Exploring intra-household factors for diarrhoeal diseases: a study in slums of Delhi, India

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ABSTRACT

While infrastructure conditions constitute 'primary routes', contamination of water within households and other behavioural determinants are considered as 'secondary routes'. However, recontaminated water has been considered not to constitute a serious risk though it occurs commonly in poorer societies. A study was conducted in Delhi where individual risk factors were located within a larger socio-economic, political and administrative framework, as they were often independent variables. This component of the larger study hypothesised that behavioural factors at individual household levels lose significance as major determinants of diarrhoeal diseases once they are analysed in a holistic epidemiology frame. Determinants at the household level were explored through a dataset based on a primary survey of 300 households in three slum clusters. Amongst households storing municipal water (proven to be safe at source), adhering to the best storage practices did not translate into lower incidence rates as compared to those with relatively unsafe practices. The explanation lay in factors which were external to the home and beyond the control of the affected household. Thus, household level behavioural factors such as storage practises should not be analysed in isolation as determinants of diarrhoeal illness particularly when pitted against stronger neighbourhood and external determinants.

Key words | Delhi, diarrhoeal diseases, intra-household factors

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INTRODUCTION

Behavioural factors at the individual household level are considered a critical determinant in the causation of diarrhoeal diseases. This paper explores this issue in a holistic social epidemiology frame which takes into account factors such as poverty, provision of services, living conditions and settlement patterns. The study conducted in three slums of Delhi argues that the household determinants should not be considered in isolation and lose their significance when pitted against stronger neighbourhood and external determinants which are beyond the control of the individual household.

It is generally agreed that transmission routes of pathogens of diarrhoea are complex. Considerable emphasis has been given to intra-household and behavioural factors as key determinants for diarrhoeal diseases including cholera. Briscoe (1984a) pointed out the importance of evaluating

multiple routes of transmission and assessing the impact of an individual determinant. While infrastructure conditions constituted primary routes, contamination of water within households and other behavioural determinants were considered as 'secondary routes'. He however cautioned that it would be erroneous to conclude that improvements in drinking water supply are not an important intervention strategy for controlling diarrhoeal diseases and advocated that improvements in the secondary routes of transmission can have a dramatic effect on disease incidence only if prior improvements in drinking water quality have been made (Briscoe 1984b). WHO (1977) considered unhygienic transportation and storage of water as a 'public health risk', which is behavioural in nature and can be 'reduced or eliminated'. The importance of secondary routes has been put into proper perspective by

some authors (Feachem *et al*. 1978; Trevett *et al*. 2005) who argued that when drinking water becomes contaminated during collection and storage in the home, which occurs quite commonly in poorer societies, the risk of faecal-oral disease is low. Pruss *et al*. (2002) considered various models for the improvement of water supply, sanitation and personal hygiene but did not take into account the extent to which household behavioural practices are relevant when water and sanitary latrine facilities are poor. They reported that benefits of continuous piped water supply were not adequately documented. Esrey's (1996) multi-country study has explored the transition between different scenarios when interventions are implemented.

Chakraborty & Das (1983) conducted a comparative study of the incidence of diarrhoea among children belonging to low income families in two different situations in Calcutta, India – one group living in slums and the other residing in relocation projects of the Calcutta Metropolitan Development Authority (CMDA) in multi-storey buildings, and observed that diarrhoea episode per child was 1.6 in slums and 1.4 in CMDA area; the difference was not statistically significant. Incidence was high among infants in both the groups but declined sharply in CMDA children at 2 years. The decline in case of slum children was observed to take place at the age of 3 years. Provision of running water and sanitary latrines (as common facilities and not at the household level) in CMDA project areas did not reduce diarrhoea to any significant extent as compared to the slum children. Incidence declined in both groups with increase in mothers' educational status. Partially breast fed children suffered the most among both groups.

