International Journal of Contemporary Issues in Social Sciences
Volume 3, Issue 2, 2024 ISSN(P):2959-3808 | 2959-2461

IMPACT OF CLIMATE CHANGE ON HEALTH COST: A CASE STUDY OF LAHORE, PAKISTAN

Muhammad Tayyab

Corresponding Author: *

Received: 26 March, 2024 **Revised:** 25 April, 2024 **Accepted:** 10 May, 2024 **Published:** 21 May, 2024

ABSTRACT

This study analyzes the impact of Climate Change[1][2] on health in Lahore. The data have been collected from selected hospitals of Lahore. The study focuses on rising Climate Change and health. The data of cardiovascular diseases (indicator of state of health) from different hospitals of Lahore have been collected to assess the relationship between health and Climate Change. The study has found inverse relationship between cardiovascular diseases and Climate Change for Lahore. This study also calculated the direct and indirect cost of cardiovascular diseases (CVD) for Lahore. The findings of this study show that direct cost of CVD is much larger then indirect cost. However indirect cost is higher then the medicine cost while less then the total cost of cardiovascular diseases.

Keywords: Climate Change, Temperature, Cardiovascular disease, logistic regression

INTRODUCTION

All the countries in the world, whether developed or developing, are struggling to achieve sustained economic development to eradicate poverty and to increase the welfare of society. In developing countries like Pakistan, climate change is an additional burden because socioeconomic and ecological systems are already facing pressures caused by rapid population growth, industrialization and economic development. The annual presage estimated cost of environmental degradation and natural resource damages in Pakistan is about Rs 365 billion which is one billion rupees per day or six percent of GDP.(World Bank, 2006).

Economically and ecologically important regions are significantly damaged by the impacts of climate change, such as changes in atmospheric temperature. Consequently, many valuable economic functions are threatened by climate change. Climate change is projected to impact the sustainable development of most developing countries in Asia [Stern (2007)].

Wealthy energy consuming nations are more responsible for climate change (International Energy Outlook, 2003). However, developing countries are more vulnerable and are immediately affected by climate change. Developed nations contributed greatly to combating climate change and are continuously accelerating towards the solutions. But developing countries, which are more vulnerable, are far behind. Thus, the topic of climate change and health needs to be researched especially in developing countries which are more vulnerable and are immediately affected, so that a viable solution may be found quickly in order to save human capital and to minimize the damages and losses in the future by devising the policies. A decision needs to be reached as to whether losses incurred by climate change should be borne today or in the future.

Human beings are the cause and effect[3] of climate change. The effects of climate change could be linked, directly and/or indirectly, with the health

[1] "Climate is usually defined as the "average weather", or more rigorously, as the statistical description of the weather in terms of the mean and variability of relevant quantities over period of several decades (typically three decades as defined by WMO). These quantities are most often surface variables such as temperature, precipitation and wind, but in a wider sense the "climate" is the description of the state of the climate system." (IPCC glossary).

[2] For the purpose of this study, we have taken only one variable, i.e., temperature as the main indicator of climate change.

[3] Human beings are cause because they are responsible for emissions of anthropogenic emissions and they are effect because they are facing damages especially health damages through climate change.

hazards faced by individuals. Healthy human beings have the capability to overcome the problems caused by climate change; however unhealthy humans face an exacerbation of the problems like workdays loss, absence from school, restrictive activity days etc. Therefore, this study focuses on impacts of climate change on human health.

Climate Change and Health

The effects of global climate change can be potentially very detrimental for the next century. The possible aftereffects include regional increases in high-temperature events, outbreaks of diseases affecting human health and safety adversely, especially among poor communities with high population densities.

If we review history, top ten warmest years in the history (1880-2014) are between 1998 and 2014(NOAA, 2014). According to IPCC, climate change is likely to have a wide-ranging and mostly adverse impact on human health, accompanied by a significant loss of life.

By 2020, more than half of Asia's urban population will be at great risk from heat waves, pollution and diseases while straining infrastructure (ADB, 2008). One of the major health impacts of climate change is the increase of heart-related diseases especially cardiovascular diseases (McMicheal et al., 2006; Haines and Patz, 2004). The highest death rate in world is 26 percent of total deaths due to cardiovascular diseases in south Asia region (WHO, 2005). IPCC also concludes, "The range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time." (IPCC 2007)

It is further stated that the susceptibility of the human and natural system to climate change varies greatly from region to region (IPCC 2007). As urban areas and the population of urban areas increases, vulnerability to heat-related mortality seems likely to increase in future. More vulnerable regions are temperate latitudes, and regions around the pacific and Indian oceans [Patz, et al.(2005)].

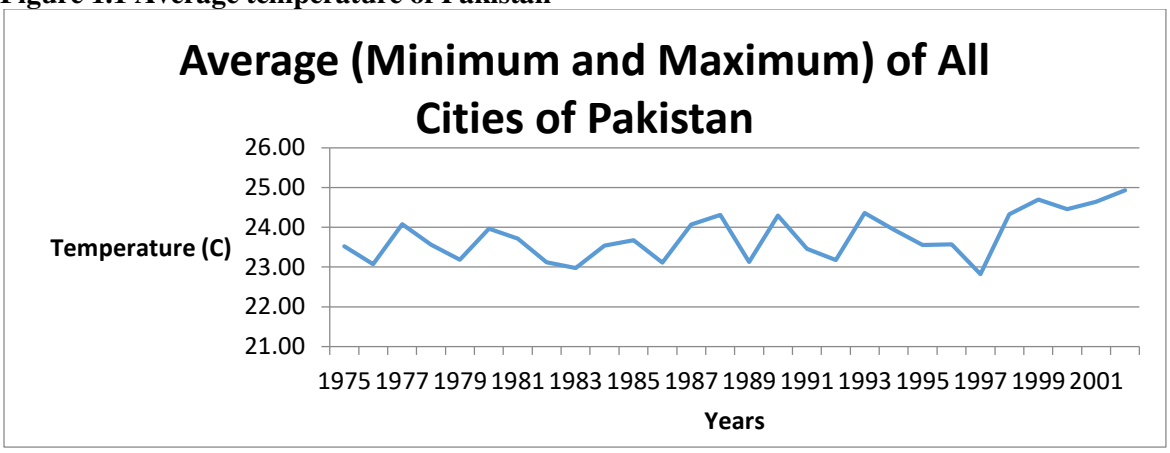
There are several limitations to the available information. Foremost is that most empirical climate-health studies and national assessments of health risks from future climate change have been done in high-income countries. Most epidemiological studies of extreme temperatures have been done in Europe and North America [Basu, (2002); McGeehin, (2001)]. It has been observed that most of the studies have been conducted in Canada, USA and Europe and a couple of studies have taken place in Asia[4]. With respect to Asia, some research on this topic has been conducted in India; however, as far as I know, no study has been carried out in Pakistan. It has also been concluded that most of the effects of climate change are adverse effects. To estimate the health cost associated with climate change in developing countries, policy makers are often forced to extrapolate results from studies conducted in industrialized countries. These extrapolations, however, may be inappropriate.

