UDC 619:616.98:579.852.11

DOI 10.29326/2304-196X-2019-1-28-63-67

ANTHRAX GLOBAL EPIZOOTOLOGY.

2. DISEASE INCIDENCE IN HUMANS AS INDICATOR OF EPIZOOTIC AND RISK FACTORS

V. V. Makarov[1], N. Ya. Makhamat[2]

[1] Doctor of Science (Biology), Professor, People's Friendship University of Russia (RUDN), Moscow, Russia, *e-mail: vvm-39@mail.ru*

[2] Post-Graduate Student, People's Friendship University of Russia (RUDN), Moscow, Russia, *e-mail: mhtnguerabe@mail.ru*

SUMMARY

The paper deals with the assessment of the implied associations between the epizootic and epidemic components of the veterinary anthrax epidemiology of animals and humans, as well as with the epidemic risk factors. Analysis of the statistical data for 2007–2017, available in ProMED international database, demonstrated that African, Asian and Near Eastern regions are permanently infected with human anthrax at the incidence rate of 1.0. The disease is very rarely reported in Europe, and it is exotic in the USA and South America. During the study period, the overall incidence amounted to over 3,700 humans: at an average of 340 humans annually ranging from min 81 to max 856. Total mortality amounted to 234 humans with average annual mortality of 21 humans ranging from min 6 to max 58, average annual lethality (patients' mortality %) – 9.8 ranging from min 3.3 to max 39.5. For the assessment of the genuine interrelation of the incidence in humans and mortality in animals, we compared the statistic samples of the annual infection incidence in a number of the most epidemically and epizootically affected African, Asian and Near Eastern countries as the basic features of the epidemic and epizootic components of the veterinary anthrax epidemiology. The analysis demonstrated no statistical relation between the reported disease incidence in animals and humans. Substantial share of the disease incidence in humans is accounted for unidentified sources of the infection. Consumption of infected products from domestic (up to 70%) and wild animals prevails among the trivial risk factors of zoonogenous infection in humans, while consumption of meat from domestic animals and contacts with diseased animals prevail among the lethality risk factors. The obtained results are indicative of multiple unidentified aspects of veterinary anthrax epidemiology.

Key words: anthrax, epizootology, epidemiology, risk factors.

INTRODUCTION

Theoretic and practical aspects of zoonoses – diseases common for animals and humans *in vivo* – are based on multiple associations between their epizootic and epidemic components. The role of anthrax incidence in humans in practical veterinary epidemiology and its significance for epizootic process are poorly reflected in research publications as a whole and there are no available data on this aspect in the national science. In general, in epidemiology the research vector and results are unidirectional "from animals to humans" as there are no attempts to assess the facts in the opposite direction[1].

It is well known that basic reasons and trends of human anthrax natural occurrence are associated with direct or indirect contacts with infected animals or objects of animal origin (animal handling, slaughter, dressing, consumption, different professional operations including leather and wool production). There is hardly known non-zoogenic spontaneous disease incidence in humans over the known natural history of anthrax[2]: the diseased human is not the source of infection. As opposed to animals, different infection courses in humans are associated with the infection route and clinical manifestation – cutaneous (local) in case of surface agent application, inhalational and gastrointestinal (generalized).

It is believed that incidence of spontaneous disease cases in humans depends on the level of epizootic infection in each particular country with due regard of national data on susceptible animal population and entirety of

[1] According to eLIBRARY.

[2] Over the recent years there have been facts of spontaneous infection with anthrax of "non-natural", extreme character and human deaths therefrom that have rather social than zoonotic nature, – use of spore contaminated objects of animal origin manufactured in Africa (drum skin) and use of heroin by the drug addicts [2, 9].

epizootic and epidemic co-factors. The long-term statistical analysis of global disease incidence in animals and humans demonstrated definite weighted average ratios. In particular, 95% of human cases involve cutaneous disease; for every one cutaneous anthrax case in humans go ten slaughtered and processed infected animals; for every 150 cutaneous disease cases go one generalized disease case [5, 8, 11, 12].