Henry & Rahim (1990) examined transmission of diarrhoea in two crowded areas with different sanitary facilities in Dhaka, Bangladesh. The degree of contamination in each child's drinking water (water borne) and on the hands of each child (water washed) was correlated with diarrhoea incidence. Diarrhoea attacks increased significantly for children with more contaminated hands. Microbiological data collected in Matlab, Bangladesh focussed on each of the possible different transmission routes and concluded that most of the transmission was through drinking water. However, on account of the existence of secondary transmission routes such as ingestion of contaminated water during bathing and also because the

dose-response relationship was approximately log-linear, elimination of the main route did not get reflected directly through major reductions in the incidence of diarrhoea.

Ghosh *et al*. (1997) explored the risk behavioural practices of mothers of families residing in slums in Calcutta and Varanasi and in rural areas in Haryana and Hyderabad in India. They observed that a sizeable proportion of children did not suffer from diarrhoea though they lived in the same area as that of the children with diarrhoea. In Calcutta slums 53.4% of children remained diarrhoea-free during the one year study period with six days a week of active surveillance. Risk factors associated with incidence of diarrhoea in a family included use of pond water for cleaning child-feeding containers, indiscriminate disposal of children's stools, bottle feeding, non-use of soap for cleaning child-feeding containers and water storage in a wide mouthed container.

A study of eight villages in rural Bangladesh explored the associations of socio-economic variables with the incidence rate of diarrhoeal diseases (http://paa2005.princeton.edu). The villages were purposively selected to represent areas of high population density. Water samples were drawn from pond water to quantify the load of faecal coliforms. The level of contamination of all water samples was found to be beyond the permissible limit. The study concluded that faecal coliforms were responsible for the high incidence of diarrhoea. "Surprisingly other SES factors like education, occupation do not have significant impact to decrease the disease incidence, which challenges the theory on 'SES and disease incidence' i.e. the higher the SES the lower the incidence of disease." It acknowledged that there was 'village effect' in the incidence of diarrhoea which required further ethnographic work to complement this exercise. Contrary to the conventional public health wisdom, 50% or more of those who used sanitary latrines suffered from high rates of diarrhoea as well. Income was found to be significantly associated with the incidence of diarrhoea at 10% level.

A recent meta-analysis by the World Bank (Fewtrell & Colford 2004) argued that hygiene education and water quality improvements were more effective at reducing the incidence of diarrhoeal disease. Point-of-use disinfection of water with chlorine, combined with safe water storage and basic hygiene education has been considered to provide a

substantial health benefit at the lowest incremental cost (http://www.waterandhealth.org/newsletter 2003). A system designed by the Centres for Disease Control (CDC) is being socially marketed in order to ensure bacteriologically safe water supply at the household level. The WHO in association with Population Services International and Sulabh International started a Pilot Project in 2002 in selected slums in west Delhi for social marketing of liquid chlorine for home chlorination and a narrow mouthed container to prevent domestic level contamination. However, the Project was discontinued since results were poor (Dasgupta 2005). Similar results have been reported by an investigation in Mexico which showed that the existing piped, treated water in the project communities was of good quality, though with sub-optimal residual chlorine (Lantagne et al. 2005). Although the project was well intentioned, it was not an appropriate intervention for these communities.

Levels of water contamination are often not addressed in such designs. Arguments continue on whether the decisive factors are infrastructural, socio-economic or behavioural. While it is imperative to provide households with adequate, safe and reliable water supply and sanitation services, household behaviour, resources and preferences of households also form critical determinants of diarrhoeal diseases. In the ultimate analysis, all these factors are highly intertwined. These include water sources, interruptions in piped supplies, water storage practices and water quality of both sources and on storage. The household's access to a sanitary latrine must also be taken into account.

METHODS

Conceptual framework

Drawing out the problems of designing studies for an epidemiological complexity from the above reviews, a study of Delhi was taken up that addressed the complexities of the organisation of the city, in terms of spaces, services, population settlements, resources and its administrative and political structure. Individual risk factors were located within the larger socio-economic, political and administrative framework, as they were often independent variables. This study starts with the premise that behavioural factors at the individual household level lose

their significance as major determinants of diarrhoeal diseases once they are analysed in a more comprehensive and holistic social epidemiology frame which takes into account factors such as poverty, provision of services, living conditions and settlement patterns.