Temperature Trends

Historical temperature of Pakistan from 1970 to 2004 revealed that temperature has changed from 0.2 to 1.0 C°. Figure 1.1 clearly shows an upward trend of temperature of Pakistan.

[4]For detail see the chapter of Literature Review.

Figure 1.1 Average temperature of Pakistan



According to the Economic Survey of Pakistan the temperature trends of major cities of Pakistan are shown in Figure 1.2. It shows slight fluctuation of temperature (mean of Maximum) in Pakistan's major cities from 1975 to 2002. While Figure 1.3 shows a significant increase in the temperature (mean of minimum) of Pakistan's major cities except for Quetta.

Figure 1.2 Mean of Maximum Temperature of Pakistan

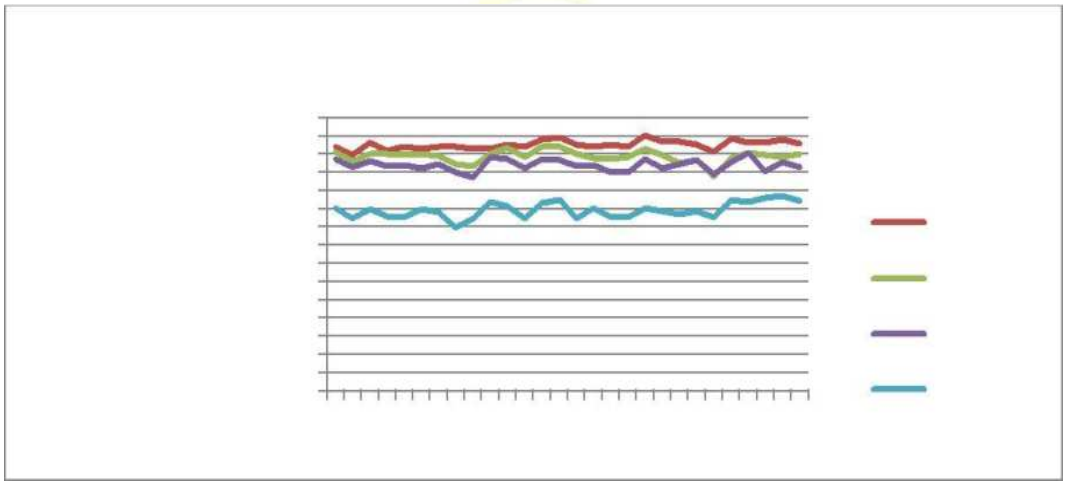
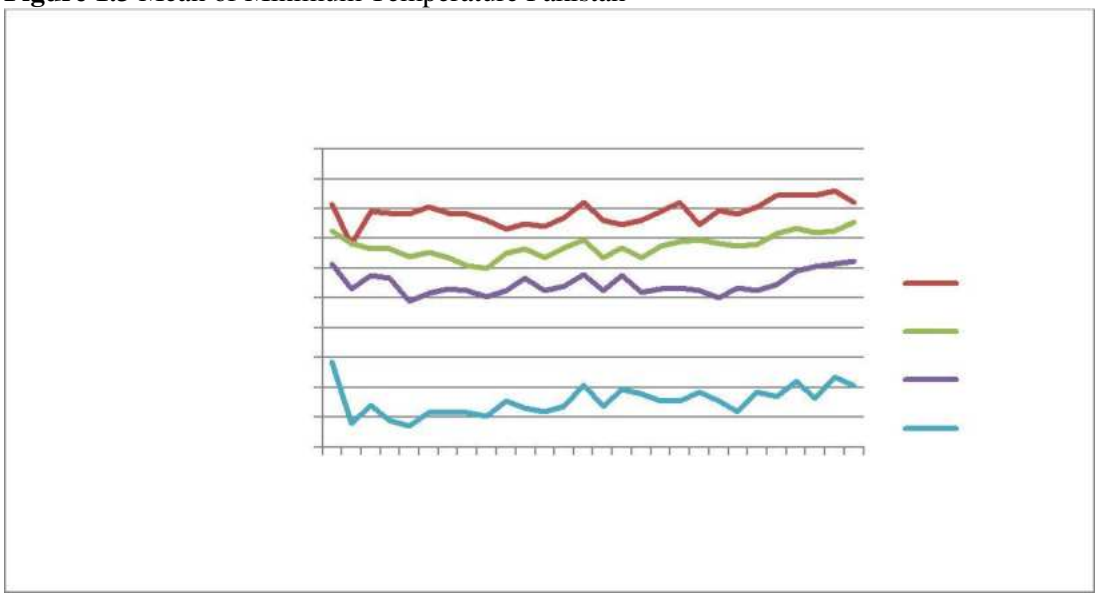
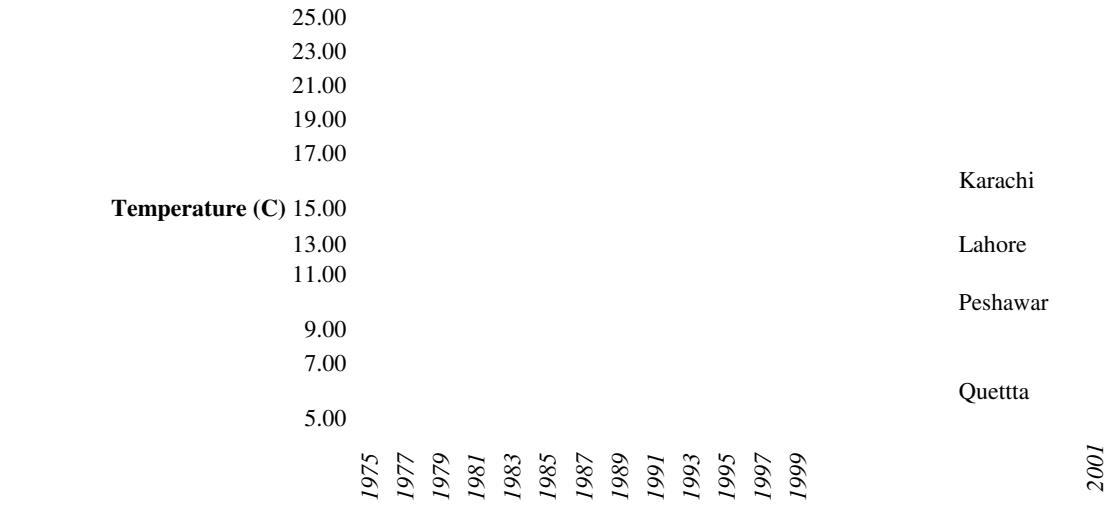




