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Mapping Cholera Vulnerability in Delhi: An Ecosocial Perspective

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Abstract: In the city-state of Delhi, the decade of the 1990s was marked by large scale in-migration, growth of industries, proliferation of slums and unauthorised colonies, shortage of water and electricity and pollution of air and water. Simultaneously, there has been a marked rising trend in cholera, particularly among migrant population. This paper examines the epidemiological situation of cholera in Delhi through the 1990s when large scale public health measures were put into operation following a major cholera epidemic in 1988. The vulnerable zones within Delhi have been mapped in detail and the epidemiological complexities identified in this paper. While some problems are technological, others are administrative and managerial. Inadequacies of safe water supplies in vulnerable colonies, sources of potential contamination and the community's reliance on alternative sources (much of which is contaminated groundwater) emerge as critical issues. Some areas with deep tubewell (municipal) water supply emerged as cholera foci since chlorinators were not operated properly by the Delhi Jal Board (DJB). Other endemic belts were located either close to sanitary landfill sites or the river Yamuna, where in the absence of piped supplies communities accessed highly contaminated groundwater. However, marked decline in cholera has also been demonstrated in socio-economically disadvantaged areas with reasonable quantities of piped supply by the DJB.

Key words: Cholera, Delhi, vulnerability, health, ecosocial perspective.

Urbanisation and Health Risks

The historical process of urbanisation in developing countries is different from that in advanced industrial societies (Safa, 1982). The literature on new urban economics explains the existence, size and structures of urban areas as market responses to opportunities for production and incomes (Mitra, 1994). It is also increasingly a 'divided city' where new landscapes of innovation, economic development, cultural exchanges, political dynamics and social inequalities are emerging. Safa (1982) explained that difference in patterns of urbanisation are due primarily to the late entry of the Third World countries in the global capitalist economy and their dependence on advanced economies for capital, technology and export markets; precipitating major changes in the organisation, structure of production and distribution and therefore in the labour force.

This dual sector approach – a modern, expansive capitalist sector with large scale production and orientation towards export and a traditional, subsistence sector for the domestic market – has been criticised by several authors (Hart, 1973; McGee, 1971; Souza and Tokman, 1976). Rather than being an impediment in the expansion of a modern capitalist economy, the informal sector has been interpreted to be the major means of survival to those not directly employed by formal sectors. Most of the urban poor work in small scale enterprises requiring a low level of skill and capital investment; often utilising the labour of unpaid family members. They inhabit squatter settlements and often do not get access to basic facilities. During the 1980s and 1990s poverty has become increasingly concentrated in urban settlements for economic and demographic reasons (Wratten, 1995). Structural adjustment policies introduced in the Third World have further accentuated

this problem owing to rising food prices, declining real wages, and redundancy in the formal labour market and reduced public expenditure on basic services and infrastructure (Moser et al., 1993; World Bank, 1991). The quality of environment has been deteriorating in many Third World countries. Risks include diseases associated with contaminated water and food, poor drainage and garbage collection, vectors, overcrowding and poor ventilation.

Environmental health problems of developing countries are wide ranging and far reaching. The pollutant of primary concern is human excreta. Poor collection and disposal of solid and liquid wastes, unsafe and inadequate drinking water, deforestation and indoor pollution due to unclean fuels are some of the critical problems that will be challenges of the current millennium. This paper explores the problems of endemic cholera in the megacity of Delhi – mapping the endemic and vulnerable areas and exploring some solutions. Asiatic cholera or classical cholera, as it emerged through the pandemics beginning since 1817 in Jessore, Bangladesh was primarily a rural disease. The El tor biotype (caused by *Vibrio cholerae*, El tor) has, in contrast, entrenched itself firmly in urban areas, specifically among the urban poor in developing countries.

Methodology

Theoretical Framework

Area socio-economic characteristics have been associated by several scholars to different health outcomes in a wide range of contexts (Diez Roux, 2001). Villermé in his 1826 study using Parisian data and Engels in the context of Manchester, England in 1844 demonstrated social gradient of diseases by location. A fairly common deterministic approach is to use regression methods at the level of individual characteristics. The methodology in this paper does not examine individual confounders across categories of area deprivation. The analysis is comparable to Breeze et al. (2005) in so far that "the combined (as opposed to the 'independent') effects of social class and area deprivation" has been captured. The caution expressed by Diez Roux (2005) in this context is significant.

