WORLD HEALTH ORGANIZATION
Regional Office for South-East Asia
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TECHNICAL REPORT

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1. INTRODUCTION

This report relates to my third visit to Bangladesh concerning the problems of arsenic in drinking water. It completes the second assignment which was commenced in February 1998 which dealt primarily with items 1,2, 6 and 7. A detailed report of that period was submitted. In this second period the focus has been on terms of reference items 1, 3-5 and 7.

2. TERMS OF REFERENCE

1. Review and adjust, as appropriate, the recommendations (Emergency Plan of Action: Health) made during the 3-14 March 1997 consultancy in light of current developments and activities by GOB and the development partners.

2. Define the essential epidemiological study/research needs and prepare detailed costed project proposals (e.g. role of nutritional status).

3. Propose a workable (under Bangladeshi conditions) strategy to combine epidemiological surveillance with water quality surveillance.

4. Investigate (literature review) the significance (if any) which may be made of other components of the food chain (e.g. rice, potatoes, etc.) to the overall arsenic-related health problems.

5. Provide the necessary medical/epidemiological advisory services, in connection with the arsenic problem, to relevant GOB officials and interested development partners.

6. Attend the International Arsenic Conference, 8-12 Feb. 1997 in Dhaka and represent WHO in connection with technical deliberations with a focus on the medical/epidemiological issues.

7. Provide advice to the WR. Bangladesh on further WHO support to GOB in addressing the arsenic problem.

3. REVIEW OF THE EMERGENCY PROGRAM

In this assignment period the Emergency Program was discussed in Dhaka with the Director Iftikar Hussain based in the National Institute of Preventive and Social Medicine (NIPSOM), and at the Dhaka Community Hospital Trust (DCH) with the Director Dr. Qauzi Quamruzzaman, Professor Mahmuder Rahman, and staff involved in the Emergency Program. A one-day field visit was made to two villages where the Emergency Program

work had been completed, one in the District of Comilla and the other in Laxmipur. A debriefing meeting involving some those active in arsenic work in Bangladesh was held in Dhaka at which five key points were presented for comment and discussion. Each key point was presented with associated recommendations and rationale for them. The following are the five key points with revisions and some further details which followed comments received at the meeting. An invitation was also made to send in written comments, but none had been received at the time of writing this report.

Point 1. The emergency program for mitigation of arsenic contamination in groundwater in Bangladesh, which aimed at providing immediate relief to the 200 most affected villages in Bangladesh, seems to have been a success as far as key objectives are concerned, in particular the identification of arsenic contaminated water with tubewells painted red, and uncontaminated tubewells painted green. However detailed information concerning the program, including the numbers of people interviewed, the number of contaminated tubewells, and the number of patients found, will not be available until July.

Recommendations: (a) That high priority be given to the program about to commence involving a further 300 villages.

(b) That the data from the first 200 villages, in particular the number of patients identified per village, should be analyzed as rapidly as possible and used along with other information to consider whether or not to add further villages to the current program.

(c) That there need be no major changes made to the organization and structure of this program focused on villages where there are patients.

Rationale: It was previously suggested that this program should continue until evidence suggested the majority of patients in Bangladesh had been identified. When very few patients are being found per new village (e.g. some villages having only one or two patients, or none), this emergency program could be stopped. The Government of bangladesh/World bank Arsenic Mitigation Water Supply project will have two components:

1. The long-term program focusing on the implementation of long-term water plans as a national priority, and an arsenic monitoring programme through the national Arsenic Mitigation Water Supply Project (NAMIC); and

2. an emergency component aimed at providing immediate relief to affected communities.

It appears that the emergency component programme will incorporate patient identification and the provision of technical facilities for arsenic-free drinking water. As the emergency character of this component requires quick and decisive action to eliminate further exposure of patients to arsenic, it would be desirable to use an organizational structure geared towards emergency output as successfully used in the Government of Bangladesh-UNDP emergency programme for mitigation of arsenic in groundwater in Bangladesh. Developing a second emergency programme incorporating patient identification would be duplicative and cause start-up delays if a different organizational structure were used.