The findings narrated in this study constitute a part of a larger study (Dasgupta 2003). It took a holistic epidemiological approach using an integrative model which located biological, environmental and behavioural factors to understand and analyse time trends of cholera and its determinants in Delhi. Cholera has been viewed as a complexity which represents the interface of biomedical, environmental and social domains. The study encompassed the entire spectrum of analysis beginning from the colonial period to the contemporary period and conducting within them population analysis for cholera prevalence and its determinants. Cholera, being a notifiable disease, was better reported than diarrhoeal diseases and the observations in connection with cholera also hold true for diarrhoeal diseases in general. The study identified that cholera was endemic in certain colonies from where 70–85% of annual incidence was reported. The principal causes included settlement and infrastructural conditions, particularly water supply, sanitary latrines and sewerage services.

Sampling

Determinants at the household level were explored through a dataset based on a primary survey of 300 households in three clusters which were geographically adjacent to each other. Two slum clusters and one resettlement colony were randomly chosen from among the colonies which are vulnerable for cholera and diarrhoeal diseases (Dasgupta & Dasgupta 2004). 100 households were chosen in each cluster by random sampling. For each cluster a simple random sample of households with replacement was drawn.

Water samples were tested from the main sources accessed, and, from storage containers in the households. 60 water samples were collected i.e. 20% of the 300 households in order to ensure epidemiologically valid results. 'Water source' was defined with reference to the means by which water was accessed; for example, shallow handpumps was one source, as distinguished from deep bore tubewells which was considered to be another distinct source. A two

stage sampling was conducted. In the first round, all the community sources were tested. Based on the results, samples of stored water from households were tested for the extent of contamination at the domestic level.

Survey instruments

An open-ended semi-structured questionnaire was administered to collect information on socio-economic variables, availability of civic services and water storage practices. The questionnaire comprised of the following sections – complete household roster and socio-economic survey, history of diarrhoeal illness, water and toilet facilities and water storage practices. The variables on which data was collected included:

- Incidence of diarrhoea among children and adults for a 2 week recall period. Diarrhoea was defined as the passage of loose, liquid or watery stools more than three times a day.
- Family size.
- Income and occupation of family members and total household income.
- Migration history.
- Toilet facilities – open field/open drain/individual sanitary latrine/community sanitary latrine.
- Sources of water supply – municipal piped supply/ shallow handpumps/tubewells.
- Whether municipal water supply was intermittent/ continuous.
- Whether supply was at individual household level/ through public standposts.
- Whether drinking water was stored separately, in a covered/uncovered vessel; whether the vessel was wide/ narrow mouthed and also whether a separate utensil was stored for drawing water from the storage vessel.
- Home chlorination of drinking water.
- Hand washing practices.

It may be noted that intervention studies on point-of-use disinfection of drinking water (Quick & Semanza 1999) and hand washing (Huttly *et al.* 1997) have reported reductions in the incidence of diarrhoea. However, the results of pilot studies in a comparable slum cluster done in this study did not reveal consistent results for these variables and therefore these variables were dropped for the main survey.

Water samples were tested using the Presumptive Coliform Test. The guidelines for drinking water quality recommended by the WHO in 1996, the ISO (IS 10500) prescribes that the coliform count of a drinking water sample should be less than or equal to 10 per 100 ml of water.

Analytical approach

Descriptive statistics from the preliminary data analysis were used in identifying the baseline characteristics with regard to socioeconomic variables, and access to infrastructure. Incidence rates for diarrhoea were subsequently calculated – age and cluster wise to establish morbidity density due to diarrhoeal diseases. Results of the laboratory tests of water samples were obtained. Correlations between water sources (safe/unsafe), income and educational levels were explored. Cross tabulations were made to analyse patterns of incidence to diarrhoeal diseases with vulnerability factors such as water sources, access to sanitary latrines and storage practices. Mean comparison tests (this entails a two sample t-test of the hypothesis that the mean of the values in one cluster equals the mean of the other cluster) were carried out for comparing the incidence rates across clusters wherever appropriate to test whether the differences in incidence rates obtained were significant across clusters.

