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Risk factors for typhoid fever in a slum in Dhaka, Bangladesh

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SUMMARY

We systematically investigated risk factors for typhoid fever in Kamalapur, a poor urban area of Bangladesh, to inform targeted public health measures for its control. We interviewed patients with typhoid fever and two age-matched controls per case about exposures during the 14 days before the onset of illness. The municipal water supply was used by all 41 cases and 81of 82 controls. In multivariate analysis, drinking unboiled water at home was a significant risk factor [adjusted odds ratio (aOR) 12·1, 95% CI 2·2–65·6]. Twenty-three (56%) cases and 21 (26%) controls reported that water from the primary source was foul-smelling (aOR 7·4, 95% CI 2·1–25·4). Eating papaya was associated with illness (aOR 5·2, 95% CI 1·2–22·2). Using a latrine for defecation was significantly protective (aOR 0·1, 95% CI 0·02–0·9). Improved chlorination of the municipal water supply or disinfecting drinking water at the household level may dramatically reduce the risk of typhoid fever in Kamalapur. The protective effect of using latrines, particularly among young children, should be investigated further.

BACKGROUND

The global burden of typhoid fever is estimated at 21·6 million cases and 200 000 deaths annually, with the highest incidence noted in the South Asian subcontinent [1]. Quinolone resistance in *Salmonella enterica* serotype Typhi, the causative organism of typhoid fever, is common, with treatment failures despite ciprofloxacin therapy reported from South Asia [2, 3]. Contaminated municipal water supplies and street-vended foods have been implicated in previous risk factor studies of typhoid fever [4–6] and are common features of life in South Asian mega-cities such as Dhaka, Bangladesh, a metropolitan area of greater than 11 million persons. Typhoid fever is the leading cause of bacteraemia in children aged <5 years hospitalized in Dhaka, with an annual incidence estimated to be about 18·7/1000 persons [7, 8]. Despite awareness of this considerable burden, knowledge of *S*. Typhi transmission routes in Dhaka is minimal, and targeted control efforts infrequent.

The documentation of specific risk factors for typhoid fever in highly endemic settings allows scientists and public health professionals to develop evidence-based prevention strategies. As a companion to a burden of illness investigation (A. Naheed, unpublished observations), we conducted a case-control

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study to identify risk factors for typhoid fever in a crowded urban slum area of Dhaka. We present below the results of this investigation and discuss appropriate steps to reduce typhoid fever in this South Asian community.

METHODS

Kamalapur, a crowded Dhaka community mostly consisting of informal settlements, has a population of about 120 000 persons living in a 4 km^2 area. The Kamalapur community was divided into 377 geographical clusters, within which each household was enumerated. A total of 85 clusters were selected at random for inclusion in active surveillance for febrile illness. We attempted to recruit all households from the 85 clusters into the study. A total of 5500 households, representing about 26 700 persons of all ages, were enrolled in the active surveillance. Research assistants made weekly visits to households and referred persons with fever during the preceding 7 days to the study clinic. Persons $\geqslant 5$ years of age reporting $\geqslant 3$ days of fever, and children aged <5 years with any duration of fever, were eligible for blood culture if they were found to be febrile (temperature $\geqslant 38°$ C) by study clinic staff. Patients were requested to provide a single blood specimen for culture. For the case-control study, we defined a case as blood culture-confirmed typhoid fever in a resident participating in the active surveillance.

We used formal calculations for a matched case-control study to estimate the required sample size. Based on a conservative assumption of 30% exposure rate in cases and 10% exposure rate in controls [6, 9], as found in previous studies of typhoid fever in endemic settings, we estimated a sample size of 90 cases and 180 matched controls to detect odds ratios of $\geqslant 2{\cdot}5$, with a confidence level (alpha) of 95%, and power (beta) of 0·8. Since the case-control investigation was nested within a population-based study to document the burden of illness, the sample size was ultimately limited to the number of typhoid fever cases identified during the period of active surveillance.

