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Trend of Mortality by Water Related Intestinal Infectious Diseases: A Study of National Capital Territory of Delhi, (2001 to 2011)

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ARTICLE INFORMATION

ABSTRACT

National Capital Territory (NCT) of Delhi has been experiencing rapid urbanization for last few decades. The area is lagging behind in water and waste management infrastructure. This is due to the fact that Delhi is recording high growth rate of population mostly through in-migration over the years which is taxing much upon the existing water resources and the provisions made for water supply. Consequently demand is higher than supply of the safe drinking water. The consumption of unsafe drinking water is therefore increasing and is causing serious health problems among the fellow residents of NCT of Delhi. These health problems are basically related to digestive as well as excretory systems of the human body. These disorders are promoting mortality particularly among those segments of population which do not have access to potable drinking water. This paper is therefore a modest attempt towards examining the population growth rate and the scenarios of demand and supply for potable water as well as the overall water related intestinal infections and related mortality at present and their future occurrence. This requires synergy between the different sectors of the state to overcome the problem of intestinal infection diseases in the region.

1. Introduction

A range of water problems including water shortage and defilement, unsustainable utilization of groundwater, ecological degradation and the risk of environmental change are being faced all around the world (WWAP, 2015; Morrison, *et al.* 2009). Due to such problems, water related disease keeps on representing a noteworthy threat to an individual health both in the developed and developing countries (Ford, 1999). About 2.6 million people are dying each year due to water-related diseases and 2.1 millions mostly children below the five years of age die from diarrhoea (WHO/UNICEF, 2013; Edition, 2011). This indicates that there is a significant relationship between drinking water quality and human health. Most of the human habituations are located along the rivers and other water bodies in India and elsewhere in the world. Thus surface water pollution has a significant impact on human health and also on human life.

The NCT of Delhi is one of the largest metropolises of India which is experiencing fast demographic expansion since last several decades. This is taxing much on the existing ground water resources which are being replenished from rivers like Yamuna and Ganga (Upadhyay, *et al.* 2011; Nallathiga, 2009; Maria, 2008). Delhi a city state is high on consumption and demand, low on internal resources and high on external dependence for water. There are limited options for Delhi for the water development within its territorial limits. With limited sources of portable water supply, the water sector is becoming increasingly complex in order to ensure affordable and adequate water supply to all the sections of the population residing in NCT of Delhi. The Mckinsey Global Institute reported in April, 2010 on urbanization in India and projected that the population of NCT of Delhi would be approximately 16.7 million by 2011 and 26 million by 2030. The city, which presently is not able to meet its water demands, is quite likely to face accentuated water stress in future and would be subjected to widespread ill health on account of water related diseases. The said study was based on World Health Organisation (WHO, 2008) report which stated that consistently there are 4 billion cases of water related diseases responsible for at least 1.8 million deaths worldwide.

2. Water Related Intestinal Diseases

There are various cause for diseases linked to water however, 'water related diseases' are the most common caused by consumption and usage of polluted water. Water related diseases includes both water borne/direct and water associated/indirect health problems (Stanwell-Smith; Hunter, *et al.* 2002).

Water related intestinal infectious diseases have widespread adverse effects on human health, in the form of mortality, morbidity, disability, illness etc. These conditions are caused and are subjected to change directly or indirectly by the change in the intake of the water quantity as well as quality of drinking water.

Generally all such diseases are caused by consuming contaminated water which carries both biological as well as chemical contaminants in improper proportions in the drinking water. Over the last few decades, the consciousness about the water related human health hazard has evolved more deeply and extensively. A significant number of the urban inhabitants in Africa, Asia and Latin America suffer from at least one of the diseases prevailed due to the improper management and inadequate provision of quality drinking water as well as improper hygiene (WHO, & UNICEF. (2000). Thus, there is an urgent need for the proper management and the augmentation of quality water supply as well as proper sanitation in order to ensure a better health particularly in developing world. It calls for the prevention of water resource from various types of contaminations on priority basis. Improvements in the quality and quantity of drinking water in order to contain the endemic diseases such as diarrhoea, cholera and typhoid would also help in maintaining a better standard of hygiene. (Mcfeters and Toranzos, 1997; Al-Kahah, 2001). A brief account of selected common water related diseases is given below.