RESULTS AND DISCUSSION

Baseline characteristics of the three clusters

The three colonies were selected from two adjacent municipal zones where the proportion of cholera cases ranged from 75 to 85% of the annual cases. The population density was estimated to be about 17–20,000 per sq. km. Per capita water supply in these two zones was about 130 litres per day and 10–30% of the population had access to sewers. The population was among the poorest in Delhi with most of them engaged in manual labour and services in the informal sector. Socio-economic status in the two slum clusters (Clusters 1 and 2) were poor whereas that of the resettlement colony (Cluster 3) was relatively better. The proportion of recent migrants (residing in Delhi for less than 5 years) ranged from 20–40% in Clusters 1 and 2.

In Cluster 3, more than a third of the respondents were resident for 15 years or more.

Cluster 1

Majority of the working adults (male and female) were labourers. Per capita income was lowest among the three clusters. 59% of heads of household and 80% of the mothers were illiterate. While almost 60% of the children (5–18 years age group) attended school, male attendance was not significantly higher than female attendance. Municipal water supply was available through public hydrants (standposts). 96% of households reported using water from municipal public hydrants as the primary water source. 32% accessed an additional water source which was exclusively handpumps. 89% of the households reported municipal piped supply as the source of drinking water while the remaining 11% used handpump water for drinking. One-third of the public hydrants had continuous supply while others had interrupted supply. 63% of the households reported using the community sanitary latrines. 36% used open fields for defecation and another 1% used open drains.

Occupational status was considered in four categories – labour, service, business (business in the slum clusters implied petty businesses and shopkeepers) and others. Majority of the heads of household in this cluster were labourers and about 80% of them earned less than Rs. 1500 per month (Rs1 US $ = Rs. 46 approximately). Service was the second largest group. 77.78% of the working women were labourers. Family income was grouped by dividing the entire income range into six percentiles (sextiles). Per capita income of the Cluster was Rs. 284.05 per month. More than two-thirds of the families earned less than Rs. 1,500 per month. The second largest occupation group comprised salaried individuals (generally employed in the informal sector) who had family income between Rs. 2001–3500 per month. The proportion of heads of household employed in labour decreased and correspondingly the proportion in service and petty business activities increased as one moved up the higher income categories. Proximity to institutional and commercial areas probably explained the relatively higher proportion of salaried personnel.

Responses on education were classified into four mutually exclusive categories – illiterate, attended school, completed school, and higher education. Information was obtained about educational levels of heads of household, mothers and children. In this cluster 59% of heads of household and 80% of the mothers were illiterate. The proportion of mothers who had attended and completed school was also proportionately much less than the heads of household. While almost 60% of the children attended school, male attendance was not significantly higher than female attendance.

Cluster 2

Municipal water supply was through public hydrants which were located along the main lanes of the cluster. Water pressure was low: the height of some of the public standposts had been lowered by the residents or, were completely removed with only a rubber tube connected to the stump, a sure recipe for contamination. 55% of the households reported using municipal water from public hydrants as the primary water source and 45% were using shallow hand-pump water. 97.3% reported accessing handpumps as an additional water source. 51% of the households reported municipal piped supply as the source of drinking water while the remaining 49% used handpump water for drinking. Water supply in the public hydrants was reported to be continuous. The entire population was using open fields for defecation.

Like Cluster 1, the majority of the heads of household in this Cluster were labourers. While service was the second largest group in Cluster 1, business was the second most important category in this Cluster. 85.71% of the working women in this Cluster were labourers. The per capita income of this Cluster was Rs. 345.71 per month. Though Clusters 1 and 2 were both slum clusters, Cluster 2 was economically better off with higher levels of income. A higher proportion of families in Cluster 2 were engaged in business and that accounted for the income differences. The relationship between proportions of heads of household engaged in labour and increasing income levels was not an inverse one as observed in the case of Cluster 1.

