The emerging epidemic of echinococcosis in Kazakhstan

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Abstract

Since independence from the Soviet Union in 1991 the annual surgical incidence of cystic echinococcosis in Kazakhstan has increased from 1.4 cases/100 000 in 1991 to 5.9 cases/100 000 in 2000. In some regions the annual surgical incidence is now over 10 cases/100 000. Twenty-nine percent of recorded cases in 2000 were in children aged <14 years, which indicates recent transmission. Most of the cases are occurring in the regions where the sheep industry is concentrated, indicating that the zoonotic sheep strain of Echinococcus granulosus is the likely cause of the problem. The gross domestic product (GDP) of Kazakhstan has declined by nearly 50% since independence. Concurrently there has been decreased health spending with decreases in the numbers of hospitals, hospital beds and physicians. This situation suggests that an increase in the diagnosis of echinococcosis is an unlikely explanation for the epidemic but that there is an increase in transmission to the human population.

Keywords: echinococcosis, Echinococcus granulosus, epidemiology, Kazakhstan, Soviet Union

Introduction

Kazakhstan is the second largest of the former states of the Soviet Union. It is a country of central Asia, extending between the eastern shores of the Caspian Sea and the Tien Shan mountains in the east, with a total land area of 2 700 000 km². Most of the central region is dry steppes, with significant agricultural activity in both the northern and southern parts of the country. The population is presently about 15 million. There has been a substantial decline in living standards and life expectancy throughout the former Soviet Union. Data from Russia suggest that this decline has been particularly marked in the poorly educated and is related to alcohol, and parasitic and infectious diseases (Leon et al., 1997; Shkolnikov et al., 1998). Since independence in 1991 the Kazakh economy has undergone major changes with the conversion from a centrally planned to a free-market economy.

Cystic echinococcosis (CE) is a serious zoonotic disease transmitted to humans either directly or indirectly from dogs—the definitive host of the causal agent, the tapeworm Echinococcus granulosus. Sheep are an important intermediate host and represent the most important source of infection to dogs through the feed of infected offal. CE is a common sheep-rearing area of the world (Gemmell, 1990) where E. granulosus cycles between dogs and sheep. In the former Soviet Union there were approximately 34 million sheep in Kazakhstan (Kazakh SSR Academy of Sciences, 1985). Humans are normally a dead end host. Human patients suffer from large cystic lesions, usually in the liver or lungs. Previously, E. granulosus was common in the sheep population, with the prevalence in some areas reaching over 50% in old sheep (Ministry of Agriculture, Kazakhstan, 1994). The reported human incidence of CE, however, was relatively low (Fig. 1). Animals were slaughtered in meat factories under veterinary supervision and in infected offal was carefully disposed of. In addition, most of the farming was organized on large state-controlled collectives remote from urban areas. Since independence, however, there has been a significant increase in incidence of human echinococcosis (Shaikenov et al., 1999), particularly in the past 3–5 years. This increase in human disease has occurred at the same time as the reform of the economy. Large collective state farms have been privatized and many livestock enterprises now consist of smaller units and transhumance type of livestock rearing is more widely practised. Furthermore, veterinary services have deteriorated owing to lack of government funding. Overall sheep numbers have also declined substantially (Kazakh Ministry of Agriculture official figures). Dog ownership appears to be more widespread than in previous times with the increased popularity of pets and for personal security. This article examines the regional distribution of hydatid disease in the human population, and how that distribution is related to the livestock industries and to socio-economic changes since independence, and confirms the deteriorating trend first reported by Shaikenov et al. (1999).

Methods

The number of hospital cases of CE was collected from official Kazakh Ministry of Health data from 1984 to the present. Thus, the data represented a considerable period of Soviet Administration (which ended in December 1991) and were the actual number of surgical cases reported by the Ministry of Health. Actual livestock numbers were obtained from official figures and published reports (Kuleyev, 1999; Smailov, 2000). Population density of sheep was calculated from figures published by the Kazakh SSR Academy of Sciences (1985) (which was population data complicated taking into account the recent official animal population from each region (oblast). Economic, and public health data were collected from official statistics and published data (Anonymous, 1998; Kuleyev, 1999; Smailov, 2000). The relative prevalences of Echinococcus in sheep were determined from published data (Ministry of Agriculture, Kazakhstan, 1994; Kareyev, 1999). Recent prevalence data for sheep from South Kazakhstan Oblast (1999–2000) were obtained by careful examination of the viscera of randomly selected sheep in slaughterhouses, including dissection of lung and liver tissue where appropriate. Prevalence data for dogs were also collected in 1999–2000 from Almaty Oblast. This information was obtained by careful examination of the intestinal contents of dogs after they had been treated with arcoquine to induce purgation (Gemmell, 1990).