Figure 1.3 Mean of Minimum Temperature Pakistan



Temperature (Mean of Minimum) of Major Cities of Pakistan



Data Collection and Methodology

In this section data collection techniques and description of different data sets have been explained briefly. In this section the relationship of Climate Change with the number of heart patients of cardiovascular disease, an indicator of health, in Lahore is examined. Daily data is required for this study as the effect of temperature is visible after an interval of three to seven days.

The primary objective of this study is to calculate the health cost of the people of Lahore. Other objectives are to quantify the losses of the economy due to adverse health effects through Climate Change and to help policy makers to develop the policies for sustainable development and to avoid the adverse impact of Climate Change. For this purpose two data sets were required. One was related to temperature and other was related to health. The data sets were collected from two sources. The First data set was obtained from the meteorological department and while second data set was obtained various hospitals to check the relationship between climate change and health and to calculate the health cost.

Generally secondary data sets on environmental indicators and their economic value are not available. For this study, we have collected data from different hospitals situated in Lahore. Other than this some secondary data sets, if available, have been used. Description of different data sets and their collection procedure is given below.

Meteorological Data[5]

The Meteorological Department Karachi provided the Lahore's daily temperature data from 1980 to 2008. This included the maximum and minimum temperature of Lahore city based on a monthly average. Daily temperature of 2009 & 2010 is available online at the meteorological department of Pakistan. Historical temperature of Pakistan from 1970 to 2004 revealed that temperature changes from 0.2 to 1.0 C°.

Lahore experiences all four seasons. May and June are considered to be the hottest months while December and January are thought to be the coldest months. The temperature of Lahore city ranges from 1.2 °C to 46 °C. Lahore's seasons can be divided into four categories according to the temperature.

- Summer [June – September]
- Autumn [October – November]
- Winter [December – February]
- Spring [March – May]

Data From Hospitals[6]

As mentioned earlier that the effect of temperature on cardiovascular disease (CVD) is visible in three to seven days therefore daily data of cardiovascular diseases from three hospitals of Lahore has been collected. The names of the hospitals are as following:

- Punjab Institute of Cardiology, Lahore.
- Jinnah Hospital, Lahore.
- Sir Ganga Ram Hospital, Lahore.

Punjab Institute of Cardiology (PIC) is the main hospital for cardiology cases. The major problem in collecting the data was that no hospital had

[5] I am thankful to **the Director** of Climatological Data Processing Centre, Karachi for providing me the daily data of temperature for different cities from 1980 to 2008. Daily temperature data is available on payment. For the students they provide limited data sets without any payment. Otherwise everybody have to purchase the data. Due to financial constraints, the only data which was provided (without payment) was used in this study i.e. temperature.

[6] It is also worth mentioning here that it took around three months to collect data from hospitals. Due to time constraint and problems mentioned in this study, we were able to collect the daily data only for four years.

computerized records of the data. All the records were written in registers. After obtaining permission from the hospital's Medical Superintendent (M.S.), the related department was contacted. The survey team acquired the records manually from registers on the predefined performa and then transferred the data to computers. The head nurse and store keeper were very cooperative and helpful in overcoming any problems faced while reading the registers. At times, the doctors and registrar's help was also sought. The survey team also conducted many interviews with Professors, Associate Professors, Assistant Professors, Consultants and doctors of the respective departments to get further information regarding cardiovascular diseases and their symptoms.

Data authentication is the primary responsibility of this study which is why the same team of highly qualified and experienced members was hired. Following is a brief description of the data collected from hospitals.

Punjab Institute of Cardiology (PIC):

Daily data of cardiovascular diseases from PIC emergency department was collected from 2005 to 2009. The data was so large that its collection required more time. Time and resource constraints especially financial constraints forced us to limit the time period to 2005 - 2009. Other then, the hospital staff did not have spare time to assist us in obtaining all the data from the storeroom's registers. Nevertheless, they gave registers belonging to different months of various years. Monthly data was available at the computer department. However, the data was categorized according to ward not type of disease. Monthly data of different wards was also collected in order to ascertain the percentage share of cardiovascular cases in the total number of emergency cases. This helped us to estimate the daily data which was not given by the emergency ward. The daily data which was collected from the registers and monthly data provided by the computer department were helpful in estimating the missing daily data. Weight was given to the daily data collected from the registers. The missing data was estimated by applying this weight to the monthly data provided by the computer department. For example a weight has been assigned to the daily data of June 2007 by dividing the daily data of June 2007 with the monthly data of June 2007 and this weight was applied to missing data for June of different years. By doing so the missing values were estimated.