Cluster 3

This planned colony has basic civic amenities. All the flats had household level connection of municipal water supply. In addition, many of the ground floor flats had handpumps

as an additional source. Several households had tubewells. Most of the households had refrigerators and drinking water was stored in bottles in refrigerators. 100% of the households reported using municipal water as the primary water source. 85.1% reported accessing handpumps as an additional water source while 12.8% used tubewells. Despite all the households having piped supply, only 79% reported using it as the source of drinking water. 19% used handpump water for drinking and another 2% used tubewell water for that purpose. The municipal water supply was reported to be continuous. All the flats had sanitary latrines which were connected to sewers.

Cluster 3, was a relatively high income cluster. In relative terms, while most of the households in Clusters 1 and 2 were poor, those in Cluster 3 can be considered as middle class. 58.16% of the heads of household were businessmen and 40.82% were in service. The majority of working women were in service. Per capita income was Rs. 879.50 per month. Those with businesses on average earned more then the salaried employees in the cluster. There was a definite shift from the service sector to business activities at higher income levels. Of the working women in Cluster 3, about 92% were salaried employees, most of them reporting family income between Rs. 3501–5500 per month.

The educational status was highest in this cluster as compared to the other two clusters with lowest proportion of illiterate mothers at 9.78%. Only 3% of heads of household were illiterate. In fact, the largest group of mothers (43.48%) and heads of household (78.35%) belonged to the higher education category. This was in sharp contrast to the other two clusters where the majority of both mothers and heads of household belonged to the illiterate category. Correspondingly, school attendance rates for both male and female children were high in this cluster at 94% and 91% respectively.

Incidence rates of diarrhoea

It is important to understand that the Clusters 1 and 2 are among the most vulnerable clusters and that the study was conducted during the most critical months (July-August) from the point of view of diarrhoeal diseases. The incidence rate of diarrhoea for a two week recall period was computed and is reported in Table 1.

Table 1 | Incidence rate (per 1000) of diarrhoea in the three clusters

	Cluster 1 All ages	Under-5 children	Cluster 2 All Ages	Under-5 children	Cluster 3 All Ages	Under-5 children
No. of cases	42	38	28	21	9	7
Population	534	241	583	97	478	104
Incidence rate	78.7	157.7	48.0	216.5	18.8	71.4

The incidence rates for all age groups are highest in Cluster 1, intermediate in Cluster 2 and lowest in Cluster 3, however, for the under-5 children the incidence rate is highest in Cluster 2. Bhatnagar & Dosajh (1986) reported a figure of 246 per 1000 for under-5 children residing in the slums of Delhi. Mehrotra's (1988) finding of an incidence rate of 79/1000 in Sunder Nagri, a resettlement colony, is comparable to the figures obtained for Cluster 3 of this study which is also a resettlement colony situated in the same municipal zone.

Mean comparison tests were carried out for comparing the incidence rates across clusters. The t-statistic revealed that in the 'all ages' category the difference in incidence rate was highly significant between Clusters 1 and 3 (1% level of significance), and, Clusters 2 and 3 (5% level of significance). However, the difference was not significant between Clusters 1 and 2. For the under-5 age group, the incidence rates were significantly different across clusters – Clusters 1 and 2 at 10%, Clusters 1 and 3 at 1% and Clusters 2 and 3 at 5% levels of significance.

Empirical analysis of vulnerability

Across clusters, municipal piped supplies were reported as the primary water source. With greater access to municipal piped supply through public hydrants that distributed in a fairly even manner, usage of this safe source as drinking water was 89% in Cluster 1 compared to 49% in Cluster 2 where poorer households were located farthest from the public hydrants (which were located near the road). In Cluster 3, the ownership of individual handpumps and tubewells (which were used as additional water sources)

were in the higher income groups. In all three clusters, the data revealed a positive association between households with an additional source of water (invariably accessing contaminated groundwater but providing a continuous and convenient source) and increasing income levels, particularly with regard to the middle income ranges across clusters.