There are three key reasons for focusing the emergency program on villages with patients. One is that this will identify the most highly exposed populations and lead rapidly to exposure reduction, and hence reduction in the high risks of future arsenic skin disease and probable high risks of cancer which have been found in other populations. (See the report of my consultancy period 3-14 March 1997, Section 3). The second is that skin lesion patients need to be identified and diagnosed to receive appropriate management and care (Section 5 of the 3-14 March, 1997 report). The third reason for focusing the emergency program on villages with patients is that the presence of patients in villages provides obvious population motivation for implementing changes in water sources. When increased arsenic water levels are found, but no patients, it is much more difficult to institute emergency changes which required population education and issues of full understanding of arsenic effects, and responsiveness to recommendations which may be difficult to believe. For each of these reasons, I continue to recommend focusing the emergency program on villages with patients. However it is important that a national high priority program be instituted in parallel focusing on screening water sources for arsenic.

With regard to recommendation (c) above, it is noted that emergency programs can proceed more rapidly and successfully the more they can utilize existing structures and organizations. The more new structures, organizations and personnel are called for, the slower the emergency response. In addition, organizations and structures arranged for a unique emergency situation generally disband after it is completed. Thus the extent to which new structures and organizations are required increases waste of resources. Even if the structures and organizations created continue with a long term non-emergency function, planning them around the emergency situation is not likely to lead to the most effective organization for long term functions. The current porgram has worked well in part because it predominantly utilizes existing structures and organization of the Dhaka Community Hospital Trust.

Point 2. While there are many suggestions, the only currently successful option for providing other sources of water to affected patients and others in the same villages appears to be alternative uncontaminated tubewells which are already present, or sinking deeper tubewells where appropriate.

Recommendation: That the current 300 village program about to commence be coordinated with a program to sink deep tubewells in areas where that is appropriate, and where there are currently insufficient uncontaminated shallow tubewells. That the same be done for the villages already visited in the 200-village program.

Rationale: Interventions which involve major actions such as treating water with chemical packets may be cheap as far as materials are concerned but are very expensive as far as training, monitoring and education costs. Treating with alum or standing to allow arsenic to settle in iron-rich water is not advisable since reducing exposure by the order of 50% does little to the cumulative dose on which arsenic disease risks are based, and may delay longer term water planning. (For example, if a short-term intervention reduces water arsenic levels by 50% for two years, but in the process the resources used and reduced motivation delay a long-term arsenic-free water solution for one year, then there has been no health benefit from the resources used because there has been no reduction in cumulative intake of arsenic). Further work is needed on other mitigation measures, but for the moment, tubewells seems to be the only successful option unless there are local contraindications. However, it is also clear that deep tubewells are not without potential problems and must be installed carefully to avoid cross-contamination from shallower aquifers.

It is emphasized that tubewells are recommended for the emergency program where they are not contraindicated in order to rapidly give a viable source of non-contaminated drinking water to villages with patients in them. This recommendation is **not** intended to suggest that tubewells should provide the long-term water solution throughout Bangladesh. The numbers of villages with patients in them is relatively small to the total number of villages. Furthermore, further research might show that other methods, such as treatment of well water to remove arsenic, harvesting of rainwater, and bacteriological treatment of surface water, may provide long-term water solutions. However the relief of villages with patients from continuing arsenic ingestion cannot wait until the necessary research and investigations are completed for long term planning of these alternative water solutions.

It is also noted that the consultant is not an expert on tubewells, neither shallow nor deep. He is also aware that there have been reports that some deep tubewells become contaminated over time, but understands that this is due to inadequate sealing. What is being recommended is based on the criterion that, from a public health standpoint, emergency interventions are best accomplished through an existing technology which is already tested and known to be well received at the population level. Another important criterion is that interventions requiring little behavioral change (e.g. using a different tubewell perhaps a little more distant) are generally more effective than interventions requiring more behavioral change (e.g. use of chemical packets to treat household water, or harvesting rain water part of the year and use of another source for the rest of the year). The use of alternative non-contaminated shallow tubewells, and the sinking of deep tubewells where there are no uncontaminated

shallow wells, would appear to be the intervention that best satisfies these two criteria for an emergency program.

Point 3. The emergency program is based on field kits to test for arsenic in water. Results of testing to date are generally encouraging.

Recommendation: Continue use of field kits for the emergency program. Priority might be given to the test kit which reliably detects 50 ug/L, is cheapest, easiest and quickest to use, and which gives some quantitative as well as qualitative (yes/no) results.