Two controls were recruited per case. At the initiation of surveillance, all residents in the active surveillance area were assigned unique identification numbers and their ages recorded. Potential controls were identified by random selection of identification numbers from the surveillance database and were matched by age range to the case (± 5 years for cases aged $\geqslant 20$ years; ± 2 years for cases aged 10–19 years; ± 1 year for cases aged 2–9 years; and ± 6 months for cases aged <2 years). Potential controls were excluded if they reported fever within the month preceding interview or a diagnosis of typhoid fever within the preceding year. Controls were questioned regarding exposures during the 14 days before the case's illness onset. To minimize recall bias, research assistants attempted to interview controls within 48 h of case interviews. If a potential control could not be contacted within 48 h, the research assistants contacted the next potential control until they were able to interview two controls per case. Questionnaires were administered to cases and each matched control by different interviewers in order to minimize interviewer bias. Case questionnaires included questions regarding clinical features of the typhoid fever episode and, thus, interviewers were aware of the illness status of the interviewee.

The questionnaires addressed demographics, indicators of socioeconomic status, food and drink exposures, and water, sanitation, and hygiene issues. The incubation period for typhoid fever can be as long as 6 weeks; however, questions regarding food and drink intake over such a prolonged period may be more likely to elicit preferences for certain items, rather than true exposures. Thus, the study team attempted to minimize recall bias by limiting the period in question to the 14 days before illness onset, hereafter referred to as the exposure period. Interviewers looked for the presence of soap in the home and tested water from the primary water source for residual free chlorine using a colorimetric method that detects chlorine concentrations $\geqslant 0{\cdot}1$ mg/l (Hach Co., Loveland, CO, USA).

Statistical analysis

For bivariate analysis among matched case-control groups, we used maximum likelihood estimates to calculate matched odds ratios (mORs) for categorical variables. Next, we performed conditional logistic regression and added, one by one, variables that were associated with illness on bivariate analysis as well as other biologically plausible variables. For the final multivariate model, we included only those variables that were associated with illness and that improved the goodness-of-fit of the model. We calculated attributable risks for individual exposures found to be significant in multivariate analysis, and the summary attributable risk, using adjusted odds ratios (aORs)

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Table 1. *Demographic characteristics of typhoid fever cases and age-matched controls, Dhaka, Bangladesh, 2003*

Variable	Cases ($n=41$)	Controls ($n=82$)	mOR	95% CI	P
Median age in years (range)	4 (0·6–45·6)	4·2 (0·7–47·5)			0·77
Male	54%	55%	0·9	0·5–2·0	0·89
Median household size (range)	5 (3–8)	5 (3–14)	n.a.	n.a.	0·35
Household head attended school	66%	73%	0·7	0·3–1·6	0·39
Own home or rent >$25 US per month	17 (42%)	52 (63%)	0·5	0·2–0·9	0·04
History of typhoid fever in the family	2 (6%)	1 (1%)	4	0·4–44·1	0·26
Travel outside the city during the exposure period	6 (15%)	10 (12%)	1·2	0·4–3·5	0·7
Use of antimicrobial agents during the exposure period	7 (17%)	18 (22%)	0·7	0·3–1·9	0·5

mOR, Matched odds ratio; CI, confidence interval; n.a., not available.

and exposure rates among cases. These calculations were performed using methods described by Bruzzi *et al*. [10]. Data were analysed in SAS v. 9 (SAS Institute, Cary, NC, USA).

Ethical issues

Informed consent was obtained for participation in active surveillance, blood culture, and interview for the case-control study. In this sociocultural setting, heads of household are typically relied upon by members of the family to make decisions that affect the entire household. Therefore, we requested heads of household to provide consent for study participation on behalf of all family members. Individual participants were informed of their right to refuse to participate at any time during the course of the study. All cases were informed of the blood-culture results and referred to the study clinic to receive appropriate therapy. The study protocol was approved by the Research and Ethical Review Committees of the ICDDR,B: Centre for Health and Population Research (Dhaka, Bangladesh) and an Institutional Review Board of the Centers for Disease Control and Prevention (Atlanta, GA, USA).

RESULTS

A total of 1333 fever episodes were recorded among active surveillance participants between January 2003 and February 2004. Blood culture was performed for 961 episodes and *S*. Typhi was isolated in 41 (4%). Clinical details and incidence data will be presented elsewhere (A. Naheed, unpublished observations). For the risk factor investigation, we interviewed all 41 cases and 82 age-matched controls between 25 February 2003 and 19 January 2004. Cases were interviewed a median of 11 days after symptom onset (range 7–25 days). Interviewers completed 78% of control interviews within 2 days of the corresponding case interview. Cases and controls were similar with respect to age, sex, and household demographics (Table 1). Forty-two per cent of cases compared with 63% of controls reported owning their homes or paying >$25 US per month for rent (mOR 0·5, 95% CI 0·2–0·9, $P=0·04$).

