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Study on the identification of arsenic exposure areas by 10% sampling method

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Objective of this work is to study the representation of 10% sampling method in identifying the areas with high arsenic concentration. Water arsenic concentration was high due to arsenicosis in all the pump wells in 31 villages from Shanxi and Inner Mongolia regions. The actual exposed high arsenic rate (Q) was calculated. All the wells of the village were marked on the village map, and then each village was divided into 5 parts (east, south, west, north and the center). 10% of the wells were sampled randomly from each of the five parts of the village, which has got more than 50 wells. For the villages with less than 50 wells, one well was sampled randomly from each of the five parts. All the wells were selected from the village which has got less than 5 wells. 10% sample exposed high arsenic rate (R) was calculated. The relationship between Q and R was analyzed. Given the exposed high arsenic rate is not less than 5% there is no significant difference between R and Q. On the contrary, if the actual exposed high arsenic rate was below 5%, R could not represent Q. The 10% sampling method can be perfectly used for detecting high arsenic areas when the actual rate exposed to high arsenic wells is below 5%.

Introduction

Endemic arsenicosis is one of the biogeochemical endemic diseases that is seriously harmful to health. Arsenicosis had been found in Bangladesh and India. Along with these countries, China has also become one of the countries suffering from the disease. Drinking water type of arsenicosis is the main type in China, while burning coal type is the unique type that is mainly found in Guizhou province. The current situation of endemic arsenicosis in China is considered as a grave public health problem. It is reported that the old epidemic areas continue to expand[1], while new areas with arsenicosis are identified gradually[2].

Due to the aggravating situation of arsenicosis now in China, identification of arsenic exposure areas throughout the country is very important for the prevention and cure of this disease. Only when an area is identified to be an arsenic exposure area, epidemiological investigation and clinical examination could be carried out. The findings then will be used to decide whether or not this area is epidemic of arsenicosis. Therefore, it is crucial to develop methods by which arsenic exposure areas are identified quickly and efficiently. Till date, the classical method to identify arsenic exposure areas is census, i.e. all the wells in the suspected village are investigated for arsenic concentration. The advantage of a census is that results obtained from it are accurate, while the disadvantages being long duration and high cost. This demands for a simple, effective and economic method to identify arsenic exposure areas fast and efficiently.

Materials and methods

Materials

All the pump wells in the 31 villages affected with arsenicosis from Shanxi and Inner Mongolia were selected. Water samples were collected from each well and investigations carried out for arsenic concentration by Arsenic Test (1.17926.0001, Merck).

Method

Census

Water samples were investigated for arsenic concentration by the fast kit purchased from Germany. Wells whose arsenic concentration went beyond the limit of 0.05mg/L were considered as high risk arsenic wells. The number of high risk arsenic wells of each village was counted and the high risk arsenic well rate i.e. actual exposure rate (shortened as Q) was calculated.

10% sampling method

All the wells of the village were marked on a village map, and then each village map was divided into 5 parts (east, south, west, north and the center). 10% of the wells were sampled randomly from each of the five parts from villages which has more than 50 wells. For the villages with less than 50 wells, one well was sampled randomly from each of the five parts. All the wells were selected from the villages with less than 5 wells. Water arsenic concentration of all the samples selected was studied in the results gained from

census. The number of randomly selected high arsenic wells of each village was counted and the randomly selected high arsenic well rate i.e. 10% sample exposure rate (shortened as R) was calculated.

Criteria of arsenic exposure areas

Among all the wells randomly selected in each village if arsenic concentration of a well goes beyond the limit of 0.05mg/L, the village is identified as an arsenic exposed area.

Statistics

All the data was entered into the computer and analyzed by SPSS 10.0 for windows. The correlation between Q and R was analyzed by linear regression.

Results

Village dividing and randomly sampling

Wells were marked on the five-section map of each village. Figure 1 is the five-section map of village No.14. Each square represents one well, the black ones represents the wells randomly selected. The other maps were omitted.

