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ORIGINAL PAPER

Implementation of food frequency questionnaire for the assessment of total dietary arsenic intake in Bangladesh: Part B, preliminary findings

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Abstract Dietary intake of water and food has been identified as one of the major pathways for arsenic (As) exposure in the rural population of Bangladesh. Therefore, realistic assessment and measurement of dietary intake patterns are important for the development of an accurate estimate of As exposure and human health risk assessment. One important consideration is to identify an appropriate tool for measuring dietary intake. In this study an interviewer-administered Food Frequency Questionnaire (FFQ) was implemented to determine age and gender specific dietary intake. The developed FFQ was unique because it developed a synergy between field dietary assessment and As concentration measurements in various environmental media. The resulting integrated database provided an accurate framework for the process of As exposure and human health risk assessment. The preliminary results reported here from the FFQ demonstrated that this technique could be used in rural areas as a tool to assess As exposure and the associated human health risk.

Keywords Dietary intake · Dietary pattern · Food Frequency Questionnaire (FFQ) · Arsenic · Exposure

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Introduction

Arsenic (As) is a known human carcinogen (Tseng 1977; Smith et al. 2000; Anawar et al. 2002; Khan et al. 2003; Chen and Ahsan 2004; Ahsan et al. 2006a) associated with bladder cancer (Guo and Tseng 2000; Morales et al. 2000; Steinmaus et al. 2003) and skin cancer (Tseng 1977) as well as a number of diverse non-cancer effects, such as memory and intellectual disorders (Wasserman et al. 2004; Wasserman et al. 2007), respiratory diseases (Milton and Rahman 2002), adverse pregnancy (Hasnat 2005) and skin lesions (Ahsan et al. 2006b). Thus, elevated levels of As in dietary components of food, such as water, rice, protein and vegetables, is a potential human health risk with the magnitude of risk dependant on the length and frequency of exposure.

In Bangladesh, ingestion of As-contaminated groundwater is not the only determinant of As dietary exposure, because recent reports demonstrate that the ingestion of large amounts of cooked rice also contributes significantly to dietary exposure to As in the rural populations (Bae et al. 2002; Meharg and Rahman 2003; Williams et al. 2005). An accurate measurement of the dietary intake of food and water for individuals is therefore essential for a realistic measurement of As-induced human health risk. In this study, a Food Frequency Questionnaire (FFQ) was implemented in 18 villages located in Laksham, Sirajdikhan and Manikganj Sadar thanas in Bangladesh to identify and quantify the rural dietary pattern of Bangladeshi villagers and to quantify its effect on human health. A FFQ is often an effective tool for identifying the dietary pattern and for estimating daily intake of various food items (MacIntosh et al. 1997; Kassam-Khamis et al. 1999; Heath et al. 2000; Chen et al. 2004; Jain et al. 1996), which when coupled with appropriate sampling for the determination of As concentrations in foods and waters can be used to examine the contribution of dietary pattern to adverse health effects. The accuracy of measurement of adverse health effects caused by dietary intake of food depends on the structure of the FFQ, how accurately and easily it can collect information on dietary patterns and the measurement of dietary intake of various foods consumed. In this paper we discuss the different stages of implementation of a FFQ in Bangladesh and discuss some of the results obtained.

The current FFQ was typically used to survey ten households within a village in 1 1/2 days. Information on dietary intake of food and water was collected from 1,023 individuals composed of 386 adult males, 397 adult females and 240 children from 18 villages. During this survey, 315 water samples were collected, including tubewell ($n = 175$), pond ($n = 135$), river ($n = 4$) and filtered water ($n = 1$). Various food samples were also collected for laboratory analysis to quantify the concentration of As, including cooked rice ($n = 180$), rice grain ($n = 180$), dal ($n = 62$) and vegetables ($n = 782$). A small number of soil samples ($n = 36$) was also collected to supplement this ongoing study (Khan, ongoing PhD research).

This paper is the second companion paper to Part A (this journal), which discussed the design of the FFQ and discusses the implementation of the previously designed questionnaire. The maximum benefit would be gained by reading both papers together.

Methods of implementing a food frequency questionnaire (FFQ) in Bangladeshi villages

Previously (see Part A) we identified that an interviewer-administered FFQ was an effective tool for the collection of information on daily diet and the measurement of various foods consumed by the people living in the rural countryside of Bangladesh. The interviewer-administered FFQ was adopted because of the low literacy rate among the survey population, and a number of other factors were taken into account (household selection, individual intake, length of FFQ, season, sampling food and water, and accessibility) during the design (Part A) and implementation phase of the FFQ.

In this section, the procedures followed during implementation of the interview-administered FFQ are discussed in detail. Implementation of the FFQ was divided into three stages, (1) pre-implementation, (2) implementation and (3) post-implementation. This paper emphasizes the pre-implementation and implementation stages of the FFQ. The design and development of the FFQ is fully discussed in Part A (Khan et al. 2008).

Pre-implementation stage

During pre-implementation stage, the FFQ was developed, modified and pretested to evaluate its performance for collecting dietary patterns and intake measurements, along with other socio-economic and demographic information. The main activities included training fieldworkers in the interview process, sample collection, labeling, recording and sample preservation techniques and selection of villages and households. The steps followed in the pre-implementation stage are discussed in detail in the following sub-sections.

Training of fieldworkers

Prior to commencing fieldwork, fieldwork teams were selected, and hands-on training was conducted to familiarize the fieldworkers with the FFQ and sampling procedures. Training of the fieldworkers was considered vital to ensure the accuracy of the information recorded in the questionnaire. The survey team consisted of a combination of male and female members. Male members were generally involved in the collection of water, soil and food samples under the direction of a female field surveyor who conducted the interview in the native language. It was found that the female villagers were almost exclusively involved in the preparation of food in the households and spoke more openly and comfortably to female interviewers because of cultural values.

Three different training activities were conducted for fieldworkers and laboratory technicians:

Training in the implementation of the FFQ was conducted for field workers to provide them information about methods and techniques of questioning respondents, recording information and motivating respondents. Sample collecting procedures were demonstrated hands-on in the field.

Training was conducted in the use of a handheld Global Positioning System (GPS) to ensure that an accurate record of sample location, sample identity and nomenclature was obtained. Training ensured that unique sample IDs were recorded for each sample in the questionnaire.

Training was provided to laboratory workers in the methods of pre-processing water, soil and plant materials for later As analysis when samples were returned to the laboratory from the field.

Identifying survey units/selecting household

The basic unit of this survey was a household. In the context of a Bangladeshi village, a household could include a cluster of individual houses (called *'bari'* locally) around a communal open area where household activities, such as washing, drying grain and processing food, occurred. The common link within these individual houses was family ties. Therefore, a rural household did not necessarily reflect the western bricks and mortar concept of a house, but rather the close knit concept of an extended family unit. In this survey we defined a household/*bari* as being equivalent to one family unit sharing common income, water and food sources and living communally in one or more rooms. In most cases, each of the surveyed households owned their own tubewell, which was the main source of drinking water.

