HOUSE, MD… AND DVM?

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The team working with Dr House at Princeton-Plainsboro Teaching Hospital. Picture source : www.wetv.com

INTRODUCTION TO THE SERIES

House, M.D. is an American television medical drama that originally ran on the Fox network for eight seasons, from 2004 onwards. The lead character of Dr Gregory House (played by British actor Hugh Laurie) is a medical doctor, working at the fictitious Princeton–Plainsboro Teaching Hospital (or PPTH), on Prospect Street, in (the non-fictitious) town of Princeton, New Jersey, the United States of America (US). Generally anti-social, rude and grumpy, he is regarded as an exceptional diagnostician, if not a genius. He heads the Department of Diagnostic Medicine, a rather nonsensical name for a hospital department; rumour has it that the department was created to make him a head of department as he would be incapable of working under anyone else. This fact is well known to Dr Lisa Cuddy (*Lisa Edelstein*), Dean of Medicine and Chief Hospital Administrator, with whom he entertains what can best be described as a mutual love–hate relationship. For much of the series, his team of diagnosticians consists of Dr Allison Cameron (*Jennifer Morrison*), Dr Robert Chase (*Jesse Spencer*) and Dr Eric Foreman (*Omar Epps*). His only friend (and colleague) is Dr James Wilson (Robert Sean Leonard), Head of Oncology at the same hospital. Most episodes are structured around an 'intro' during which a person is seen falling victim

to an accident or disease event (usually a collapse or seizure) and is then referred to Dr House's team due to the complexity of their symptomatology.

Through repeated differential diagnosis, listing symptoms and possible causes on a whiteboard, then eliminating most of them, the team ends up arriving at the correct diagnosis. This generally occurs when the patient's condition becomes critical (in some cases the patient dies, but never without being diagnosed, in rare cases during the post-mortem). Typically, the patient is misdiagnosed at least once and accordingly receives some treatments that are, at best, useless. This usually causes further complications, but – as the nature of the complications often provides valuable new evidence – eventually these complications help the team to diagnose the patient correctly. House often tends to arrive at the correct diagnosis seemingly out of the blue, often inspired by a passing remark made by another character [1].

S TATISTICS ON THE SERIES

Produced by Bryan Singer, best known for his 1995 crime thriller *The Usual Suspects*, this Emmy, Golden Globe and Screen Actors Guild winning medical drama debuted on Fox on 16 November 2004, and – 177 episodes later – aired its last episode on 21 May 2012, more than five years ago. *If* you live in the United States and have cable, that is! In most parts of the world, the series is still being broadcast today.

In the US alone, the series has been viewed by between 8.7 and 19.4 million people. According to Wikipedia, *House, M.D.* was in the top-ten series in the United States from its second to fourth seasons, with no less than 17 million viewers per episode. In 2011, the programme was the most widely discussed television series on Facebook. Distributed to 66 countries, it was the most-watched television programme in the world in 2008, with an audience of over 81.8 million worldwide, far surpassing the viewership figures of the leading TV dramas of the previous two years (*CSI* and *CSI: Miami*). The show was the third most popular programme on Canadian television in 2008 and that same year, it was the top-rated television programme in Germany [1]. The following year, it was the second most watched TV show in the world after *CSI*.

IMDb, the International Movie Database, rates the series at an exceptionally high 8.8 out of 10 [2] and the audience rating system of the movie review site Rotten Tomatoes rates it at a very high 96%, meaning that 96% of audiences gave the series a score of 3.5 stars (out of 5) or higher. Moreover, season 5 was rated by Rotten Tomatoes' critics at 100% on the 'Tomatometer' and season 6 at 86% [3].

Season 2, episode 7, 'Hunting' (Echinococcosis, fox hunting)
Picture source : http://keywordsuggest.org

O BJECTIVES, MATERIALS AND METHODS

The objective of this essay is not to verify the scientific or veterinary relevance of what is portrayed in *House, M.D.*, however tempting that may be. Instead it aims to try to understand the impact that the storylines involving human–animal interaction could have had on its viewers and the public in general, worldwide, given the abovementioned viewership and critical acclaim.