Within all three clusters there are no unidirectional associations between incidence rates and income levels. The correlation coefficient between family income and educational level of head of household was not significant for any of the clusters at the 5% level. The correlation coefficient was marginally higher at 0.06 for Cluster 1 as compared to 0.03 for the other two Clusters. With improvement in educational status of both the parents, use of handpump water for drinking purposes reduced significantly in Clusters 1 and 2. The trend was different in Cluster 3. 100% of head of households using tubewell water and 66.67% of those using handpump water for drinking purposes belonged to the higher education groups; they were also households reporting high incomes. But among mothers belonging to the higher education group, 87.5% were using municipal water for drinking. As educational status of mothers declined, consumption of handpump water for drinking increased significantly.

In Cluster 1, 90% of those with lowest family incomes accessed community sanitary latrines. This dropped to an average of about 60% for the higher income levels. In Cluster 2, there were no provisions for community sanitary latrines. Also, there was no scope for construction of individual latrines, irrespective of household incomes.

All residents therefore defecated in the adjacent open fields and drains. Dwelling units in Cluster 3 were constructed with individual sanitary latrines. Thus, in these clusters, colony level factors were critical rather than individual income levels in determining access to sanitary latrines.

In Cluster 1, the water sources were only shallow handpumps and public hydrants. The distribution of these community sources were 3 shallow handpumps and 6 public hydrants. Water samples were collected from all these sources since these were the only sources accessed by all the households in these clusters. The handpumps (Table 2), all 3, had the maximum possible contamination with counts of 2400 each. The public hydrants, all 6, passed the test with the best possible quality – a count of 0 each. Like Cluster 1, the water sources were only shallow handpumps and public hydrants in Cluster 2. The distribution of these community sources were 8 shallow handpumps and 4 public hydrants. Water samples were collected from all these sources since these were the only sources accessed by all the households in these clusters. The handpumps, all 8, were found unfit. The MPN counts ranged from a minimum of 75 to a maximum of 2400. The public hydrants, all 4, passed the test with MPN counts ranging from 0 to 4.9. In Cluster 3, there were 2 households using water from tubewells as the source of drinking water. Samples were taken from both these tubewells. One tubewell was found to be fit (MPN count 3.1) while the other was found to be unfit (MPN count 13). The municipal pipelines supplying these flats entered the colony from two sides. Two samples were taken, one from each side.

Table 2 | Results of bacteriological tests of water sources

| Cluster | Sources | | | | | | | |
| | Handpump | | Municipal (Public Hydrant) | | Municipal (Household) | | Tubewell | |
	F	U	F	U	F	U	F	U
Cluster 1	0	100	100	0	NA	NA	NA	NA
Cluster 2	0	100	100	0	NA	NA	NA	NA
Cluster 3	0	100	NA	NA	100	0	50	50

Note: All figures are in percentages. F: Fit. U: Unfit. NA: Not applicable.

The rationale was that the supply made available should be evaluated on the basis of the quality of water in the main pipelines as the responsibility of the provider was up to this level only. Beyond these points, the maintenance of the service pipelines was the responsibility of the consumers (residents). All the municipal piped water samples tested fit. There were 19 households drinking water from shallow handpumps. These were all individually owned handpumps in contrast to community handpumps in the other two clusters. All the handpumps tested unfit for drinking purposes.

For analysing the relevance of storage practices with regard to diarrhoeal incidence rates households were classified on the basis of the source of drinking water accessed by them, municipal and non-municipal. For households which stored water drawn from municipal sources, data was analysed with reference to the storage practices. For purposes of comparison, incidence rates of diarrhoea were also computed for households which accessed municipal sources but did not store. Incidence rates were also computed for the remaining set of households, namely, those which accessed non- municipal sources. Since bacteriological tests revealed (Table 2) that municipal sources (public hydrant and household) were 100% fit, in order to isolate the effect of storage practices, after controlling for source contamination, only water stored from municipal sources has been considered for the analysis. The impact of use of a separate utensil to draw water from the storage containers is relevant only in the case of those households which stored water in wide mouthed containers. Table 3 reports the findings.