Individual households were selected as the fifth stage of an administrative selection process following the hierarchy: first stage, district; second stage, thana; third stage, union; fourth stage, village. Districts were selected based on As-contamination, loosely characterized as being high, medium or low, according to previous studies (Owens et al. 2004) and were identified by the Bangladesh government as being of interest. Thanas likewise were selected from within districts based on the severity of As-contamination exhibited in those regions. Villages were selected based on a number of criteria, including:

As-contamination of water categorized as either low (0–10 μg L^{-1}), medium (10– <50 μg L^{-1}) or high (>50 μg L^{-1}).

Reported incidence of arsenicosis within the village.

Spatial adjacency of the villages to allow landscape models to be developed.

Accessibility of the villages by road year round. This latter point was considered particularly important when monsoon flooding could isolate some villages and prevent access and sampling.

Operation of an existing community health program within the village implemented by Dhaka Community Hospital (DCH).

Households within each village were selected based on the criteria defined in a previous AusAID-funded project (Owens et al. 2004) where households were selected from each village based on a combination of economic conditions, existence of a backyard garden and the incidence of As-contamination. Using these criteria, the selected households including

Three low income households

Three medium income households

Three households having As incidences

One household with extensive homegrown vegetable cultivation.

Low income was considered to be <1,500 taka per month, middle income was between 1,500 and 3,500 taka per month, and high income was >3,500 taka per month. Although high-income houses were not targeted for selection, some were surveyed randomly in the course of the study.

Households from each village were located by analyzing satellite imagery (Quickbird-IIB) and marked on the hardcopy satellite imagery provided to the field workers to identify houses and proceed with the implementation of the FFQ. While identifying the houses for this survey, the previously surveyed households, collected during 2003–2004 (Owens et al. 2004), were excluded.

Sample naming convention

The nomenclature adopted ensured that a unique identifier was given to each sample. This survey adopted a predefined sample collection and coding methods were used in a previous survey (Owens et al. 2004). The sample nomenclature used the nine-digit coding system ABC-DEa-123, where the first three letters indicated the village name (first three letters from the village name) DE coded for the sample type and 123 coded for the sample number. Since two groups were often operating simultaneously to speed up the work, one group used even numbers, while the second group used odd numbers. Thus, ABI-IPc-012 indicated the irrigated plant (IP) sample collected from Abirpara (ABI) village given the sample location number 12 by the even sampling team. The nomenclature for coding water, soil and food, which was adopted from Owens et al. (2004), was:

Soils

ISa = Irrigated soil sample 0–15 cm
ISb = Irrigated soil sample 15–30 cm

Food and vegetables

IPa = Cooked rice sample
IPb = Rice grain sample

The letters c, d, etc., signified different vegetables.

Water:

IW = Irrigation water
TW = Household tubewell
PW = Pond water
RW = River water

Implementation stage

Implementation of the FFQ was performed in predefined steps as described in the subsequent sub-sections.

Recording household and water source locations

In the implementation stage, fieldworkers identified houses based on the household location map prepared using satellite imagery, they introduced themselves to the household members, described briefly the objective of the FFQ and obtained their participation consent.

Each household location was recorded as an *X*, *Y* coordinate using the Global Positioning System (GPS). A handheld GPS receiver (Etrex, Garmin, USA) was also used to record the spatial location of the household, water sources (tubewell, pond, dugwell and rainwater tank) as well as soil and plant (vegetables from the home gardens) sample location. In addition, a DGPS equipped mobile mapper (Mobile Mapper CE, Thales) including ArcPad 6.0 software (ESRI) was used to map village boundaries for the purpose of later GIS analysis. For later quality checking, the interviewer's name and signature was also recorded.

Selections of samples

The number of samples collected from each household was dependent on various parameters, including the availability of a food item, sources of water usage in a household, existence of a vegetable garden and the use of market rice and vegetables in the household diet. The number of samples that could reasonably be collected within 1 day to provide a snapshot of the dietary intake patterns of the villagers was based on the Australian Standard for sampling potentially contaminated soils (AS 4482.1 1997). This indicated that around 200 samples per village and thus around 20 samples per household could be reasonably collected during the FFQ (Owens et al. 2004). The availability of food samples in the household for analysis was also influenced by the cost of the food item. For instance, while all households were generally willing to supply cooked rice and rice grain for analysis, many households were unwilling to provide dal samples because of the expense of this item. This survey did not offer financial incentives for the supply of food items.

Information on field samples (water, soil and food) collected during the FFQ survey included: sample type, a unique identification (ID) number (see "Sample naming convention" section) and the sample location in terms of an *X*, *Y* coordinate. The unique ID was maintained throughout the survey and enabled samples to be unambiguously related to households for the development of the household level As-concentration database for later input into a GIS for analysis and modeling. Detailed sample (food, water and soil) information was recorded by fieldworkers in separate field data books, divided into three sections (water, soil and food) for encoding the various sample parameters.

Measurement of exposure and dietary intake parameters

The interviewer-administered FFQ allowed information on demographics (age, gender and body weight), socio-economics (income, level of education and profession) and dietary intake of food and water (amount, frequency and type) of all available household members to be collected. Each member present was recorded in the FFQ with a unique identifier (ID) and the absence of any household members noted.

Body weight and age While recording demographic information in the 'general household information' section of the FFQ (see Part A), the body weight of each individual family member present in the household was also measured and recorded. Body weight was recorded using an electronic balance. There was some reluctance among female respondents to be weighed. The reason for this was a conservative attitude among some elderly female family members and shyness among young female members. Throughout this FFQ, self-reported age was recorded for all study participants.

Amount of rice and water The daily intake of water was assessed using the "glass method," which is similar to the "cup method" used by Ohno et al. (2007) and Watanabe et al. (2004). In the glass method, a typical glass commonly used within the household was requested; this glass was zeroed on a electronic balance and the water provided by the household transferred to the glass and measured. The total daily water intake was assessed by then asking the household members how many glasses of water they consumed in a day.

Similar "plate methods" have been applied for measuring total intake of rice and were adopted in this survey. A typical plate from the household was provided and the amount of rice (g) per plate determined. The survey respondents were then asked how many plates of rice they consumed each meal.

From this simple measurement, the total daily intake of water and rice was estimated using Eqs. 1 and 2, respectively.

$$\text{TDWI}\ \left(\text{L person}^{-1}\ \text{day}^{-1}\right) = \text{W}_\text{A} \times \text{N}_\text{G} \tag{1}$$

$$\text{TDRI}\ \left(\text{g person}^{-1}\ \text{day}^{-1}\right) = \text{R}_\text{A} \times \text{N}_\text{P} \times \text{T}_\text{D} \tag{2}$$

where

TDWI	= total daily intake of water (L/day/person)
TRDI	= total daily intake of rice (g/day/person)
W_A	= amount of water per glass
N_G	= number of glasses consumed in a day
R_A	= amount of rice measured on a plate
N_P	= number of plates of cooked rice eaten per meal
T_D	= times eaten (rice) per day

Tubewell depth and installation year After identifying a tubewell as a water source, information on the depth, the year sunk and the year abandoned were collected to derive accurate As exposure durations. Recording of tubewell depth is important because generally shallow tubewells have higher As concentrations than deep tubewells. Results related with tubewell depth and As concentration are discussed in the "Tubewell depth and As concentration in drinking water" section.

