

Emergence and re-emergence of Zoonoses. Context and consequences

V. Sala*, E. De Faveri*

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Abstract

Zoonoses have been and are still considered merely a “veterinary problem”. Instead, the understanding of their emergence, re-emergence and persistence is more effectively addressed in the context of a “struggle” between pathogens, animals and man. The expression properties of pathogens are related with three interfaces: human-environment, environment-animal and human-animal. Animals and man can be either reservoirs or vectors of pathogens, while interfaces can amplify the clinical impact in all the species involved. The disease course is similar in animals and humans in terms of infection, clinical approach and control. Thus, this “epidemiological model” may be the key to an “updated” interpretation of infectious diseases involving humans and animals. Control and prevention should be carried out in an interdisciplinary context, without separating the medical and veterinary domains, in light of the fact that the activity of pathogenic microorganisms is not species-dependent. Finally, if human public health and veterinary public health are closely linked, knowledge and information can be pooled and used for mutual benefit.

Introduction

For many years, we have considered infectious diseases as a struggle, at times uneven, between two biological systems of different complexity: on the one hand, pathogenic microorganisms, with specific traits in terms of survival, infectiousness and pathogenicity, on the other, man and/or animals, characterised by a homeostatic balance in which the built-in immune response is often the critical element in determining the chances of survival. Such “basic” concepts of infectiology have been transferred – apparently unaltered – to the study and understanding of zoonoses, often considered merely a “veterinary problem” (1).

With the passing of time, and mainly as a consequence of the fine-tuning of epidemiological studies, the circumstances in which the pathogen-animal-man “struggle” occurs began to be seen as a qualifying trait in this respect; thus, the emergence, re-emergence and persistence of zoonoses have become more easily understandable, because three different interfaces have been related to the expression property of pathogens (2):

Human-environment interface, where the behavioural habits associated with people’s lifestyle, state of health and economic level interact with the urban environment, where the ecology of animal populations and environmental hygiene and sanitation determine the levels of

* Department of Veterinary Science and Public Health (DIVET), University of Milan, Italy

survival and maintenance of pathogens (Example: *Toxocara canis* in the sapro-zoonosis of recreational area).

Animal-environment interface, typical of intensive animal husbandry, where very numerous animal populations are influenced by the breeding environment and modify, by their presence, the surrounding environment; moreover, some wild species have changed their habits, becoming potential vectors for both man and domestic animals – for example, sea-gulls, now present in urban environments also in non-coastal cities and already reported as vectors of chlamydial infections in domestic ruminants and humans.

Human-animal interface, logically related to zoonotic infections, but enormously strengthened, in terms of infectious contacts, by the urban density of pets (interspecific cycles of *Giardia lamblia* in children and domestic carnivores) and the density of intensive animal husbandry (amplification of the salmonella risk).

Against this backdrop, animals and man can be both reservoirs and vectors of pathogens, facilitated by the increasing ease and frequency of travel between continents; as a consequence, territorial distance is no longer in itself an effective barrier against the spread of a disease, or for its containment, and the epidemiological relevance of interfaces can be amplified rather quickly (3).

Moreover, economic interdependence among countries has significantly increased, while market instability, with its price variability, has triggered a change in consumption patterns: the international trade in animals and animal products has increased sharply over the last decade, and systems producing at low cost – but also at low health safety levels – have become part and parcel of the “global” market economy. The variability of supplies in a very competitive and increasingly mobile food production system

has indeed contributed to the spread of zoonotic diseases that were once confined to specific geographical areas (4).

The effects of globalisation and ease of transportation have brought about a huge increase in animal transport flows, as well as an increase in the consumption of products of animal origin, along with the possibility for man to reach far off places in the blink of an eye; the unquestionable positive effects of this facet of modernisation inevitably goes hand in hand with the negative – and certainly undesired – effects of the exchange of pathogens and their spread. The same applies to the commercialisation of wild and exotic **animals**: more and more species are imported for exhibition in zoos or as an “alternative” to animals traditionally considered as pets.

The importing of some protected species is currently strictly regulated; despite this, illicit trade has unfortunately become a growing phenomenon that, given its nature, can in no way guarantee health safety. Such practices, apart from obviously affecting animal well-being, pose a concrete risk for human-animal health and for social safety. In spite of all this, most clinical cases of zoonoses with this origin (such as psittacosis) concern legally imported wild fauna (5).

Whenever a zoonosis breaks out, or resurges, its spread may be fostered by shifts within and among human and animal populations; growing migratory flows, also defined “long-term population re-settlements”, probably enable the spread of diseases characterised by long periods of latency or infectiousness, while short-term mobility for “tourism” or “business” purposes may rapidly spread infections and provoke clinical disease forms that, in most cases, have short resolution periods. Yet, it is also possible that business travellers in particular, even more so if “repetitive” in terms of

destinations, may become simple vectors of infection “transfer” (6).