The formula which was used to convert the monthly data into daily data is as under.

$$WDD_{mi} = DDR_{mi}/MD_m$$

Where

WDD = Weight of Daily Data

DDR = Daily Data from registers

MD = Monthly Data from Computer Dept.

m = jan, feb, mar …….dec (month)

i = 1,2,3,…….31 (no of days)

Then this calculated weight was applied to other months whose daily data was not available but monthly data was available. In short the following formula was applied.

$$DD = WDD_{mi} * MD_m$$

Where DD = Daily Data

A Brief Description of Punjab Institute of Cardiology (PIC) Data:

The daily data of PIC which was collected is from period January 1, 2005 to April 17, 2010. The total number of cardiovascular patients in this period was 42710.This is the total numbers of emergency cases available in the computer department for 2007, 2008 and 2009 only. The figure for 2005 and 2006 was not available. Hospital authorities clarified that they started compilation of emergency cases in 2007. Before 2007 they had data for different wards but not for the emergency ward. For 2010 the data was still not compiled. Consequently, the data was collected from the emergency ward's registers. The breakup of the monthly total emergency cases, cardiovascular cases and the percentage of the cardiovascular cases to total emergency cases are reported in Table 1.1

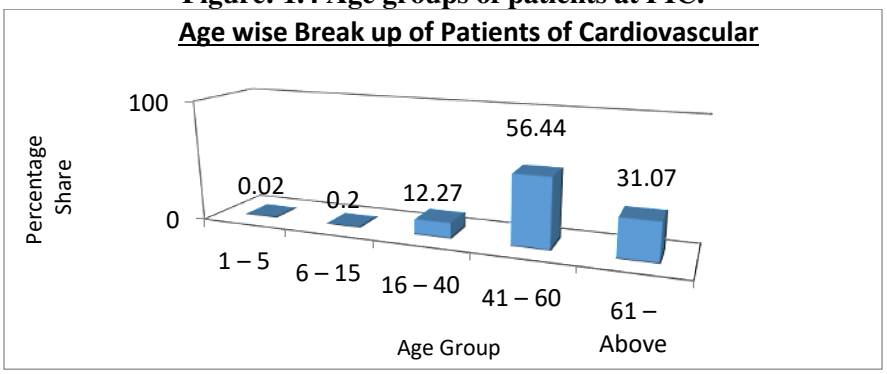
Table: 1.1 Emergency cases at Punjab Institute of Cardiology, Lahore

	2005			2006			2007			2008			2009			2010		
	Total # of Emer Gency Cases	# of CV Cases	perce Ntage of CV Cases	Total # of Emer gency Cases	# of CV Cases	perce ntage of CV Cases	Total # of Emergency Cases	# of CV Cases	Perce Ntage of CV Cases	Total # of Emer gency Cases	# of CV Cases	perce ntage of CV Cases	Total # of Emer Gency Cases	# of CV Cases	perce ntage of CV Cases	Total # of Emer gency Cases	# of CV Cases	t
Jan	N/A	712		N/A	935		5839	1081	19	6295	1163	18	7080	1219	17	N/C	820	
Feb	N/A	594		N/A	654		5738	711	12	6414	778	12	7946	854	11	N/C	681	
March	N/A	643		N/A	740		6360	770	12	6190	812	13	6671	924	14	N/C	672	
April	N/A	577		N/A	590		5977	711	12	6236	644	10	6921	730	11	N/C	433	
May	N/A	605		N/A	571		6014	662	11	6246	629	10	6939	763	11			
June	N/A	510		N/A	516		5665	601	11	6263	573	9	7088	669	9			
Jul	N/A	525		N/A	496		5905	545	9	6573	548	8	7237	664	9			
Aug	N/A	577		N/A	601		5830	662	11	6404	609	10	7684	706	9			
Sep	N/A	635		N/A	576		5141	556	11	6069	537	9	7233	545	8			
Oct	N/A	596		N/A	529		5769	532	9	6792	523	8	7232	613	8			
Nov	N/A	592		N/A	606		5930	659	11	6686	602	9	6528	595	9			
Dec	N/A	791		N/A	714		6638	635	10	6569	651	10	7495	744	10			
Avg		**613**			**627**		**5901**	**677**	**11**	**6395**	**672**	**11**	**7171**	**752**	**11**		**652**	

Source: Hospital source

Out of the total number of cardiovascular cases, 73.82 percent were male while 26.18 percent were female. In PIC the patients came from 93 cities in this period. Out of the total number of cardiovascular patients, 72.78 percent belonged to Lahore city and the remaining 27.22 belonged to other cities. The patient's age ranged from 4 years to 120 years. The largest number of patients fell in the age group of 41 – 60 years. The Figure 1.4 shows the breakup of the patients according to age.

Figure: 1.4 Age groups of patients at PIC.



Source: Hospital sources

As shown in the Figure 1.4 the major portion of the patients fall in the age group of 41-60 years. This age group is the main concern for two reasons. The first concern is that this is a major portion and the second concern is that a higher fraction of population in this age group is economically active population. In addition, in this age group we have experienced human capital. The majority of people retire after this age. It is imperative to make a policy which places focus on this specific age group, in order to benefit from their experience and knowledge.

Most of the patients at PIC, 72.78 percent are from Lahore. Other than Lahore, major cities whose major cases have been moved to PIC are reported in Table 1.2.

Table: 1.2 List of cities and their percentage share of cardiovascular patients in PIC, Lahore.

City	percentage of Cardiovascular Cases
Kasoor	13.48
Sheikhupura	12.67
Gujranwala	6.58
Narowal	5.91
Nankana Sahib	5.25
Sahiwal	4.08
Pakpattan	4.04
Sargodha	3.97
Okara	3.82
Gujrat	3.05
Sialkot	3.05
Hafizabad	2.76
Bahawal Nagar	2.72
Faisalabad	2.65
Others (78 cities)	25.97
	100.00

Source: Hospital sources

Jinnah Hospital:
Daily data of cardiovascular diseases was collected from Jinnah hospital. This data was taken from the outpatient department from 2005 to 2010. The hospital management gave registers belonging to different months of various years. Monthly data was available in the computer department. But it was total number of patients of cardiology and related to inpatient cases and not separate for the cardiovascular disease. The authorities in the outpatient department said that they had misplaced the registers of years 2006 and 2007.

A Brief Description of Jinnah Hospital Data:
The daily data collected from Jinnah hospital is from May 1, 2005 to January 25, 2010. Total number of cardiovascular patients in this interval was9164. Total number of outpatient cases with reference to cardiology was available for 2005, 2006, 2007, 2008 and 2009 only. For 2010 the data has not been compiled yet. Earlier data was available in registers but the hospital authorities refused to bring the old data from store. The breakup of the monthly total outpatient cases of cardiology is reported in Table 1.3.