Results

The data presented can be divided into 2 main periods: the communist administration up to 1991, and the subsequent period since independence until 2000. The annual surgical incidence of human CE in the communist era was generally low. Most areas had an annual surgical case rate of <1 case per 100 000, with similarly low absolute numbers of cases recorded (Fig. 1). The south of the country and the far north-west had...
a higher incidence which varied between about 1 and 5 cases per 100 000. In some regions there may be evidence of some increase towards the end of the Soviet Administration during perestroika. For example, West Kazakhstan did not report any human echinococcosis in 1984, with a slow increase in subsequent years until independence. However, since the middle of the 1990s there has been an inexorable rise in human CE. The increase in the disease is mainly seen in these southern regions and in West Kazakhstan (Fig. 1). Between 1990 and 2000, in South Kazakhstan Oblast, the incidence increased from 2.7 to 9.3 cases/100 000; in Almaty City from 4.3 to 5.9 cases/100 000; in Almaty Oblast from 3.6 to 11.2 cases/100 000; in Zhambul Oblast from 3.8 to 12.3 cases/100 000 and in West Kazakhstan Oblast from 1.6 to 11.5 cases/100 000. Over the whole country the surgical incidence has increased from 1.4 to 5.9 cases/100 000. The total annual number of surgical cases reported for the country has increased from 237 cases in 1991 to 807 cases in 2000. The central and northern parts of Kazakhstan appear to be areas of low incidence. However, even here there is a considerable increase in case numbers: 19 cases recorded in 1991 rising to 103 cases in 2000. A disproportionate number of cases appear to be in children aged <14 years. In 2000, 29% of the total cases in Kazakhstan were in such children (Table 1).

The area where human CE has the highest incidence corresponds to both the main sheep-rearing areas (Fig. 2) and the areas where the prevalence in sheep is the highest (Fig. 3). There is a much less distinct relationship between the geographical distribution of other livestock species and human CE (data not shown). There has also been a dramatic decline in the population of sheep and other livestock in Kazakhstan since the end of the communist administration (Fig. 4). In 1991 the total sheep population stood at about 34 million, which had changed very little in the previous decade. Since then, however, the sheep population has declined and now stands at about 10–12 million. Likewise the population of cattle has also declined markedly (KULLEKEYEV, 1999; SALTILOV, 2000).

In South Kazakhstan Oblast prior to independence 812 (13.6%) of 5968 sheep examined (of all age-groups) were infected in the 1980s. A similar postmortem survey of 917 sheep conducted in the same area in 1999–2000 indicated that 339 (37.0%) were infected with *Echinococcus* (*P* < 0.0001).

The limited data available for the prevalence of *E. granulosus* in dogs before 1991 indicate just one village dog (of 232 examined) infected with *E. granulosus* in Almaty Oblast. Present data from a survey in the same area and type of dog indicate that 5 out of 69 village dogs were infected, which is significantly more (*P* = 0.0003).

In parallel with the free-market reforms, there has been a serious decline in the living standards and economic performance of Kazakhstan. The gross domestic product (GDP) is now substantially lower than in 1991 (Fig. 5). Between 1991 and 1995 economic activity slumped and the estimated real GDP declining to barely half of the figure before independence. There was a brief recovery in 1996 and 1997 with GDP growth rates reaching a respectable 2.5%, but in 1998 and 1999 there was renewed, albeit less severe, economic recession linked to the economic crisis in Russia. Parallel to the decline in real GDP, there has been a decline in the numbers of hospitals,
Table 1. Number of surgical cases of cystic echinococcosis reported in Kazakhstan in 2000