These indicators are, however, quite conditional and variable. They can have opposite meaning in rural areas with high poverty rate, lack of food, poor veterinary and public health control and generally low economic and sociocultural status (Chad, Ethiopia, Zambia, Zimbabwe in Africa, India, Central Asia, south and subarctic regions of the Russian Federation, etc.), where food habits allow consumption of meat of diseased, dying and even dead animals, and the raw meat is used in processing and trade[1]. Here, ten or more cutaneous and intestinal anthrax cases in humans may fall on each anthrax diseased animal slaughtered and used for human consumption. In Haiti, for instance, cutaneous anthrax is rather wide spread in humans but animal cases are scarcely reported [11, 12, 13].

Herewith, intestinal anthrax cases are extremely rare in the locations, where traditions involve cooking of meat (boiling) well before its consumption (Haiti, Kazakhstan). On the other hand, habits of rural population in some regions in Africa (to the south from Sahara) and Asia (Thailand, Korea) involving consumption of rare meat and non-heat treated food (salted, smoked, pickled, dried, frozen) facilitate infection in such cases when demand for food overweighs the risks of infection [11, 13].

It was noted that in spite of canonic anthrax lethality, in such environment the abovementioned disease forms are often lack extreme malignancy in humans, they are subclinical and result in immunity acquisition. It is acquired immunity, often, mass immunity, that supports the opinion existing in the marginalized groups of livestock breeders on the safe use of specifically non-treated products from the diseased animals [11, 12, 13].

This work was aimed at the assessment of the supposed veterinary and epidemiological associations between human and animal anthrax and some factors of epidemic risk based on the statistical data available in the international database ProMED[2] for 2007–2017 [14].

MATERIALS AND METHODS

The research was performed in the format of systematic review, generalization and analysis of the available data on the anthrax veterinary epidemiology for 2007–2017. In addition to ProMED database, the data sources included [14] some modern domestic and foreign reports and publications [2, 4, 7, 8, 11].

Principles and tools of descriptive epizootology used as a methodological framework for handling statistical data on anthrax as for calculation of quantitative parameters, graphical construction and other analytical parameters are taken from handbook "Epizootological test method" [10] synthesized and published by the RUDN University and from the up-to-date guides on general epidemiology and evidence-based medicine [1, 6]. Biometric approaches and methods were taken from handbook "Biometrics" [3]. When necessary, the methodical explanations were given as the presentation of the obtained result proceeded.

The following key conceptual elements were used in the work.

Incidence index – multi-year retrospective analysis-based index of the epidemic situation. This index is calculated as a correlation of the number of years the disease was reported to the total number of years within the study period (usually ten years and over):

$$X = \frac{\text{number of years the disease was reported}}{\text{total number of years within the study period}}.$$

Correlation of anthrax epizootic/epidemic components is a simultaneous, statistically coincident annual anthrax infection rate in humans and animals. *Correlation index* is calculated as a ratio of a number of years anthrax was simultaneously reported in animals and humans and total number of years the infection was reported during the study period:

$$X = \frac{\begin{gathered}\text{number of years the disease was simalteneously}\\ \text{reported in animals and humans}\end{gathered}}{\begin{gathered}\text{total number of years the disease was reported}\\ \text{within the study period}\end{gathered}}.$$

RESULTS AND DISCUSSION

In the most general understanding and according to the analysis of the statistical data [2, 3, 7, 8, 11, 14], African, Asian and Near Eastern regions are continuously infected with human anthrax at the incidence rate being 1.0. The disease is very rarely reported in Europe, and it is exotic in the USA and South America. During the study period, the overall incidence amounted to over 3,700 humans: at an average of 340 humans annually ranging from min 81 to max 856. Total mortality amounted to 234 humans with average annual mortality of 21 humans ranging from min 6 to max 58, average annual lethality (cases' mortality, %) – 9.8 ranging from min 3.3 to max 39.5.