"The assumption is that the people living in the least deprived areas are a good proxy for what the people living in the most deprived areas would be like if they did not live in the most deprived areas. Usually in epidemiological jargon, this implies no residual confounding by measured variables and no unmeasured confounders. The inability to undeniably confirm the validity of this assumption is the crucial limitation of observational analyses."

A fully adequate causal model for public health must therefore be able to explain the disease at the ecological level. In contrast with universalism (of natural sciences), ecologism of biological sciences entails localisation and attention to the bounds that limit generalisations about biological, human and social systems. Ecological constructs attempt to deal with true complexity of the biological world. Ecosocial perspectives have thus emerged in order to explain the social, political and economic processes that shape epidemiological patterns (Pearce, 1996; Susser, 1996; Krieger, 1995). Social epidemiology *per se* is not 'powerfully predictive'; however, accurate prediction depends on 'stitching together' contexts in particular populations live and work. This paper adopts the framework outlined by Krieger (2001) in exploring determinants of vulnerability for cholera endemic areas. Emphasis has been given on two key concepts:

- A cumulative interplay between exposure, susceptibility and resistance conceptualised at multiple levels – neighbourhood, regional and politico-administrative jurisdictions and in multiple home and public settings
- Accountability and agency in relation to institutions and communities

While emphasising accountability the paper argues that much of the vulnerability stems from 'institutional discrimination' precipitated by notions of legality and planning in urban spaces; deriving these material pathways at multiple levels. Thus this approach transcends standard 'biological' or 'social' analyses and explores a more holistic explanation of vulnerability to water-borne diseases. Cholera has been used as a marker of water-borne diseases since it is closely monitored and laboratory confirmed data is available.

To explore the causal linkages detailed contemporary epidemiological data is contextualised within the present organisation of the city. This organisation involved understanding constructs such as zoning, locating within them colonies of different types of populations, understanding the processes of resettlement and provision of services to the marginalised, the health service infrastructure and, cholera surveillance and monitoring institutions. Zones or colonies with consistently high prevalence of cholera or frequent focal outbreaks of cholera were considered as vulnerable; the socio-economic and environmental conditions that generate vulnerability were identified. Individual risk factors when located within the larger socio-economic, political and

administrative framework become less significant as compared to simplistic studies which look at individual behaviour alone (Dasgupta, 2007).

Time Series Analysis: 1994-2000

The contemporary phase focused on the study of 'vulnerability' issues in understanding time trends and determinants of cholera in Delhi. Data sources for this period included records and published articles available at the National Institute of Communicable Diseases and the Municipal Corporation of Delhi. Informal discussions were held with the zonal level officials of the Municipal Corporation of Delhi and the Delhi Jal Board. Repeated visits to the concerned field areas and interactions with the community provided valuable information and insights for the analysis.

In this context, it is to be noted that civic services are provided by three local bodies in Delhi – Municipal Corporation of Delhi (MCD), New Delhi Municipal Committee (NDMC), and the Delhi Cantonment Board (DCB). For administrative purposes, the MCD is divided into 12 zones. NDMC and DCB are planned areas with adequate civic services and the resident population groups are socio-economically well-off and stable. The MCD areas, on the other hand, cater to large bodies of population who are either poor or infrastructure-deficient or both. Since the public health problems including cholera and other diarrhoeal diseases are almost exclusively confined to the MCD areas, this part of the study is confined to the MCD areas.