<table>
<thead>
<tr>
<th>Oblast</th>
<th>Total surgical cases</th>
<th>Surgical incidence per 100 000</th>
<th>Cases in children aged &lt;14 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Akmola</td>
<td>14</td>
<td>1.7</td>
<td>2</td>
</tr>
<tr>
<td>Aktobe</td>
<td>9</td>
<td>1.2</td>
<td>7</td>
</tr>
<tr>
<td>Almaty</td>
<td>186</td>
<td>11.2</td>
<td>50</td>
</tr>
<tr>
<td>Atyrau</td>
<td>18</td>
<td>2.9</td>
<td>5</td>
</tr>
<tr>
<td>East-Kazakhstan</td>
<td>20</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td>Zhambul</td>
<td>123</td>
<td>12.3</td>
<td>32</td>
</tr>
<tr>
<td>West-Kazakhstan</td>
<td>71</td>
<td>11.5</td>
<td>22</td>
</tr>
<tr>
<td>Karaganda</td>
<td>43</td>
<td>4.4</td>
<td>12</td>
</tr>
<tr>
<td>Kostan</td>
<td>5</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>Kyzl-Orda</td>
<td>36</td>
<td>5.9</td>
<td>11</td>
</tr>
<tr>
<td>Mangstau</td>
<td>5</td>
<td>1.5</td>
<td>0</td>
</tr>
<tr>
<td>Pavlodar</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>North-Kazakhstan</td>
<td>11</td>
<td>1.5</td>
<td>5</td>
</tr>
<tr>
<td>South-Kazakhstan</td>
<td>198</td>
<td>9.3</td>
<td>54</td>
</tr>
<tr>
<td>Almaty City</td>
<td>67</td>
<td>5.9</td>
<td>24</td>
</tr>
<tr>
<td>Kazakhstan overall</td>
<td>807</td>
<td>5.9</td>
<td>231</td>
</tr>
</tbody>
</table>

Fig. 2. Estimated density of the sheep population in Kazakhstan.

Fig. 3. Regional prevalence of echinococcosis in sheep in Kazakhstan in the early 1990s.

Discussion

The data presented in this paper show a number of trends. The incidence of echinococcosis seems to be increasing in most regions of the country but the majority of cases appear to be confined to the major sheep-rearing regions. This distribution suggests that the zoonotic strain of *E. granulosus* in Kazakhstan is likely to be the sheep strain (THOMPSON, 1995). This aetiology is in common with many human cases of CE throughout the world. Although official figures are not available, the number of hospital beds and medical staff available (Table 2) suggests that the incidence of CE may be underestimated. Furthermore, according to official figures, spending on health services decreased from US$485 million in 1995 to US$323 million in 2007.
Echinococcosis in Kazakhstan

Table 2. Numbers of physicians, paramedics, hospitals and hospital beds in Kazakhstan, for recent years

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicians</td>
<td>63300</td>
<td>60100</td>
<td>57900</td>
<td>54500</td>
<td>53200</td>
<td>50600</td>
</tr>
<tr>
<td>Paramedics</td>
<td>175400</td>
<td>168400</td>
<td>150100</td>
<td>129500</td>
<td>120400</td>
<td>110400</td>
</tr>
<tr>
<td>Hospitals</td>
<td>1651</td>
<td>1518</td>
<td>1244</td>
<td>1006</td>
<td>917</td>
<td>917</td>
</tr>
<tr>
<td>Hospital beds</td>
<td>205700</td>
<td>192600</td>
<td>164400</td>
<td>136400</td>
<td>123500</td>
<td>108200</td>
</tr>
</tbody>
</table>

available, there is much anecdotal evidence that there has been an increase in the dog population. This increase in numbers of dogs could be an obvious important factor in transmission. Whatever the nature of the dog population, either transmission to dogs from sheep must have increased, or humans must now have a greater association with dogs than in Soviet times (or both). The increased infection rate in village dogs in Almaty Oblast supports this hypothesis. In the last 10 years of Soviet Administration the livestock population was fairly constant. Although the parasite prevalence was quite high (MINISTRY OF AGRICULTURE, KAZAKHSTAN, 1994) an equilibrium status, almost certainly of an endemic-type steady state (as defined by ROBERTS et al., 1986, 1987) was likely to be present. The sheep population was relatively stable for the previous 2 decades and farming practices unchanging and under state control. Thus, there was constant transmission between the life-cycle hosts, but lower transmission to the human population due, presumably, to lower contact with dogs. The rapid decline in the sheep population could, all other things being equal, lower the potential transmission rates to dogs once the sheep population has become constant again. Whilst the sheep population is declining, however, it could have made potentially more hydatid cysts available to dogs, particularly if the older sheep are the animals that are culled disproportionately. Older sheep are more likely to contain fertile cysts, since it has been reported to take as long as 6-8 years for cysts to become fertile (GEMMELL et al., 1986) and hence infective to dogs. This effect of sheep age could have a positive feedback, promoting transmission to younger sheep, as the prevalence in dogs and the environmental infection pressure are likely to increase. Eventually in the absence of control it is possible that a new equilibrium state will be reached with a higher prevalence in both sheep and dogs. This view is speculative because equilibrium will also depend upon the dynamics of contact between infected sheep and dog populations. Mathematical models (ROBERTS et al., 1986, 1987) may be able to help in predicting the evolution of the epidemic and how best to control it.

