RESEARCH REVIEW JOURNALS
Volume-03
Issue-08
August-2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Climate Change Attributable Burden of Disease: A Case Study of Delhi During 2010-2017

Shailesh Kumar

School of Economics, University of Hyderabad, Gachibowli, Hyderabad, India-500046

ARTICLE DETAILS

Article History
Published Online: 07 August 2018

Keywords
Climate Change, Burden of Disease, Economics, Epidemiology.

ABSTRACT

The climate change has stimulated many health consequences and this has become a serious concern for the humanity in the 21st century. It has an adverse effect on all community and groups such as elderly, economically backward, women etc. are utmost vulnerable to these phenomena. As climate emerged as a crucial determinant of human health, environmental epidemiology has gained relevance in understanding these health issues in the context of climate change. The estimations of disease burden based on sound epidemiological research pave the way ahead towards public policy in healthcare sector. The set of diseases and the interventions that public policy must emphasize upon can be inferred from such evidence. The present study is a quantitative study of the impacts of environmental change in terms of the current disease burden, measured as Disability Adjusted Life Years (DALYs) in Delhi during 2010-2017. From the analysis of environmental epidemiology found that the current burden of disease due to climate-sensitive health outcomes have more number of premature deaths in Delhi are caused due to diarrheal disease among 0-14 years of population group whereas for above 15 years of age group number of deaths are caused due to cardiovascular disease and this could be said due to the heat waves and pollution. Further study investigated the economic cost of health outcome associated to mortality and morbidity due to climate change in the context of Delhi.

1. Introduction

The changing scenario of climate conditions around the globe is leading to adverse impact on human health and well-being. Climate change can affect human health in both direct and indirect ways. It can affect directly through natural disasters like floods, drought, and storms and indirectly through the range of changes in vector borne diseases (through mosquitoes), infectious diseases, water quality, food quality and living conditions. Infectious diseases are due to socio demographic factors like housing type and location, density of human population, land use and irrigation system, deforestation, etc (Curriero et. al., 2001). The report of Intergovernmental Panel for Climate Change (IPCC) fourth assessment says that in the coming years there is an increasing threat to human health due to the overall changing patterns of climate, particularly in lower income populations mainly the countries which fall under tropical/sub-tropical.

Climate change and pollution have proved to be one of the biggest threats to humanity. It affects the health of the individuals and development of nations as a whole. The health issues resulting from climate change range from diarrhea, malaria, dengue, tuberculosis to known acute diseases and known chronic diseases. As climate emerged as a crucial determinant of human health, environmental epidemiology has gained relevance in understanding these health issues in the context of climate change. Environmental epidemiology focuses on region-specific environmental hazards and its health effects. The estimations of disease burden based on sound epidemiological research pave the way ahead towards public policy in healthcare sector (Last & Logan, 1999). The negligence in recognizing the need for preventing disease to improve the quality of health might have negative consequences upon the welfare of families that have been affected on economic, social and environmental grounds. This also holds true about diseases that are largely centered among adults of working age and the poor, as in the case with Cardio-Vascular Disease (CVD), respiratory diseases, malaria, diarrheal disease etc. India has fairly large evidence of such negative effects, many a times due to the incongruence between disease burden with its causal factors as well as the interventions adopted and priorities in allocation of resources.

The concept of disease burden was generalized in public domain by Murray and Lopez which is basically a basic description of population health with regard to both morbidity and the total number of premature death. An important and widely used measure for disease is DALY, which consists of the sum of Years of Life Lost (YLL) owing to premature death and Years of Life Lived with Disability (YLD). For YLL, comparison is made against maximum life expectancy, whereas for YLD, disease duration, disability weight, future discounting and the age of onset are significant (Murray 1994). Thus, DALY is an indicator that blends time lost because of both premature mortality as well as non-fatal conditions. It expands the concept of potential years of life lost as a consequence of premature death to let in equivalent years of “healthy” life lost due to residing in the state other than good health (Kumar & Sharma; 2014).

One of the significant challenges for researchers in epidemiology remain is to quantify the effects of environmental change by taking into consideration the repertoire of diseases and conditions in relation with them. This paper is a description of the impacts of environmental change in terms of the current disease burden, measured as DALYs. It also investigates the economic cost of health outcome associated to mortality and morbidity due to climate change in the context of Delhi during 2010 to 2017.