The 'materials and methods' consisted of watching all 177 episodes with the assistance of a notebook, and some of the better Wikipedia pages [4] and fan blogs [5, 6], to capture the final diagnosis, as well as some of the differential diagnoses and aggravating or potentially dissimulating conditions, such as HIV–AIDS immune suppression, pregnancy, drug abuse, autism, etc. Also recorded were the type of patient (infant, child, adolescent, adult or elderly person) and the final diagnosis (infectious, and chemical/toxic, genetic/autoimmune or oncological, all of which are non-infectious).

Events pointing to human–animal interaction in the short side-storylines often related to House's aversion to clinic duty, such as the case of *Ecthyma contagiosum* in a young woman, contracted from a donkey whilst rehearsing for a nativity play (season 4, episode 10) are not included in the final dataset. Also excluded are the many differential diagnoses mentioned in the main storyline, for example anthrax in the case of a young boy who turns out to be suffering from leprosy (season 1, episode 13). Also, non-infectious agents of animal origin — toxins, such as those implicated in tick paralysis (season 2, episode 16), toad egg toxicity (season 7, episode 1) or Spanish fly (cantharides) poisoning (season 7, episode 21) — were not considered.

The term 'animal-borne' refers to something carried or transmitted by not only mammals, birds and aquatic species, but also by invertebrates, such as (tsetse) flies, lice and fleas.

For the identification of what constitutes a zoonosis, not solely in relation to domestic animals, but also to wildlife, aquatic life and invertebrates, the author referred to the Pan American Health Organization (PAHO) handbook on zoonoses [9] but did not necessarily include all of the diseases mentioned in the handbook, as its scope includes 'communicable diseases common to man and animals' (i.e. pathological agents that infect both man and animal), but do not necessarily transmit from animal to man. An example in point is amoebiasis *(Entamoeba histolytica).*

B RIEF OVERVIEW OF MEDICAL CASE REPORTS

The series starts (in the pilot episode entitled 'Everybody lies') with a food-borne zoonosis, neurocysticercosis, caused by the consumption of undercooked ham, thus suggesting the ingestion of viable larval cysts in the meat. Unfortunately, this makes no epidemiological sense, as the consumption of infected pork, as per the lifecycle of the parasite, can only lead to the development of a tapeworm, *Taenia solium*. The neurological form of this disease, caused by cysts in the brain, can only be contracted by directly ingesting *T. solium* eggs through faecal contamination, either from other people, polluted water or the swine-related contamination of food. At best (or worst), the ham could have been contaminated during processing or packaging.

Another case of swine-related zoonosis, directly transmitted this time, occurs in season 4, episode 5: a case of eperythrozoonosis in a young man selling agricultural equipment to farmers. Infection by *Eperythrozoon suis* (or *Mycoplasma suis* as it is now classified) is a disease of swine which can be transmitted to humans through the manipulation of animals, animal fur, faeces and raw meat. The first recognised and confirmed human case of eperythrozoonosis worldwide was only reported in 1986 [8] and is not included in the 2003 reprint of the 3rd edition of the PAHO handbook on zoonoses [9]. Since the disease occurs in pigs and other farm animals in the United States [10], it would seem plausible that cases occur in humans, as an occupational hazard of farm-related workers as has been shown in countries like China [11].

In the case of (sexually-transmitted) sleeping sickness or human African trypanosomosis (HAT), a disease exotic to the United States, it must be assumed that this was a case of *Trypanosoma brucei rhodesiense* if it is to qualify as a zoonosis, West African sleeping sickness, caused by *T. b. gambiense* having little or no relation to animal reservoirs. The vector, of course, in both cases is an animal, the tsetse fly (*Glossina* spp.), but, again, this was allegedly a case of direct human-to-human transmission. Indeed the World Health Organization states that transmission of the parasite through sexual contact has been documented [12].

Then there's the case of the paraplegic young man, with his guide dog. No zoonosis this time, but a case of strongyloidiasis, caused by a strictly human nematode (roundworm) called *Strongyloides stercoralis*. Treatment with ivermectine fails to improve the man's condition and the diagnosis of strongyloidiasis is sidelined to the status of differential diagnosis, until the patient eventually dies and post-mortem examination reveals that it was indeed strongyloidiasis. Minutes later, his dog too dies, the assumption being that the patient, rather

than taking the ivermectine pills himself, fed them to his dog. The dog, infested with the heartworm *Dirofilaria immitis*, suffered a cardiac post-adulticide thromboembolism due to the massive release of dead adult *Dirofilariae* into its bloodstream. There is a lot to say about what is scientifically wrong with this story, but that, again, is not the point. The link between man and animal in this case is correct: some drugs used in the treatment of human disease are the same as in veterinary science.