Interestingly, an increase in human CE has also been reported in Bulgaria, also occurring after the transition from a planned to a market economy (TODOROV & BOEVA, 1999). Likewise, in Bulgaria there has been a significant decline in the sheep and cattle population but this decline has been accompanied by a large increase in the goat population (SERBEZOV et al., 1999). In Bulgaria the hypothesis of increased numbers of older sheep being fed to dogs accounting for increased canine infection would also be relevant. The increase in the goat population would be less significant as goats, being browsers, harbour fewer hydatid cysts (TORGERSEN et al., 1908) than sheep. The resulting trend would be a lower infection pressure to dogs as the proportion of goats in the small ruminant population increased. Work is currently being undertaken in Kazakhstan to establish the levels of infection in the life-cycle hosts and the degree of contact between the sheep, dog and human populations, so that the epidemic can be modelled and these questions can be addressed.

Apart from the geographical association of CE with the sheep-rearing areas, there is also an association between increase in disease incidence and economic decline. Echinococcosis is a disease often associated with inhabitants living in close proximity to their domestic animals, a low level of knowledge concerning the transmission cycle, and a life style characterized by poor sanitation (ANDBERSON, 1997). Such conditions are more likely to occur concurrently with the increasing levels of poverty that inevitably accompany such a serious decline in GDP that Kazakhstan has recently experienced (Fig. 5). In particular in the first half of the 1990s the Kazakh economy was characterized by economic collapse and high inflation.

The issue of ascertainment bias must be addressed. It is possible that the reported increase in incidence is due to improved medical technology (such as the use of sonography) improving the detection rate in humans. However, a considerable amount of evidence presented in this paper indicates that this is not the case. First, medical services are less well supported financially now than they were previously (Table 2) with a declining number of physicians, hospitals and hospital beds. There was also a decline in the amount of money spent on health services in the past decade. Consequently, the contrary is more likely. Under-reporting of CE probably occurs more frequently now than in the Soviet era, and the present figures may substantially under-represent the true extent of the disease in the population. Because of the substantially lower performance of the Kazakh economy than previously there are not only fewer resources for health care but also for public health programmes and veterinary services. In addition, as there is a substantial lag phase between increase in transmission and the appearance of new human cases, the epidemic may become much worse than so far recorded. An important pointer to this potentially worsening situation is the substantial number of cases in children, an important marker for recent transmission. Finally, evidence from the increased transmission in animals is convincing. Data presented demonstrate that, in areas such as South Kazakhstan Oblast, the prevalence in sheep is substantially higher than in the latter part of Soviet Administration. Since sheep do not appear to develop any protective immunity to Echinococcus by natural exposure (GEMMELL et al., 1986; ROBERTS et al., 1986, 1987), the level of infection in sheep accurately reflects the level of environmental contamination with Echinococcus eggs. Consequently, the higher levels of Echinococcus eggs in the environment increase the risk of human infection compared to previously. In South Kazakhstan Oblast, the incidence in humans increased from about 2 cases/100 000 in the late 1980s to 9-3 cases/100 000 in 2000. In parallel the prevalence in sheep increased by 270% in this region. It is quite possible that the increased rates of transmission are underestimated because of the breakdown in the availability of diagnostic services. However, data are not yet available to illustrate this possibility.
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References


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Announcement

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There are no restrictions by nationality or age, and fellowship of the Royal Society of Tropical Medicine and Hygiene is not a requirement. Applications from non-Fellows should be supported by a Fellow who can attest to the value of the project and to the competence of the applicant to carry out the work.

• One Garnham Fellowship of up to £2000 will be awarded annually.
• The Garnham Fellowship is to be used for short-term field projects of up to 2 years' duration.
• Preference will be given to topics in parasitology or medical entomology and to applicants with less than 5 years' postdoctoral experience.
• Applicants are required to submit a detailed project, with costing of the work proposed, and a supporting statement from their head of department or supervisor, at least 6 months before the date of commencement.
• A short report should be submitted within 3 months of completion of the study.

Application forms may be obtained from the Administrator, Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W1B 1EY, UK; fax +44 (0)20 7436 1389, e-mail mail@rstmh.org.

The closing date for receipt of applications is 15 September annually.