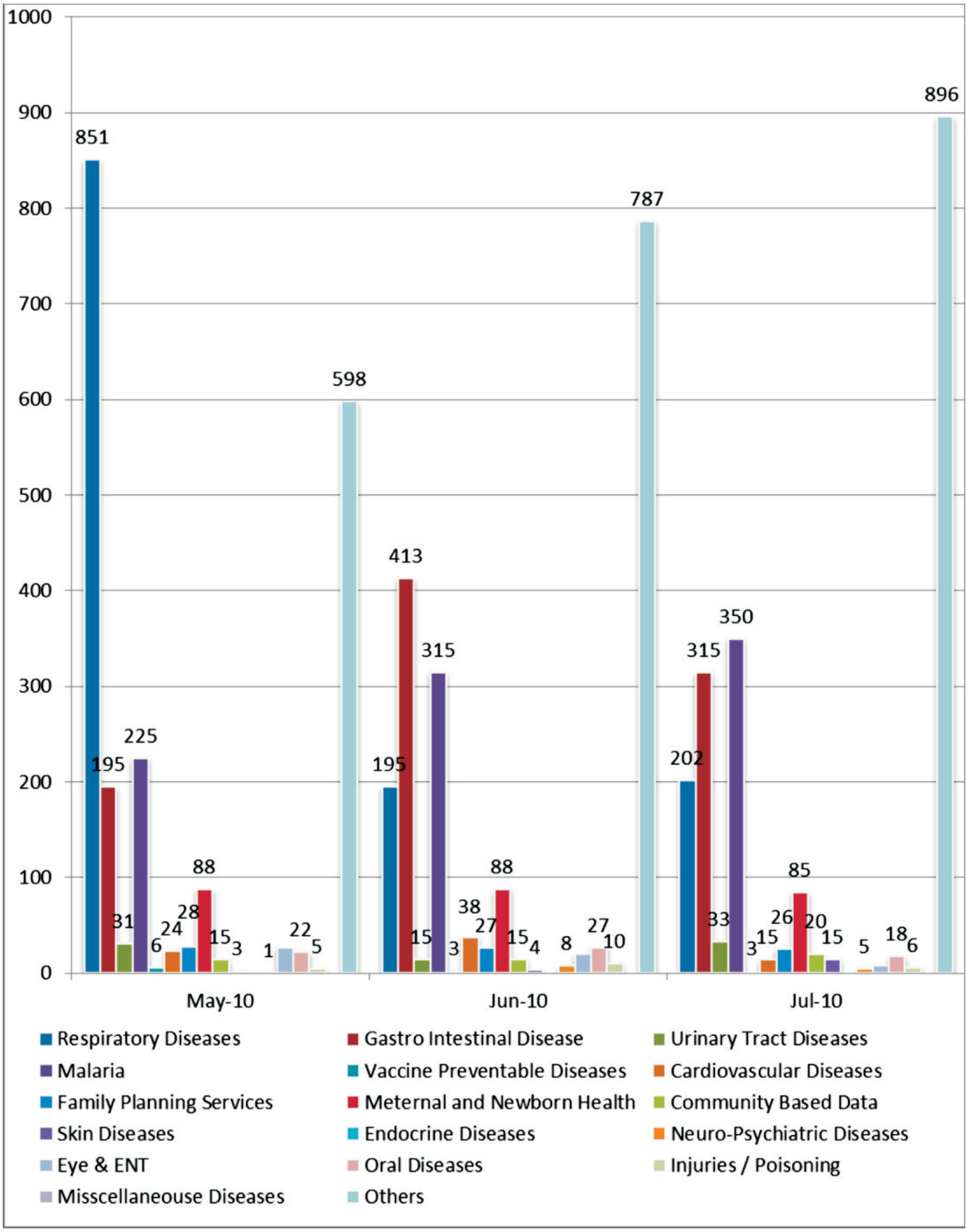


Figure 9
Pattern of Disease Before and After PHET - District Gawadar