Rationale: In my report in February 1998, I suggested that field kits should be used if they can detect contamination of water with 100 ug/L or more (see sensitivity and specificity criteria given in the report). It would obviously have been better still if they could reliably detect 50 ug/L. Two recent testing reports have become available at least in preliminary form. The first is the Comparative Study of Methods of Arsenic Analysis. Part 1: Field Kits, 20 May 1998 DRAFT, UNICEF, which tested the Aqua field kit used by UNICEF and the Merck field kit. The report stated that the Aqua kit, which gives a qualitative Yes/No result, performed well on all samples. The Merck kit also correctly identified contaminated samples but the quantitative results tended to underestimate concentrations. (A possible reason for this was that water samples were preserved with acid, whereas in field use no acid is used).

The second recent report on field kits was available as a Draft Final Report (Assessment of Arsenic Field Testing Kits, National Environmental Engineering Research Institute, Nagpur, India, June 1998, Sponsored by WHO). NEERI evaluated five field kits: the Merck kit, Germany; the Asia Arsenic Network kit , Japan; the Aqua Consortium, Calcutta kit; the NIPSOM kit, Bangladesh; and the kit of the All India Institute of Hygiene and Public Health (AIIH & PH). The Aqua kit was noted to be hazardous since mercury bromide paper was touched by hand in its use. The Asia Network kit, and the NIPSOM kit which is a modification of it, were reported in the summary to have the lowest detection limits (0.02 mg/L or 20 ug/L). It was noted that the NIPSOM kit test could be completed in a shorter time (5 minutes) than the other kits which required 15 minutes or more. Thus the kit locally adapted and used in Bangladesh by NIPSOM had several advantages including a low detection limit, semi-quantitative results rather than just Yes/No, low cost, as well as the shortest time requirement.

Further information concerning the NIPSOM kit is In Press in JOPSOM, the Journal of Preventive & Social Medicine. (Arsenic field test kit: A cheap and easy device for detection of arsenic in water. Sk. Akthar Ahmad, MH Salim Ulla Sayed, Sk. Abdull Hadi, Abdul Wadud Khan). In this paper was noted that the instruments and accessories are locally made, and the chemicals used found on the local market. Other features of the modifications

included minimizing production costs, saving time in getting the tests done, and increasing the ease of use by non-technical personnel.

Point 4. It is not clear the extent to which health assistants at Thana Health Complexes are continuing to monitor patients and their water sources.

Recommendation: Each Health Complex in Thanas in which there are arsenic patients might be asked to dedicate some field workers to visiting arsenic patients in their homes on a regular basis (perhaps one health assistant per 100 patients). These field workers would be trained to use field kits for water testing.

Rationale: The emergency program is focused on villages with patients in part because of their motivation to want to change there water once they understand the problem. However, the health education involved requires repeated visits. There is a tendency to slip back to using the contaminated water, at least occasionally, and in part this is likely to be due to some incredulity concerning their crystal clear tubewell water actually causing the skin problems. In addition, there is a need to continue occasional testing of tubewell water to ensure it does not become contaminated.

While Thana Health Complex field workers have been involved in some areas of the 200 village program, on the surface it would appear that training all field workers would not be as effective as dedicating some to arsenic work during the emergency program period. This small number could be better trained to recognize arsenic disease and to use field kits for on-going monitoring of drinking water sources. Their duties might include visiting arsenic patients on a monthly basis for one year. Transport such as provision of bicycles would be critically important to their work. After one year of patient monitoring, education and follow-up, the program could be evaluated to see if it needed to be continued.

(Note: In view of other commitments of Thana Health Complex field workers, it may be difficult to dedicate some to arsenic work in the emergency period without supplementary funding to the Thana Health Complexes. The consultant also noted that what happens in practice at the field worker level may fall far short of what is thought to happen in theory because of a variety of reasons including lack of resources including transport. Periodic unannounced evaluation of field work resources and activities is recommended).

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4. TRAINING MANUALS

It was good to find that there is now a Training Manual written in Bangla. This comprehensive manual adds to the Training Manual in English supplementing it with important new material, in particular in the area of health education. Extensive work has gone into producing it. One small, but important point. Both the Training Manuals produced by NIPSOM in English,

and the current manual published in Bangala may imply that treatment of arsenic exposed patients with chelating agents to remove arsenic from their bodies is effective. The new manual in Bangala goes further in suggesting that such treatment cannot be afforded in a country such as Bangladesh. However, as noted in my previous reports, there is no scientific basis for recommending chelation therapy for arsenic exposed patients. The reason is that arsenic is excreted rapidly from the body provided intake of inorganic arsenic in contaminated drinking water stops. If exposure stops, there is no benefit likely from chelation therapy. If exposure continues, then it should be noted that long term chelation therapy will undoubtedly result in side effects due to loss of other minerals from the body. It should also be noted that the idea that chelation would reduce future cancer risk would be trivial since there would be minimal impact of short-term chelation on lifetime cumulative arsenic dose to target sites in the body.