Sources of rice The information on rice sources was self reported by participants and recorded by identifying the percentage of rice consumption from locally (own) grown rice and from that purchased at the market.

Water usage in the cooking process In this survey, special attention was given to obtain information on the cooking process and accurate measurement of the amount of water used in cooking rice and dal. Interviewers asked the respondents to show them the cooking pot and the amount of water they used for cooking rice and dal. The survey team measured the cooking water for rice and dal with a measuring jug and reported to the interviewer for recording the amount of water used per kilogram of rice grain and per 125 g of dal (lentils). This information was vital for quantifying the indirect ingestion of water through food.

Recording dietary information

Since food preparation is mainly performed by senior female members of the household, dietary (intake and pattern) information of the individuals in the household was obtained by interviewing the housewife in the household. For each item on the food list, the respondent was asked to estimate the amount and frequency of food consumed for each member of the household. The interviewer also noted when any food was consumed only occasionally (i.e., every 6 months or once per year). The amount consumed was often collected as a self-reported amount by the respondent because not all food types were available for direct field measurement. It would also have been time prohibitive to rigorously record weights for every food item available. However, given the importance on rice and water in the diet, the amount of both water and rice consumed was recorded by direct field measurement for each adult male, female and child in the household.

The type of food items consumed and the frequency of food consumption varied between households and also among individual members of a household. This survey used semi-quantification to record the dietary intake of food per individual as well as per household. In semi-quantification rather than weighing every individual's intake of a particular food item, a reference amount was weighed accurately, and the respondents provided information about their intake relative to that reference amount. The method for measuring the amount of water and rice intake is discussed in the "Measurement of exposure and dietary intake parameters" section.

Sampling and coding water, food and soil

Food samples for analysis were collected from the household kitchen, the household garden or the local market. Soil was collected from the household garden from the same location where a vegetable sample was taken. Water samples were collected from either household tubewells or a nearby pond if it was also used by the household for food preparation. All samples locations were captured by GPS as an *X*, *Y* coordinate. The sample naming system utilized has been discussed previously in the "Sample naming convention" section.

Sampling water While collecting water, the sampling team also recorded the pH and EC. For each tubewell, four distinct water samples were collected, designated F (filtered un-acidified), UFA (unfiltered and acidified), FA (filtered acidified) and 3A (passed through an arsenic speciation quill and acidified). This combination of water sampling allowed the effect of particulate matter and As speciation between As(III) and As(V) to be determined. Filtered samples were passed through a 0.45 μm cellulose acetate disposable filter, while acidified samples were acidified by the addition of concentrated nitric acid (three drops). Acid-washed 50 ml centrifuge tubes were used to collect samples, with the exception of 3A samples, which were collected in 15 ml centrifuge tubes. For each pond or river source, only one water sample (unfiltered) was collected for analysis because the total As was believed to be consistently low from pond water, making speciation unwarranted.

Sampling soil Topsoil (0–15 cm) was collected within the immediate vicinity of where vegetables had been collected from the garden. Soils were a triplicate composite sample collected approximately 1 m apart. In some cases, at every tenth sample, some of the subsurface soil (15–30 cm) was collected from the same location. Samples were packed in zip-lock bags labeled with the appropriate code.

Sampling rice and other food Cooked rice, rice grain, dal and vegetables were collected from the household kitchen. Vegetable samples were also collected from the backyard garden or the local market as appropriate. Both cooked food and uncooked food (rice grain, vegetables, dal) were weighed in the field and then packed into zip-lock bags appropriately labeled with sample ID and food type using a permanent ink marker.

Post-implementation stage

This stage involved pre-processing of soil, water, rice and vegetable samples in Bangladesh at the DCH laboratories and subsequent shipment to CERAR laboratories in Australia for analysis of As and other metal(loid)s. All soil and food samples were analyzed for As and other metal(loid)s using ICP-MS following acid-assisted microwave digestion. All water samples were analyzed by ICP-MS directly without treatment except for occasional filtering. All data collected through the FFQ were entered into a Microsoft Access database for calculating exposure and human health risk, as well as creation of input datasets for GIS models. Data manipulation and structuring were also conducted using R for statistical analysis and creating input data files for WinBugs 1.4.

Results and discussion

Socio-demographic composition of the survey population

Demographic variables, such as age, gender and body weight, play an important role for the accurate calculation of risk associated with dietary intake of As. Therefore, accurate collection of this information would ensure a reliable estimate of risk. Age was self reported, gender was self evident, and body weight, where possible, was measured. Missing body weight was calculated by adapting a LOWESS method (Owens unpublished method) by subdividing age dependence of body weight into three linear sections and interpolation. The distribution of average body weight by thana is presented in Tables 1 and 2, illustrating the distribution of the surveyed population by age group, gender and body weight.

FFQ results showed that in the surveyed villages, common professions included farmers, day laborers, rickshaw pullers, housewives, students, government and private service workers, and doctors. Distribution of the the surveyed population by profession and by district is shown in Table 3. A significant proportion of the study population, 6, 14 and 11% from the Laksham, Sirajdikhan and Manikganj Sadar thanas, respectively, were involved in agricultural activities. Many of the respondents identified themselves solely as housewives who were responsible for food

Table 1 Distribution of child body weight (BW) by age and thana

Age group	Average BW (kg)		
	Laksham thana	Sirajdikhan thana	Manikganj Sadar thana
0–5	13 ($n = 28$)	13 ($n = 29$)	12 ($n = 18$)
5–10	23 ($n = 45$)	22 ($n = 30$)	22 ($n = 26$)
10–13	34 ($n = 30$)	33 ($n = 22$)	34 ($n = 11$)
0–13	23 ($n = 103$)	22 ($n = 81$)	22 ($n = 55$)

Data source: FFQ 2005–2006

BW Body weight

Table 2 Distribution of adult body weight (BW) by age, gender and thana

Age group	Average male BW (kg)			Average female BW (kg)		
	Laksham	Sirajdikhan	Manikganj Sadar	Laksham	Sirajdikhan	Manikganj Sadar
14–25	51 ($n = 59$)	55 ($n = 45$)	52 ($n = 46$)	43 ($n = 65$)	48 ($n = 70$)	45 ($n = 50$)
26–35	58 ($n = 25$)	58 ($n = 35$)	59 ($n = 26$)	48 ($n = 24$)	55 ($n = 33$)	49 ($n = 20$)
36–45	53 ($n = 18$)	58 ($n = 15$)	56 ($n = 19$)	46 ($n = 21$)	54 ($n = 13$)	46 ($n = 22$)
46–55	54 ($n = 15$)	52 ($n = 15$)	56 ($n = 16$)	41 ($n = 13$)	48 ($n = 13$)	44 ($n = 12$)
55–65	49 ($n = 11$)	54 ($n = 9$)	52 ($n = 13$)	41 ($n = 8$)	46 ($n = 8$)	41 ($n = 12$)
65+	50 ($n = 6$)	47 ($n = 6$)	46 ($n = 7$)	36 ($n = 4$)	30 ($n = 8$)	35 ($n = 7$)
14–65+	53 ($n = 134$)	55 ($n = 125$)	54 ($n = 127$)	44 ($n = 135$)	50 ($n = 139$)	45 ($n = 123$)