Other ailments would appear exotic, until one consults the US Centers for Disease Control and Prevention (CDC) statistics [13] that confirm that a few cases of bubonic plague (*Yersinia pestis*) still occur in the United States every year. The reservoir for this disease, as the narrative in season 2, episode 18, nicely demonstrates is a rodent (prairie dogs it is assumed in this case), with onward transmission to fleas, domestic dogs (bought in the southern United States) and a man. A similar case occurs in season 3, episode 4, when an autistic child is suspected of all kinds of neurological problems until the child's sandpit and his appetite for substances that are largely non-nutritive, such as sand in this case (eating disorder, pica), is found to be the cause of an infection with raccoon roundworm (*Baylisascaris procyonis*).

The portrayed case of rabies, usually caused by bat bites in the Americas, and the case of (*Ixodes* tick-borne) Lyme disease (*Borrelia burgdorferi*), a bacterial zoonosis, for which several wildlife species act as a reservoir [14] are textbook scenarios. So is the case of echinococcosis in a father-son duo of avid fox hunters. The disease is caused by the oral ingestion of *Echinococcus multilocularis* eggs from hunted carnivores, such as foxes, usually through faecal contamination of tissues at slaughter. It is therefore regarded as an occupational hazard (e.g. for trappers, hunters and veterinarians), leading to alveolar hydatidosis with cysts most often located in the liver [9].
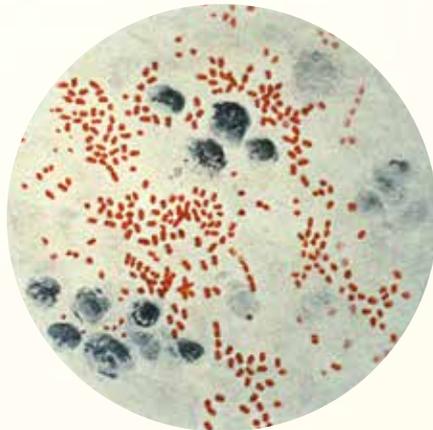
Table I

Diagnostic details of illnesses resulting from human–animal interactions in House, M.D. episodes, including the disease name, causal agent and (likely) source of the infection/infestation (in the programme)

Rank	Season	Episode	Episode title	Final diagnosis	Causal agent	Source	Date of broadcast	Viewers in the United States of America (millions)
1	1	1	'Everybody lies' (pilot)	Neurocysticercosis	*Taenia solium*	Pork ham	16 November 2004	7.05
7	1	7	'Fidelity'	Sleeping sickness	*Trypanosoma brucei rhodesiense* *	Sexual transmission	28 December 2004	6.91
10	1	10	'Histories'	Rabies	*Lyssavirus (Rhabdoviridae)*	Bats	8 February 2005	14.97
17	1	17	'Role model'	Toxoplasmosis	*Toxoplasma gondii*	Unspecified	12 April 2005	15.04
21	1	21	'Three stories'	Repeated dog bites	*Streptococcus spp.*	Aggressive dog	17 May 2005	17.68
25	2	3	'Humpty Dumpty'	Psittacosis	*Chlamydia psittaci*	Cock fights	27 September 2005	13.37
29	2	7	'Hunting'	Echinococcosis	*Echinococcus multilocularis*	Fox (hunting)	22 November 2005	14.72
36	2	14	'Sex kills'	Brucellosis	*Brucella melitensis*	Sheep's milk cheese	7 March 2006	20.56
40	2	18	'Sleeping dogs lie'	Bubonic plague	*Yersinia pestis*	Dog (prairie dog)	18 April 2006	22.64
50	3	4	'Lines in the sand'	Raccoon roundworm	*Baylisascaris procyonis*	Faeces (sandpit)	26 September 2006	14.52
60	3	14	'Insensitive'	Fish tapeworm	*Diphyllobothrium spp. (D. latum)*	Trout (fishing)	13 February 2007	25.99
73	4	3	'97 seconds'	Strongyloidiasis **	*Strongyloides stercoralis*	Beach (Thailand)	9 October 2007	18.03
75	4	5	'Mirror mirror'	Eperythrozoonosis	*Mycoplasma suis*	Pig (farms)	30 October 2007	17.29
77	4	7	'Ugly'	Lyme disease	*Borrelia burgdorferi*	Unspecified	13 November 2007	16.95
83	4	13	'No more Mr Nice Guy'	Chagas disease	*Trypanosoma cruzi*	Peace Corps	28 April 2008	14.51
105	5	19	'Locked in'	Leptospirosis	*Leptospira interrogans*	Rats	30 March 2009	12.51
106	5	20	'Simple explanation'	Visceral leishmaniasis	*Leishmania spp. (L. chagasi)*	Beach (Brazil)	6 April 2009	13.29
139	7	7	'A pox on our House'	Rickettsial pox	*Rickettsia akari*	Mice, cat (ship)	15 November 2010	10.77
140	7	8	'Small sacrifices'	Rhodococcosis	*Rhodococcus equi*	Horses	22 November 2010	9.24
148	7	16	'Out of the chute'	Bartonellosis	*Bartonella spp. (B. henselae)* *	Cat scratch	14 March 2011	10.41
150	7	18	'The dig'	Q fever	*Rickettsia burnetii (Coxiella burnetii)*	Raccoon	11 April 2011	8.93
165	8	10	'Runaways'	Ascariasis	*Ascaris suum* or *A. lumbricoides* *	Canal (Florida)	30 January 2012	8.73
170	8	15	'Blowing the whistle'	(Flea-borne) typhus	*Rickettsia typhi*	Rats (military)	2 April 2012	6.67

