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%.

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 0.05 mg/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 village which has got less than 5 wells. Water arsenic concentration of all the samples selected was studied in the results gained from...
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.

**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.

**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.

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

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of accordance</th>
<th>Number of villages sampled</th>
<th>Accordance rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q&lt;10%</td>
<td>2</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>10%=Q&lt;50%</td>
<td>12</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>Q=50%</td>
<td>10</td>
<td>10</td>
<td>100</td>
</tr>
</tbody>
</table>

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
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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