Continuing with the analytical epidemiological approach, time trends were analysed in detail for each of the zones for the period 1994-2000 on the basis of available zone-wise data. Within these zones, endemic areas were identified, from where cholera cases are regularly reported. These colonies were thus considered to be vulnerable colonies and detailed analysis was made with regard to population, settlement and infrastructure characteristics in order to identify key vulnerability issues

Delhi – Population and Services

Compared to the Indian million-plus metropolises, Delhi experienced the highest demographic growth over the last few decades, at about +50%. Despite a recent slowdown in the growth rate, such demographic expansion has obvious implications for town planning, as the demand on urban services escalates. The National Capital Territory of Delhi (NCTD) is spread over an area of 1484 sq. km and is bound by the states of Haryana and Uttar Pradesh. The MCD covers 1397.3 sq km and includes 238 villages and is administratively divided into 12 zones (Civic Guide, 1995). Considering the settlement pattern in the urban areas under the jurisdiction of the MCD, the DUEIIP (2001) puts the population residing in slum clusters[1] at three million in 1997 – about 24.5% of the total population. Further, 15% were residing in unauthorised/regularised colonies, 13% in resettlement colonies and 9% in urbanised villages – all of which has been classified as "substandard housing".

Delhi's solid waste collection is the lowest compared to that of the major Indian cities. All the metros and other major cities have collection of 80% and above while one-third of Delhi's solid waste remains uncollected at any point of time (TEDDY, 1999). Gross managerial inefficiencies and poor maintenance of vehicles remain principal obstacles to proper collection and disposal of solid waste. No services are provided for unauthorised colonies that account for about 20% of the population. Disposal of solid waste is being "carried out by landfilling in an unscientific manner at four disposal sites" (DUEIIP, 2001).

There are seven Sewage Treatment Plants (STPs) and several more are under construction. The current total capacity is 1573 million litres per day (MLD)[2]. A study by the Central Pollution Control Board (CPCB), cited by the DUEIIP Report (2001), found that only 950 MLD (60% of the installed capacity) of sewage was reaching the STPs and was being treated. Outfall sewers exist in 10 resettlement colonies (22%). Out of 108 urban villages under MCD, sewerage exists in just 69 villages (64%). The situation in JJ colonies and resettlement colonies developed by the DDA is indeed serious. The sullage flows in open surface drains which ultimately reach the Yamuna river. Out of the 17 drains, five carry 95% of the pollution load.

In Delhi, about 65% of the water demand is met, in aggregate terms. About 1470 million litres of raw water are being drawn daily from the Yamuna river. Standard norms demand that 80% of this water should return as treated wastewater; i.e. 1170 million litres. In the dry season, about 2800 million litres of wastewater are being

[1] Slum clusters/squatter settlements are locally referred to as Jhuggi Jhonpri clusters or J J clusters. Some of them may be 'notified' slums making them eligible for somewhat better range of services. Thus, slum clusters and J J clusters will be used interchangeably in this paper.

[2] There are plans to augment the treatment capacity to a total of 2282 MLD.

discharged in the Yamuna. This implies that a significant proportion of the daily requirement of water is being met by accessing groundwater. Consumption of untreated groundwater has been repeatedly implicated as a causal factor for cholera in a number of studies in Delhi.

These aggregate figures fail to capture the reality of the situation in terms of access to safe water sources and availability of adequate quantity across different socio-economic groups within Delhi (Barah et al., 1998; Mazumdar, 1983; Kundu, 1993; Zerah, 2000; Dasgupta and Dasgupta, 2004). The Delhi Urban Environment and Infrastructure Improvement Project (DUEIIP, 2001) has explored the inequity in water supply and has observed that 10% of the population has no piped water supply and 30% has grossly inadequate access. It is interesting to take a look at the arbitrary standard of calculating requirement by the Delhi Jal Board – 270 lpcd for planned colonies, 153 lpcd for regularised colonies and 50 lpcd for unauthorised colonies and other areas (DUEIIP, 2001). It is a gross violation and undermining of the WHO norms, right at the planning stage with further inadequacies and inequities when it comes to actual distribution. Delhi Cantonment Board and New Delhi Municipal Committee emerge as the most privileged areas with a per capita supply of 509 and 462 lpcd respectively; at the other end of the spectrum, Mehrauli Zone of the Delhi Jal Board has a per capita supply of 29 lpcd only.

Time Trends of Cholera

Since 1947, there had been a general decline of classical cholera in the country. Following the introduction of El tor cholera in India in 1964, it began spreading to other Indian states. In 1965, El tor cholera was reported from several states including Delhi (Patnaik and Kapoor, 1967). A major epidemic in 1988 raised several administrative, infrastructural and managerial issues. In the aftermath of the epidemic a series of steps were taken for prevention and control of diarrhoeal diseases. Despite these measures, there was another spurt of cases in 1994-95 owing to the introduction of a new strain O139 Bengal. Figure 1 shows the trends in incidence rates of cholera cases (per 1000 cases) during the period 1965-2000.