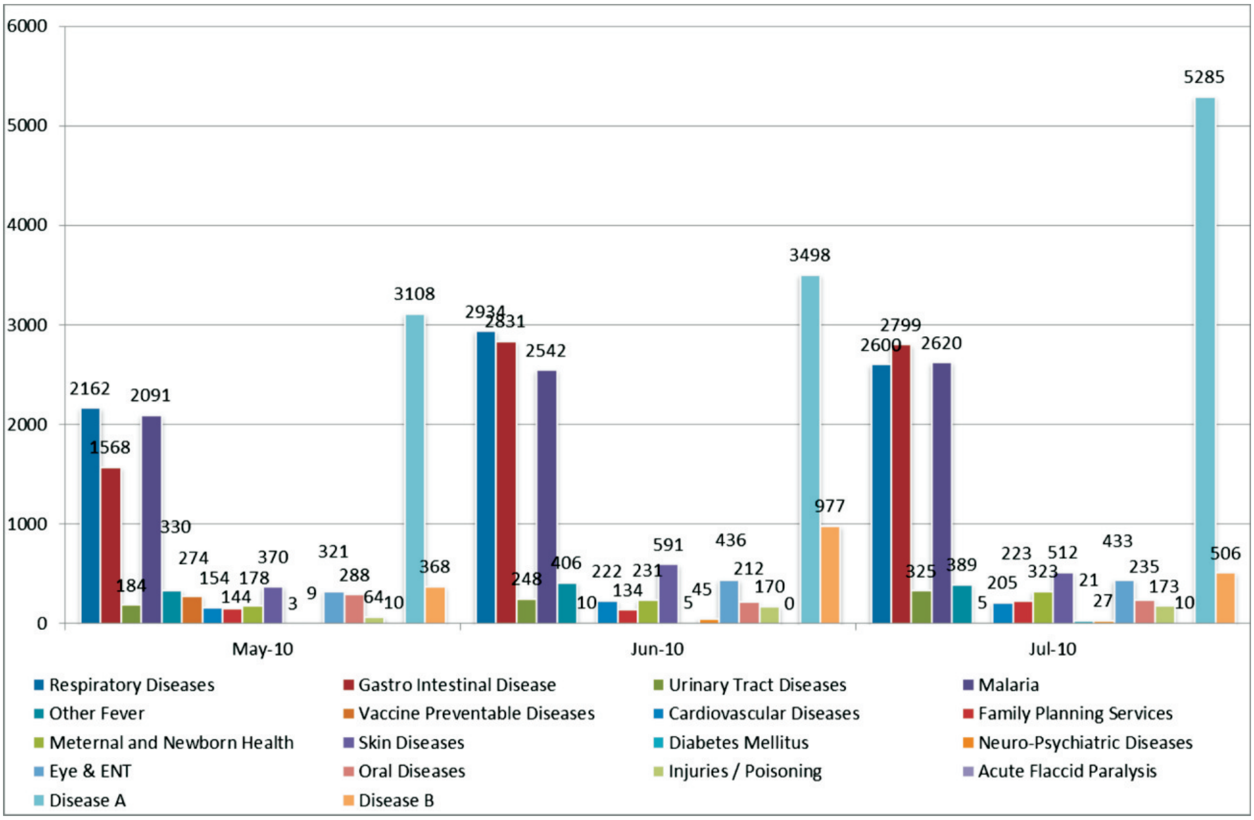
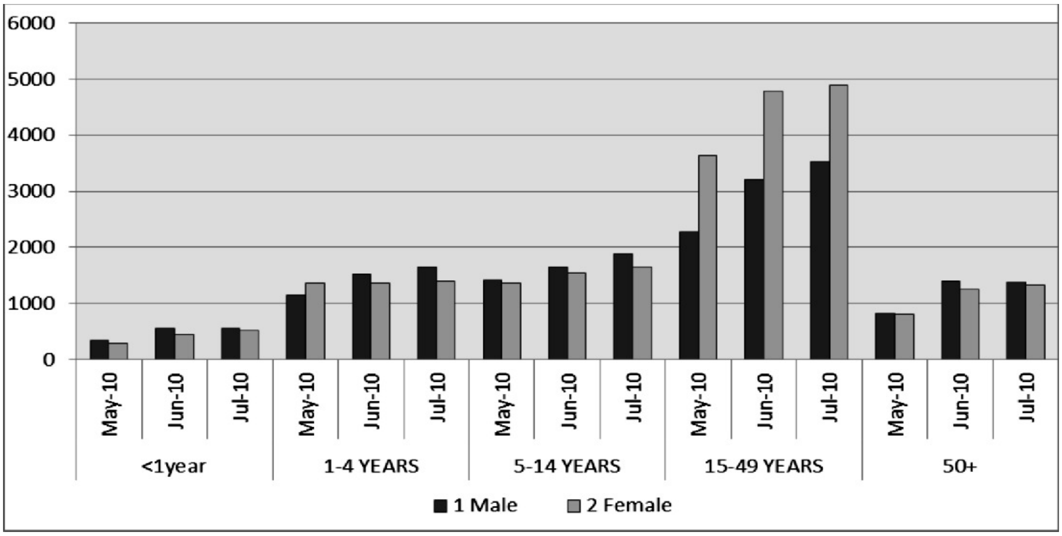