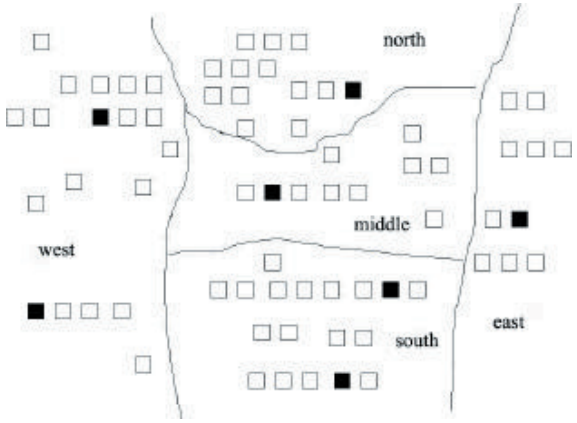

Fig 1. Five-section map of village No.14. (Total wells is 70, and the number randomly selected is 7.)

Relationship between Q and R

Among all the 31 villages, 29 villages were identified as high arsenic exposure areas, which is consistent with the results of census. Only 2 villages were detected as zero, exposure (R = 0), which is opposite to the results of census. There is no significant difference between Q and R in the 29 villages, and the value of p is beyond 0.05 (see table 1). Marked linear relationship is observed between Q and R (r=0.975, p=0.0001). The regression equation is listed in fig. 2.

Accordance of Q and R

Among all 31 villages, there are 29 villages whose Q and R is accordant (p > 0.05). The total accordant rate is 93.55 per cent. In the villages with more than 50 wells, when Q>10%, the accordant rate (number of accordance/number of villages * 100%) is 100%; when Q<10%, the accordant rate is 50% (see table 2). The value of Q in the two villages whose Q and R is not accordant is 2.8% and 1.69%, respectively. These are 5 villages with less than 50 wells, and the number of accordance is 5. The accordant rate is 100%.

Evaluation of 10% sampling method

Among all 31 villages known under the exposure of high arsenic, 29 are identified as arsenic exposure areas by 10% sampling method. The sensitivity is 0.9355.

Table 2. Accordance between actual exposure rate (Q) and 10% sampling rate (R)

Group	Number of accordance	Number of villages sampled	Accordance rate (%)
Q< 10%	2	4	50
10%=Q< 50 %	12	12	100
Q=50%	10	10	100

Discussion

We investigated 31 villages that are known as epidemic areas of arsenicosis by the 10% sampling method, there is a significant linear relationship between actual exposure rate (Q) and 10% sample exposure rate (R). R in 29 villages can represent Q reasonably. The sensitivity is beyond 0.9. Therefore, 10% sampling method is sensitive for identifying high arsenic areas of drinking type arsenicosis.

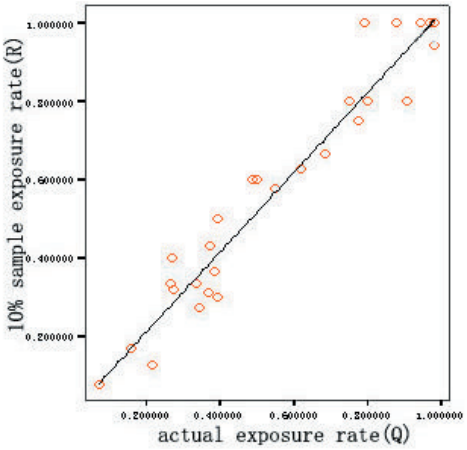

Fig 2. Correlation between actual exposure rate (Q) and 10% sampling rate (R)

Two villages (number 7 and 8) in Inner Mongolia were found to be zero exposure, i.e. not a single well is found to have a high arsenic well by the method, so that these two villages are accordingly identified as non arsenic exposure areas. Further analysis indicates that the actual exposure rate in these two villages is relatively low, which is 2.8% and 1.69% respectively. The actual high arsenic wells of village