Diarrhoea also referred as 'Looseness of the bowels'. It is normally a side effect of a disease in the intestinal tract which promotes watery loose motions and dehydration. It is caused by a host of bacterial, viral and parasitic organisms such as Rotavirus and *Escherichia coli*, which are the most common agents. Other important pathogens which cause diarrhoea are *cryptosporidium parvum* and *shigella* species. Diarrhoea generally spreads by taking bio-contaminated water or food which is contaminated by the above mentioned biological agents. Its prevalence become high when there is lack of clean water supply for drinking, cooking and washing dishes as well as when basic hygiene is not observed. Diarrhoea spreads from person to person through mechanical vectors also. Food if prepared or stored in unhygienic conditions is another cause of diarrhoea. Water contaminated with human faeces through the mixing of municipal sewage, septic tanks and latrines with the drinking water is therefore of special concern. Such dirty water also contaminates horticulture crops during irrigation, and fish as well as seafood if obtained from such polluted waters may also spread diarrhoeal diseases. Animal faeces also contain the microorganisms that cause diarrhoea.

Cholera is additionally an irresistible ailment that causes severe watery diarrhoea infection, which frequently prompt lack of hydration and even demise if untreated. It is caused by eating food or by consuming drinking water polluted with a bacterium called *Vibrio cholerae*. At the point when the microorganisms attaché them to the small digestive system's walls, the human body starts to discharge enormous amount of water leading to diarrhoea and the causes fast loss of body liquids and salts. Unfit potable water and food prepare by contaminated water are the primary source of cholera infection.

Typhoid is an infectious bacterial disease. The symptoms of typhoid are illness or weakness, loss of appetite, abdominal pain, severe headaches and irritation, high fever and fatigue, etc. This infection causes an ailment and intense fever in the body and is caused by the bacterium *Salmonella typhoi*. It is additionally called as enteric fever which spreads effectively through contaminated water, unhygienic nourishments and furthermore because of the poor hygienic conditions. The bacterium is conveyed by the infected individuals in their digestive system and circulatory system and it goes through the urine and faeces. The disease is normally spread when waste water gets mixed with potable water and it is consumed or when an individual consume any food or water taken care of by an infected individual.

The inability to give safe drinking or potable water and satisfactory sanitation facilities and services to all individuals is perhaps the greatest developmental failure as well as a challenge of the city government. The most outrageous consequence of this failure is the high rate of mortality among all age groups of people from these preventable water-related diseases. This paper therefore examines the present and future scenarios of the mortality consequent of water related intestinal diseases occurring in NCT of Delhi.

3. Objectives

The following are the main objectives of the study.

- To find out the gap between the demand and the supply of safe drinking water in the NCT of Delhi.
- To examine the population growth rate and the trends of mortality on account of water related intestinal infectious diseases.
- To suggest plausible measures for reducing the death rate caused by these diseases.

4. Study Area

National Capital Territory of Delhi is located between the latitudes of 28°24′17″N and 28°53 00″ N and longitudes of 76°50′24″ E and 77°20′37″ E (Fig. 1). An area of 1484 kms is covered by NCT of Delhi as depicted by the Survey of India Toposheets NOs. 53D13/14, 53H1/2, 53H1/5 and 53H1/6.

Delhi has been one of the most popular cities in the country since historical times and many kings and Rajas have ruled the country from Delhi. The state of Delhi has been evolved as a metropolitan city which has shown great signs of development over the years. The city currently is dealing with issues like pollution and population that have gone up alarmingly during recent times (Directorate of Census Operations, NCT of Delhi (2011).

The NCT of Delhi is one of the most densely populated state of India (Joshi, 2011; Chandramouli, & General, 2011). It ranks 18th in sequence with a population of 18 million persons with a density of population of about 11297 persons per square kilometre. The state has a decadal growth rate of about 20% which exceeds the national growth rate of about 17%. It is all due to rapid development and increasing job prospects. The literacy rate in the state is about 86% which is fairly higher than the national literacy rate of about 74.04%. This explains the phenomena of more immigration of job seeking male members of the family from the country side and other urban places. The sex ratio in Delhi is 866 which is below the national average of 943 females per 1000 of males.