* Not specified in the series
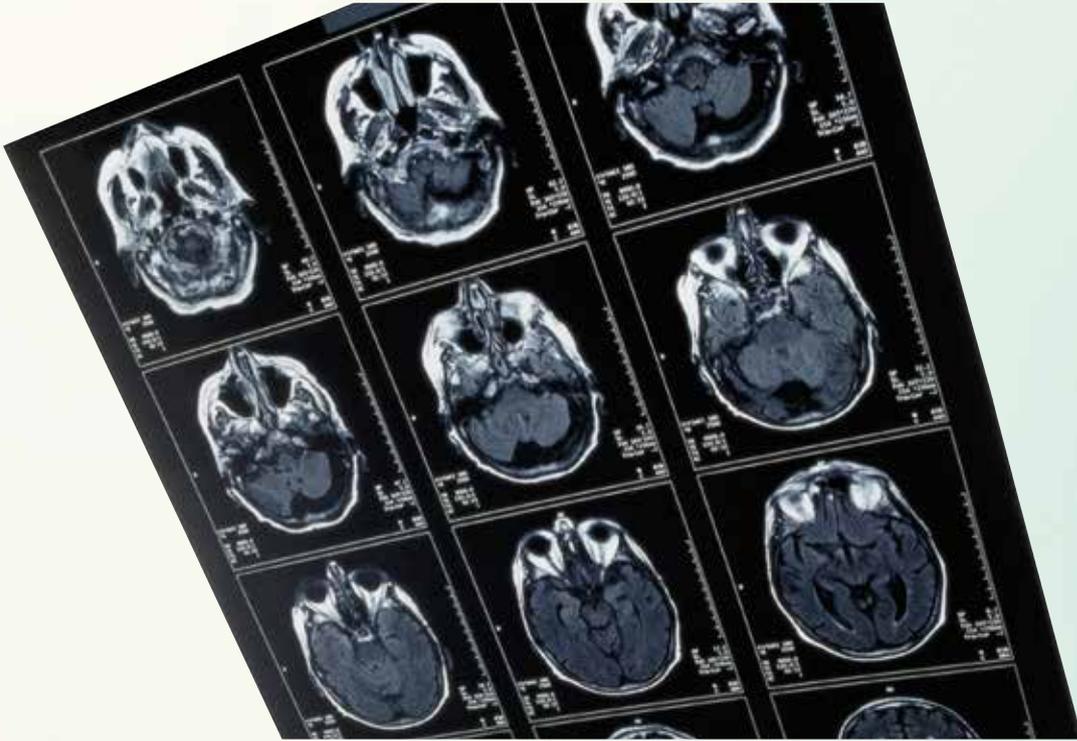** With alleged, related ivermectine treatment failure

Table I completes the set of animal-related events in the series, most of which are zoonoses, but only a few are transmitted by domestic animals. Pigs (neurocysticercosis and eperythrozoonosis) and dogs (visceral leishmaniasis, bubonic plague) are most often implicated, whether directly or indirectly via vectors and food.