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2. Literature Review

Murray (1994), proffers the development of a new method which estimates disease burden, detailing the disability adjusted life year (DALY).In her study, she opines the pros and cons of different methods pertaining in assessment of number of deaths at each age. DALYs requires a standard expected-life lost which is based on model life-table West Level 26. DALYs employs an exponential equation representing the dependency of the young and elderly on adult age, and it captures the value of time lived at different ages. *McMichael et al (2008)* have observed that the Stem report, in 2006 brings out the eventfully alarming distress to the economic system of world from climate change which has been unanticipated. They makes point that if current trend remains perpetual to erode the earth`s life support system then it will cause the vitality and health of all species suffer from greater risk. The study concludes that health professionals can play crucial role to make public comprehend for important linkage between climate and health to deal with this crisis. *Onzivu (2009)* focused on developing countries and evaluated the impact of climate change that brought about more challenges to humanity. Climate change adversely affects human health as it de-stabilizes the ecosystem. Multilateral climate change treaties are a mechanism to prepare state and other actors to combat climate change. The environmental health regimen in developing countries seems potential. However unfortunately, to combat the problems of climate change through implementation of environmental health measures, developing countries have to face multiple hurdles. Onzivu stresses out that a number of legal and practical problems arise due to the effectiveness of legal and institutionalized attempt or other mechanisms related to health regimen in order to relegate climate change issues affecting health status of people. The article suggests that developing countries must try to improve the health regimen through developing the institutional and legal reforms in the era of legal regime of climate change. *Marimuthu et al (2009)* in their study analyzed the sickness prevailing in slum of metropolitan city. The objective of the work is to measure the morbidity of slum population in Delhi by taking into account their socio-economic and democratic perspectives. The paper uses a cross-sectional method. Data were composed by a two-stage random sampling method. Initially, slum locations were selected and in the next stage households were selected. Data were collected from 1049 households consisting information of 5358 individuals. The results revealed that the overall morbidity prevalence is 15.4%. It is 14.7% for males and 16.3% for females. The reported higher morbidity prevalence and the illiteracy status are pointedly associated. *McDonald et al (2014)*, pioneered a scalable model of “climate health justice” for assessing and understanding the incidents, cost of treatment and socio-spatial differences for diseases which are properly documented link with climate change. The study is conducted with the help of secondary data and identifies normative environmental justice and theoretical perspectives of health inequalities should be synthesized. This model uses International Classification of Disease, Ninth Revision Clinical Modification (ICD-9-CM) disease codes and can be employed in other contexts, suitable with different spatial scales and appropriate for comparative studies. They created various disease categories (i.e., respiratory, gastronomical, heat-related and cardiovascular) related to climate change and chose corresponding ICD-9 codes with the highest hospitalization for future analyses. The study unearths that the Blacks were disproportionately suffering from these disease in comparison to non-Hispanic whites. Distribution of diseases rates in different spaces shows geographic zones of risk which is disproportionate. *Nagpure et al (2014)* assesses the health risk of human being in the Delhi, the national capital in terms of morbidity and mortality because of air pollution. The model applied in this study includes spreadsheet model, the menace of mortality/morbidity due to air pollution (Ri-map) to assess the health impacts of different air pollutants existing in various parts of Delhi during the time span of 1991-2010. Researchers employed the guidelines of World Health Organization (WHO) on the concentration of air contaminants SO2, NO2 and total suspended particles (TSP), concentration-response relationship and population attributable-risk proportion. The study brings out that there were about excess case of 11934, 3912, 1697, and 16253 total mortality, cardiovascular mortality, respiratory mortality, and hospital admission of COPD respectively for the entire NCT Delhi in the year 2000. However, within a one decade, in year 2010, these numbers became 18229, 6374, 2701, and 26525 almost doubled.

The above review gave a lot of insights to formulate the present study. There is no study based on the recent data particularly in the context of Delhi to address the outcome of climate change on health. The present study also analyses the economic burden of morbidity and mortality occurring due to the climate change. The objective of the research is to investigate the economic cost of health outcome associated to mortality and morbidity due to climate change in the context of Delhi.

3. Methodology

The data for calculating DALYs have been taken from the Institute for Heath Metrics and Evaluation (IHME) which constitutes Years of Life with Disability (YLDs), prevalence, life expectancy, and incidence. The data for calculating economic value of DALYs needs per capita Net State Domestic Product (NSDP) at constant prices with base year 2011-12 for Delhi. These data has been taken from Central Statistics Office (CSO).