5. Database and Methodology

The present is based on the secondary data which are spatial as well as non-spatial in nature. Spatial data pertaining to the base map of the study area were procured from the U.S. Geological Survey using Arc GIS Software version 10.2.
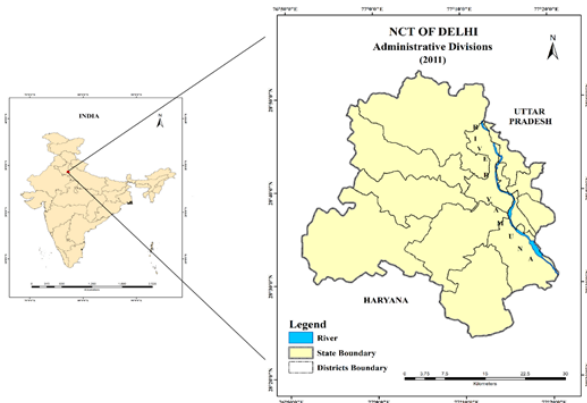

Figure 1: Location Map.

The Non-spatial data like demographic profile of the study area were collected from Census of India (2001 & 2011) and the Delhi Gazette from the website of Delhi Government. The data pertaining to the quality and quantity of water were collected from Economic Survey of Delhi, Central Pollution Control Board (CPCB), Central Ground Water Control Board and National Sample Survey Organisation (NSSO) for the years 2001 to 2011.

The mortality data were collected from the records of "Medical Certification of Cause of Deaths in Delhi" published by "Directorate of Economics & Statistics and the Office of the Chief Registrar (birth & deaths)", government of NCT of Delhi, Census of India, World Health Organisation (WTO), and Statistical Handbook of Delhi. All these attributed data were collected on yearly basis from 2001 to 2011.

Simple descriptive statistical techniques are used to estimate future mortality trends from the water related intestinal diseases.

Equation 1 is used to calculate Growth rate of deaths from water related intestinal diseases from 2001 to 2011.

$$Pt = PO \times \left(1 + \frac{r}{100}\right)^t \qquad (1)$$

Where

r = Percentage of growth in mortality.

$P2$ = Number of deaths at the end of the year.

$P1$ = Number of deaths at the beginning of the year.

t = Number of years.

Equation 2 is used to calculate projected assessment of deaths from water related intestinal diseases from 2011 to 2021.

$$r = \left[\left(\frac{p2}{p1}\right)^{\frac{1}{t}} - 1\right] \times 100 \qquad (2)$$

Where

Pt = Number of deaths after the time 't' in years.

$P0$ = Number of deaths at the beginning of the year.

r = Percentage of growth in mortality.

t = Number of years.

Polygraphs are used to depict the trends in population growth, gap between the demand and supply of potable water and the mortality rate from 2001 to 2011. Bar graph is used to show the age wise mortality rate and Pie chart is drawn to represent the percentage distribution of deaths from the selected diseases.

6. Result and Discussion

Increasing urban population, rapid population growth, poor urban water management, diverse use of water at a higher rate, dwindling sources of freshwater supply, poor and ageing water infrastructure, intermittently poor quality water supply and low water tariffs, all have combined to manage urban water supply a difficult goal to be achieved as the result of which the related rate of deaths is increasing in the NCT of Delhi.

It is observed that over the years the population of Delhi has increased from 139.13 lakh in 2001 to about 167.53 lakh in 2011 registering a decadal growth rate of about 24 percent. This phenomenal growth of population is mostly on account of in-migration and is inclusive of about 2.42 lakh persons which added to the city population during the same period of time due to natural increase. The immigration of population has also triggered the growth of urban slums.