For the assessment of the true relation between the incidence in humans and mortality in animals being the basic features of the epidemic and epizootic components of the veterinary anthrax epidemiology, we compared the statistic samples of the annual infection incidence in a number of the most epidemically and epizootically affected African, Asian and Near Eastern countries. The data on the selected countries for the study period (11 years) are accumulated in the groups of temporal and spatial infected cluster units (number of countries × number of years) and summed over a number of statistical indicator criteria. The results are shown in the Table.

According to the data in the table, it can be stated that levels of epidemic/ epizootic components, animal mortality and human morbidity are quite high and could be the statistical basis for the correlation of these

[1] Examples of such actions of livestock farmers may include real-life events described in the wonderful book "Memories and thoughts of a veterinarian" by Pavel Petrovich Rakhmanin (2018), who worked in Tajikistan for a long time.

[2] ProMED (Program for Monitoring Emerging Diseases) is an Internet-based database for emerging disease monitoring that was established in 1994. Since 1999, the database has operated as an official program of the biggest professional society – International Society for Infectious Diseases. The database is intended for daily collection of information on occurrence of new acute outbreaks of dangerous infectious diseases and other events with pathological and destructive properties posing emerging global threat to human, animal or plant health and for electronic dissemination of information of such events among the stakeholders for rapid response according to the principle "forewarned is forearmed". All the data are immediately published on the ProMED web-site in all major languages (including Russian) [14].

Table
Integrated specifications of anthrax epidemic/ epizootic components according to the data reported from the mostly affected regions and countries

Criteria	Africa	Asia	Europe
Countries with high incidence	Guinea, Zambia, Zimbabwe, Kenya, Namibia	Israel, India, Indonesia, China, Mongolia	Great Britain, Germany, Italy, France, Sweden, Georgia, Armenia
Number of countries with high incidence	5	5	7
Epizootic index	0.36	0.42	0.22
Epidemic index	0.40	0.50	0.19
Animal mortality, Σ	999	1131	340
Human morbidity, Σ	878	486	189*
Incidence limits, min–max: animals	51–508	73–535	14–69
humans	41–369	3–298	1–57
Number of clusters	55	55	77
Infected clusters, Σ	31	31	29
Contiguous clusters, Σ	12	14	2
Contingency index	0.39	0.45	0.07
Human/ animal incidence relation, Δ	1.37	2.3	1.8
min–max	0.64–2.78	1.79–2.85	–
Human anthrax incidence with no disease reported in animals: number of countries	5	4	3
number of clusters (%)	13 (42)	8 (26)	13 (45)
number of cases, Σ (%)	386 (44)	68 (14)	183* (97)

Σ – sum of a variety of the parameters (mortality, morbidity, etc.);
Δ – mean value of a number of parameters;
* including dozens of cases of infection via anthrax spore contaminated heroin [2, 9].

parameters. Deep and detailed analysis could explain big difference as for "human/animal" incidence relations and limits for Asian countries as compared to the values for Africa and Europe.

Extremely low values of the contingency of animal and human anthrax infection (numbers and indexes) should be also mentioned. Moreover, in many counties of the selected regions over 700 human anthrax cases were reported without any reports of animal mortality and this number accounts for more than half (51%) of the total human morbidity.

The results indicate that according to the ProMED reported incidence no statistical links or any veterinary and epidemiological associations were identified between animal and human anthrax cases.

In spite of some conditionality of historical, spatial and other concordance of reported yearly anthrax epidemic/ epizootic levels, these data have no real explanation, they require specific social and epidemiological analysis and currently they can be recorded only as a fact.

Records of the European countries can be exceptionally preconditioned by recently reported high incidence of new clinical form of human anthrax with unconventional infection routes involving use of *Bacillus anthracis* contaminated heroin by the drug addicts [2, 9].

As mentioned above, human anthrax with different outcomes occurs due to various contacts with products and raw materials originated from the infected animals. Results of the quantitative and graphic analysis of different human infection risk factors are shown in Figures 1 and 2. The analysis is based on the data reported to ProMED in 2007–2017.