Figure 10
Pattern of Disease-Age & Sex distribution before and after PHET



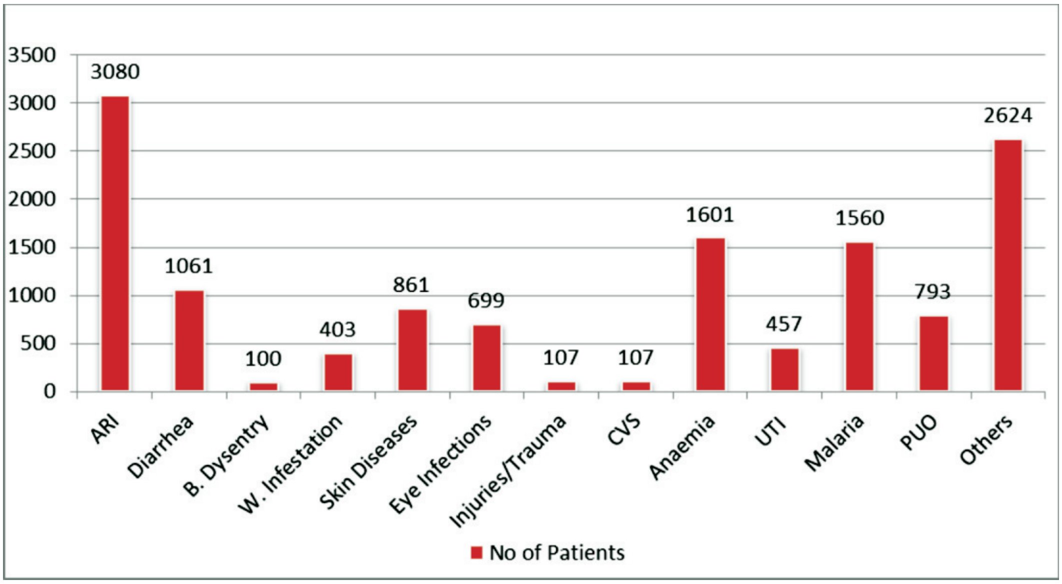
Overall disease pattern for District Gawadar before and after PHET indicates (a) marked increase in ARI, Diarrheal Diseases, and Malaria and (b) marked increase is observed for the under 1 year male and female, with an increase in females 15-49 years. The reason may be that post-disaster effects in females are more marked[22].

Medical Camps

To meet the challenges and real threats raised by the cyclone PHET, medical camps were arranged for internally displaced persons. These camps remained operational for a period of one month. These were arranged by the "Gawadar Disaster Working Forum", this forum comprised of the representatives from the 'Peoples Primary Health Care Initiative (PPHI)', the 'Save the Children (SAVE)', and 'National Commission for Human Development (NHCD)' in collaboration with the Balochistan Health Department.

The initiatives of the Forum covered the health needs and services to the effected communities. The increased burden of diseases like diarrhea, Malaria, and malnourished children were covered by the activities of this Forum. The Forum arranged for thirteen medical camps in areas where it was difficult for the communities to access healthcare facilities. A total of 13,453 patients were provided treatment in these medical camps. Among these ARI patients were 3,080: Diarrhea – 1,161; Malaria – 1,560 and nutritional problems – 1,601.

Figure 11
Pattern of Disease - Patients at the Medical Camps



Department Preparedness and Performance

The information on PHET was fully received one week in advance. Emergency preparations were initiated and series of regular meetings with district health management team (DHMT), with other relevant departments, NGOs, and District Administration were held. Need assessments were made with contingency action plans for the cyclone. Emergency was formally declared, with information to all health facilities, all staff was directed to be available on their posts.

The logistics and supplies were provided to First Level Care Facilities. The additional need of emergency medicine and particularly transportation was submitted to District Coordination Officer, who made arrangements for the same in line with the available resources. There was close liaison with provincial health department with particular focus on replenishment in the area of human resource deployment in case of short fall.