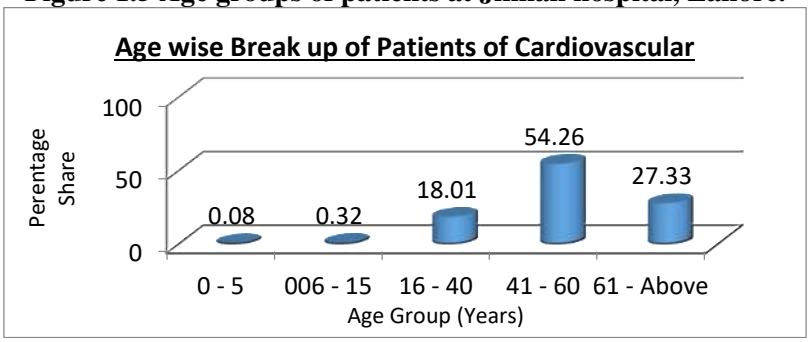
Table: 1.3 Numbers of cases of cardiology at Jinnah hospital, Lahore

	2005	2008	2009
January	N/A	N/A	256
February	N/A	N/A	261
March	N/A	325	262
April	N/A	312	265
May	313	271	293
June	253	206	325
July	224	252	438
August	231	218	730
September	252	168	562
October	214	208	497
November	164	206	338
December	140	209	420
Total	**1791**	**2375**	**4647**

Source: Hospita
N/A = Not Available

Out of the total cardiovascular cases in Jinnah hospital in the reported period, female patients have a share of 49.76 percent while male cases are 50.2 percent. The age of the patients ranges from 4 to 106 years. As shown in the Figure below the major portion (54.26 percent) of the patients lies in the age group of 41-60 years. This age group is our main concern for the reasons as explained in previous section. The age wise frequency distribution of the patients is given in Figure 1.5.

Figure 1.5 Age groups of patients at Jinnah hospital, Lahore.



Source: Hospital sources

As shown in the Figure given above the major portion of the patients lies in the age group of 41-60 years. It is so in the PIC case as well. Consequently, the policy and implications of Jinnah hospital data are the same as mentioned in the PIC category.

Sir Ganga Ram Hospital:

Daily data of cardiovascular diseases was collected from Sir Ganga Ram hospital. This data was taken from the inpatient department from 2006 to 2009. They gave patients files pertaining to different months of various years. Monthly data was available in the computer department. However, the information was related to the total number of patients in each block; as such it was not divided according to the wards or cardiovascular cases. In 2009 they started compiling monthly data according to wards. Currently they hold monthly data for all cardiology patients. Nevertheless, it is of prime importance to compile the data separately according to the different diseases of cardiology like cardiovascular disease.

A Brief Description of Sir Ganga Ram Hospital Data:

The daily data of Sir Ganga Ram hospital was collected from January 1, 2006 to December 31, 2009. The total number of cardiovascular patients in this period was 951. Data has been collected from the inpatient department's files. Earlier data was available in files but hospital authorities refused to bring the old data from store. The breakup of the monthly total inpatients cases of cardiovascular patients is shown in Table 1.4.

Out of the total number of cardiovascular cases in Sir Ganga Ram hospital during the reported period, female patients hold a share of 32.62 percent while male cases have a share of 67.38 percent.

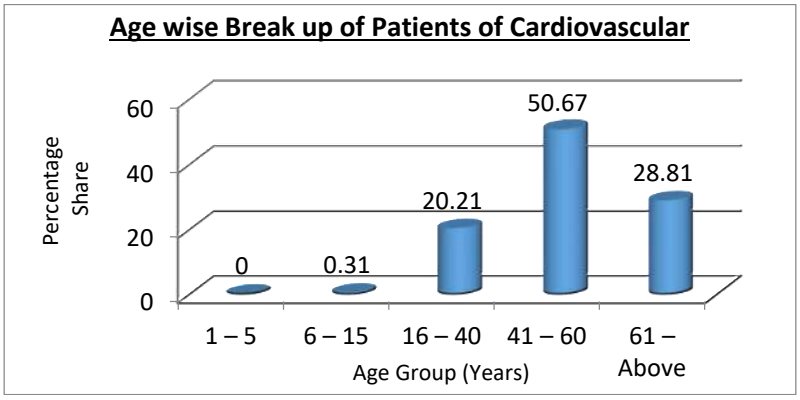
Table: 1.4 Number of cases of cardiovascular patients at Sir Ganga Ram hospital, Lahore

Months	2006	2007	2008	2009
January	29	15	19	26
February	23	21	18	20
March	18	19	17	5
April	10	18	27	13
May	11	19	15	18
June	14	17	16	12
July	17	22	25	26
August	25	34	27	21
September	27	18	24	18
October	23	23	21	15
November	26	24	9	22
December	24	14	23	23
Total	**247**	**244**	**241**	**219**

Source: Hospital sources

The age of the patients ranges from 13 years to 92 years. The patient's age frequency distribution is given in Figure 1.6.

Figure 1.6 Age groups of patients at Sir Ganga Ram hospital, Lahore.



Source: Hospital sources

As shown in the Figure given above the major portion of the patients falls in the age group of 41-60 years. This is the same for PIC and Jinnah hospital. Most of the patients in Sir Ganga Ram hospital are from Lahore which are around 92.46 percent. Other than Lahore the other major cities from where cases were registered are shown in Table 1.5.

Table: 1.5 List of cities and their percentage share of cardiovascular patients in Sir Ganga Ram hospital, Lahore.

City	Percentage of Cardiovascular Cases
Narowal	0.83
Kasoor	0.62
Okara	0.52
Sheikhupura	0.52
Others (30 cities)	5.05

Source: Hospital source

Household Health Production:

Since the dependent variable is not a continuous variable but it is a discrete variable indicating the incidence of cardiovascular disease. The data collected from the hospitals gives us the count types of events of health cases related to cardiovascular disease. In this case, the appropriate regressions model is Poisson model because it accounts for the discrete nature of dependent variable and least square does not consider this type of variable. So for estimation purpose in this study Poisson regression model has been used.

$$Prob(Y=y/x) = \mu^{Y}e^{-\mu} / Y!$$

$$Y=0,1,2,\ldots\ldots\ldots$$

Where variable Y is the count variable i.e. number of patients/visits of hospitals and it takes non-negative integer values and Y! is the Y factorial.

The resulting regression will be nonlinear in parameter. By taking the log we will obtain the following regression which is linear in parameters.

$$Ln\ \mu_i = \beta_0 + \beta_1 X_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots\ldots \beta_{ni} X_{ni}$$

Where X's are some of the variables that affect the mean value of our dependent variable i.e. number of visits of hospital.