The Delhi *Jal* Board (DJB) is the nodal agency which is responsible for water resource management, monitoring the pollution level of water, treatment and supply of clean drinking water, wastewater collection, establishing water treatment and disposal facilities, etc. Delhi *Jal* Board is supplying on an average about 115 litres percapita per day (LPCD) water (2011) to about 81.30% of its population. Most of the water is supplied to the urban part of NCT of Delhi. The water supply to the outer areas of Delhi is less and there is a great disparity in the supply pattern as there is no proper pipelines system in the outer part of the study area. Such areas in outskirts are generally unauthorised, not properly regularised colonies, *Jhuggi Jhopri* clusters (JJ Cluster) and resettlement colonies in which the water is mainly supplied through tankers. Economic Survey of Delhi report (2014-2015) examined that the total water requirement for Delhi as per DJB was 3185 MLD (million litres per day) in 2001 which was increased to 5281 MLD in 2011. The per capita water demand as per DJB in Delhi is about 251 LPCD (litres per capita per day). Taking into account the DJB water supplying capacity of 2104 MLD in 2001 and 3573 MLD in 2011 there was a huge gap to the tune of 1081 MLD in 2001 and 1708 MLD in 2011 between demand and supply of the safe drinking water (Fig. 2). Some of the potable water is procured by the inhabitants of Delhi by purifying the tube well water by installing domestic R.O. systems or by purchasing water in the form of bottled water as supplied by the registered or local water suppliers. However the quality of R.O. water supplied by local suppliers is always questionable on various accounts.

As per Central Pollution Control Board (CPCB) the sewage generated in the N.C.T of Delhi in 2001 was 1812
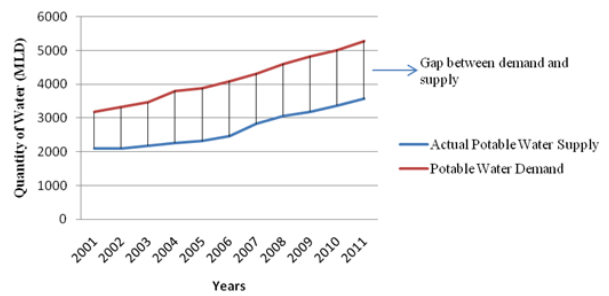

Figure 2: NCT of Delhi Gap between Demand and Supply of Potable Water (2001-2011).
Source: Delhi *Jal* Board Report, 2011 and Centre for Science and Environment, New Delhi, 2005-2006.

MLD and in 2011 it was 4144 MLD while the coverage of sewage network was increased from 86 percent (2001) to 90 percent (2011). There were 17 waste water treatment plants with a total treatment capacity of about 2,330 MLD. However, the actual sewage treated was about 1,478 MLD. The remaining sewage was disposed untreated in the River Yamuna. So the proper scientific disposal of the waste generated was not fully carried out due to underperformance of the existing sewage treatment plants as well as on account of under development of proper sewage treatment facilities. This in fact is inducing serious levels of surface water pollution and is indirectly contaminating the ground water resources also particularly in the close vicinity of the river banks.

Presently there are eight water treatment plant (WTP) under operation for supplying drinking water to various parts of NCT of Delhi. These plants are located at Chandrawal, Wazirabad, Haiderpur, Bhagirathi, Bawana, Nangloi, Okhla and Sonia Vihar. Potable water demand is increasing due to fast urbanization and rapid increasing population of Delhi. So there is ever increasing pressure on existing water supply system. Due to inadequate as well as substandard supply of water people fall prey to water related diseases and are subjected to morbidity as well as mortality. However, the trend of disease prevalence is inconsistent on yearly basis.

The occurrence of death due to intestinal infectious diseases such as cholera, typhoid, diarrhoea and gastro-intestinal diseases in Delhi from 2001 to 2011 is shown in Fig. 3 given below.

The Figure 3 represents the clinical records from medical certification of the cause of death from 2001 to 2011. Out of the total deaths, Diarrhoea and gastrointestinal occupies a leading position among diseases as a cause of death and illness and which is responsible for approximately 63 percent cases of deaths in a decade. It is followed by cholera which accounts for about 22 percent of deaths. The typhoid is on
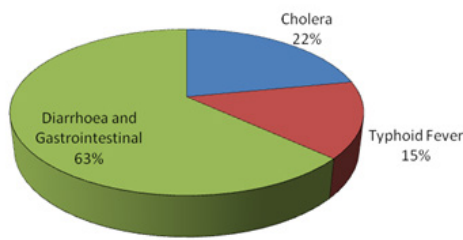
Figure 3: NCT of Delhi Average Mortality by Cause (2001 to 2011).
Source: Government of NCT of Delhi report on "Medical Certification of Cause of Deaths in Delhi" (2001-2011).

the lowest level which claimed only 15 percent of deaths in the study area.