Information of cyclone was given to local communities about high intensity of the cyclone. It helped the people to evacuate to safer places and camps. All available district transport, including ambulances, remained engaged in evacuation and rescue operations with Pakistan Navy and other agencies. Medical services were provided in the camps for internally displaced persons. Safe drinking water was ensured in camps and for those communities where water supply system was damaged. The increased burden of injuries, diarrheal diseases, Malaria, nutritional problems, etc, were fully managed and provided for. Serious cases were referred by Navy Helicopter service to Karachi. Only one case succumbed to injuries, all other cases were safe and secure. Preventive measures were ensured to prevent outbreaks taking epidemic shape.

After rescue operation the priority was given to safe drinking water and food to the displaced communities. Mosquito nets were provided. The garbage disposal system in Gawadar Town, Pasni, and Jiwani, was given serious attention for system restoration for proper disposal of garbage and waste, which increased many folds due to the devastating aftermath of PHET, this work is still on-going due to the huge size of this problem.

The provincial Health department remained alive to the problems in district Gawadar and extended full operational support from the provincial HQ, till the end of emergency phase, inclusive of medial teams and medicines.

Ironically PHET also had an encouraging side to it. This was the first time ever that the Pakistan Metrological Department was recognized in their full public service role. It was only due to their timely warning that not only that the Pakistan Metrological Department's information / warning became highly useful in preparedness, it made the people alert and allowed to be evacuated to safer places, the fishermen were not allowed to go to the sea for fishing and those who were already out at sea returned heeding the warning, so thousands of fishermen life was saved. This is a sharp rather glaring contrast to the past when such vital information was not made available, resulting in heavy losses. However, due to the diligence of the Pakistan Met department, despite the highest level of dangerous nature of PHET the losses due to heavy rains are actually no comparison to the plausible situation that would have struck had the Pak Met department's warning not been there. The Met department must be recognized for their services with appreciation and thanks.

Obstacles

Communication was paralyzed due 5-6 feet water on roads. The main Coastal Highway was broken at many places. Internal communications linking villages to tehsil and trade centers were severely damaged. This directly affected the communities to reach health facilities and working of the referral system. Fuel costs were increased and due to this the rescue operation was also affected as the adequate funds could be made available timely. The fundamental and most serious obstacle was the damage and destruction caused to the residences of the people and to the health infrastructure by the PHET cyclone.

Recommendations

The major suggestions recommended consequent to the analysis of observations made during this study are:

- Ministry of Health in collaboration with the country office of WHO in Pakistan should initiate an exercise on the issue of climate change and health in the region.
- It is established from this study that any health system which is adequately functional as a routine, before any catastrophe, is the key to a successful response to disasters whether climate associated or otherwise. Therefore, it is now yet another point forcing the necessity to ensure rectification of and making the existing health system responsive to public needs in normal times, which will ensure a better performance during disasters.
- The highly, rather the singular pivotal, beneficial experience is of the timely warning of the Met department. It is therefore recommended that an Early Warning System should be established for each population pocket under threat from such events.
- National Disaster Management Authority and Provincial Disaster Management Authority plausibly have a disaster management plan for each district. Funds were allocated for an authority that would be established at each district headquarters with their job descriptions specified for the objective of mitigating in a disaster, it has however not materialized yet. It is therefore recommended that contingency district disaster plans must be developed, and kept under proper rehearsal for all who would be responsible in such a situation.
- In continuation to the above, it is recommended that special focus should be made for replenishing human resource from outside the disaster zone for disaster mitigation, an element which did not figure out well during this study. Such human resource should be well prepared and trained in advance.
- In light of the understanding emanating from this study it is recommended that each new health facility, hospital, and school or college building must be designed, built and maintained, so that the chance of it continuing to function in a disaster situation is assured.
- The remarkable performance in disaster mitigation by the mid-level district management, the Gawadar Disaster Respond Forum, Pakistan Army, Pakistan Navy, and particularly the district health establishment with the DHMTs, the than District Coordination Officer, and the community at large, in coping with the cyclone PHET 2010, stands proof to the fact that if the people decide that they will try and help themselves instead of looking towards the top management to guide the way and extend help, a lot of loss can be controlled, if not prevented altogether. It is therefore recommended that the experience of mitigation practiced for PHET should be made a part of essential community training and professional's training at the provincial level.

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