Data source: FFQ 2005–2006

BW Body weight

Table 3 Percentage of surveyed population involved in different professions

Profession	Laksham		Sirajdikhan		Manikganj Sadar	
	Count	%	Count	%	Count	%
Business	17	4.6	15	4.3	12	3.9
Day labor	6	1.6	1	0.3	–	–
Doctor	1	0.3	–	–	2	0.7
Driver	1	0.3	–	–	–	–
Factory worker	1	0.3	–	–	2	0.7
Farm day worker	11	2.9	7	2.0	7	2.3
Farm owner	13	3.5	45	12.8	29	9.4
Fisherman	–		–	–	6	2.0
Garment worker	–	–	–	–	2	0.7
Government service	3	0.8	–	–	–	–
Goldsmith	–	–	–	–	2	0.7
Handicraft	–	–	–	–	5	1.6
Housewife	82	22.0	87	24.8	95	30.9
Imam	3	0.8	–	–	–	–
Press worker	–	–	–	–	2	0.7
Primary student	53	14.2	38	10.8	37	12.1
Private service	3	0.8	–	–	1	0.3
Rickshaw puller	2	0.5	1	0.3	–	–
Secondary student	59	15.8	52	14.8	35	11.4
Service	8	2.1	9	2.6	10	3.3
Store owner	6	1.6	7	2.0	3	1.0
Store worker	2	0.5	6	1.7	3	1.0
Tailor	4	1.1	–	–	2	0.7
Teacher	8	2.1	2	0.6	2	0.7
Tertiary student	5	1.3	8	2.3	14	4.6
Unemployed	28	7.5	20	5.7	8	2.6
Unspecified	3	0.8	2	0.6	1	0.3
Village doctor	1	0.3	–	–	3	1.0
Worker	2	0.5	–	–	–	–
Working abroad	12	3.2	8	2.3	–	–

Data source: FFQ 2005–2006

preparation, food distribution, child raising, washing and also crop processing, comprising 22, 25 and 31% of the surveyed population in the Laksham, Sirajdikhan and Manikganj Sadar thanas, respectively. The significant proportion of students in the surveyed population potentially indicates an increase in literacy rate and awareness regarding education nationwide. A nationwide 9% increase in literacy between 2000 and 2005 was indicated by government statistics (BBS 2006). The percentage of average unemployment across all villages surveyed was 6%, which was one third of the national average of 18% for 1995–1996 (Banglapedia 2004).

Income is another important variable that can provide a basis for risk characterization on socio-economic classes in the rural landscape. There were some relationships between income and nutritional status in the villages in Bangladesh. While the correlation between nutritional factors and As metabolism has not been fully quantified, it is believed that low nutritional status in humans may increase susceptibility to chronic As toxicity (Milton et al. 2004). Some reports indicated that elevated income can be indirectly protective by reducing the risk associated with As by allowing improved nutrition (Tseng 1977; Hsueh et al. 1995; Mazumder et al. 1998). Milton et al. (2004) identified that socio-economic status is a potential confounder for body mass index (BMI).

In this study, the income variable was recorded as a self-reported income in the local currency. One previous survey (Sarker et al. 2005) had used an indirect assessment of income based on observations of household assets, i.e., electronic items, such as TVs, radios and cassette players, and the building materials used in the construction of the house. These two alternate methods for collecting information on income have limitations. In recording self-reported income, respondents may hesitate to disclose the actual income of the household, and there was a tendency to under-report the actual income. In contrast, evaluating income by assets assessment by the interviewer may lead to either over or under estimation of the income depending on the astuteness of the interviewer. In addition, it is difficult to quantify a qualitative assessment of assets with an average weekly income. Thus, self-reported income was considered acceptable. The self reported median monthly income was 4,000, 5,750 and 5,000 taka per household (about USD 58, 84 and 73) for Laksham, Munshiganj and Manikganj Sadar thanas, respectively. The monthly nominal rural household income of 6,096 taka (BBS 2006) based on a household income and expenditure survey in 2005 was in good agreement with the income determined here. Among the 18 villages, Iruaine village in the Lakham thana (10,000 taka, USD 146) showed the highest median monthly income compared to other villages within Laksham and other villages from Sirajdikhan and

Manikganj Sadar thana. The reasons Iruaine village exhibited a higher income compared to other villages can be attributed to the amount of agricultural land, fish cultivation area and people involved in business. Income distribution by villages is illustrated in Table 4.

Dietary pattern

A number of studies have identified that the typical meal consists of a large portion of rice and vegetables (Kile et al. 2007; Islam et al. 2004), but do not provide much quantitative information on this dietary pattern. This survey indicated that the typical daily meal in the Bangladesh village was a large portion of rice with a small amount of vegetables and supplemented by a small amount of fish (consumed on average four times a week) or dal. In most cases, people occasionally consumed meat (beef or goat) and chicken is typically eaten only once a month. The results were used to provide quantitative estimates of dietary intake for As exposure and health risk assessment.

Estimation of direct dietary intake of water

Drinking contaminated tubewell water has been identified as a major As exposure pathway associated with increased human health risk in Bangladesh and West Bengal (Kile et al. 2007; Watanabe et al. 2001; Das et al. 2004). The water intake by children, adult females and adult males from 18 villages within Laksham, Munshiganj and Manikganj Sadar thana is shown in Table 5. Both the water intake and the As concentration in the water varied widely across the thanas and within each village.