The trendline for the incidence rates (per 100,000 population) of cholera cases in Delhi demonstrates an increasing trend over the years. This is in contrast to an overall declining trend over the corresponding period in India. Case fatality rate was as high as 9% in 1965. This dropped sharply during the following years and settled

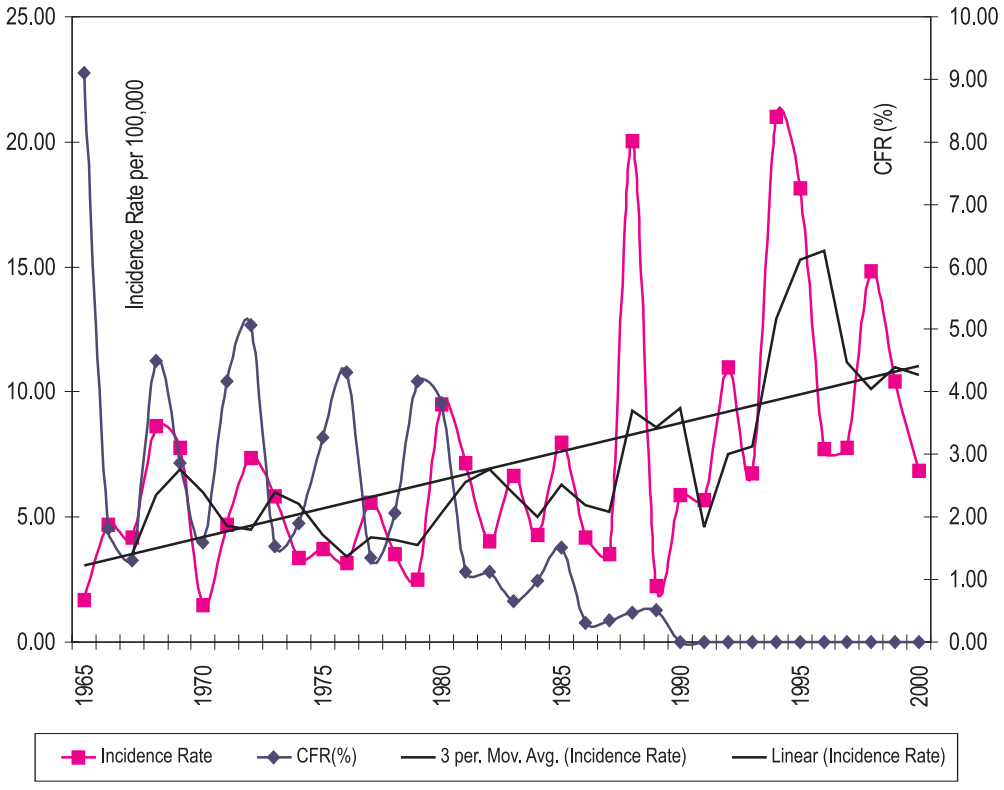


Figure 1: Incidence rate and case fatality rate of cholera cases in Delhi (1965-2000).
Data Source: National Institute of Communicable Diseases and Infectious Diseases Hospital, MCD.

