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A SEROLOGICAL SURVEY OF ZOONOTIC INFECTIONS IN YAKUTIA

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The article analyzes the results of three field surveys concerning the seroepidemiology of various zoonoses in the Sakha Republic (Yakutia). These studies were carried out from 2007 to 2018 in Artic (Verkhoyansk area) and subarctic (Vilyuysk area then Central Yakutia) regions. The first major finding was the presence of Lyme borreliosis in both Vilyuysk and Verkhoyansk areas. Then an elevated incidence rate of Q fever was observed in the Verkhoyansk area. Transmission of saprozoonotic toxocariasis and food-borne trichinellosis was remarkably low in the three surveyed places. Finally, the epidemiological status of echinococcoses, alveolar and cystic, must be clarified by further field studies which will have to assess the etiology and the respective part of these major zoonoses.

Keywords: zoonoses, seroepidemiology, Yakutia.

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Introduction. According to One Health initiative [1], the current concept of the epidemiology of zoonoses focuses onto interactions between and among humans, animals, plants, parasites, microbes, and chemical contaminants in terrestrial, aquatic, and marine ecosystems [2]. Also the diversity and the complexity of cultural factors should be addressed in such an approach. Contact with either domestic or pet animals or with wildlife [3-4] is considered an important source of disease [5] and zoonoses represent an increasing threat for human health [6]. Therefore, the results from any survey about zoonoses should be analyzed according to One Health principles [7].

Globally, the growing need for resources leads to increased human pressure on the environment, thus inducing changes that are particularly apparent in Arctic and subarctic regions. This pressure may be local, due to logging, mining, gas or oil extraction, or global, from climate change in particular. "*With the Arctic warming about twice as fast as anywhere else on the planet, and the prospect of an ice-free Arctic summer now all but inevitable, scientists fear that zoonoses will spread, threatening the indigenous people and wildlife that inhabit the region*" [8].

The Sakha Republic (Yakutia), in Eastern Siberia, is a member of the Russian Federation. Its surface area is 3,083,523 square kilometers, of which approximately 1/3 lays beyond 60° North and belongs therefore to subarctic or Arctic regions. In 2004, the French Archaeological Missions in Eastern Siberia research group, a partnership between Paul-Sabatier University, Toulouse, the French National Center for Scientific Research, Paris, and the Northeastern Federal University, Yakutsk, was formed for the purpose of studying the peopling of Eastern Siberia. The focus of this collaboration was subsequently extended to include the diversity of modern Yakutian populations and human ecology. Particularly, studies about zoonoses among Yakut people appeared to be of great interest, because the Yakut way of life still includes in most cases strong interactions between humans and animals [9-10]. Moreover, given the geographical situation of Yakutia, climate change could potentially affect the time and space distribution of zoonotic agents, along with that of hosts and vectors (if involved) [11].

Materials, subjects and methods. Three field surveys concerning the epidemiology of zoonoses in subarctic or Arctic Yakutia were carried out, first in 2007 [12], then in 2012 [13] and finally in 2018 [14]. The first survey was conducted in 2007 in Vilyuysk city, which is located in the Northwestern part of the Sakha Republic (latitude: 63° 45' North - longitude: 121° 27' East - 10,529 inhabitants). The second survey took place in the Arctic area of Verkhoyansk, more precisely in the villages of Suordakh (66° 40' North - 131° 46' 16" East - 325 inhabitants) and Tomtor (67° 12' 17" North - 132° 8' 10" East - 282 inhabitants). The third survey was carried out in 2018 in Central Yakutia and concerned three localities: Maralayy village (61°59' North - 131°55' East - 837 inhabitants) in the Churapchinsky *ulus*, Pavlovsk village (61°52' North -129°53' East - 2091 inhabitants) in the Megino-Kangalassky ulus, and Borogontsy town (62°40' North - 131°08' East - 5,222 inhabitants) in the Ust-Aldansky *ulus*.