The Figure 4 depicts the age wise distribution of mortality and cause of deaths as recorded between 2001 to 2011. It is observed that in the study area deaths due to Diarrhoea and gastrointestinal (GI) ranked highest among all selected water related intestinal infectious diseases which are found more prevalent among the juvenile and senile segments of the population. The population between 0-14 age group is badly hit by diarrhoea as compared to senile population. This fact point out that there is a lack of hygiene among this population segment. On the other hand senile segment is suffering on this account for their weak defence due to their advancing age. Followed by it, Typhoid was also most common among the children's of 5-14 age group and the age groups of 65 and above of the persons followed by Children's below 4 age and adults of 15-24 age group. It is evident from Figure 4 that deaths due to typhoid were less among the persons of the age groups of 35-44. This show that the incidence of water related diseases may be a result
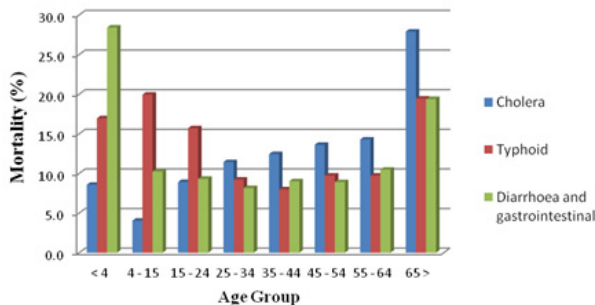
of inability to get access to portable drinking water. While Cholera deaths were most common among the segment of the population of 65 and above age and on the other hand lowest among the children between the ages 5-14. Higher occurrence of cholera among senile segments of the population may be attributed to increased susceptibility and low immunity. Consequently the outcomes demonstrate that juvenile means children below the age of five are more probable and prone to be affected by diarrhoea and typhoid fever and senile segment of population more affected by cholera.

The Figure 5 represents the trend of overall mortality rate from 2001 to 2011 against the population growth rate of NCT of Delhi. The graph represents an inconsistent trend. It is obvious that with the increase in the number of people the demand for potable water has also increased proportionately. The gap between the demand and supply of potable water is therefore gradually increasing (Fig. 2). Although the coverage of the supply area of potable water has also increased but the quantity of water provided is not sufficient to satisfy the basic needs. So people are using water from other sources which are sometimes unfit for direct human consumption. Hence, the population is more prone to water related intestinal infectious diseases. The numbers of deaths therefore have also increased from 143 persons in 2001 to 248 persons in 2011. The increase in the number of deaths over the years may therefore be indirectly attributed to overcrowding, congestion and lack of proper sanitation facilities etc. The Table 1 and 2 represent the provision of sanitation facilities and drainage system in NCT of Delhi. In spite of all negative aspects the difference in the number of deaths from 2001 to 2011 is not much and is only of 105 persons over the period of ten years which is approximately ten persons per year. This low mortality due to water related infection diseases under the adverse conditions of hygiene and improper drinking water quality is perhaps due to better availability and better access to medical facilities
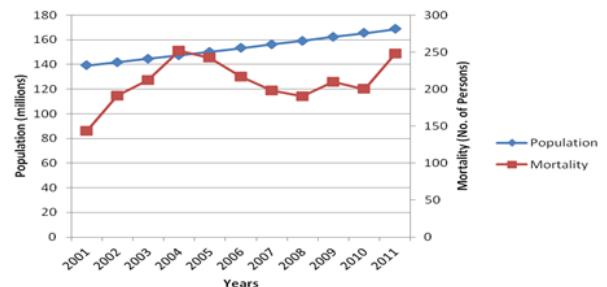

Figure 4: NCT of Delhi Age Wise Mortality by Intestinal Infections Diseases (2001 to 2011).
Source: Government of NCT of Delhi report on "Medical Certification of Cause of Deaths in Delhi" (2001-2011).

Figure 5: NCT of Delhi Population Growth and Mortality Rate (2001-2011).
Source: Economic Survey of Delhi, 2011 and Report on Medical Certificate of Cause of Deaths in Delhi (2001-2011).