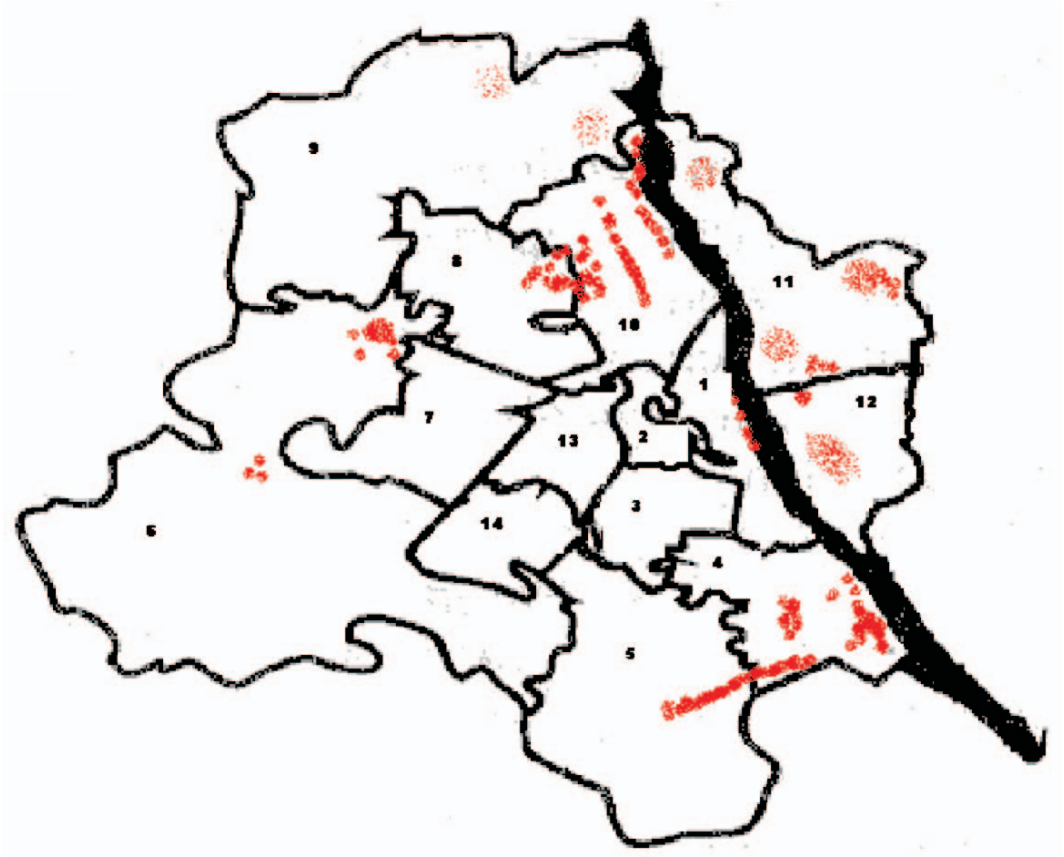
in this phase of the epidemic to a 2-4% level and continued throughout the seventies. Though incidence rate continued to rise steadily across 1980s and 1990s, in Delhi, case fatality rate (CFR) dropped down further to zero level, in keeping with the national trend. Case fatality rate was relatively higher in the earlier high incidence years of 1980 and 1985. It registered a sharp decline after 1980 only to rise to a 3%+ level in 1985. In 1986 it dropped sharply to 0.3% and even the 1988 epidemic witnessed a CFR of 0.47%. It is observed that the 1988 epidemic recorded the second highest incidence rate in this 25 years series ~20.02 per 100,000 and the rate in 1994 was the highest ~21.02 per 100,000. Since 1990, no cholera deaths have been reported and consequently the CFR has also dropped to 0%.

Mapping Cholera in Delhi

Data is available on the number of notified cholera cases for the 12 municipal zones for the years 1994-2000. Incidence rate of cholera cases has been computed per 100,000 population for each zone. The validity of this data lies in comparative analysis over space (inter-zonal) and time rather than as figures for real incidence rates.

The zonal incidence of reported cholera cases ranged from 2.92 per 100,000 to 64 per 100,000 in 1994; during 1998 it ranged from 2.81 per 100,000 to 488.71 per 100,000 and in 2000 it ranged from 0.91 per 100,000 to 22.40 per 100,000. While all the zones were markedly affected in 1994-95, in 1998 Civil Lines and Rohini Zones were the most affected while others showed minor increases. Over the period 1996-2000 different zones show starkly differing trends. Rohini, Narela and Najafgarh Zones have demonstrated a downward trend. Shahdara (North) and Shahdara (South) Zones too have shown a similar trend. In contrast, a rising trend is visible in 1999-2000 in Central and more so in South Zone.

