ENVIRONMENTAL EPIDEMIOLOGY. I. ENVIRONMENTAL AND PROSPECTIVE EPIDEMIOLOGICAL INVESTIGATION OF CHOLERA OUTBREAKS

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Introduction

The association of water and food, particularly the former, with the occurrence of cholera outbreaks is beyond questioning. However, the specific role played by these vehicles, especially in endemic areas, has not been documented. One question is whether or not a multiplication step in food, drink or fomites contaminated with infected water or feces is either necessary for disease transmission or even a frequent mode of transmission. Another question is whether contamination of water, food and fomites totally within the household of one infected person is an important mode of transmission.

A major problem in studying this question is that the uses of water are so many and so pervasive that distinctions needed for meaningful analysis are blurred. Thus, the usual methods used have been unable to penetrate beyond a broad picture of the transmission cycle.

The approach we have taken to this problem is to study actual outbreaks as they are occurring using techniques of environmental microbiology and prospective epidemiological surveillance. The use of both methodologies should allow us to pinpoint potentially critical points in the transmission of cholera. We can then ascertain the significance of each risk factor and quantitate the cholera vibrios actually present in each vehicle involved at that

point. In this way, we will be able to "track" the organism through the environment and relate the extent of its presence to the incidence of infection in the population at risk.

Materials and Methods

Patients admitted to the Matlab hospital with cholera were used as "pointers" to areas in which V. cholerae was likely to be found. The morning after an admission a team of epidemiology field staff and microbiology laboratory personnel would visit the bari from which the patient came. The water use pattern of each member of all families was determined by questionnaire as was the occurence of diarrhea. Rectal swabs were taken from everyone in the index family or who shared a water source for any reason with the index family. Environmental samples taken for analysis included those from water sources, cooking and drinking water jars in houses, contact plates of food preparation surfaces, enrichment broth rinses of left hand fingers and of empty cooking pots and utensils, and samples of left over food. These last were collected just prior to their being heated for the evening and morning meal. All food samples were held in ice boxes until they could be processed. All specimens were examined for V. cholerae using standard CRL procedures for direct detection and enrichment, except that direct plates were prepared so as to obtain a count of organisms present in contaminated samples.

This intensive sampling was carried out on a daily basis and more families and water sources were included if they could have been contaminated on succeeding days. This sampling was continued until all samples in a study area were negative for three consecutive days.

The study was carried out from October 1976 through January 1977.

Results and Discussion

The tabulation of this data is far from complete and only a very preliminary analysis can be provided. So far the data of 13 sites has been partially tabulated. This covers 695 individuals in 118 families. The average family size is 5.9 (SD = 1.2). In all 47/695 persons were infected with V. cholerae El Tor (6.7%). The serotype in all cases was Inaba. The gross results of our environmental sampling are given in Table 1. The number of contact plates and utensil rinses has not yet been tabulated but in no case were El Tor vibrios detected.

The cumulative infection rate and the rate as a function of exposure to various sources of infection is given in Table 2. There is a pronounced shift in peak when the infection rate is distributed as a function of exposure, particularly exposure to cooking jars. This shift may be indicative of a significant role

played by these sources in the transmission of cholera at these study sites.

The clinical picture of the 47 infections covered in this study is fairly typical of El Tor outbreaks: 1 hospitalized, 11 with mild to moderate diarrhea and the remainder asymptomatic. The age distribution was also usual for cholera - all symptomatic persons were children as were half of those were asymptomatic.

Fomites and foods were intensively sampled throughout these outbreaks. Absolutely no contamination of either was detected except for two food samples which were not associated with any detectable infection after their ingestion. There is virtually no possibility that these were significant vehicles in cholera transmission. There is no possibility whatsoever that a multiplication step occurred with any reasonable frequency in food.

The role of water as a vehicle in these outbreaks is incontrovertible. However, the data analysis has not proceeded to a point in which a final decision on the specific mode of transmission can be made. Exposure to contaminated bathing water (Table 3) and contaminated cooking jar water (Table 4) were both highly significant risk factors. Drinking water jars which were filled from tubewells were virtually never contaminated so their role is negligible. Thus, bathing water and cooking water appear to be the most important vehicles at this point. As Table 5 shows,

there is a great deal of overlapping use of the same water source for both of these purposes. When the bacteriological findings are included, the effective difference is only 3.4%. Some indication of the relative importance of exposure to each source on infection rate may be had from the analysis in Table 6. Considering only those persons exposed to contaminated bathing water on day 1, only those who were also exposed to contaminated drinking jar water were at risk of becoming infected. The reverse analysis, i.e. distribution of infection among the 37 persons already exposed to contaminated cooking jar water as a function of concomitant exposure to a contaminated bathing site shows no significant difference. It appears, therefore, that water brought into the house for cooking purposes may be, in some manner yet unknown, the major vehicle for cholera transmission in these outbreaks. This conclusion is highly tentative at present and must await a complete analysis of the data.

We hope to be able to tabulate the data from this study and carry out its analysis using the computer facilities available to CRL in Bangladesh. This activity will represent the remaining future work on this protocol.

Table 1

Detection of V. cholerae El Tor in Environmental Samples

Sample Type	No. Positive/Total Samples
R/S	65/5064
Cooking jars	110/1571
Food samples	2/1511
Finger wash	0/ 677
Water sources	103/1067

Table 2

Cumulative Attack Rate as a Function of Exposure to Various Water Sources on Day 1

	Vibrio cholerae isolated	Total infected	Cumulative Infection Rate (%) on day 2	3	4	5	6	7	8	9
Cooking jars	+	37	10.8	40.5	54.0	73.0	83.8	94.6	97.3	100.
	-	10	40.	60.	70.	90.	90.	90.	90.	100.
Bathing site	+	28	14.3	35.7	50.	71.4	85.7	100.	-	-
	-	19	15.8	52.6	68.4	84.2	84.2	84.2	89.5	100.
Overall		47	17.0	44.6	57.4	76.6	85.1	93.6	95.7	100.

Table 3

Infection Rate for 8-day Period Following Exposure to *V. cholerae* — Positive Bathing Water on Day 1

	Persons at Risk		
Bathing	Infected	Not Infected	Total
Positive	28	192	220
Negative	19	274	293
	47	466	513

$$P\ (X^2 \geq 5.15) < 0.01$$

Table 4

Infection Rate for 8-Day Period Following Exposure to *V. cholerae* — Positive Cooking Jars on Day 1

	Persons at Risk		
Cooking Jar	Infected	Not Infected	Total
Positive	37	122	159
Negative	10	348	358
	47	470	517

$$P\ (X^2 \geq 53.4) \ll 0.001$$

Table 5

Differences in Water Use for Cooking and Bathing by Families in Outbreak Study

No. using same site for both			86
No. using different sites			33
V. cholerae isolation (Day 1)		0/0	25
" isolation	"	+/+	4
" isolation	"	+/0 or 0/+	4
			119

Differential on basis of *V. cholerae* isolation = 4/119 = 3.4%

Table 6

Infection Rate for 8-Day Period Following Exposure to a *V. cholerae* - Positive Cooking Jar on Day 1 in that Population Who also Used a Contaminated Bathing Site on Day 1

	Persons at Risk		
Cooking Jar	Infected	Not Infected	Total
Positive	27	98	125
Negative	1	79	80
	28	177	205

$P(X^2 \geq 14.8) < 0.001$