The exposure of human populations to animal contact – and thus to potential zoonotic infections – is radically different in urban and rural areas. While, in the latter, the risk is related to professional exposure and, possibly, transmission from workers to their family members, in an urban environment, a high number of new epidemiological cycles occur as a consequence of the “mixing” of two numerous and constantly expanding populations: human and animal, with the latter constituted by domestic species as well as synanthropic ones.

Moreover, the increasing global flow of people, goods, food products, domestic and wild animals is bound to influence “microbial traffic”, which is also globalised and associated with the outbreak of “emerging zoonoses” of a viral, bacterial and parasitic origin.

The new exploitation models have intensified agriculture and animal husbandry – often through imprudent deforestation practices and the alteration of soils and waters – as well as the “trespassing” of pathogens previously restricted to wild fauna species (*Francisella tularensis*, the agent of tularemia in wild lagomorphs) (7); all this has contributed to the transmission of pathogens between different, fully receptive species, and the outbreak of epidemic diseases involving humans and animals alike (8-9).

A telling example can be discerned in the environmental changes brought about by the mushrooming of building sites, especially for touristic purposes, in previously unpopulated locations, leading to a rise in the number of cases of Dengue fever, due to increased contact between human groups and the *Aedes aegypti* mosquito that carries the virus (10).

New and increasingly varied types of risk for consumers stem from the broad

area of food-borne infections (think for instance of the diversification associated with the fast-food industry, or that of pre-cooked food for catering), associated with the food and agricultural domain, via the industry transforming and preparing food of animal origin. This supply and production chain must indeed be considered in all of its constituent elements, including the production of raw materials for feeding animals that are destined, in turn, to become food for the sustenance of human populations: “We are what we eat” is and remains a meaningful statement.

Many of these problems stem directly from the maximisation of livestock breeding systems and a constantly expanding market that seeks new, more profitable commercial opportunities in countries that ensure raw materials at low cost, but which do not always provide the necessary guarantees from a health safety standpoint.

Finally, in countries with “evolved” animal husbandry systems, intensive breeding, sometime inadequate sanitation and the overcrowding of animals have resulted in systematic antibiotic use and, as a consequence, the selection of antibiotic-resistant microorganisms, which have now become a health emergency issue (11-13).

Several studies carried out jointly by sociologists, physicians and veterinarians have hinted at a number of different social and cultural factors very likely linked to the outbreak of zoonotic diseases; first of all, as mentioned above, the demographic changes resulting from unprecedented population shifts giving rise to a multi-racial society – one with different cultures, but also different food habits (14).

Such habits are increasingly varied, being influenced by culture, religion and the social position of “newcomers” in societies that are – at least formally – “evolved”; taste (i.e., what is considered

good) is a cultural trait that influences the preparation of food. New dishes and foodstuffs, prepared according to varying customs, have become part of the dietary habits of populations that previously did not know them, thus entailing a further zoonotic risk, since this phenomenon has indirectly increased the request of products of animal origin, some of which are imported from non-EU countries (15).

One example is the practice of ritual slaughter, where inspection standards are not always easily applied (in this situation new and different diffusion ways of echinococcosis are possible) or mixed cooked preparations (like kebab), or again, the consumption of raw meat or fish (as in the case of sushi), that can objectively facilitate the permanence and spread of zoonotic agents, especially of a parasitic nature (Anisakiasis) (16).

The popularity and extensive presence of pets are cultural phenomena subject to social and economic circumstances; in a limited minority of cases, they are species bred for exhibitions, business or commercial purposes, and thus subject to various contacts and frequent movements; more often, they are animals with which people develop a social and affectionate bond that goes well beyond the mere notion of economic value (17).

Cats and dogs are naturally the most widespread domestic animals (63% of US households include at least one cat or dog) and their presence generates beneficial effects on the physical and mental health of their owners, both in everyday life (more motor activity in the elderly and emotional support for the lonely), and in areas defined as “co-therapeutic”, like pet therapy (18); in these cases, the presence of the animal makes it possible to establish a channel of active communication between patient and physician, with the intermediation of the animal, whose healthiness is a fundamental requirement,

especially for groups of people potentially immuno-compromised, like children, the elderly and immuno-depressed (HIV and antineoplastic-treated patients) (19-20).

Many persistent zoonoses remain cyclically active and still potentially dangerous for public health despite all the surveillance plans implemented; in 2011, and for the first time in Europe, the prevalence of Campylobacteriosis overcame that of Salmonellosis; this is an “indirect cost” of the economic crisis – *Campylobacter jejuni* is mainly found in chicken meat, whose consumption has risen worldwide in the current scenario, due to a lower market cost, and to the detriment of other, more expensive protein sources (21).