With these observations of incidence of cholera cases at the zonal level, further disaggregation was attempted. Analysing relevant characteristics of the zones and



1. City Zone, 2. Karol Bagh Zone, 3. Sadar Paharganj Zone, 4. Central Zone 5. South Zone, 6. Najafgarh Zone, 7. West Zone, 8. Rohini Zone 9. Narela Zone, 10. Civil Lines Zone, 11. Shahdara (North) Zone 12. Shahdara (South) Zone,

[1 to 12 are Zones of the Municipal Corporation of Delhi (MCD)

13. New Delhi Municipal Committee 14. Delhi Cantonment Board

Figure 2: Zonal map of Delhi; Cholera endemic areas are marked in red.

vulnerable colonies helped in identifying determinants of cholera in Delhi. Further, the spatial distribution of the cholera cases in each zone (by residential addresses in the notification) indicated that there were several areas from where these cases were consistently reported. The mean contribution of cholera cases reported from these endemic pockets to the annual cases for the respective, is fairly consistent over the study period and works out to be 76.85% of the total reported in Delhi, with a standard deviation of 2.67%.

Issues of Vulnerability

The growth in provision of housing, water and sanitation facilities has failed to keep pace with the demands of increasing numbers, attracted by the growth in economic activities and opportunities. The fallout is seen in the growth of unauthorised colonies, squatter settlements and extension of *laldora* in urbanised villages. These settlements have emerged as endemic areas for cholera in Delhi.

Civil Lines and Rohini Zones have relatively lower population densities, higher per capita availability of water (274 lpcd), higher coverage of sewers (60-80%), and yet, high incidence rates of cholera. Though the averages in terms of availability of services, seem to be on the higher side, yet, there are wide disparities among population groups within the zones, including the level of services available to them. In the 2001 Census, North West District which corresponds to the vulnerable belts of Civil Lines, Rohini and part of Narela Zones experienced the second highest decadal growth rate (+60.12%) and, much of this growth comprised of population groups of low socio-economic status employed mostly in unorganised and semi-organised sectors. Therein lies the explanation why 87% and 80% of the cholera cases from Civil Lines and Rohini Zones respectively, are being reported from the vulnerable colonies of these zones. The locations where these population groups are located are either close to the river (with superficial but highly contaminated groundwater) or are close to the sanitary landfill sites.

Across the River Yamuna, Shahdara (North) Zone experienced similar levels of population growth (+62.5%) during 1991-2001. Shahdara (South) Zone had a growth rate of (+41.61%). Per capita water availability is 130 lpcd and sewerage services are poorer than in Civil Lines and Rohini Zones. Yet the incidence rates are much lower. Although the average per capita availability of water in absolute terms is lower, lesser disparities within these zones imply that even the poorer sections actually receive far larger quantities of water than in some other zones with higher average availability. The rate of decline of incidence in Shahdara North and South Zones is largely attributable to the commissioning of the Bhagirathi water treatment plant (drawing water from Ganga River through pipelines from the adjacent state of Uttar Pradesh). However, sewerage services will need to be augmented to fully reap the benefits of added availability of water.

City, Sadar Paharganj and Karol Bagh Zones have good availability of services. In particular, availability of sewerage services is high for all segments of the population, independent of socio-economic class. Despite being zones with the highest population densities, these zones have actually experienced a decline in the population growth rate during 1991-2001. In the backdrop of an average growth rate of (+46.31%) the Central district that roughly corresponds to these three zones, recorded a negative decadal growth rate –1.91%. The incidence rates of cholera are among the lowest of all the zones.

The two zones that have demonstrated a definite rising trend in incidence rates towards the second half of the 1990s are South and Central Zones. The apparently low population density of South Zone is misleading as nearly two-thirds of the zone comprises rural areas with very low population density. In the post liberalisation period, during the 1990s, there was phenomenal growth of the tertiary and services sector based activities in these zones. This growth in economic activity corresponded with a high decadal growth rate of population of +50.27%. The vulnerable colonies of these zones comprise urbanised villages and colonies located along the Mehrauli-Badarpur Road. The proportion of vulnerable population is more in the South Zone than in Central Zone. The residents of these vulnerable colonies belong to lower middle socio-economic groups. Along with high population density in these colonies, there is a high proportion of tenancy occupation. There is acute water scarcity and high levels of contamination because of a combination of factors operating at both the colony and household levels. Large disparities exist in the availability of water between these vulnerable colonies and the rest of the zone. The per capita availability of water is only 29 lpcd in these vulnerable colonies, as compared to a zonal average of 148 lpcd. The situation is summarised in Table 1.