Given technical limitations due to the remote situation of the surveyed areas, all studies relied only upon serology of various bacterial, parasitic or viral agents of zoonoses (Table). Blood samples were obtained from 90 subjects in Vilyuysk, from 77 subjects at Suordakh and Tomtor, and from 90 subjects in Central Yakutia. All subjects were volunteers, adult and apparently healthy. Every volunteer

had to give a written informed consent then to reply an oral questionnaire which inquired about demographic, occupational and environmental characteristics, and also about food habits. For Vilyuysk and Verkhoyansk surveys, immunodiagnoses of bacterial and parasitic diseases were performed in the Department of Parasitology and Mycology, Toulouse University Hospitals, France, whereas those for viral diseases were carried out at the National Reference Center for Arboviruses, IRBA, Marseilles, France. Concerning the study in Central Yakutia, serodiagnoses of three surveyed helminthiases were carried out in the Laboratory of Molecular Genetics at the Northeastern Federal University in Yakutsk. Laboratory procedures have been detailed in the relevant articles [12-14].

Results. The seroprevalence rates of the surveyed zoonoses appear in Table. Statistical analysis did not find any significant relation between the recorded personal or environmental characteristics and the incidence (Q fever) or prevalence (other diseases) of the studied zoonoses. Moreover, no significant difference ($\chi 2$ or Fisher's exact tests) in the distribution of the positive results was found between the surveyed areas.

Discussion. The seroprevalence of partially (toxoplasmosis) or totally (alveolar or cystic echinococcosis, cysticercosis, toxocariasis) soil-transmitted zoonoses (saprozoonoses) was remarkably low in Yakutia (Table). This finding was particularly surprising for cystic echinococcosis and toxocariasis, given the high degree of *Echinococcus sp*. or *Toxocara canis* infection in Yakut dogs [15]. This very low level of transmission for the investigated saprozoonoses was likely the positive consequence of the high pressure exerted by the peculiar Siberian environment. Climatic conditions in surveyed areas are characterized by very low temperatures (below -55°C) during the winter period, approximately 320 frost days per year, and an annual mean temperature ranging from -10°C in Vilyuysk to -15°c in the Verkhoyansk area. In such a harsh climate, propagules that are spilled on the soil, namely, helminth ova or oocysts of *Toxoplasma gondii*, are destroyed. However, this explanation applies only in part to echinococcoses, since *Echinococcus* sp. eggs that would be spread in humid soil are very resistant to temperatures up to -30°C [16]. Another reason may lie in the genetic diversity of *Echinococcus* sp. in Russia. A recent study has demonstrated that the species predominant in Yakutia, where husbandry concerns mainly cattle or horses, is *E. canadensis* including the genotypes G6, G8 and G10 [17]. In the human intermediate host, this species elicits predominantly pulmonary cysts [18] that are less detectable by serology than hepatic involvement.

Interestingly, similar low incidence or seroprevalence rates for saprozoonoses have been observed in Arctic or subarctic Canada. For example, only 108 cases of cystic echinococcosis have been reported between 2001 and 2005 for the whole country [19]. Concerning toxocariasis, the seroprevalence ranged from 0% to 10% in the Cree communities of the subarctic area of James Bay [20].

In Yakutia, the seroprevalence of trichinellosis appeared to be very low whatever the place of survey. The food-borne route, through ingestion of meat from various domestic or wild carnivorous or omnivorous mammals is the major route of contamination for this zoonotic helminthiasis. Human infections originates frequently in the use of meat from brown bear (*Ursus arctos collaris*) or polar bear (*Ursus maritimus*) that accounted for 60.2% of the outbreak cases recorded between 1998 and 2002 [21]. Consumption of pork was the second major risk factor, followed by badger meat (*Meles leucurus sibiricus*). In the three above-cited surveys, the questionnaire about volunteers' culinary habits found that pork or bear meat always was used well cooked, which certainly reduced drastically the risk of contamination. Moreover, in the rural areas of Yakutia, people used to store meat from game or domestic animals outside the home for weeks, in pantries that are therefore exposed for at least 8 months per year to Siberian cold. In Eastern Siberia, the prevalent species of *Trichinella* is *T. nativa* [22]. Inside muscles, *T. nativa* larvae survive easily to temperatures between 0°C and −20°C but, at lower temperatures, survival time reduces rapidly [23]. Therefore the traditional storage habit for meat could achieve natural sanitization.

Whether the ongoing global warming could reduce this sanitizing effect of the harsh Siberian climate is a great question. In the Canadian Arctic, Inuit people have suffered epidemics due to *Clostridium botulinum* because the summer temperatures were over 4°C, thus making their traditional practices of fermentation or smoking for the conservation of meat or fish less efficient [24]. Although the annual average temperature has increased in Yakutia by 1.1°C between 1955 and 2000 [25], the risk of diminished efficacy of the traditional deep-freeze outside storage appears to be low, at least in the near future.