Emerging zoonoses

The definition “A zoonosis that is newly recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range”, recognised and adopted internationally, underlines that it is no longer possible to limit the concept of “emerging zoonoses” only to diseases that originate from tropical or developing areas, or to underestimate their potential spread.

Indeed, most recent data demonstrate that zoonotic diseases are gaining ground precisely in the most industrialised countries, bringing about new problems or causing the resurgence – with different epidemiological traits – of infections far too hastily considered eradicated (bovine tuberculosis and brucellosis); where population density creates favourable environmental conditions, microorganisms find a new chance to emerge, as has occurred repeatedly in North America and Europe (22).

The emergence and re-emergence of zoonotic diseases may be detrimental considering the level of morbidity and

mortality of animals destined to food production (23); recovery actions intended to prevent, contain and eradicate the disease are always, from an institutional viewpoint, linked to the public veterinary structures, both at a domestic and international level. Such actions include, first of all, any necessary epidemiological surveys, then the implementation of quarantine and health surveillance systems, and finally compensation for damage ensuing from the forced elimination of animal stock and the resulting production loss.

In underdeveloped countries and, to a lesser extent, in emerging ones, the more agricultural and food production is intended to satisfy local demand, the more veterinary structures are insufficient; only countries that have gained access to the export market have had to enhance veterinary infrastructures to satisfy the requirements of importing countries.

As a consequence, it was possible to recognise new diseases, or known ones in previously unmapped areas, and the global epidemiological design of different zoonoses also improved (24); the scenario is totally different, instead, in the event of sudden political changes (coups) or conflicts between neighbouring countries.

Therefore, the economic impact of a zoonotic disease depends on a multitude of factors, but the perception of its actual severity – often misled by inaccurate or incompetent information – may cause a disproportionate social response, or one impacting the market of animal-derived foodstuffs (e.g., the crisis in the avicultural sector due to excessive scaremongering vis-à-vis ‘bird flu’) (25).

Interdisciplinary perspectives

The spread and clinical treatment of zoonotic diseases in animals and man overlap, in time and quantity, in ways of exposure, evolution of symptoms and

control actions; therefore, this “epidemiological model” may be the key to an updated interpretation of infectious diseases in humans and animals.

As far as man is concerned, the mortality rate of emerging zoonoses is relatively low, especially when compared with that of other infectious diseases; in fact, we can safely say that none of the most recent evidence exhibits particularly high mortality rates – yet the impact cannot be measured solely by the number of cases of infection or death.

A telling example is the economic and social damage that avian influenza caused to local avicultural production, even in countries where no locus of infection was reported; and again, the decline in trade and tourist flows from and to the most seriously affected regions, with such severe socioeconomic consequences that political stability was jeopardised.

To be effective in similar circumstances, any prevention and control action should be carried out in a concretely interdisciplinary context that does not separate the medical and veterinary domains, in light of the fact that the pathogenic activity of microorganisms is not species-dependent; if public health and public veterinary health are closely linked, knowledge and information can be pooled and used for mutual benefit.

Whether the discourse is about emerging or re-emerging zoonoses, comparative infectivology can be – especially in the epidemiological and diagnostic domain – the “new frontier” of Public Health, and prevention through risk analysis is bound to become a common practice; it can encompass the different aspects in the animal-human-food of animal origin relationship in an urban context, but also the professional risk in the primary and secondary production areas, relying on the exchange of constantly updated diagnostic and clinical information.

Riassunto

Emergenza e riemersione delle zoonosi. Contesto e conseguenze

Le zoonosi sono state e sono ancora considerate soltanto come un “problema veterinario”. Invece, la lettura delle emergenze, riemersione e persistenze è più facilmente comprensibile considerando il “confronto” patogeno-animale-uomo. Alle proprietà di espressione dell’agente patogeno sono state correlate tre interfacce: uomo-ambiente, animale-ambiente e uomo-animale. Animali e uomo, possono essere serbatoi o vettori degli agenti patogeni, mentre le interfacce possono amplificare l’impatto clinico in tutte le specie coinvolte. L’andamento delle malattie è sovrapponibile negli animali e nell’uomo per infezione, clinica e controllo; perciò, questo “modello epidemiologico” può essere la chiave per una lettura aggiornata delle malattie infettive dell’uomo e degli animali. Gli interventi di controllo e prevenzione dovrebbero realizzarsi in un ambito interdisciplinare, senza separare il settore medico da quello veterinario e tenendo conto che l’attività patogena dei microrganismi è indipendente dalla specie; infine, se sanità pubblica e sanità pubblica veterinaria sono strettamente connesse, conoscenze e informazioni possono essere messe in comune e utilizzate a reciproco vantaggio.

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Corresponding author: Prof. Vittorio Sala, Department of Veterinary Science and Public Health (DIVET), University of Milan, Via Celoria 10, 20133 Milano, Italy
e-mail: vittorio.sala@unimi.it

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