Table 1. Actual exposure rate (Q) and 10% sampling rate (R) of each village

Table cell heading	Village	Number of wells	Actual high arsenic wells	Q	Number of sampling	Number of 10% sampling	R	P
wells < 50	1	16	8	0.5000	5	3	0.6000	1.000
	2	12	9	0.7500	5	4	0.8000	1.000
	3	10	8	0.8000	5	4	0.8000	1.000
	4	43	39	0.9070	5	4	0.8000	0.438
	5	37	18	0.4865	5	3	0.6000	1.000
wells=50	6	125	9	0.0720	13	1	0.0769	0.581
	7	143	4	0.0280	14	0	0	-
	8	59	1	0.0169	6	0	0	-
	9	134	9	0.0672	13	1	0.0769	1.000
	10	97	38	0.3917	10	3	0.3000	0.821
	11	256	88	0.3438	26	7	0.2692	0.444
	12	150	40	0.2667	15	6	0.4000	0.664
	13	183	72	0.3934	18	9	0.5000	0.379
	14	70	26	0.3714	7	3	0.4286	1.000
	15	163	35	0.2147	16	2	0.1250	0.601
	16	117	39	0.3333	12	4	0.3333	1.000
	17	249	68	0.2731	25	8	0.3200	0.617
	18	114	44	0.3860	11	4	0.3636	1.000
	19	128	47	0.3672	13	4	0.3077	0.903
	20	57	15	0.2632	6	2	0.3333	1.000
	21	57	9	0.1579	6	1	0.1667	1.000
	22	181	178	0.9834	18	17	0.9444	0.345
	23	327	317	0.9698	33	33	1.0000	0.608
	24	59	58	0.9831	6	6	1.0000	1.000
	25	81	50	0.6173	8	5	0.6250	1.000
	26	57	45	0.7895	6	6	1.0000	0.482
	27	58	51	0.8793	6	6	1.0000	0.581
	28	261	143	0.5479	26	15	0.5769	0.777
	29	89	84	0.9438	9	9	1.0000	1.000
	30	84	65	0.7738	8	6	0.7500	1.000
	31	92	63	0.6848	9	6	0.6667	1.000

-: 10% sampling rate is 0, which is not accordant with the fact, so that need not to be analyzed.

7 and 8 are 4 out of 143 and 1 out of 59, respectively. Low actual exposure rate is near the zero point of the regression line, hence, it is the low actual exposure rate that results in the zero sampling. According to it, when actual exposure rate is lower than 5% or even much lower, 10% sampling method is not suitable any longer. In this condition, if the wells are relative, increasing the sampling ratio should be considered; If the wells are less, it is best to use census method.

Arsenicosis of drinking water type is an endemic disease that is seriously harmful to health, so that it is very important to identify epidemic areas accurately as soon as possible. Accurate judgment is the basic element of prevention and treatment of this disease. Wrong judgment will lead to untimely treatment and continuous lesions to the villagers. The situation of arsenicosis in China is that old epidemic areas expand gradually and new areas emerge continuously. Therefore, timely, accurately and cautiously identifying arsenic exposure areas is of significant value to the prevention and treatment of this disease. The identification method of classical census requires high time and cost and is difficult

to carry out[3]. Under the condition of relatively high actual exposure rate, 10% sampling method can represent the real situation, and is easy and simple to carry out. This method is adaptive to the situation of China, and could be selected as the screening method for the identification of high arsenic areas, especially the screening near the old epidemic areas with high actual exposure rate such as Shanxi province. But in the areas with relatively low actual exposure rate or areas with unknown situation, it is necessary to increase the ratio of sampling or select some villages being investigated by census, so as to decrease the chance of wrong identification resulting from sampling error.

Conclusion

Under the condition of relatively high actual exposure rate, 10% sampling method can represent the real situation, and is easy and simple to carry out.

Reference

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