According to the data demonstrated in Figure 1, at least three different groups of human anthrax causes can be identified: (*i*) trivial risk factors, i.a. consumption of meat of infected animals (both domestic and wild ones); various contacts with the diseased animals; dressing of carcasses of emergently killed diseased animals (dressing of dead animals is not excluded); handling of hides of the diseased (dead) animals; (*ii*) extraordinary causes, i.a. use of contaminated heroin by the drug addicts (including actual

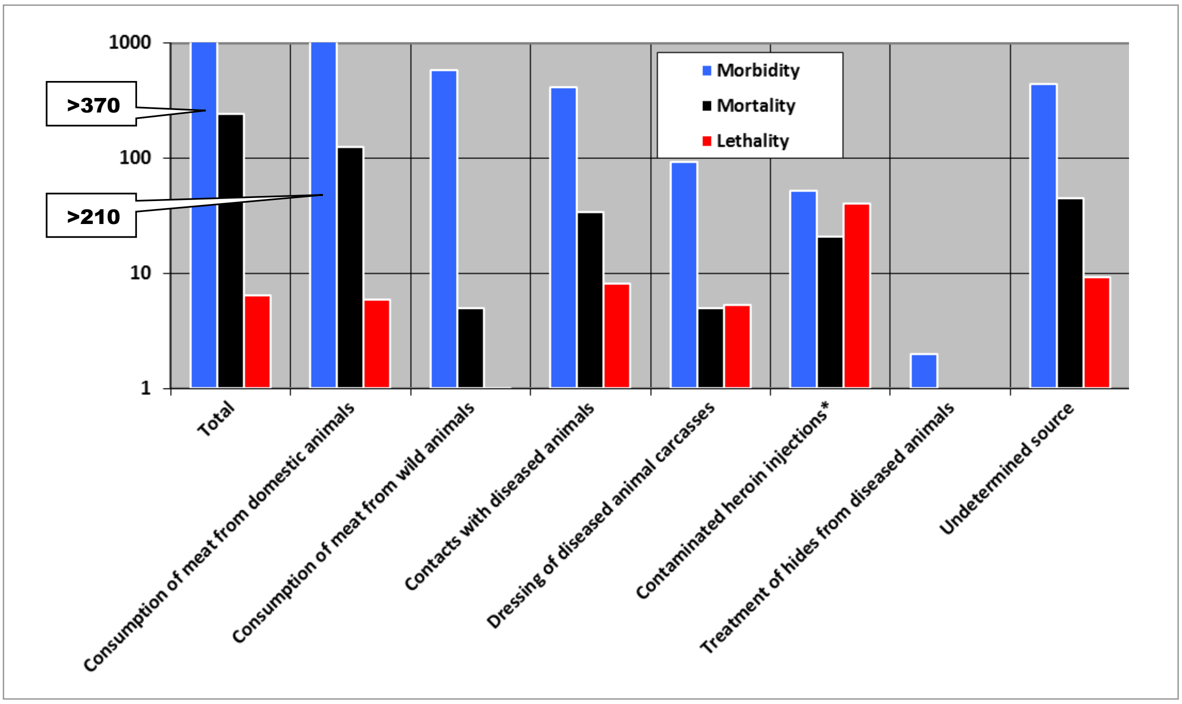


Fig. 1. Global human anthrax morbidity, mortality, lethality and various contacts with infected materials

ProMED data, 2007–2017 (log-transformation).