There are two important points in the Poisson regression. First, an important assumption is that the events occur independently over time. Second, a unique feature of the Poisson distribution is that its variance is equal to its mean value.

$$Var(Y) = \mu$$

This paper concludes with the technique used for estimation based on the type of data collected. As mentioned earlier that dependent variable is discrete type so it is concluded that the best technique for this type of data is Poisson regression technique. In next section the author has estimated the effect of an

increase in temperature on the mean value of number of patients in hospitals by using the Poisson regression model.

Impact of Climate Change on Health and Health Cost

In this section focus is on analysis of the health sector particularly the health of cardiovascular patients. As mentioned earlier, secondary data in developing countries with respect to health indicators is insufficient. So the data have been collected from the following three hospitals in Lahore.

1. Punjab Institute of Cardiology, Lahore.
2. Jinnah hospital, Lahore.
3. Sir Ganga Ram Hospital, Lahore.

For the estimation purpose, in this study, the daily total numbers of patients of cardiovascular disease in each of Lahore's hospitals are used and regressed against the daily maximum temperature in Lahore (the data was collected on a daily basis). When the response variable is count type or discrete type, then the more appropriate method is the Poisson method which is used here. The estimated results are as follows.

Aggregates of Three Hospitals of Lahore.

The results of the regression are as follows:

$$Log(Y) = \beta_0 + \beta_1 X$$

Table 1.6 Regression results of impact of temperature on CVD

Dependent Variable: patagg			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	4.027867	.0333842	120.65 [0.000]
Maxagg	-.0141384	.0010648	-13.28 [0.000]

Pseudo R-Squared 0.0325

Where

Patagg= Daily aggregate number of patients of three hospitals of Lahore city.
Maxagg = Daily maximum temperature of Lahore city.

The results, reported in Table 1.6, indicate that in Lahore, the relationship between the number of cardiovascular patients and the maximum temperature is negative. It means that if there is an increase in the temperature the number of heart patients of cardiovascular decreases. The results of Table 1.6 can also be written in the following form:

$$Patagg = e^{4.03} \times e^{-0.014(Max)} \quad \ldots\ldots(1)$$

The equation given above is also useful in calculation of the relative risks with reference to the number of cardiovascular patients which increases as a result of the change in the maximum temperature. For example the relative risk of the 30 degree celsius with the increase to 31 degree celsius can be calculated as follows:

$$e^{-0.014(30)} / e^{-0.014(31)} = 1.014 \quad \ldots\ldots(2)$$

The negative sign of the coefficient coincides with the opinions expressed by heart specialists during their interviews. They suggested that in Lahore the relationship of the number of cardiovascular patients and the maximum temperature is negative. In

developed countries it is positive. The temperature-mortality relationship varies considerably by latitude and climatic zone. People in warmer cities are affected by colder temperatures, and people in colder cities are more affected by warmer weather. (Curriero FC, Temperature and mortality in 11 cities of the eastern United States 2002). For example in the UK and other northern high latitude countries, seasonal mortality rates and incidence of illness are higher in summer then in winter (Huynen, et al. 2001; Keatinge, 1997; Aronowand Ahn, 2004; Keatinge and Donaldson, 2004; Weerasinghe, et al. 2002).

To check the robustness of the results given above, the same method has been applied in each hospital of Lahore separately (see Tables 1.6, 1.7 and 1.8 reported below). The results are the same as above and it has been concluded that the relationship is negative in Lahore and the doctors' opinion from each hospital is consistent with these results. There may be some other damages of increased temperature on health but this is not the case with reference to cardiovascular disease in Lahore. Thus, more research needs to be conducted in order to ascertain other impacts of climate change on health.

Punjab Institute of Cardiology (PIC).

The remaining results are as follows. The results of Punjab Institute of Cardiology are as follows:

$Log(Y) = \beta_0 + \beta_1 X$

Table 1.7 Regression results of impact of temperature on CVD of PIC

Dependent Variable: pat			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	3.6549	.0211831	172.54 [0.000]
Maxpic	-.0195557	.0007011	-27.89 [0.000]
Pseudo R-Squared 0.0557			

Where

Pat = Daily number of patients in the Punjab institute of cardiology

Maxpic = Daily maximum temperature of Lahore city.

The results show that in PIC the relationship of number of cardiovascular patient is negative with the maximum temperature. It means that if there is an increase in the temperature the number of patients of cardiovascular diseases will be lower.

The results of Table 1.7 can also be written in the following form:

$$Pat = e^{3.66} \times e^{-0.02(Max)} \quad \ldots\ldots(3)$$

The equation given above is also useful to calculate relative risks about the number of patients of cardiovascular diseases due to change in the maximum temperature. For example the relative risk of the 30 degree celsius with an increase to the 31 degree celsius can be calculated as follows:

$$e^{-0.02(30)} / e^{-0.02(31)} = 1.020 \quad \ldots\ldots..(4)$$

Sir Ganga Ram Hospital

Next the relationship of number of cardiovascular patients from Sir Ganga Ram Hospital with the maximum daily temperature of Lahore city was estimated. The results are as follows.

$Log(Y) = \beta_0 + \beta_1 X$

Table 1.8 Regression results of impact of temperature on CVD of Ganga ram

Dependent Variable: patganga			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	.4570476	.1023668	4.46 [0.000]
Maxganga	-.0067861	.0033125	-2.05[0.040]

Pseudo R-Squared 0.0012

Where
Patganga= Daily number of cardiovascular patients at Sir Ganga Ram Hospital Maxganga = Daily maximum temperature of Lahore city.

The results show that in Sir Ganga Ram Hospital the relationship of number of cardiovascular patient is negatively related to the maximum daily temperature. It means that if there is an increase in the temperature the number of cardiovascular patients will be decrease.

The results of Table 1.8 can also be written in the following form.

Patganga = $e^{0.46} \times e^{-0.007(Max)}$ ………………………………………………(5)

The equation given above is also useful in calculation of relative risks with reference to the number of patients of cardiovascular diseases due to change in the maximum temperature. For example the relative risk of the 30 degree Celsius with the 31 degree Celsius can be calculated as follows:

$e^{-0.007(30)}$ / =1.007………………………………………………(6)

Jinnah Hospital

Next the relationship between the number of cardiovascular patients from Jinnah hospital and Lahore's maximum daily temperature has been estimated. The results are as follow.