Most of the diseases are vector-borne (invertebrates, i.e. fleas, mosquitoes, sand flies and tsetse flies) with wildlife species (bats, foxes and raccoons) and/or urban rodents (prairie dogs, mice and rats) acting as reservoirs. The case of *Diphyllobothrium* spp. tapeworm completes the palette of species as it alerts the viewer to the
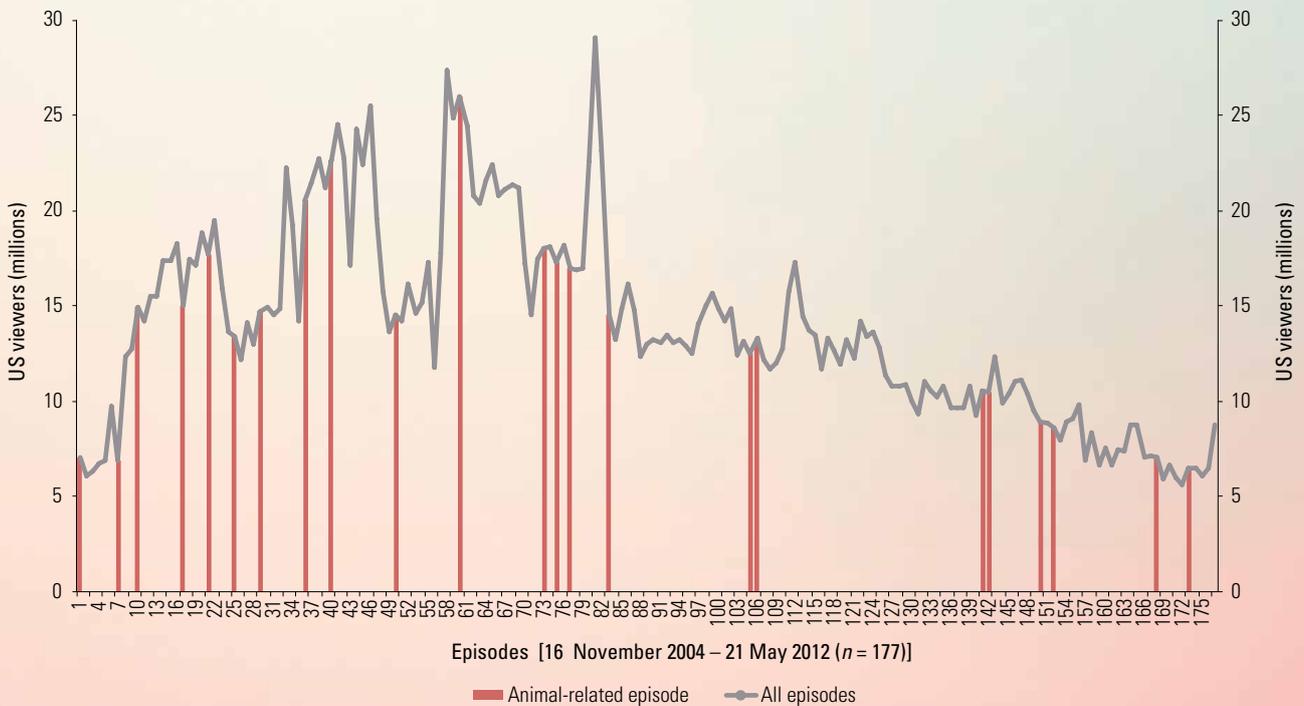
Fig. 1

Chronological overview of *House, M.D.*'s viewership in the United States of America from episode 1 to 177

with animal-related episodes highlighted (*n* = 23)

© FOX

Season 3, episode 14, 'Insensitive' (fish tape worm, *Diphyllobothrium* spp.)
Picture source : http://www.fanpop.com/clubs/mika-boorem

fact that, in addition to the Jaws franchise, aquatic species can also cause harm to humans, such as through the consumption of (rainbow) trout. The competition of the parasite with its host for the absorption of vitamin B_{12} is an excellent illustration of what it means to be a 'parasite' and leads House to arrive at the right diagnosis. This was also the most-watched episode of all 'zoonotic' episodes, with 25.99 million viewers in the United States alone.