Across the three thanas, the overall average daily water intake per child, adult female and adult male was 1.4 ± 0.6 ($n = 240$), 2.7 ± 1.1 ($n = 397$) and 3.3 ± 1.3 ($n = 386$) L day^{-1}, respectively. The difference in water intake between adult females and adult males was only 0.59 L day^{-1} and was insufficient to suggest any significant variation in daily water consumption between adult female and male populations in the villages of Bangladesh. The potential reasons for insignificant variation in water intake between the male and female population could be identified as personal habits and involvement in work by both genders that required hard physical

Table 4 Variation in monthly household income by village

Laksham thana						
Village	Iruain ($n = 10$)	Vakudda ($n = 10$)	Kandirpar ($n = 10$)	Auspara ($n = 10$)	Salepur ($n = 10$)	Fatepur ($n = 10$)
Median (Taka)	10,000	4,000	4,000	5,750	3,500	4,000
Median (USD)[a]	146	58	58	84	51	58
Sirajdikhan thana						
Village	Daniapara ($n = 10$)	Abirpara ($n = 10$)	Uttar Tajpur ($n = 10$)	Dakatipara ($n = 10$)	Rashunia ($n = 10$)	Tenguripara ($n = 10$)
Median (Taka)	5,014	6,750	5,000	6,000	5,000	5,500
Median (USD)[a]	73	98	73	87	73	80
Manikganj Sadar thana						
Village	Sarupai ($n = 10$)	Noyakandi ($n = 10$)	Dholai ($n = 10$)	Kunduria ($n = 10$)	Berirchar ($n = 10$)	Nabogram ($n = 10$)
Median (Taka)	5,000	5,000	6,500	4,250	5,000	6,500
Median (USD)[a]	73	73	95	62	73	95

[a] 1 USD = 68.6 taka (rate was based on 06.12.07)

Data source: FFQ 2005–2006

Table 5 Daily water intake (L day^{-1}) by adult males, females and children

Village	Daily water intake (L day^{-1})		
	Child	Adult female	Adult male
Laksham thana			
Salepur	1.43 ($n = 14$)	2.63 ($n = 24$)	3.05 ($n = 21$)
Iruain	0.98 ($n = 21$)	2.53 ($n = 23$)	2.48 ($n = 30$)
Fatepur	1.20 ($n = 19$)	2.45 ($n = 23$)	2.78 ($n = 20$)
Kandirpar	1.32 ($n = 22$)	2.08 ($n = 20$)	2.13 ($n = 23$)
Vakudda	1.10 ($n = 15$)	2.49 ($n = 21$)	3.02 ($n = 13$)
Auspara	1.48 ($n = 13$)	2.02 ($n = 24$)	2.55 ($n = 27$)
Average	1.23 ($n = 104$)	2.37 ($n = 135$)	2.62 ($n = 134$)
Sirajdikhan thana			
Daniapara	0.89 ($n = 11$)	2.26 ($n = 24$)	3.03 ($n = 20$)
Abirpara	1.44 ($n = 18$)	2.50 ($n = 30$)	2.84 ($n = 22$)
Dakatipara	1.90 ($n = 10$)	2.91 ($n = 21$)	3.30 ($n = 23$)
UttarTajpur	1.89 ($n = 9$)	2.55 ($n = 24$)	3.21 ($n = 23$)
Rashunia	1.35 ($n = 18$)	2.51 ($n = 19$)	3.45 ($n = 19$)
Tangoripara	1.25 ($n = 15$)	3.39 ($n = 21$)	4.38 ($n = 18$)
Average	1.42 ($n = 81$)	2.67 ($n = 139$)	3.34 ($n = 125$)
Manikganj Sadar thana			
Sarupai	1.13 ($n = 12$)	3.35 ($n = 20$)	2.90 ($n = 17$)
Berirchar	2.57 ($n = 6$)	2.70 ($n = 18$)	3.95 ($n = 22$)
Dholai	1.40 ($n = 12$)	2.76 ($n = 23$)	3.92 ($n = 23$)
Kunduria	1.35 ($n = 9$)	3.29 ($n = 23$)	4.20 ($n = 17$)
Noyakandi	1.61 ($n = 11$)	2.77 ($n = 20$)	3.93 ($n = 25$)
Nabogram	2.22 ($n = 5$)	3.25 ($n = 19$)	4.27 ($n = 23$)
Average	1.58 ($n = 55$)	3.02 ($n = 123$)	3.89 ($n = 127$)

Data source: FFQ 2005–2006

labor. While males worked in the field for crop cultivation and irrigation, females cooked with open fires, dried crops and sometimes worked in the field with their male partners.

Estimation of direct dietary intake of rice

Rice is the dietary staple in Bangladesh, comprising about 70% of the total diet (Bae et al. 2002), and contributes 73% of the calorie intake (Meharg and Rahman 2003). In close agreement with previous studies (Bae et al. 2002; Mehrag and Rahman 2003), the FFQ indicated that rice contributed 66% of the total dietary intake (without water) in the study areas. Our estimate was in good agreement with the estimate of 62% of the total diet from the Bangladesh National Nutrition Survey, 1995–1996.

Rice is consumed in large amounts, three times per day in the rural areas of Bangladesh. Cooked rice has been identified as one of the major dietary As exposure pathways to humans in Bangladesh and West Bengal by a number of studies, especially when the rice is cooked with As-contaminated water (Bae et al. 2002; Duxbury et al. 2003; Meharg and Rahman 2003; Das et al. 2004; Watanabe et al. 2004; Williams et al. 2005). While rice typically contains a much smaller amount of As when compared to the As present in contaminated drinking water, the larger daily intake of rice may contribute a considerable amount of As to the total As ingested by humans (Williams et al. 2005). Our survey indicated that both age and gender influenced the daily intake of rice. Children, adult females and adult males from the Laksham, Munshiganj and Manikganj thanas ingested on average 900 ± 600 ($n = 238$), 1,600 ± 600 ($n = 397$) and 1,800 ± 700 ($n = 386$) g day^{-1} FW (fresh weight) of cooked rice, respectively. Thus, probably no differences exist between rice ingested by gender, but children do eat significantly less. Our estimated rice intake is slightly higher than the estimates of the Bangladesh national nutritional survey of 1995–1996, which estimated the consumption of rice grain to be 460 g DW (dry weight), which is equivalent to 1,278 g day^{-1} FW rice intake by the rural population in Bangladesh. The Bangladesh national survey presented rice intake without any age and gender distinction. While the variation in the daily rice intake was significant between villages ($p < 0.001$), no statistically significant variation was observed between thanas (Table 6).

Other food intake

Vegetables contributed about 6% of the total solid diet in the study villages. The study population consumed 32 different varieties of seasonal vegetables all year round. The FFQ identified that the average daily consumptions of seasonal vegetables in the villages for the child, adult female and adult male populations were 80 g ($n = 239$), 148 g ($n = 397$) and 154 g ($n = 386$), respectively. Small differences in daily intake of food between the adult male and female population were observed which reflected cultural practices, indicated that better meal and larger portions given to males over females (FAO 1999). Therefore, gender inequity prevailed in

Table 6 Average daily cooked rice intake by (g day^{-1} FW) males, females and children