Table 1: NCT of Delhi Households using Improved Sanitation Facilities.

	Census 2001	Census 2011
Total Households	25.54 lakh	33.41 lakh
Toilet facility available inside the house	77.96%	89.5%
Proportion of population using latrines (Toilet facility available)	NA	96.7%

Source: Census of India: 2001 and 2011
Note: NA= Not Available.

Table 2: NCT of Delhi Drainage System (2011).

HHs Sanitation Connectivity	Number of HHs	Percentage of HHs
(i) Closed drainage for waste outlet	19.78 lakh	59.2
(ii) Open drainage for waste water outlet	12.24 lakh	36.6
(iii) No drainage to waste water	1.38 lakh	4.2

Source: Census of India: *2011.*
Note: HHs= Households.

Figure 6: NCT of Delhi Projected Mortality Rate (2001–2021).
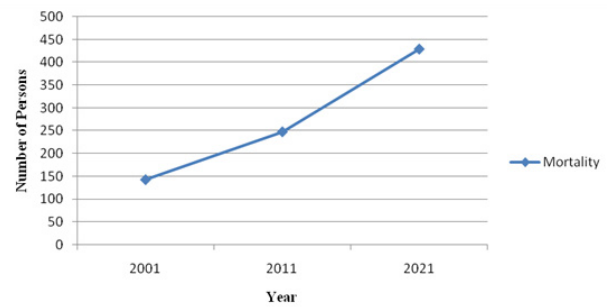
and increased awareness among the residence about these diseases.

It can therefore be stated that high living standards are good for human health but at the same time unhealthy urbanization is not good for human health. The preponderance of the evidence suggests that required improvement in the supply of potable water between 2001 and 2011 could not be done in large part of NCT of Delhi due to fast population growth. Consequently outbreak of various water related intestinal infectious diseases leading to mortality are observed during the study period. On the basis of 2001 and 2011 mortality figure the projected value of the number of deaths for 2021 considering MPD 2021 would be about 430 persons (Figure 6). This calls attention of the planners and planning agencies as enormous stress would be on existing water supply services to provide substantial quality and quantity of water to meet out the demand of growing population which would be about 230 lakh in 2021.

Conclusion

It is found that the availability of drinking water is not at par with the growing population in NCT of Delhi. It is also noticed that not only the quantity but the quality of water

is also compromised by the residents especially in localities inhabited by poor persons. Delhi *Jal* Board plays a pivotal role for the collection, treatment and distribution of water by different means like piped supply and tanker supply. In spite of whole efforts on the part of DJB the results of this study demonstrate that there persists an ever-widening gap between the demand and supply of quality drinking water. This requires more effective and more efficient water resource management system in order to averse the scenario of mortality and morbidity on account of these diseases. In the study area deaths due to diarrhoea ranked highest among all selected water related intestinal infectious diseases. It is followed by typhoid and cholera. The findings reveal that Diarrhoea is most prevalent within the age of 0-4 years. It is therefore suggested that more hygiene must be observed for this segment of the population by their respective parents as well as by creating more awareness about it, among the juvenile by educating them. While senile segment of population are most affected by cholera. This segment of population can be protected from these diseases by improving the level of personal care and precaution in drinking water intake by this segment of persons. The population falling in other age group is also suffering Typhoid fever, cholera and diarrhoea. This calls for more precautions to be taken, in drinking water supply by the agencies so that these agencies can raise their moral and confidence level for a better quality water supply on one hand and safety of water consumers from these diseases on the other hand.

In fact present study has additionally noticed that the river Yamuna as a water source is getting to be dirtied and the limit of treatment plants isn't sufficient to stop the contamination and decrease the harm on general wellbeing. The limit of these plants should be expanded. Consequently; there is a need to wake up as ahead of schedule as conceivable to be set up to handle the developing issue of water shortage to advance human wellbeing. There is a need for government intercession with dynamic individuals' cooperation to overcome such issues. If no intervention is taken to address neglected essential human requirements for water, the same or more number of people will die from these diseases in

future. This issue is getting to be a standout amongst the most genuine general well being emergencies for us, and requires more consideration and assets than it has gotten up until now.

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