We found no statistically significant differences between cases and controls with respect to history of typhoid fever in the family during the 3 months preceding the case's illness onset, the use of any medications, or travel outside the city during the 14-day exposure period.

Cases were 3·6 times (95% CI 1·1–11·2, $P=0·03$) more likely to report eating food from a restaurant or street stall during the 14-day exposure period than their matched controls (Table 2). There was no association between consumption of dairy products and illness. Cases were nearly 3·9 times more likely than controls to report eating *katkuti*, a local sweetmeat made from molasses (mOR 3·9, 95% CI 1·5–10·1, $P=0·003$). Although 90% of cases and 95% of controls reported eating at least one of the 10 specific raw fruits and vegetables on the questionnaire, none of these individual items was associated with illness (Table 2). Cases were 2·5 times more likely than controls to report eating hog plum, locally known as *amra*, but this finding did not reach statistical significance (mOR 2·5, 95% CI 0·9–7·1, $P=0·08$), Eating 'other fruits' or 'other vegetables' (mOR 2·5, 95% CI 0·9–6·7, $P=0·05$) was more often mentioned by cases than by controls. Respondents were requested to specify which 'other' fruits or vegetables they had

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Table 2. *Bivariate analysis of food exposures among typhoid fever cases and age-matched controls, Dhaka, Bangladesh, 2003*

	Cases ($n=41$)	Controls ($n=82$)	mOR	95% CI	P
Food exposures					
Food from restaurant/stall	88%	70%	3·6	1·1–11·2	0·03
Pre-cut fruit	24%	13%	2·3	0·8–6·9	0·11
Milk	85%	77%	1·9	0·7–5·4	0·23
Yogurt	33%	24%	1·7	0·7–4·2	0·22
Ice cream	50%	53%	0·9	0·9–2·0	0·77
Sweets (*mishti*)	49%	57%	0·7	0·3–1·5	0·35
Katkuti	44%	19%	3·9	1·5–10·1	0·003
Molasses	20%	15%	1·5	0·5–4·5	0·45
Specified fruits and vegetables					
Carrots	12%	7%	2·1	0·5–9·5	0·33
Tomatoes	28%	32%	0·8	0·3–2·0	0·65
Cucumber	54%	42%	1·6	0·8–3·6	0·21
Guava	33%	33%	1·7	0·7–3·6	0·21
Hog plum (*amra*)	35%	22%	2·5	0·9–7·1	0·08
Apples	33%	42%	1·4	0·5–4·3	0·55
Grapes	27%	33%	0·6	0·2–1·8	0·37
Plums	10%	16%	0·3	0·1–1·8	0·19
Sugar cane	35%	30%	0·8	0·2–3·2	0·72
Olives	18%	12%	1·8	0·6–5·4	0·33
'Other fruits' or 'other vegetables'	81%	65%	2·5	0·9–6·7	0·05
Water, sanitation, and hygiene					
Hand pump to municipal supply	83%	67%	2·4	0·9–6·3	0·07
Pipe to municipal supply	20%	35%	0·5	0·2–1·1	0·08
Use of reservoir	15%	35%	0·3	0·1–0·8	0·02
Residual free chlorine detected in water from primary source	8%	12%	0·6	0·2–2·5	0·50
Disinfected water at home using boiling or filtration	54%	61%	0·7	0·4–1·6	0·44
Drank unboiled water at home	90%	58%	7·6	2·2–26·5	0·0015
Foul-smelling water	56%	26%	3·2	1·5–6·8	0·003
Cloudy water	42%	27%	1·8	0·8–3·8	0·14
Drank unboiled water away from home	62%	63%	0·9	0·4–2·0	0·83
Drank water from a restaurant or street stall	24%	20%	1·3	0·5–3·2	0·53
Used latrine	61%	73%	0·3	0·1–1·0	0·053
Used potty	20%	13%	0·6	0·6–6·2	0·31
Soap observed in home	71%	82%	0·5	0·2–1·3	0·18

mOR, Matched odds ratio; CI, confidence interval.

consumed during the exposure period. In total, 39% of cases and 20% of controls reported eating papaya, a food that was not specified on the questionnaire. When cases and controls who denied eating 'other fruits' or 'other vegetables' or who did not specifically mention eating papaya were coded as 'no', cases were 3·4 times as likely to report eating papaya than controls (mOR 3·4, 95% CI 1·3–9·0, $P=0{\cdot}02$). Papaya consumption was reported throughout the year. Homes of cases with papaya consumption were located throughout the Kamalapur area and were not geographically clustered.