** Refer to [2, 9] for the details.*

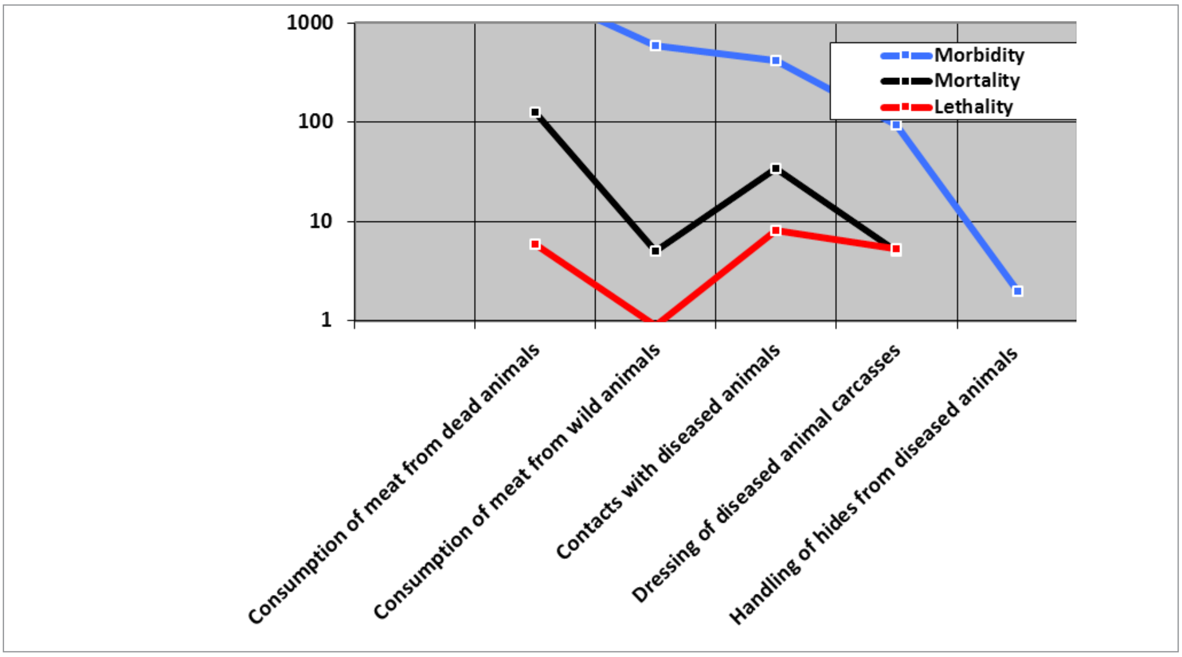
facts of *Bac. anthracis* use as a bioterrorism agent [5]); (*iii*) unknown disease causes.

The last group involves the significant part of the morbidity share (over 10% with lethality being also about 10%), that essentially agrees with the selected data in the table and could be explained with poor hygiene of the livestock breeders and aboriginal population in some regions of the Third World countries.

Among the quantitatively and graphically described trivial factors of the zoogenic risk of human infection (Fig. 2) of key importance are the following (downwards): consumption of infected products from domestic animals (sheer domination, up to 70%) → from wild animals → contacts with the diseased animals → dressing of the diseased animal carcasses → handling of hides from the diseased animals. The sequence of the lethality risk factors is different: consumption of meat

Fig. 2. Trivial contacts of humans with infected materials, morbidity, mortality and lethality as a consequence thereof

ProMED data, 2007–2017 (log-transformation).



from the domestic animals → contacts with the diseased animals → consumption of meat from the wild animals and dressing of carcasses.

Graphically demonstrated values are actually indicative of different effect of the trivial risk factors and their consequences for the anthrax epidemiology. Similar to the assessment of the veterinary and epidemic associations this fact has no actual explanation and can be recorded only as a fact.

The overwhelming predominance of the alimentary route can be somewhat conventionally explained by heavy doses of the agent involved in the contact with the susceptible subjects. Herewith, in view of the fatal outcome of the intestinal anthrax in humans, statistical evidence of low human mortality with quite high morbidity, inter alia in African and Asian countries (about 10% lethality), is standing out. Taking into account the well-known unsatisfactory public health in the Third World countries, the abovementioned suggestion on naturally acquired immunity developed in the local livestock keepers due to routine consumption of the infected products of animal origin can be taken as one of the explanations [11, 13].

The obtained quantitative and graphical analysis results are generally indicative of multiple unclarified aspects of anthrax veterinary epidemiology.

The publication was prepared with RUDN "5–100" Programme support.

Conflict of interest. The authors declare no conflict of interest.

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Submitted on 26.12.18
Accepted for publication on 18.01.19