Village	Daily cooked rice intake (g day^{-1} FW)		
	Child	Adult female	Adult male
Laksham thana			
Salepur	1,456 (n = 14)	2,177 (n = 24)	2,079 (n = 21)
Iruain	871 (n = 20)	1,682 (n = 23)	2,011 (n = 30)
Fatepur	1,005 (n = 19)	1,434 (n = 23)	1,750 (n = 20)
Kandirpar	1,216 (n = 22)	1,667 (n = 20)	1,754 (n = 23)
Vakudda	1,018 (n = 15)	1,615 (n = 21)	1,614 (n = 13)
Auspara	1,041 (n = 13)	1,793 (n = 24)	2,140 (n = 27)
Overall average	1,092 (n = 103)	1,735 (n = 135)	1,926 (n = 134)
Sirajdikhan thana			
Daniapara	466 (n = 11)	1,371 (n = 24)	1,500 (n = 20)
Abirpara	842 (n = 18)	1,647 (n = 30)	1,757 (n = 22)
Dakatipara	647 (n = 10)	1,527 (n = 21)	1,798 (n = 23)
UttarTajpur	822 (n = 9)	1,300 (n = 24)	1,525 (n = 23)
Rashunia	751 (n = 18)	1,590 (n = 19)	1,787 (n = 19)
Tangoripara	586 (n = 15)	1,271 (n = 21)	1,358 (n = 18)
Average	697 (n = 81)	1,457 (n = 139)	1,628 (n = 125)
Manikganj Sadar thana			
Sarupai	625 (n = 11)	1,477 (n = 20)	1,741 (n = 17)
Berirchar	1,173 (n = 6)	1,256 (n = 18)	1,676 (n = 22)
Dholai	687 (n = 12)	1,360 (n = 23)	1,769 (n = 23)
Kunduria	842 (n = 9)	2,008 (n = 23)	2,010 (n = 17)
Noyakandi	1,113 (n = 11)	1,575 (n = 20)	1,844 (n = 25)
Nabogram	910 (n = 5)	1,376 (n = 19)	1,729 (n = 23)
Average	862 (n = 54)	1,522 (n = 123)	1,789 (n = n=127)

Data source: FFQ 2005–2006

household food distribution and food choices. The fish intake rate and amount were higher compared to animal protein. The meat (beef, goat) intake rate and amount were insignificant in the total diet because meat was eaten irregularly due to its irregular availability in rural markets and the price, which was beyond the financial capacity of the majority of households. The distribution of various foods in the daily diet in three different thanas is summarized in Table 7.

Tubewell depth and As concentration in drinking water

The source of water is one of the most important variables related to dietary intake of As (WHO 2001; Chen and Ahsan 2004; Watanabe et al. 2004a; Heck et al. 2007). The source of water for drinking, cooking and irrigation in a given landscape is crucial for identifying and quantifying the exposure route since the contamination level is often spatially distributed across the landscape. For instance, pond water is generally much less contaminated than tubewell water, but significant variation in As load can also occur between tubewells, even when located in close proximity.

According to the Department of Public Health and Engineering (DPHE), the average depth of a shallow tubewell in Bangladesh is 30 m, and depth ranges from 10 to 50 m (BGS 1999). In this study, the overall mean depth of tubewells (18 villages) was 31 m (n = 60) and ranged from 5 to 244 m, whereas the mean depth of the tubewells located in Laksham, Sirajdikhan and Manikganj Sadar thanas was 34, 75 and 29 m, respectively. The information on tubewell depth and installation year were self reported by participants since no labeling regarding depth or date of installation was found on any household tubewells.

Table 7 The amount of foods consumed by the village population in Bangladesh

Food	Laksham Child ($n = 103$)	Sirajdikhan Child ($n = 81$)	Manikganj Sadar Child ($n = 55$)	Laksham Female ($n = 135$)	Sirajdikhan Female ($n = 139$)	Manikganj Sadar Female ($n = 123$)	Laksham Male ($n = 134$)	Sirajdikhan Male ($n = 125$)	Manikganj Sadar Male ($n = 127$)
Wheat flour g day^{-1}	64.2	52.7	89.6	103.6	162.8	99.2	133.4	158.6	138.0
Eggs g day^{-1}	55.3	49.7	60.8	66.2	69.4	64.0	66.6	86.3	56.9
Milk g day^{-1}	128.3	116.6	171.6	80.3	79.1	70.0	98.0	65.1	79.4
Fish g day^{-1}	48.2	37.7	55.0	70.2	62.1	59.5	74.0	91.7	66.4
Meat g month^{-1}	54.2	47.4	47.3	75.7	66.6	59.1	85.1	83.2	77.7
Fruits g week^{-1}	118.4	106.7	145.0	151.7	124.7	128.5	224.8	137.2	140.8
Dal g day^{-1}	26.2	24.1	24.6	36.4	33.8	37.2	39.0	41.9	38.6
Vegetable g day^{-1}	86.5	65.6	88.5	125.6	168.5	145.8	148.3	168.5	142.7

Data source: FFQ 2005–2006

Therefore, the depth and installation year of the tubewell for establishing relationships with the level of As concentration and assessment of As exposure need to be treated with caution.

The overall mean As concentration in tubewell water across all 18 villages was 148 μg L^{-1} and ranged from 0.28 to 969 μg L^{-1}. The mean As concentration in the Laksham, Sirajdikhan and Manikganj Sadar thanas were measured as 317, 46 and 77 μg L^{-1}, respectively. Arsenic in tubewell water also varied significantly between households within a shorter proximity. While many researchers have reported a relationship between As concentration in tubewell and well depth (BGS 1999; Burgess and Ahmed 2006; Harvey et al. 2006), in this study we observed no direct relationship between tubewell depth and As concentration ($R^2 = 0.11$). The lack of any positive relationship may be due to the reliance on a self-reported depth instead of an actual depth measurement. Table 8 shows the mean depth and mean As concentration of tubewells recorded from 18 villages. Although we observed no linear relationship between As concentration and well depth across all three districts, we did observe a relationship between exceedance of the Bangladesh guideline value (50 μg L^{-1}) and well depth (Fig. 1). The number of wells exceeding 50 μg L^{-1} when plotted versus well depth indicated a peak of higher As concentrations around 18.7 m depth (Fig. 1). A small number of tubewells exceeded 50 μg L^{-1} at lower depth, and also a few tubewells exceeded 50 μg L^{-1} at depth above 70 m.

Table 8 Mean depth and As concentration in tubewell by villages

Laksham thana							
Village	Iruain	Vakudda	Kandirpar	Auspara	Salepur	Fatepur	Overall mean
Depth (m)	27	19.5	27.5	19.2	25.9	85.3	34.1
As (μg L^{-1})	225.1	397.2	303.3	481	326.6	179.4	318.8
Sirajdikhan thana							
Village	Daniapara	Abirpara	UttarTajpur	Dakatipara	Rashunia	Tenguripara	
Depth (m)	58.4	66.1	79.9	94.3	69.6	96.5	77.5
As (μg L^{-1})	8.3	113.1	23	8.5	4.3	68.4	37.6
Manikganj Sadar thana							
Village	Sarupai	Noyakandi	Dholai	Kunduria	Berirchar	Nabogram	
Depth (m)	29.4	30.2	32.3	33.4	29.7	20.9	29.3
As (μg L^{-1})	82.6	27.7	87	38.7	85.4	35.8	59.5