There may be a place for clinical research studies of chelation therapy, for example to see if cessation of exposure, plus short-term chelation therapy, speeds up the possible improvement in skin lesions. However, there is a matter of medical research which would need careful review by committees governing the ethics of experimentation on humans. In the meantime, chelation therapy can only be recommended for acute poisoning with arsenic (e.g. accidentally ingesting a high dose of arsenical pesticides). It is strongly recommended that the next edition of the training manual should make clear that there is neither medical nor scientific evidence to support giving chelating agents to patients with chronic past exposure to inorganic arsenic in drinking water.

5. RESEARCH NEEDS

There is an urgent need for health related research on arsenic and various researchers are ready to undertake projects. A variety of projects were recommended in my previous report. Most address important questions needed to be answered to correctly manage arsenic health related problems.

Recommendation: (a) That researchers in Bangladesh commence to prepare proposals for research to be funded from the World Bank Program which is about to commence.

(b) The proposals for research should be requested addressing specific topics which are of practical importance to dealing with the arsenic situation in Bangladesh.

(c) That all proposals be independently peer reviewed and scored based on scientific merit, contribution to knowledge about arsenic and its health effects, and relevance to solution of the arsenic problems in Bangladesh.

Rationale: There is little objective information on the latency of arsenic caused skin disease, the progression and prognosis of it with cessation of exposure, and the effect of various treatments. The role of nutrition has not been studied in relation to susceptibility to develop skin lesions, nor its impact on prognosis. Methods of health education concerning arsenic need to be formally studied. The relationship between arsenic water concentrations, cumulative dose, and the risk of skin lesions warrants more study. Investigations to see if cancer rates will rise after sufficient latency are needed to see if the dramatic increase in cancer rates found in other countries will also occur here. Such information is urgently required for patient management, even just to inform them of the prognosis of their skin lesions. Based on information given by Babar Kabir, the World Bank Program has $3 million for arsenic health research which should allow several important projects to commence.

Scientists and physicians in Bangladesh, perhaps in collaboration with overseas scientists, should prepare now for a concerted research program. There are several research centers in Bangladesh including NIPSOM, IPGMR, ICDDR, DCH, and no doubt others, willing to conduct arsenic health related research, although research experience and skills related to population and clinical studies are limited. To ensure fairness, and good scientific quality of research, it is recommended that open solicitation of research proposals be made to be reviewed by an independent committee of local and overseas experts which is multidisciplinary in composition. WHO might facilitate this process, and also help link local health research investigators to potential overseas collaborators and advisors.

6. COMBINING EPIDEMIOLOGICAL SURVEILLANCE WITH WATER QUALITY SURVEILLANCE

A surveillance program is an important long term objective and was listed as item 5 of my terms of reference. However there is insufficient information at this stage to come forward with a reasonable plan. The emergency program on the health side has completed the first phase involving 200 villages. However the data have not yet been analyzed form that phase, and it would be premature to design a surveillance system without having information from both this first phase of the emergency program, and the second phase involving 300 villages.

7. CONTRIBUTION TO ARSENIC RELATED PROBLEMS FROM FOOD SOURCES

The possibility that arsenic exposure may occur from food as well as drinking water sources has often been raised as a concern in various populations exposed to arsenic in drinking water. This is a reasonable question since the possibility exists that drinking

water may not be the only source and solving the drinking water problem may still leave a population exposed to inorganic arsenic from food sources.

Some populations are indeed exposed to quite high levels of arsenic form fish intake. However arsenic present in fish is predominantly arsenobetaine. In this form, the arsenic is rapidly excreted in urine where levels may rise significantly for a day or so after having a fish meal. Arsenobetaine has very little toxicity, and has not been identified as a concern to population health.

The real issue is ingestion of arsenic in inorganic form, and perhaps also as other organic forms including MMA and DMA which are present in food. All food contains some arsenic. Estimates of average intake of arsenic have been made for different populations throughout the world. However the arsenic is often not speciated and includes arsenobetaine. A 1998 report from the Food and Drug Administration in the U.S. estimated arsenic intake from the Total Dietary Study, which is a continuous yearly market basket study. Total arsenic intake form food in adults ranged between about 20 and 90 ug per day, depending on age and sex. However the large majority originated form fish intake. It was estimated that the intake of inorganic arsenic was about 10 ug/day.