Epidemiological logic suggests that incidence rates for diarrhoea in households with best storage practices should be the lowest. In the context of the present dataset, best storage practice would correspond to households which store water in covered vessels with narrow mouths and the use of a separate utensil to draw out water from the storage container also constitutes best practice. It was found that incidence rates of diarrhoea in households which did not use a separate utensil to draw water from storage containers was higher than those which did in Clusters 1 and 2. These results were as per theoretical expectations. However, in Cluster 3, the incidence rates were higher for homes which used separate utensils. In Clusters 1 and 3, the highest incidence rate for

diarrhoea was observed in the best practice category while for Cluster 2, the expected results are obtained.

These findings prompted further exploration of the vulnerability factors underlying the apparent paradox. Analytically, a standard starting point is to explore differences in diarrhoeal incidence rates by age. A distinction was made between children under-5 years (U-5) and those in the age group of 5–18 years. It was hypothesised that U-5 children who stay at home, particularly where the proportion of working mothers is low, were likely to be under better supervision and therefore have lower incidence of diarrhoea. In contrast, school-going children may consume unsafe water and drinks outside the home.

It was observed that the proportion of U-5 children in the best practice category of households was lower in Cluster 1 as compared to the other storage categories; diarrhoea incidence was higher among the 5–18 years age group in the best practice category. In Cluster 2, this pattern was reversed with there being a higher proportion of U-5 children and a lower incidence of diarrhoea among children in the 5–18 years age group in the best practice households. In Cluster 3, the pattern of Cluster 1 was observed with a lower proportion of U-5 children and higher incidence of diarrhoea in the 5–18 years age group for the best practice households.

These findings prompted further exploration of school-going children. The proportion of children attending school was computed for each cluster. It was found that in Cluster 1, 64.2% children attend school while 38.2% and 93% attend school in Clusters 2 and 3 respectively. Corroborating these attendance rates with the evidence on incidence rates of diarrhoea as discussed above lead to confirmation of the hypothesis that school going children from lower socio-economic households were exposed to greater risks of diarrhoeal diseases by consuming contaminated water, drinks, and food. In Guatemala, Koo (1996) had identified that ice-based candies prepared with unsafe water were highly contaminated and also that *Vibrio cholerae* survived in these items. It is probable that similar routes of transmission may explain the higher incidence of diarrhoea among school going children among poorer communities of Delhi particularly when water, cold drinks and ice candies (locally called *chuskies*) were consumed from street vendors in a regulatory environment which is extremely poor.

Table 3 | Storage practices in the three clusters

| | Municipal sources | | | | Not stored | Non-Municipal sources |
| | Covered vessel | | Uncovered vessel | | | |
	Wide mouth	Narrow mouth	Wide mouth	Narrow mouth		
Cluster 1						
No. of households	37	39	6	6	1	11
Incidence rate	63.8 (12)	107.9 (23)	68.9 (2)	64.5 (2)	0 (0)	44.1 (3)
Cluster 2						
No. of households	15	12	21	–	3	49
Incidence rate	70.4 (5)	27.0 (2)	53.4 (7)	–	62.5 (1)	44.7 (13)
Cluster 3						
No. of households	38	36	2	3	–	21
Incidence rate	65.4 (11)	104.3 (17)	0.0 (0)	47.6 (1)	–	86.2 (10)

Note: Incidence Rate per 1000 population; cases of diarrhoea in parentheses.

CONCLUSIONS

For each age group, Cluster 3 had the lowest incidence rates compared to the other two clusters, clearly a reflection of better infrastructure and socio-economic conditions. Cluster 1 had the highest incidence of disease for all age groups and recall periods except the under-5 yrs. age group and adults (>18 years); the recall period being 2 weeks in both the cases. For all other categories the incidence rates of Cluster 2 were substantially lower than those of Cluster 1.

Though nearly all households reported accessing municipal water as the primary source of water in Cluster 1, about a tenth did not use it for drinking purposes. Compared to the other clusters, the use of handpumps was the lowest in Cluster 1. Despite these relative safety factors, the vulnerability of this cluster lay in the fact that the water supply was intermittent. This forced all but one household (located next to a public hydrant), of those surveyed, to store municipal water.