RESULTS

Of the 177 episodes, 4 deal with the main characters only and do not lead to a diagnosis of any disease. Of the 173 remaining episodes, the majority deal with non-infectious disease causes, such as trauma, chemical intoxication, mineral deficiencies or imbalances, allergies and auto-immune diseases, hereditary diseases and genetic disorders, as well as cancers, whereas only 62 deal with infectious diseases (36%). Twenty-three (23) of these 62 episodes lead to the diagnosis of an *infectious* animal-borne disease (Fig. 1), either by direct transmission (e.g. Q fever in season 7, episode 18) or food-borne (e.g. brucellosis in season 2, episode 14). In one case, the animal link is the common treatment for a non-zoonotic disease occurring simultaneously in the owner (strongyloidiasis) of a dog (dirofilariasis), leaving 22 of the 62 episodes, or 35% considered deal with genuine zoonoses. This percentage

is well below the international consensus [15] that 60% of human diseases originate in animals, but this is New Jersey, not central Africa, and the chances of suffering from diabetes or getting run over by a truck are probably much higher than of suffering from tuberculosis.

In some cases, assumptions had to be made as to the zoonotic nature of the disease as the precise genus could not always be established. For example, in the case of cerebellar schistosomiasis delayed hypersensitivity (season 6, episode 16), usually attributed to *Schistosoma mansoni*, a strictly human, non-zoonotic *Schistosoma* species (which was excluded from the results). In other cases, an opportunistic agent such as *Streptococcus* spp. in dog saliva was clearly implicated in the dog-bite infection of the dog's owner (season 1, episode 21) and was included in the results.

Animal-related parasitic diseases are popular causes of ill health in the programme (43%), followed by bacterial (30%), chlamydial/rickettsial (22%) and viral (4%) diseases. In one case of a potential zoonotic fungal disease, histoplasmosis (season 3, episode 21), no link to an animal source was mentioned and the assumption was made that this was an environmental (soil-borne) case.

Only six of these diseases are listed by the OIE [16], and not always from a public health perspective:
– Infection with (*Brucella abortus*), *B. melitensis* (and *B. suis*) (*Terrestrial Animal Health Code [Terrestrial Code]*, chapter 8.4.)
– Infection with *Echinococcus multilocularis* (*Terrestrial Code*, Chapter 8.6.)
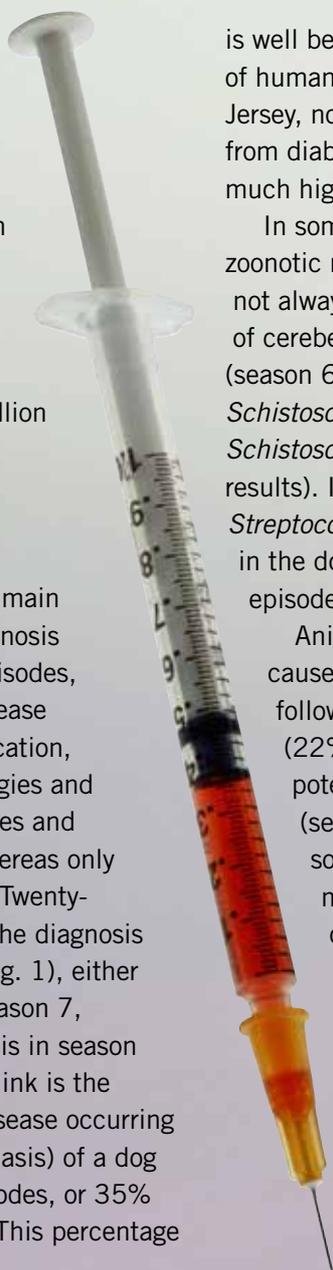
– Infection with rabies virus
(*Terrestrial Code*, Chapter 8.14.)
– Infection with *Taenia solium* (porcine cysticercosis) (*Terrestrial Code*, Chapter 15.4.)
– Q fever (listed, but no *Terrestrial Code* chapter yet)
– Trypanosomosis (tsetse-transmitted) (listed, but no *Terrestrial Code* chapter yet).