$Log(Y) = \beta_0 + \beta_1 X$

Table 1.9 Regression results of impact of temperature on CVD of Jinnah hospital

Dependent Variable: patjin			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	2.648153	.0582195	45.49 [0.000]
Maxjin	-.0031647	.0018343	-1.73 [0.084]

Pseudo R-Squared 0.0006

Where

Patjin = daily number of cardiovascular patients at Jinnah hospital

Maxjin =daily maximum temperature in Lahore city.

The results show that in Jinnah hospital the relationship between the numbers of cardiovascular patients is negatively related to the maximum daily temperature of Lahore. It means that if there is an increase in the temperature, the number of patients of cardiovascular diseases will decrease.

The results of Table 1.9 can also be written in the following form:

$Patjin = e^{2.65} \times e^{-0.003(Max)}$ ……………………………………………………..(7)

The equation given above is also useful in calculation of relative risks of the number of heart patients due to change in the maximum temperature. For example the relative risk of the 30 degree Celsius with an increase to the 31 degree Celsius can be calculated as follows:

$e^{-0.003(30)} / e^{-0.003(31)}$ =1.003……………………………………………..(8)

Summary of Results:

The following Table shows the summary of results of all hospitals separately and on aggregate level.

Table 1.10 Summary of regression results

Variable(s)	**Patagg (Z)**	**Pat (Z)**	**Patganga (Z)**	**Patjin (Z)**
C	4.027867 (120.65)	3.6549 (172.54)	.4570476 (4.46)	2.648153 (45.49)
Maxagg	-.0141384 (-13.28)	-	-	-
Maxpic	-	-.0195557 (-27.89)	-	-
Maxganga	-	-	-.006786 (-2.05)	-
Maxjin	-	-	-	-.0031647 (-1.73)
Observations	614	1826	1461	614
Pseudo R^2	0.0325	0.0557	0.0012	0.0006

The results show negative and statistically significant impact of climate change on the cardiovascular disease. It means when there is rise in the temperature then, on average, there is decrease in the number of patients of cardiovascular patients and vice versa.

Cost of Cardiovascular Disease:

In Lahore all public hospitals are currently providing medical services free of charges to the cardiovascular patients. Therefore patients do not have to bear any cost. For analytical purposes, hospital authorities were asked about the cost incurred on cardiovascular patients. Unfortunately, the cost of cardiovascular disease was not available separately. The cost of cardiovascular disease was calculated from our survey conducted in Lahore. The summary of the cost is as follows:

Table 1.11: Minimum, maximum and average cost/day/person

	Cost of Medicine/ per day (Pak Rs.)	Total Cost/day (Medicine+ Doctor +Travel) (Pak Rs.)	Wages Lost/day (Indirect Cost) (Pak Rs.)
Minimum	8	30	100
Maximum	4000	9833	4000
Average	270	1464	856

Source: Calculations based on survey conducted by author

Apparently, minimum cost is very low. However, the fact is that this represents the cost which the destitute would have incurred on the treatment who can't afford to go to a specialist doctor or a hospital which is situated far away from their homes. In order to save time and travelling cost they go to the doctors nearby and often these doctors are unregistered practitioners.

The total number of cardiovascular patients in three hospitals of Lahore was 14848 in 2009. The cost given above has been used as the total expenditures[7] of cardiovascular patients, in three hospitals of Lahore in 2009, as shown in the following Table:

Table 1.12: Total (min and max) and average expenditure for year 2009

	Expenditure (Million Pak Rs.)	Indirect Cost (Million Pak Rs.)
Minimum Total Expenditures	0.45	1.49
Maximum Total Expenditure	146.00	59.39
Average Expenditure	21.74	12.71

Source: Calculations based on survey conducted by author

Conclusions

The relationship of temperature with the number of patients of cardiovascular disease, an indicator of health, in Lahore city is examined.

The main conclusion is that in Lahore the relationship of cardiovascular disease is inversely related to the Lahore's average temperature. So this is contrary to the findings in developed world. The main difference is that the major studies have been conducted in Europe, Canada and America where cold weather prevails during most of the year[8]. People in these areas are used to live in a cold area so an increase in temperature would lead to cardiovascular complications. Lahore is mostly warm. People living in Lahore are used to warm weather. Consequently, when the weather gets warmer, cardiovascular problems do not increase. For this purpose various doctors, belonging to different hospitals in Lahore, were interviewed; they concurred that in winter there are more cardiovascular patients than in summer.

[7]Assuming that every patient has stayed in hospital for one day.

[8]In Pakistan, 12 locations are cooler, 22 are warmer. Globally, 2282 are cooler, 698 are warmer (World Climate 2010).

Policy Implications:

As it has been concluded that the climate is changing i.e. temperature is increasing. The risks of serious impacts of this increase in temperature indicate that there is a dire need to quickly resolve the problem.

There is considerable disagreement within and between nations, concerning which policies should be implemented to mitigate climate change and its various impacts. Environmental damages are not associated with private cost (household, firms etc.) therefore the role of public policy is necessary for the solution of the problem. Waiting for economic recovery rather than making a decision now will create more obstacles in future. Therefore following policies are suggested.

- There must be fair and strong good global governance or international body such as United Nations or IPCC which can strongly enforce the international agreements. Every region must participate in them[9]. Each country must be bound to the decisions made by this body.
- Clean Development Mechanism (CDM) was agreed in the Kyoto Protocol (IPCC 2007) and defined in the Article 12 of the protocol. It is defined as, the industrialized countries should assist developing countries to achieve sustainable development and contribute to prevention of dangerous impacts caused by climate change. Industrialized countries should abide by the agreement and should invest in developing countries to prevent and combat climate change.
- As mentioned earlier that developed countries are more responsible for climate change and developing countries are more at risk. Developing countries lack the capacity to pay for emissions reduction so it is the responsibility of the developed world to invest in developing countries.
- Developed countries should reduce emissions and developing countries should stop further increase in emissions which are causing the increasing of temperature. They do not have the capacity to reduce emissions but they can initiate the measures to control the emissions by introduction of the green technology.
- The International community has an obligation to support developing countries, which are not responsible for climate change, in adapting and mitigating the impact of climate change
- We must reduce subsidies on those items that create the emissions and increase of temperature.
- The results of the survey indicate that people are willing to pay a huge amount for the health system especially for cardio related disease. The Government should use this opportunity and provide better health services and state of the art technology to the people.

[9] Pakistan is already actively participating in the meetings of IPCC and UNFCC an mentioned in the first chapter of the thesis.