All cases and controls obtained drinking water from the municipal water-supply system during the 14-day exposure period. When asked to name all sources from which household drinking water was obtained during the exposure period, 83% of cases and 67% of controls reported using hand pumps to draw water from the municipal water system (mOR 2·4, 95% CI 0·9–6·3, $P=0{\cdot}07$) and 20% of cases and 35% of controls obtained water from a pipe connected directly to the municipal supply (mOR 0·5, 95% CI 0·2–1·1, $P=0{\cdot}08$) (Table 2). Interviewers detected residual free chlorine in water samples from the

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primary water source for only 8% of case homes and 12% of control homes (mOR 0·6, 95% CI 0·2–2·5, $P=0·5$). Six (15%) cases and 29 (35%) controls reported using reservoirs to store water from the municipal supply (mOR 0·3, 95% CI 0·1–0·8, $P=0·02$). Among those who reported using reservoirs for water storage, all cases and all but one control reported that their reservoirs were located underground.

Cases were 7·6 times more likely than controls to report drinking any unboiled water *at home* during the 14-day exposure period (mOR 7·6, 95% CI 2·2–26·5, $P=0·002$). There was no difference between cases and controls with respect to consumption of unboiled water *away from home* or consumption of water from a restaurant or street stall. Water from the primary source was reported to be cloudy during the exposure period by 42% of cases and 27% of controls (mOR 1·8, 95% CI 0·8–3·8, $P=0·14$). During the 14-day exposure period, 56% of cases and 26% of controls noted that water from the primary source had a foul odour (mOR 3·2, 95% CI 1·5–6·8, $P=0·003$).

Cases were less likely than controls to use a latrine for defecation (mOR 0·3, 95% CI 0·1–1·0, $P=0·053$). There was no significant difference between cases and controls with respect to the use of potties, small pots typically used for defecation by young children. Interviewers observed soap in 71% of case homes and 82% of control homes (mOR 0·5, 95% CI 0·2–1·3, $P=0·18$).

Variables were tested in multivariate modelling (Table 3). Exposures significantly associated with illness in the final multivariate model (Table 4) were drinking unboiled water inside the home, foul-smelling water, eating papaya, and using a latrine for defecation. The population attributable risks of drinking unboiled water in the home and of foul-smelling water from the primary source were 82% and 48% respectively. Papaya consumption had a population attributable risk of 32%. Using a latrine for defecation was significantly protective (aOR 0·07, 95% CI 0·006–0·72).

Drinking unboiled water and foul-smelling water both pointed to the municipal water supply as a potential source of typhoid fever and, thus, did not represent independent exposures. Therefore, we chose not to include foul-smelling water in the summary attributable risk calculation. The summary attributable risk of unboiled water in the home and papaya for typhoid fever was 92%.

Table 3. *Exposures tested in multivariate modelling of typhoid fever risk and protective factors, Dhaka, Bangladesh, 2003*

Socioeconomic factors
- Owning home or paying >$25 US per month for rent

Water
- Drinking unboiled water at home
- Reporting foul-smelling water
- Using a hand pump to draw water from the municipal water supply
- Using a reservoir to store water

Food exposures
- Eating from a restaurant or stall
- Hog plum (*amra*)
- *Katkuti*
- Papaya

Sanitation
- Using a latrine for defecation

We investigated latrine use in more detail and noted that all cases and controls aged $\geqslant 5$ years used latrines. Only one case and one control aged <2 years did so. Among children aged $\geqslant 2$ years old and <5 years old, 8 (44%) of 18 cases, *vs.* 24 (77%) of 37 controls, were reported to use a latrine for defecation (mOR 0·3, 95% CI 0·07–1·1, $P=0·07$). We attempted to perform multivariate analysis on this age subgroup using all variables associated with illness for the full sample but were constrained by the limited sample size of 18 cases and 37 controls. The only model that converged included use of a latrine and foul-smelling water. Foul-smelling water was associated with illness (aOR 9·6, 95% CI 1·1–83·6). Use of a latrine was significantly protective against illness in this age subgroup (aOR 0·06, 95% CI 0·006–0·665).