The burden of disease and their economic cost has been analyzed. To quantify the burden of disease from morbidity and mortality, the method of Disability-Adjusted Life year (DALY) is employed (Alkire et. al., 2015). This Paper gives information according to disease, sex, age wise. The DALY can be considered as one lost year of ‘healthy life’. The combined DALY across the population or the burden of diseases, measures the gap between health status of a society and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. DALY is calculated using the formula:

$$DALY=YLL+YLD$$

Where Years of Life Lost (YLL) in the above formula indicates the number of deaths multiplied by the standard life expectancy at the age which death occurred. YLL is calculated using the formula:

$$YLL=N*L$$

Where N is a number of death, and L is standard life expectancy at age of death in year. Years Lost due to Disability

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(YLD) tabulates the people living with the health conditions or its consequences. It is calculated using the formula

$$YLD = I*DW*L$$

Where I is number of incident cases, DW is disability weight, and L is average duration of the case until remission or death in years. For the economic value of disease burden, per capita Net State Domestic Product (NSDP) has been used and it is calculated as

$$\text{Economic Cost} = DALY * NSDP$$

4. Results and Discussion

1. Current Burden of Disease

The estimates for 2017 are in the process yet to come out, so here in this context the term "current" refers to the year 2016. The current burden of disease due to climate-sensitive health outcomes, which includes but not confined to diarrhea, vector-borne diseases, respiratory disease and cardiovascular diseases in cold waves and heat waves, is substantial. The proportion of total burden of disease of premature death is 59.2% and disability and morbidity is 40.8% in 2016. Diarrheal disease accrued for 1.24% of total DALYs, whereas malaria accrued for 0.09% of DALYs and that for cardiovascular disease, and respiratory disease are 2.2%, 15.19 % of DALYs respectively for Delhi (Table 1).

The total number of deaths that happened accruing to all causes came to approximately 16031 and the total number of deaths that occurred due to diarrheal disease, malaria, cardiovascular disease, and respiratory disease stands to 323, 22, 3466, and 2437 respectively. On one hand the years of life lost (YLLs) are 549611.6, 10721.46, 1543.926, 14249.93, and 122548 respectively for every selected disease in 2016 and on the other hand years lived with disability (YLDs) are 2206341.36, 23688.11, 1174.34, 44433.76, 122548.4, and 8041.92 respectively for 2016. As mentioned earlier DALYs is the sum of years of life lost (YLL) due to premature death and years of life lived (YLD) with disability, it has come to 5412041.1, 97627.02, 16853.62, 731092.05, 242807, and 11162.71 respectively. An essential point to be taken into account was that diarrhea, malaria and other vector borne diseases accounted for approximately 26 million DALYs or approximately 10% of the total burden of disease.

Table 1: Some leading causes of DALYs: Delhi estimates for 2016

DALY	Deaths	YLLs	YLDs	DALY's	DALY (%)
All causes	16031	549611.6	2206341	2755953	100
Diarrheal disease	323	10721.46	23688.1	34409.6	1.24
Malaria	22	1543.926	1174.34	2718.27	0.09
Cardiovascular diseases	3466	14249.93	44433.8	58683.7	2.12
Respiratory disease	2437	296290.5	122548	418839	15.19

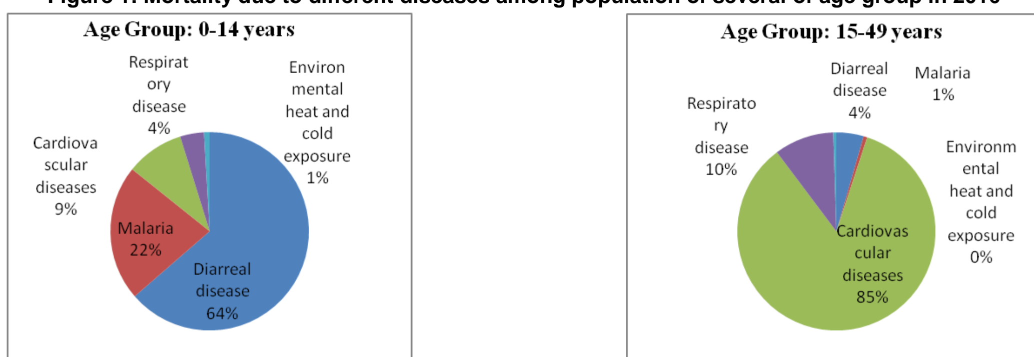
Source: Author's Calculated with data from IHME and HMIS

Figure 1 indicates Mortality due to different diseases among population of several age groups. It shows that more number of premature deaths is caused due to diarrheal disease which accounts for 64% followed by malaria disease which is 22% among age group 0-14 years. That of 85% of premature deaths for the age group 15-49 years are caused because of cardiovascular disease and 10% of deaths are caused due to respiratory disease. The number of premature death caused because of cardiovascular disease is more for the age group of 50 years of age and above which accounts for 82% followed by respiratory disease which accounts for 17%.