Earlier studies in other populations have found a range of arsenic intake form food. A comprehensive study in Canada estimated average intake for adults to be about 50 ug/day (Dabeka RW et al. Survey of arsenic in total diet food composites and estimation of the dietary intake of arsenic by Canadian adults and children. J. AOAC Internat. 76:14-25, 1993). Fish was again the predominant source. In the United Kingdom, an estimate of 89 ug/day was published in 1984, an estimate of 55 ug/day was published for New Zealand in 1978, and in Austria, 27 ug/day was an estimate in 1977. Based on these studies, and excluding probable fish contribution, a ballpark estimate for dietary intake of inorganic arsenic in most populations is about 10 ug/day, with the total intake of arsenic (inorganic and organic combined) varying widely according to the extent of fish consumption.

For populations with low levels of arsenic in drinking water, food may be an important source of intake of inorganic arsenic. For example, if drinking water contained 1 ug of inorganic arsenic/liter and a person drank 2 liters per day, then their daily intake form water would be 2 ug/day. In such a person, food intake of perhaps 10 ug/day would be much greater. However if the drinking water contained 50 ug/liter, then an intake from food of 10 ug/day would be trivial compared to the 100 ug/day coming from drinking water. From this assessment it is clear that if people with high arsenic levels in their drinking water, have typical levels of inorganic arsenic in their food, then the only real concern is the arsenic in the water and food sources can be ignored.

The real question we are confronted with then is whether or not food sources might be contaminated with arsenic beyond that which is typical in those same areas where drinking water levels are high. So far we have limited data on this topic. Some studies have been

conducted in Taiwan, and major investigations have been undertaken in Chile, although I have not seen published reports from Chile yet. Arsenic has been measured in rice and yams in Taiwan although the relationship with the arsenic-exposed regions is not clear. It was estimated that mean intake from yams and rice with 31 ug/day and 19 ug/day for total inorganic intake form yams and rice, respectively, for a total of 50 ug/day within a range of estimates of 15-211 ug/day.

While there are major projects on food sources of arsenic underway, so far there have not been any published reports of food intake and urine levels in exposed populations. Because of this the significance of arsenic in food in areas where food might be contaminated form irrigation water, or from high soil concentrations, is not known.

Two things can be said which are important in making conclusions on this topic. Firstly, there has been no population so far identified with high levels of arsenic in their drinking water in which food was an important contributor to total dose. Thus in all populations so far studied, the drinking water is the only real concern when it contains high levels of arsenic.

The second important point is that concerns about food can be investigated quite simply without going to large scale and expensive measurements of arsenic in food. Even when these measures are available, the question of actual human exposure remains. It is far more direct and simple to directly measure biological samples in humans. If there is concern about arsenic in food once the water source of arsenic has been stopped, then urinary arsenic should remain high. For this reason, I have recommended that research be undertaken on some populations to monitor urine levels. If they are high in arsenic this means either that they are continuing to drink contaminated water, or if not then inorganic arsenic must be present in the food. If such a study showed that food was of concern then investigations could be done measuring arsenic in rice, etc.

8. FURTHER WHO SUPPORT TO GOB

Based on my three visits to Bangladesh to date, I believe that WHO has and can play an important role in arsenic related work in Bangladesh pertinent to human health. The following are some ideas which might be considered:

1. Hold a training workshop in Dhaka concerning arsenic. Some interest was expressed in this, and it was noted that WHO had organized a training program in Calcutta, India.

2. WHO could play an important role in facilitating review of research proposals for funding by the World Bank Program. In addition, it could play a role in linking Bangladesh scientists with potential overseas advisors and collaborators for health research investigations.

3. As an expansion of the above, WHO might arrange and provide multidisciplinary scientific research advice from international experts for each approved and funded research project addressing an important issue concerning arsenic.

4. The work comparing field kits is an important contribution. Further work might be undertaken in improving methods and quality assurance in laboratory estimation of arsenic, linking with overseas reference laboratories, etc. In addition, WHO might facilitate and help provide training for laboratory measurement of arsenic in biological samples such as urine, with capital costs perhaps being provided by a donor agency. Currently there is no laboratory in Bangladesh measuring arsenic in urine.

The above are some general ideas. Further ideas might be obtained by sending scientists and government officials involved in arsenic work in Bangladesh a brief questionnaire asking them to suggest roles that WHO might play in dealing with the arsenic problems in Bangladesh.