DISCUSSION

This study highlights the multifactorial nature of typhoid fever transmission in the Kamalapur community of Dhaka. These data underscore the importance of fundamental infrastructural improvements or household disinfection of water in the context of poorly functioning municipal water-supply systems for prevention of typhoid fever. The analysis also highlights the need for additional study of papaya as a risk factor for typhoid fever, and of latrine utilization practices among young children and the implications for microbial quality of water and food in households in Kamalapur.

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Table 4. *Multivariate analysis of risk factors among typhoid fever cases and age-matched controls, Dhaka, Bangladesh, 2003*

Variable	Cases ($n=41$)	Controls ($n=82$)	aOR	95% CI	P	Population attributable risk
Unboiled water	89%	58%	12·1	2·2–65·6	0·004	82%
Foul-smelling water	56%	26%	7·4	2·1–25·4	0·002	48%
Use of latrine	61%	73%	0·1	0·01–0·9	0·03	n.a.
Papaya	39%	20%	5·2	1·2–22·2	0·03	32%

aOR, Adjusted odds ratio; CI, confidence interval; n.a., not available.

Both unboiled water consumption and foul-smelling water point to the municipal water supply as a likely source of *S*. Typhi in Kamalapur. The lack of adequate chlorination in the Kamalapur municipal water supply, and thus, the potential for contamination, was evident with residual free chlorine detected in only 8% of sources in case homes and 12% of sources in control homes. Improvements to reduce microbial contamination of municipal water systems, such as filtration and chlorination, led to considerable declines in typhoid fever incidence and mortality in industrialized countries in the early 1900s [11]. However, if such improvements are not sustained, decaying piped water supplies can be extremely efficient channels for transmission of typhoid fever and can lead to large outbreaks [5, 12]. Interventions to secure a high-quality municipal water supply for Dhaka's population are critical for preventing the spread of enteric pathogens such as *S*. Typhi through piped water sources.

The population attributable risk of drinking unboiled water suggests that the majority of typhoid infections in the community may be prevented by reducing exposure to drinking water from the municipal supply that is not disinfected. While water authorities strive to strengthen municipal systems, household water disinfection may be appropriate to improve drinking-water quality in homes and in places where food and beverages are prepared and sold [13–15]. Although more than half the cases reported treating water at home by boiling or filtering, 90% reported the consumption of any unboiled water during the 14-day exposure period. This suggests that household disinfection is, at best, intermittent in the community. Recent data from a drinking-water chlorination programme in Nigeria underscored the importance of regular use of household disinfection techniques to prevent against waterborne enteric disease [16]. Efforts to reduce typhoid fever should include the promotion of boiling combined with safe storage of water, or other point-of-use water-disinfection technologies, such as household chlorination, which may prevent re-contamination. Programmes to promote household water treatment should emphasize the importance of disinfecting water every day to prevent waterborne infections.

Papaya consumption was associated with typhoid fever in Kamalapur. Our findings that patients reporting papaya consumption were detected throughout the surveillance year and came from all parts of the surveillance community argue against a point-source exposure. Papaya has a neutral pH, and its cut surface can support the growth of various microorganisms [17]. In Kamalapur, papaya is often cut and kept unrefrigerated in homes for hours. Street vendors, who have limited access to hand-washing facilities and who use the municipal water supply, often cut and display fruit such as papaya at ambient temperatures periodically freshening their wares by sprinkling them with water. If papaya becomes contaminated with *S*. Typhi either by the vendor's unwashed hands or by contaminated water, the flesh of the fruit can support growth of the organism. However, we cannot be sure why papaya, and not other fruits, was associated with typhoid fever. This finding warrants further investigation of vendor practices, as well as examination of agricultural practices, such as the use of night soil, for growing papaya.

We identified one factor that protected against typhoid fever: the use of a latrine for defecation. The association appeared to be of borderline significance on bivariate analysis but was associated with a decreased risk of typhoid fever in multivariate modelling. Not having a toilet in the household was associated with typhoid fever in a risk factor study from Indonesia [18]. The median age of patients in the Indonesia study was much higher at 16 years than the median age of patients in our study at 4 years. The protective effect of latrine use in Kamalapur was

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entirely a result of the difference between cases and controls in the 2–5 years age group. Since all cases and controls aged $\geqslant 5$ years used latrines, and there was no evidence of confounding with adjustment for home ownership or high monthly rent, it does not appear that latrine use was either related to availability of latrines or that it was simply a proxy for high socio-economic status.