DISCUSSION AND CONCLUSION

Did the series miss anything?

Many of the diseases portrayed in the series hardly ever occur in the United States today (and certainly do not end up in the same hospital) but have the merit, from a veterinary perspective, of illustrating the variety of ways in which animals can have an impact on a human's health, including through such common avenues as a dog bite or, differential diagnosis, a snake bite (season 1, episode 21).

Anthrax, botulism, listeriosis, avian influenza, tularaemia, severe acute respiratory syndrome (SARS), Ebola and even equine encephalitis (season 5, episode 13) and Lassa fever (season 6, episode 4) are mentioned by House or his team as possible causes of observed symptoms. Creutzfeldt–Jakob disease (CJD) too is mentioned (season 4, episode 4) but it must be assumed that this refers to classical CJD and not the zoonotic vCJD (variant). *Clostridium perfringens*, histoplasmosis and melioidosis (*Burkholderia pseudomallei*) are listed as zoonoses by PAHO [9], but animal involvement in the context of the storylines (season 2, episode 9; season 3, episode 21 and season 5 episode 9, respectively) is unclear.

Hence, little is left to the imagination, except maybe Nipah virus, which emerged somewhere in 1997–1999, or the latest MERS-CoV epidemic, none of which occurred even close to the United States, except as imported cases, for example the two US cases of MERS-CoV in May 2014 [17], long after the series ended in 2012. Likewise, by the time the now famous Hantavirus outbreak in Yosemite National Park

(California) occurred in August 2012, the series had already been completed.

Our imaginations were stretched to their limits though with the discovery of a sunken 17th century era Dutch slave ship in the Caribbean, and the subsequent symptomatology of a young girl who cut herself on a wine bottle from the ship when diving. This led to a federal (CDC) alert for smallpox, eradicated in 1980, which – based on the symptoms of the ship's dead cat described in the logbook of the ship's cook– turns out to be *Rickettsia akari* or rickettsialpox (season 7, episode 7).

Throughout the series, several differential diagnoses are based on the proximity of the patient to animals (cats, dogs, donkeys, horses, laboratory rats, pigeons, pigs, poultry, rabbits and raccoons) but are then routinely dismissed at a later stage. Referring to the list of important animal host categories for human zoonoses and emerging human zoonoses by Cleaveland *et al.* [18], only ungulates (i.e. cattle, sheep, goats and wild even-toed animals [mainly deer, elk and caribou]) seem under-represented in the context of the United States (the other under-represented category in the series are the primates, less relevant in the context of the United States).

So, does all of the above make the series a shining example of the 'One Health' approach?

No, it does not. At no point in the series is there a genuine attempt from any medical team to interact with members of the other relevant professions, environmental professions and least of all veterinarians, none of which appear in the line-up. Attention on the 'environmental' causes of patients' symptoms is what drives the team to go out and routinely break into a patient's house to search for environmental pollutants, toxins, narcotics and, yes, animal droppings…

But despite the fact that the series sometimes cuts scientific corners and uses often preposterous storylines (remember the *The Apprentice*-styled selection of a new team, one of whom was Dr Remy

Hadley known as 'Thirteen' [*Olivia Wilde*]…), the exposure this series has given what PAHO refers to as 'communicable diseases common to man and animals', is unparalleled. Gross global extrapolations based on the rather robust US audience statistics and limited data on international viewing audiences, indicate that between 2004 and 2012, between 38 million (towards the end of the series in 2012) and 102 million (at the height of its success, in season 3 in 2006) people tuned in to watch the programme every week. Many more continue to enjoy the series today, perhaps even adding to the tally as a result of this article. Assuming that not all of these TV viewers are from the medical profession and indeed could use some insight into the relationship between humans, animals, pathogens,

their vectors and the environment, the impact can only be qualified as enormous. The series outstripped any previous attempts to conduct global public awareness campaigns or to deliver extension messages through audiovisual means.

We therefore forgive Dr Gregory House's obnoxious behaviour; borderless arrogance; appalling and sexist treatment of women in general, and his female colleagues in particular; irresponsible drug-abuse (Vicodin); bottomless self-pity; stratospheric egoism; and widely libertarian interpretation of the concepts of loyalty and truth. But then again: 'everybody lies'.

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