Cluster 1 had lower per capita income at Rs. 284.05 as compared to Rs. 345.71 in the case of Cluster 2. The income distribution was skewed towards the lower end in Cluster 1

with 68% of the household earning not more than Rs. 1,500 per month. In as much as the level of the family income is an indicator of vulnerability, capturing the effects of factors not otherwise accounted for (such as the ability to afford better alternatives in a situation of contamination or to adopt better preventive practices), family income levels showed that Cluster 1 was at a relative disadvantage as compared to the other two clusters, especially Cluster 3.

Educational status of mothers in both these slum clusters was comparable with most of them (over 80%) being illiterate. The proportion of literates among heads of household was better for Cluster 1 than that of Cluster 2. Illiteracy among heads of household as well as illiteracy among mothers had a positive association with the consumption of handpump water. A similar association had also emerged between family income levels and the consumption of handpump water.

While both income levels and illiteracy emerged as vulnerability factors for Cluster 1, it is to be noted that the educational status in Cluster 2 could be a potentially important factor, indicating aspects of vulnerability such as awareness levels. This is further substantiated by

evidence on school attendance by female children, with much higher numbers of female children in the five-plus age group, not attending school in Cluster 2. Combined with the total lack of sanitary latrines and the relatively higher reported usage of handpump water as the primary means of accessing water for household purposes, the infrastructural problems combined with the educational status towards making this particular cluster vulnerable to the incidence of diarrhoeal disease.

Cluster 3 reported the lowest incidence of illness for all age groups and recall periods. This also finds obvious correlation with the data on several socio-economic characteristics. The per capita income at Rs. 879.49 per month was substantially higher. While the cluster also ranks best in terms of the educational status of the head of the household, the differences are marked in the case of the mothers' educational levels with less than 10% of the mothers being illiterate as compared to over 80% in the other two clusters. With 100% households having access to sanitary latrines, Cluster 3 was at an advantage compared to the other 2 clusters in terms of the vulnerability indicators analysed in this study.

It is to be noted that in Cluster 3, as many as 40% of the households reported use of handpump water as a secondary source of water for household purposes. On the one hand, it was statistically not possible to establish a unidirectional causation between the incidence of illness and the extent of contamination arising from the mere use of a secondary source of water. However, it would be valid to hypothesise that where 19% of the households report direct consumption of water from handpumps, and 40% report the usage of handpump water as a secondary source to supplement the primary source, the cluster would become potentially vulnerable to diarrhoeal illness, although perhaps to a less extent than the other clusters where socio-economic factors would combine to make the situation more acute.

Amongst households storing municipal water (proven to be safe at source), adhering to the best storage practices did not translate into lower incidence rates as compared to those with relatively unsafe practices. As has been argued earlier a possible explanation for this lies in factors which are external to the home and largely beyond the control of the affected household members. While Information, Education and Communication (IEC) is no doubt important, its relevance is weakened when the surrounding conditions are not favourable. Vulnerability of children in schools emerges as an issue of concern. Children from these clusters attended either municipal primary school or private schools. Both these suffer from lack of basic civic amenities. Street foods are poorly regulated and working status of mothers often implied that children most often do not carry food from home and instead consume them outside. In another study on health of school children of Delhi (currently under progress), it was observed that the next meal which children consumed after breakfast was dinner since both the parents were working in a large proportion of cases; a variable quantity of street food was purchased and consumed by the children during the day depending on the pocket money available with the child and his/her preferences. These have serious implications for children in general and diarrhoeal diseases in particular. There is also a need to strengthen mid-day meals at schools on which increased emphasis is currently being placed; however, these measures are not implemented in private schools which are major providers of education. These all round measures will ensure control on diarrhoeal diseases. Thus, household level behavioural factors such as storage practises should not be analysed in isolation as determinants of diarrhoeal illness particularly when pitted against stronger neighbourhood and external determinants which are beyond the control of the individual household. The typical low-income urban household faces these serious threats and are yet 'targets' for IEC campaigns of behavioural modifications when it comes to control of waterborne diseases when the sustainable solutions are infrastructural and regulatory and not just 'behavioural'.

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