Why should the use of a latrine protect against typhoid fever in young children or, conversely, why should not using a latrine be a risk factor? *S.* Typhi survives in faeces at ambient temperatures for 2–62 days [17]. A relatively high dose (10^5) is believed to be necessary to cause illness, although the infectious dose may be decreased in case of reduced gastric acid secretion or ingestion of a large inoculum [20]. Importantly, however, studies of infectious dose have primarily been conducted among adult volunteers and, thus, do not inform us regarding the dose required to cause illness among young children. Alternatively, an intermediate step involving *S.* Typhi replication, for example in food or water, may be involved in transmission of typhoid fever to children defecating in non-sanitary conditions. In Kamalapur, drinking water is often stored in wide-mouthed containers, a practice that has been implicated in outbreaks of various enteric pathogens. In this community, food is typically consumed by hand and not by utensils. Children who do not use latrines may be exposed to stool and *S.* Typhi in the environment, contribute to contaminating water or food in the home, and subsequently develop illness from consuming contaminated water or food. This hypothesis may be tested by further study of the microbiological quality of drinking water and food stored in homes of children who use latrines and children who do not. Reasons for non-use of latrines among children who have access to them should be explored further.

Soap use has been found to protect against typhoid fever in endemic settings [4, 18, 19, 21]. In this study, cases were less likely than controls to have soap in the home. This finding was not statistically significant, perhaps due to the limited sample size. Alternatively, the febrile illness may have prompted soap purchase, thus biasing the association towards the null. Latrines in the crowded Kamalapur area are in close proximity to residents' homes. Bars of soap for hand washing are typically kept in the home and, sometimes, at the latrine itself. Children who are not using latrines may have decreased access to soap and water for hand washing after defecation, thereby increasing their risk of exposure to the organism.

This study faced several limitations. The study design allowed in-depth investigation of the typhoid fever burden and risk factors in a single Dhaka community. Risk factors for typhoid fever in Kamalapur may not be representative of transmission patterns in all of the estimated 7000 Dhaka slums. However, most Dhaka residents also rely on the municipal water-supply system, which was implicated in typhoid fever transmission in Kamalapur. Thus, the information gleaned from the Kamalapur community may be relevant for many Dhaka slum communities where typhoid fever is similarly prevalent. We enrolled all patients with culture-confirmed typhoid fever from the active surveillance but the sample size was lower than targeted, which may have decreased our ability to detect risk factors with smaller, but relevant associations with illness. Despite the restricted sample size, this analysis clearly identified plausible risk and protective factors with significance. A third limitation was the restriction of the exposure period to 14 days in order to limit recall bias. In doing so, we may have missed relevant risk factors that contributed to illness with a longer incubation period. However, reduced recall bias probably allowed us to identify risk factors with greater specificity than would have been possible had we enquired about a longer exposure period. Given that previous studies of endemic typhoid fever have frequently identified multiple pathways for transmission, we sought to test a comprehensive set of exposures in this study. This runs the risk of identifying statistically significant associations that may be spurious. However, our findings of increased risk of typhoid fever with consumption of unboiled water or papaya, a fruit that is often pre-cut by vendors, are both biologically plausible and consistent with previous data. Direct questioning regarding whether water at home had been foul-smelling may be subject to recall bias among ill persons. However, such bias was not noted with other similar questions, including whether water had been cloudy, drinking unboiled water outside the home, or drinking water from a street food vendor or stall. Finally, within this study, we did not have resources to culture water or food products for *S.* Typhi, which would have provided valuable microbiological data supporting the epidemiological findings.

This study underscores the continued high burden of typhoid fever resulting from distribution of contaminated water through a municipal water-supply system in a Dhaka slum community. Improvements to water-supply infrastructure or promotion of household disinfection of water represent important measures to reducing the burden of typhoid fever in endemic areas. Reasons for the unique role of papaya in typhoid fever transmission in Kamalapur and the protective effect of latrine use against typhoid fever should be investigated further.

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DECLARATION OF INTEREST

None.

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