Data source: FFQ 2005–2006

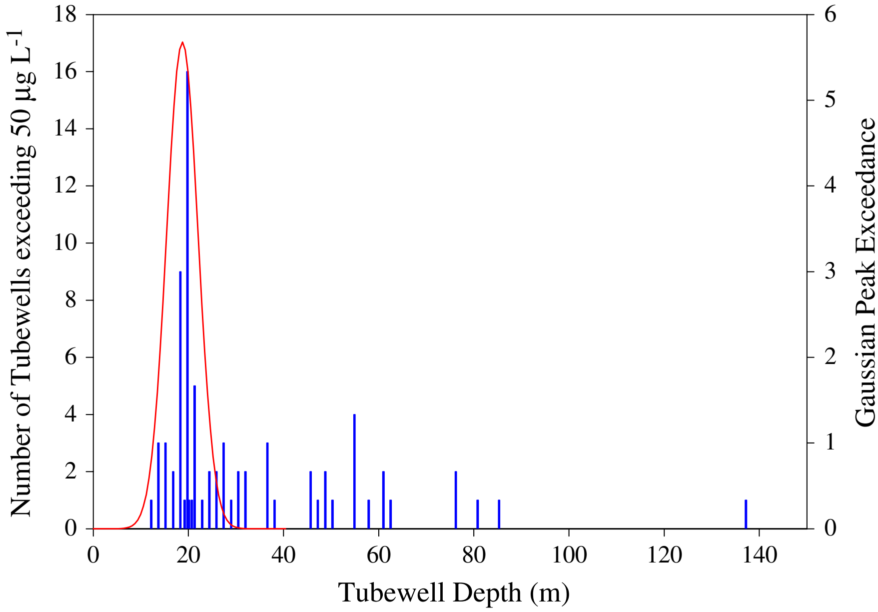

Fig. 1 Tubewells exceeding the Bangladesh drinking water arsenic guideline value of 50 µg L^{-1}

Source of water for drinking and other usage

Tubewells were the main source of drinking water in all three thanas, with 93% of the surveyed population used deep and shallow tubewells as their principle source of drinking water. Only 7% of the population used alternative water sources, such as dugwells, ponds and rainwater to collect their drinking water. However, 75% of the entire surveyed population indicated that they used pond water exclusively for cooking. The percentage of pond water used for cooking varied with geographic location being 100, 80 and 48% for Laksham, Sirajdikhan and Manikganj Sadar thanas, respectively. The higher usage of tubewell water (52%) for cooking in Manikganj Sadar thana was potentially due to a limited number of ponds in this region compared to Laksham and Sirajdikhan. A number of reasons identified by respondents for increase usage of pond water for cooking were: (1) tubewell water discolored rice because of the high Fe content; (2) dal took longer to cook with tubewell water and in most cases dal became harder; (3) the knowledge that pond water was safe for cooking because the boiling process killed bacteria. These observations also indicated that the villages were knowledgeable and aware of issues associated with the use of As-contaminated water. The source of water for the household vegetable gardens was predominantly (60%) pond water, and only 34% from tubewell, 3% from river and 4% from canal water (Table 9). There was some variation in water sources used for crop irrigation between thanas. While overall 50% of the total water used for irrigating field crops was obtained from tubewells, in contrast 45% of the total water used for field crop irrigation in the Sirajdikhan thana was obtained from canals. One of the prime drivers for adopting alternative sources for field irrigation would seem to be the availability of reliable alternative water source and the cost of tubewell irrigation.

Source of rice consumption

The source of rice, whether locally grown or purchased from the local market, is also an important parameter for determining daily As intake. Locally grown rice will potentially be high in As due to cultivation in local contaminated soil and irrigation with As-contaminated water. In contrast, rice from the market will potentially show lower concentrations of As due to dilution from mixing of rice from various geographic locations, or in some cases importation to the village from neighboring localities or from other countries. Our findings are an agreement with Smith et al. (2006), who also measured higher As concentration in the locally grown rice when compared to market rice. This survey indicated that across all villages rice was primarily obtained

Table 9 Percentage distribution of water usage by water source

Type and source of water usage	Deep tubewell (%)	Shallow tubewell (%)	River (%)	Pond (%)	Canal (%)	Dugwell (%)	Rain water (%)
Laksham thana							
Drinking	3	89	0	2	0	3	3
Cooking	0	0	0	100	0	0	0
Irrigation	37	24	0	16	12	0	10
Garden	0	28	0	72	0	0	0
Sirajdikhan thana							
Drinking	53	44	0	0	0	4	0
Cooking	3	2	6	80	0	3	6
Irrigation	29	7	19	0	45	0	0
Garden	0	17	4	75	4	0	0
Manikganj Sadar thana							
Drinking	3	87	0	0	0	10	0
Cooking	0	52	0	48	0	0	0
Irrigation	25	29	8	17	13	0	8
Garden	4	54	4	32	7	0	0

Note: The percentage was calculated based on 60 households in each thana

Data source: FFQ 2005–2006

from the market, with 65.5, 3 and 31% of the surveyed households obtaining rice from the market, homegrown and a mixture of market and homegrown sources, respectively. The percentage distribution of rice sources across all three districts is illustrated in Fig. 2. Among the three thanas, Laksham showed the highest percentage of consumption of homegrown cultivated rice because villages in the Laksham thana had more cultivable land than any other thanas (see Part-A).

Amount of rice and dal consumption and cooking method

Daily amount of rice and dal cooked in the household

The FFQ results were used to collate information on the daily amount of rice grain and dal cooked in the villages. On average, 2.35, 2.01 and 3.01 kg of rice grain were used for preparing three meals per day in the households in Laksham, Sirajdikhan and Manikganj Sadar thanas, respectively, while the amount of dal cooked on a daily basis in Laksham, Sirajdikhan and Manikganj Sadar thanas was 200, 170 and 167 g, respectively. In contrast with household daily rice consumption, daily dal consumption was very low because dal is cooked like soup and eaten with rice and dal is more expensive than rice. Table 10 shows the average amount of rice and dal consumed per village.

Amount of water used in food preparation

Since a number of previous studies have indicated that the As concentration in cooked rice could be elevated due to the cooking process and/or the water used in cooking (Watanabe et al. 2001; Bae et al. 2002; Ohno et al. 2007), this study identified the rice and dal cooking methods typically used in the villages and quantified the amount of water used in cooking. To our knowledge, this facet of indirect As intake has not been considered previously in any detail.