Figure 2 shows that in 2016 the causes of YLLs due to various diseases among males is 1.9% for diarrheal disease, 0.3%, 22.33%, 3.68% and 0.12 % for malaria, cardiovascular, respiratory and environmental heat and cold diseases and among females causes of YLLs due to diarrheal disease is 2.95%, malaria, cardiovascular, respiratory and environmental heat and cold diseases are 0.79%, 19.95%, 3.85% and 0.066% respectively. From the data it can be seen that the cause of YLLs due to environmental heat and cold exposure is high in males (0.12%) than females and the cause due to malaria disease is high in females (0.79%) than males and the reason could be likely to temperature and water.

The data in the above Figure 3 indicates that the causes of YLDs by different diseases in males stands out at 1.18% due to diarrheal diseases, 0.058% due to malaria, 1.99%, 6.62% and 0.39% due to cardiovascular, respiratory and environmental heat cold exposure. In females due to diarrheal disease is 0.96%, malaria, cardiovascular, respiratory and environmental heat and cold diseases are 0.05%, 2.04%, 4.59% and 0.33% respectively. The proportion of cause of YLDs due to respiratory disease is higher among males than females.

Figure 1: Mortality due to different diseases among population of several of age group in 2016



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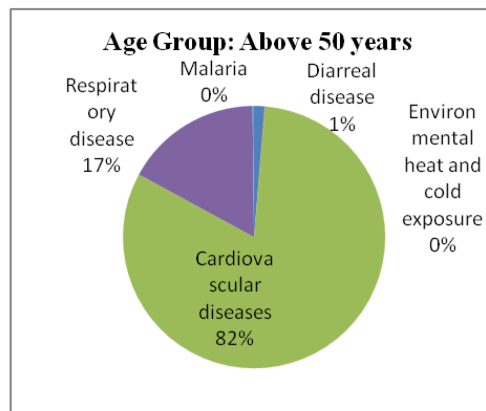
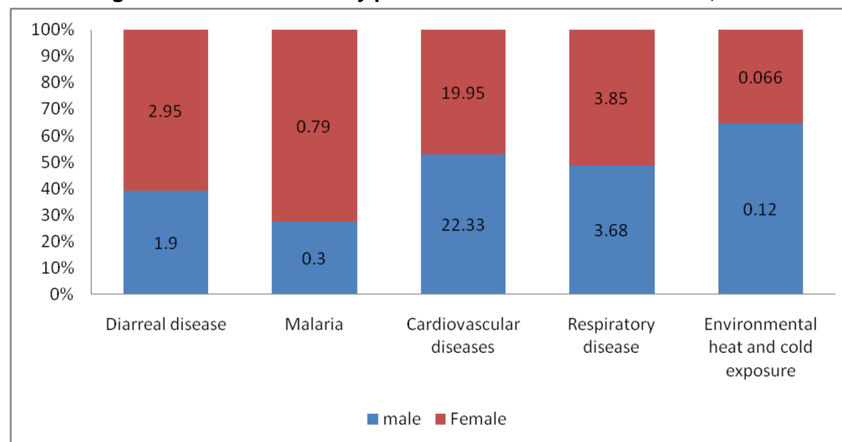


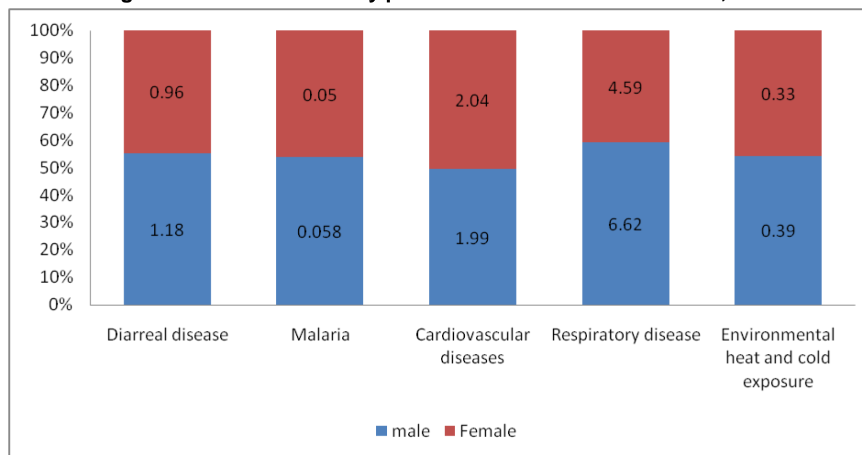
Data Source: ICMR, PHFI, IHME (https://vizhub.healthdata.org/gbd-compare/india)