Concluding Remarks

Rapid increase in population (fuelled, in part, by large scale in-migration), inadequacies of safe water supplies

Table 1: Determinants of vulnerability to cholera in MCD zones

Zone	*Avg. Inci. Rate (per 100000)*	*% of cases from vul. colonies*	*Predominant economic activity*	*Pop. density (per sq. km.)*	*Per capita piped water supply (lpcd)*[1]	*Pop. having access to sewers*[2]
Civil Lines	33.39	86.94	Small and medium industries, wholesale markets, trading	13,500	274	60%
Narela	32.05	61.70	Agriculture, agro-based industries	743	32	Nil
Najafgarh	23.55	73.86	Agriculture, industries, services	1,127	74	25%
Rohini	22.50	79.92	Trading, transport, services	8,848	274	90%
South Central	18.20 11.76	77.19	Services, small scale industries, trading	4,237 21,486	148	50% 60%
Shahdara (North)	12.30	84.31	Trading, small scale industries	17,200	130	10%
Shahdara (South)	5.48	74.31	Services, trading	20,529		30%
Sadar						
Paharganj	5.42	45.43	Wholesale markets, trading, services, small scale industries	98,250	205	100%
Karol Bagh	3.71	63.04	Wholesale markets, trading, services, industries	33,116	337	90%
City	3.40	43.30	Wholesale markets, trading, services	80,000	272	90%
West	1.91	0.00	Trading, services, small scale industries	15,193	202	90%

Note: 1 – DUEIIP, 2001; 2 – Personal Communication with Delhi Jal Board.

in vulnerable colonies, sources of potential contamination and the community's reliance on alternative sources much of which is contaminated groundwater emerged as critical issues. The state of functioning of the chlorinators of the Delhi Jal Board (DJB) implored one to conclude that to a significant extent cholera in colonies supplied by DJB tubewells (to which these chlorinators are attached) is 'man made'. This being evidently a managerial failure implies scope for correction and consequent reduction in the disease burden of cholera. While piped water supplies of the DJB is generally safe, illegal tapings and poor maintenance of service pipes by households often lead to focal contamination. Attempts to enhance household level supply through individual initiatives such as use of online booster pumps, further aggravated risks of contamination. Therefore wherever piped supplies exist, correct and adequate operation and maintenance is crucial. DJB tankers have, in recent years, been deployed in large numbers in some of the vulnerable colonies, and the benefits in terms of decline in incidence of cholera have been evident. This is neither cost effective nor a sustainable solution.

Open defecation and/or improperly constructed sanitary latrines in JJ clusters and unauthorised colonies coupled with an acute dependence on untreated groundwater has been crucial to the emergence of these settlements as highly endemic for cholera. The strong association established between 'sanitary' landfill sites and high incidence of cholera in localities that surround them has ominous implications that must be taken into account in future planning processes.

This study assumes importance and relevance in the context of the third Master Plan of Delhi (MPD III). Intense debates are on as to the possible impact of the MPD III on the already stretched infrastructural services. Stress is being laid on providing efficient infrastructure and adequate growth opportunities in the towns of the National Capital Region, as a way to decongest Delhi. The new proposed floor area ratios are going to add to the increasing population density. The proposed regularisation of industries in residential areas is bound to have adverse environmental health impacts. The future plans therefore have the "almost impossible task of having to make-up for 40 years of neglect" (Roy, 2000). The Delhi Jal Board has recently expressed its inability to provide sewers to 253 of the 1639 unauthorised colonies that were regularised before the Delhi Assembly elections in November 2008 since most of these colonies

have neither peripheral trunk sewers nor adequate water! Urban planning, in developing countries, is often a bubble waiting to burst. Yet, it defines neighbourhoods and spaces in terms of legality/illegality; extending that tag to populations who reside in these spaces. Institutional exclusions randomly peppered with political charity of skeletal 'public' or 'free' services create a vicious cycle of vulnerability and disease; cholera in this instance is one but significant marker of the phenomenon.

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