This survey identified that water for cooking was sourced primarily from pond water (75%), followed by tubewell water (20%) and river water, dugwell water or rain (5%). The FFQ indicated that for rice cooking on average 3.5 L of water was used per kilogram rice grain (DW), whereas 10.3 L of water was used for per kilogram dal (lentils) (DW) cooking. Table 11 shows the variation in the amount of water used in cooking rice and dal according to village. For dal, this average estimate varied according to the types of dal and the

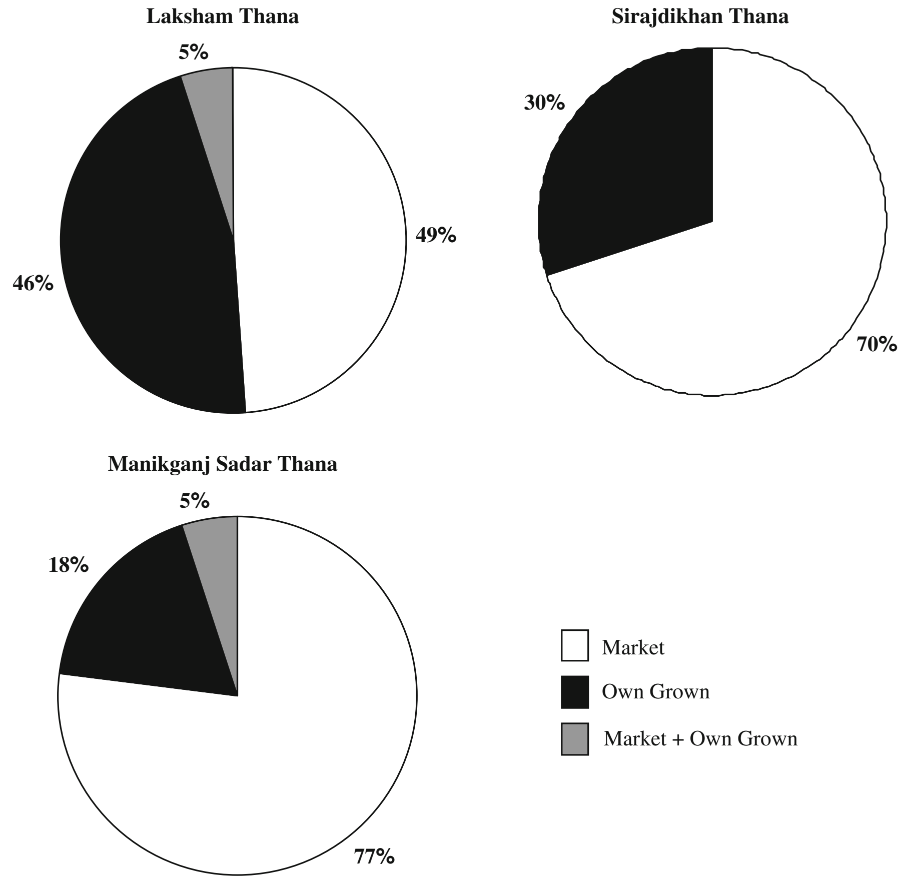

Fig. 2 Average percentage distribution of rice usage with various sources in the households of Laksham, Sirajdikhan and Manikganj Sadar thanas

Table 10 Average rice grain (DW) and dal (DW) consumption in the rural household by village

Laksham thana							
Village	Iruain	Vakudda	Kandirpar	Auspara	Salepur	Fatepur	Overall mean
Mean rice DW day^{-1}	3,250	1,825	2,475	2,100	2,450	2,025	2,354
Mean dal DW day^{-1}	222	158	248	193	208	183	202
Sirajdikhan thana							
Village	Daniapara	Abirpara	Uttar Tajpur	Dakatipara	Rashunia	Tanguripara	
Mean rice DW day^{-1}	2,000	1,925	1,588	2,625	2,125	1,800	2,010
Mean dal DW day^{-1}	165	208	185	132	135	185	170
Manikganj Sadar thana							
Village	Sarupia	Noyakandi	Dholai	Kunduria	Berrirchar	Nabbogram	
Mean rice DW day^{-1}	2,163	3,350	7,628	1,838	1,875	1,225	3,012
Mean dal DW day^{-1}	138	210	188	206	160	88	167

Data source: FFQ 2005–2006

consistency of dal preferred by the household. However, the result presented in Table 11 indicated that dal was being cooked with a large amount of water compared to the amount of dal (DW) and that large amounts of water remained in the cooked dal.

Conclusions and lessons learned

The implementation of an FFQ was shown to be an effective method for collecting information pertinent to the dietary intake of rural populations. In

Table 11 Amount of water used for a traditional cooking method in the rural areas of Bangladesh

Laksham thana							
Village	Iruain	Vakudda	Kandirpar	Auspara	Salepur	Fatepur	Overall mean
Mean water L^{-1} kg^{-1} DW rice	3.0	3.2	3.3	3.6	4.0	3.6	3.5
Mean water L^{-1} kg^{-1} DW dal	17.5	20.0	7.6	8.5	8.6	8.4	11.8
Sirajdikhan thana							
Village	Daniapara	Abirpara	Uttar Tajpur	Dakatipara	Rashunia	Tanguripara	
Mean water L^{-1} kg^{-1} DW rice	3.3	3.2	3.1	3.5	3.5	3.6	3.4
Mean water L^{-1} kg^{-1} DW dal	9.1	9.5	7.6	8.7	10.2	8.0	8.9
Manikganj Sadar thana							
Village	Sarupia	Noyakandi	Dholai	Kunduria	Berrirchar	Nabbogram	
Mean water L^{-1} kg^{-1} DW rice	3.6	4.4	3.8	4.2	3.8	2.5	3.7
Mean water L^{-1} kg^{-1} DW dal	11	13.5	9.1	9.4	10.6	8.6	10.4

Data source: FFQ 2005–2006

particular, the FFQ was shown to be capable of collecting dietary intake information of individuals in combination with various demographic, socio-economic and spatial information. The FFQ was also capable of simultaneously enabling collection and documentation of exposure-related information and field samples (water, food and soil). The advantage of the developed FFQ was that it does not require a separate sampling session for collecting samples and therefore is quicker and more cost effective. Due to the simple and homogeneous diet of the people in rural Bangladesh, this FFQ was implemented in three different regions of the country without modification and could easily be extended to any rural region with similar dietary consumption. Data collection with the FFQ was a promising means of obtaining input data for the assessment of dietary patterns, as well as the daily dose of As through direct ingestion of water and food. These data will provide an accurate basis for the measurement and modeling of As exposure related human health risk and will be discussed in future papers.

During the implementation of the FFQ, gaps were identified that may need to be considered in future studies.

1. The body mass index (BMI) was not determined in this study. Since many studies rely on reference to BMI rather than body weight alone, the collection of height measurement along with body weight should be considered in future studies so that the BMI can be calculated.
2. With the exception of rice, cooked food samples were not collected. The collection of cooked vegetables, dal, fish and meat could potentially be considered so that the measurement of As concentration can be identified in total cooked food (cooked with spices and water). However, if this were done, then the survey would need to be conducted during meal times and would therefore take longer to complete. In addition, little benefit would be gained by gathering this information given that vegetables and meat generally contain very small amounts of As compared to water and are consumed in smaller amounts and more infrequently than rice.
3. The implementation of the FFQ indicated that people hesitated to mention the actual income of the household. Therefore, indirect measurement of income via observations of wealth, such as possession of a television, radio, or stereo, or house type, could potentially be incorporated into the FFQ to corroborate self-reported incomes.

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