Figure 2 causes of YLLs by percent for both sexes combined, 2016



Data Source: ICMR, PHFI, IHME (https://vizhub.healthdata.org/gbd-compare/india)

Figure 3 causes of YLDs by percent for both sexes combined, 2016



Data Source: ICMR, PHFI, IHME (https://vizhub.healthdata.org/gbd-compare/india)

2. Economic Burden of Disease

Table 2: Economic values of DALY's (all causes, both sexes, all ages) (in Thousands)

year	Deaths	YLDs	DALY's	Economic value of DALY's
2010	88	1815	5223	541241042
2011	89	1860	5217	966854435
2012	90	1931	5259	1015683331
2013	91	2001	3231	6512384935
2014	92	2071	5343	1136268532
2015	92	2146	5362	1215008964
2016	94	2206	5412	1300610893

Data Source: ICMR, PHFI, IHME (https://vizhub.healthdata.org/gbd-compare/india)

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The data from the above Table 2 shows that in the year 2010 total deaths due to all causes stood at 88 thousands and YLDs is 1815 thousands. Further it also shows that 5223 thousands DALYs were lost due all causes in 2010 and the estimated economic value of DALYs lost due to all causes totaled 541241042 thousands and this loss of economic value has been increased to 1300610893 thousands in 2016. The number of deaths in males due to all causes in Delhi has increased to 55 thousands deaths and 1126 thousands YLDs in 2016. The loss of economic value of DALYs (2958000) lost to all causes in case of males was estimated at 306487257 thousands and this has been highly increased to 738452998 thousands in 2016. The number of deaths in females due to all causes in Delhi has increased to 38 thousands deaths and 1081 thousands YLDs in 2016. The loss of economic value of DALYs (2266K) lost to all causes in case of females was estimated at 234753785 thousands and this has been highly increased to 562157895 thousands in 2016.

For the age group of 15-49 22 thousands premature deaths were recorded due to all causes in 2010 and 1034 thousands for YLDs. The loss of economic value of DALYs lost to all causes increased from 227834269 thousands in 2010 to 582216160 thousands in 2016. The premature deaths due to diarrheal diseases stood at 3000 and that of YLDs at 20,000 in 2010. 137 thousands DALYs were lost as a result of diarrheal disease in 2010 caused an effect of the economic value of 14178540 thousands. The loss of economic value of DALYs increased to 23461530 thousands in 2016. The premature deaths due Environmental heat and cold exposure to stood at 87 and that of YLDs at 7006 in 2010. 10276 DALYs were lost as a result of Environmental heat and cold exposure in 2010 caused loss of the economic value of 14178540 thousands. The loss of economic value of DALYs increased to 2682600142 in 2016.

5. Conclusion

The analysis of burden of diseases and loss of economic value found that the current burden of disease due to climate-sensitive health outcomes, which includes but not confined to diarrhea, vector-borne diseases, respiratory disease and cardiovascular diseases in cold waves and heat waves, is substantial. It shows that more number of premature deaths in Delhi is caused due to diarrheal disease among 0-14 years of population group whereas for above 15 years of age group number of deaths are caused due to cardiovascular disease and this could be said due to the heat waves and pollution. Further it can be seen that the cause of YLLs due to environmental heat and cold exposure is high in males (0.12%) than females and the cause due to malaria disease is high in females (0.79%) than males and the reason could be likely to temperature and water. The estimated loss of economic value lost to all causes, among different age groups, sexes and various kinds of diseases due to change in climatic conditions has been increasing highly from 2010 to 2016.

The three diseases malaria (and other vector borne diseases), diarrhea and nutritious deficiencies which are closely associated with climate change pose a threat to India. Moreover even the MDG have been unable to meet their stipulated deadlines. The ongoing measures of prevention, control and treatment are not sufficient and any unanticipated shock due to climate change will bring into question the effectiveness of the financial and non-financial operations that are being performed in relation to these diseases. Also it is observed that the states and districts which have done poor in terms of MDG are also the ones whose performance have been very abysmally low in terms of various indicators of human development. Various reports on environment in India portray the susceptibility of different regions to floods, drought, pollution, changes in land use and agricultural degradation (MoEF, 2009 2010). The implication is that the socio economically backward and vulnerable sections of the country are the ones affected very badly. Though there is inclusion for disease surveillance and vector-borne disease control in this estimate but the question remains unanswered whether at all there has been any attempts made for mitigating hunger, control of diarrheal, enteric or cardiovascular diseases.

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