The results of the serological investigations for tick-borne zoonoses were more unexpected. Lyme borreliosis was found to be present in Vilyuysk and, more surprisingly, also in the Verkhoyansk area. Antibodies to the viral agent of tick-borne encephalitis (TBE) were found by the Vilyuysk surveys but were not detected by

Seroprevalence of various zoonoses in Yakutia

Agents	Disease	Vilyuysk. 2007 90 subjects		Verkhoyansk. 2012 77 subjects		Central Yakutia. 2018 90 subjects	
		Rate (%) [a]	95% CI [b]	Rate (%) [a]	95% CI [b]	Rate (%) [a]	95% CI [b]
Bacteria *Borrelia burgdorferi s.l.* *Coxiella burnetii*	Lyme borreliosis Q fever	3.3 NA [c]	0.7 – 9.4	10.4 2.6	1.4 – 12.8 0.3 – 9.1	NA [c] NA [c]	
Parasites *E. granulosus* *E.multilocularis* *Taenia solium* *Toxocara spp.* *Toxoplasma gondii* *Trichinella spp.*	CE [d] AE [e] Cysticercosis Toxocariasis Toxoplasmosis Trichinellosis	0 0 NA [c] 4.4 8.8 4.4	0.0 – 4.0 0.0 – 4.0 1.2 – 11.0 3.9 – 16.8 1.2 – 11.0	0 1.3 0 0 5.2 0	0.0 – 4.8 0.0 – 7.0 0.0 – 4.8 0.0 – 4.8 1.4 – 12.8 0.0 – 4.8	4.4 NA [c] NA [c] 1.1 NA [c] 2.2	1.2 –11.0 0.0 – 6.0 NA [c] 0.3 – 7.8
Viruses	TBE [f]	3.3	0.7 – 9.4	0	0.0 – 4.8	нт	

a seroprevalence - b 95% confidence interval - c not available data (not tested)
d cystic echinococcosis - e alveolar echinococcosis - f tick-borne encephalitis

the Verkhoyansk study. The indisputable presence of Lyme borreliosis in these areas was notable since Northeastern and Arctic Siberia were considered free of this zoonosis [26]. However, a previous study which had been carried out in the countryside around Vilyuysk in 2006 had found a 19.5% positivity rate [27]. These findings confirm the presence in Arctic and subarctic Yakutia of infected ticks that likely belonged to the cold-resistant species *Ixodes persulcatus*. Since no information was available in the international literature about the epidemiology in Yakutia of the above-cited tick-transmitted zoonoses, it was not possible to draw firm conclusions from our surveys.

The investigations on the epidemiology of Q fever were carried out only in the Verkhoyansk area. They were prompted by the long tradition of cattle breeding among the Yakut people, extending to the Arctic regions. Q fever is a bacterial zoonosis of which the transmission is either direct, between humans, from the inhalation of bacteria, or indirect, from contact with the milk, urine, feces, vaginal mucus, or semen of infected animals [28]. Unsurprisingly, we found a substantial incidence rate. Although no retrospective analysis was possible given the lack of any information about the historical incidence of *Coxiella burnettii* infection in Yakutia [29], it seems likely that Q fever in this region is not an emerging zoonosis, but rather that its transmission occurred on a regular basis.

Conclusion. Concerning Lyme borreliosis, it was not possible to firmly conclude that the presence of tick-transmitted zoonoses in subarctic and particularly in Arctic Yakutia was a "newly emergent" phenomenon or, rather, a "new recognition" due to the lack of previous studies in these areas. Should the first hypothesis be verified in the future, global climate change favoring the spread of the tick vector beyond its current more Southern distribution might be retained as plausible explanation. Anyway, along with Q fever, Lyme borreliosis would represent a major threat to the health of people living, sporting or working in Upper subartic or Arctic Yakutia.