References

Andrew K. Githeko, Steve W. Lindsay, Ulisses E. Confalonieri, & Jonathan A. Patz. "Climate Change and Vector-borne diseases: A regional analysis." *Bulletin of the World Health Organization, 2000, 78(9)*, 2000.

Anna Alberini, Maureen Cropper, Tsu-Tan Fu, Alan Krupnick, Jin-Jan Liu, Daigee Shaw and Winston Harington."Valuing health effects of air pollution in developing countries: the case of Taiwan."*Journal of Environmental Economics and Management*, 1997.

Anthony J. McMicheal, R. E.. "Climate change and human health: Present and future risks". The Lancet; *ProQuest Medical Library*, 859, 2006

Aronow WS., and Ahn, C.. "Elderly nursing home patients with congestive heart failure after myocardial infarction lining in New York city have a higher prevalence of mortality in cold weather and warm weather months." *Journal of Gerontol A. BiolSci Med Sci.*, 2004: 146-147.

Basu R., S. J. "Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence". 24(2),. *Epidemiol Rev*, 2002: 190-202

Braga, Alfesio L.F., Zanobetti, Antonella. And schwartz, Joel. "The Effect of Weather on Respiratory and Cardiovascular Deaths in 12 U.S. Cities."*Environmental Health Perspective 110*, July 2002: pp 859-863.

Climate, W. (2010). *Climate Charts - USA Climate Index*. Retrieved 12 25, 2010, from World

Climate.2010. in Pakistan, 12 locations are cooler, http://www.climate- charts.com/ Locations/p/PK41571.php (accessed 12 25, 2010)

Cline, William R. "The Economics of Global Warming."*XVII Conference of the Indian Association for the Study of Population.* Tamil Nadu, India: Institute of International Economics, Washington, D.C., 1992.

Compendium on Environment Statistics of Pakistan. Islamabad: Federal Bureau of Statistics, Government of Pakistan, 2004.

Cropper, Maureen L., Nathalie B. Simon, Anna Alberini, and P.K. Sharma."The Health Effects of Air Pollution in Delhi, India."*Development Research Group, Policy Research Working Paper 1860.* The World Bank, 1997.

Curriero FC, Heiner KS, Samet JM, Zeger SL, Strug L and Patz JA."Temperature and mortality in 11 cities of the eastern United States."*American Journal of Epidemiol*, 2002: 80:87.

Economic Survey of Pakistan. Islamabad: Finance Division, Government of Pakistan, Different Issues.

GC, Keatinge WR and Donaldson."The Impact of global warming on health and mortality. *South Medical Journal*, 2004: 1093-1099.

Haines, Andrew, Anthony J. McMichael, and Paul R. Epstein. "Environment and Health: Global climate change and health." *Canadian Medical Association, CMAJ.*, 2000: 163(6):729-34.

Health, Committee on Environmental. Global Climate Change and Children's Health. *The American Academy of Pediatrics*, 2007.

Houghton, J.T., Jenkins, G.J. and Ephraums, J.J. "Climate Change: the IPCC Scientific Assessment". Cambridge: *Cambridge University Press for the IPCC*, 1990.

Huynen, MM., P. Martens ,D.Schram, MP. Weijenberg and AE. Kunst. "The Impact of Heat Waves and Cold Spells on Mortality Rates in the Dutch Population." *Environ Health Perspect*, 2001: 463-470.

Huynen, MM., P. Martens ,D.Schram, MP. Weijenberg and AE. Kunst. "The Impact of Heat Waves and Cold Spells on Mortality Rates in the Dutch Population." *Environ Health Perspect*, 2001: 463-470. IPCC. "IPCC Fourth Assessment Report." 2007.

Jonathan A. Patz, D. C.-L. "Impact of Regional Climate Change on Human Health". *Nature 438*, 2005: 310-317

Keatinge, GC. Donaldson GC and WR. "Mortality related to cold weather in elderly people in southeast England", 1970-94." *BMJ*, 1997: 1055-1056.

Keatinge GC, Donaldson and WR. "The Impact of global warming on health and mortality." *South Medical Journal*, 2004: 1093-1099.

Kumar, S and D.N. Rao. "Valuing Benefits of Air Pollution Abatement Using Health Production Function: A Case study of Panipat Thermal Power Station, India." *Journal of Environmental& Resource Economics, (20)*, 2001: 91 - 102.

McGeehin,M. A. "The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States". *Environ Health Perspect 109(Suppl 2)*, 2001: 185-189.

McMichael, A. J. et al. "Climate Change and Human Health: Risks and Responses*".* this book prepared jointly by the *WHO, WMO and UNEP*., 2003.

Meehl, G. and C. Tebaldi. "More intense, more frequent and longer lasting heat waves in the 21st century." *Science, 305*, 2004: 994-997.

NASA, C. (2015). *Global Climate Change*. Retrieved September 05, 2015, from http://climate.nasa.gov/400ppmquotes

NOAA. (2014). *National Oceanic and Atmospheric Administration*. Retrieved September 05,2015, from Natioanl Centers for Environmental Information: http://www.ncdc.noaa.gov/sotc/global/201413*Pakistan Energy Yearbook.* Islamabad: Ministry of Petroleum & Natural Resources, Various issues.

Patz, Jonathan A., diaarmid Campbell Lendrum, Tracey Holloway, and Jonathan A. Foley."Impact of Regional Climate Change on Human Health."*NATURE* (Nature Publishing Group) 438/17 (November 2005).

Stern, Nicholas. *The Economics of Climate Change.* Cambridge University Press, 2007.

Stern, Nicholas. The Economics of Climate Change, Pre publication Edition, 2006UNFCC. *Kyoto Protocol.* 1997. http://unfccc.int/kyoto_protocol/items/2830.php (accessed 2011).

Weerasinghe, DP., Macintyre, CR. and Rubin, GL."Seasonality of coronary artery deaths in New South Wales, Australia."*Heart*, 2002: 30-34.

WHO. World Health Report: "A safer future; global public health security in the 21st century". Geneva, Switzerland: *World Health Organization*, 2007.

WHO. . "Climate Change and Human Health - Risks and Responses". *WHO, UNEP and WMO*, 2005.

WIPO magazine, Geneva."Climate Change: The Technology Challenge." February 2008: No.1.

Zell, Roland. "Global Climate Change and Emergence/Re-emergence of Infectious Disease." *International Journal of Medical Microbiology*, 2004: pp 16.