Among the investigated helminth zoonoses, clearly toxocariasis does not represent a health problem in the Sakha Republic. For alveolar (AE) or cystic (CE) echinococcosis, the results of our studies should be confirmed by field surveys combining serology and ultrasonography in the human intermediate host [30]. Respective parts of AE or CE have to be clarified by checking by computerized tomography any subject found positive by ultrasonography and by using western-blot to confirm the positive results from ELISA [31]. These future studies also will have to investigate concomitantly the canine definitive hosts. The search for *E. granulosus* DNA in the feces will yield crucial information for assessing the transmission pressure. Moreover, genotype studies will have to be carried out on this fecal material in order to clarify the role of *E. canadensis*.

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IMPACT OF MEDICAL AND SOCIAL FACTORS ON OBESITY IN PRESCHOOL CHILDREN IN THE NORTH OF VIETNAM: A CASE-CONTROL STUDY

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Obesity in children increases the risk of overweight and obesity in adults and leads to several complications, both physical and mental, which put a strain on public health. A case-control study of 360 obese children and 786 normal children (according to WHO 2006 criteria) as a control group helped to elucidate the influence of medical and social factors on the development of childhood obesity. Univariate regression analysis showed the following risk factors: overweight/obesity of the father with OR = 5.1 (95% CI: 3.8 – 6.9): mother's overweight/obesity with OR = 6.1 (95% CI: 3.8 – 9.7); stress during pregnancy of mother with OR = 1.5 (95% CI: 1.1 – 2.1); excessive weight gain of mother during pregnancy (≥ 12 kg) with OR = 1.75 (95% CI: 1.3 – 2.3). Risk factors related to nutrition and physical activities were found: fast eating speed with OR = 2.1 (95% CI: 1.2 – 3.9); soft drinks with OR = 1.6 (95% CI: 1.1 – 2.3); time for TV watching if ≥ 2 hours per day with OR = 4.7 (95% CI: 3.4 – 6.5) or during 1 – 2 hours per day OR = 2.6 (95% CI: 1.9 – 3.5), respectively. Multivariate regression analysis identified the most significant risk factors for obesity in children: BMI of the father and mother, time for TV watching per day and eating speed, with the further development of a formula for calculating the probability of obesity, which can be used in organizing a preventive program for obesity in children.

Keywords: children, obesity, social, feeding rate, BMI, risk factor, Vietnam.

Introduction. According to WHO, in 2019, about 38 million children under the age of 5 were overweight or obese and it is estimated that by 2030 almost a third of the world's population may be overweight or obese [1]. In the USA for 2017 - 2018 obesity was specified in 13.4% of children 2 - 5 years old; in 20.3% of children 6-11 years old and in 21.2% of children 12-19 years old [2]. In Russia, the number of children and overweight and obese children is also increasing over a ten-year period [3, 4]. In Vietnam, from 2000 to 2015, the proportion of overweight children more than quadrupled from 3.3% to 17.5% related to urbanization and food transitions [5]. Childhood obesity is becoming a global public health problem around the world.

Obesity in children increases the risk of adult overweight and obesity by 70 - 80%, accompanying a number of complications such as metabolic disorders, vascular – cardiac diseases, environmental diseases, diseases of the musculoskeletal system and psychological disorders [6]. Ethnic variations in prevalence of overweight and obesity between Kinh, Muong, Tay (as main ethnic groups in Vietnam) children under 5 years old [7] were identified in a study in 2019 suggested that childhood obesity depends on the genotype and the environmental factors. In Vietnamese children primary school was found the significant relationship between delivery method, birthweight, night sleep duration and *BDNF* Val66Met polymorphism to adiposes [8]. In a review, degree of dependence of obesity on susceptible genes may be different in various populations [9] but in general, childhood obesity more depends on a number of reversible cultural and environmental factors such as diet, physical activity, lifestyle... [10].

Identifying reversible medical and social risk factors for obesity in preschool children could stands the base for reducing the risk interventions on individual level and provide a rationale for developing an obesity prevention program from an early age on population level.

Methodology and materials. This study was conducted from 1/1/2019 to 31/12/2019 on 16175 children aged from 24 to 60 months old living in the north of Vietnam. Participants were chosen from various randomly selected kindergartens located in 6 north cities and provinces of Vietnam including Hanoi, Thanhhoa, Namdinh, Phutho, Caobang, Hoabinh, to ensure the representative characteristics for North Vietnam of sample.

Nutritional status as malnutrition, norm, overweight and obesity was classified according to the WHO 2006 criteria. Obesity was defined if the child had the

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