A Quantitative Prioritisation of Human and Domestic Animal Pathogens in Europe



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Abstract

Disease or pathogen risk prioritisations aid understanding of infectious agent impact within surveillance or mitigation and biosecurity work, but take significant development. Previous work has shown the H-(Hirsch-)index as an alternative proxy. We present a weighted risk analysis describing infectious pathogen impact for human health (human pathogens) and wellbeing (domestic animal pathogens) using an objective, evidence-based, repeatable approach; the H-index. This study established the highest H-index European pathogens. Commonalities amongst pathogens not included in previous surveillance or risk analyses were examined. Differences between host types (humans/animals/zoonotic) in pathogen Hindices were explored as a One Health impact indicator. Finally, the acceptability of the H-index proxy for animal pathogen impact was examined by comparison with other measures. 57 pathogens appeared solely in the top 100 highest H-indices (1) human or (2) animal pathogens list, and 43 occurred in both. Of human pathogens, 66 were zoonotic and 67 were emerging, compared to 67 and 57 for animals. There were statistically significant differences between H-indices for host types (humans, animal, zoonotic), and there was limited evidence that H-indices are a reasonable proxy for animal pathogen impact. This work addresses measures outlined by the European Commission to strengthen climate change resilience and biosecurity for infectious diseases. The results include a quantitative evaluation of infectious pathogen impact, and suggest greater impacts of human-only compared to zoonotic pathogens or scientific under-representation of zoonoses. The outputs separate high and low impact pathogens, and should be combined with other risk assessment methods relying on expert opinion or qualitative data for priority setting, or could be used to prioritise diseases for which formal risk assessments are not possible because of data gaps.

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Introduction

Disease or pathogen risk prioritisation exercises are used by organisations charged with providing surveillance and mitigation measures including disease management and control, and biosecurity measures. Qualitative, semi-quantitative or quantitative approaches can be used, but most take significant time to develop, so their use is limited, and when research involving the study of multiple diseases or pathogens is planned, agents are rarely systematically selected.

Quantitative measures for risk prioritisation include the calculation of epidemiological parameters such as disease incidence, prevalence, mortality and morbidity rates, costs of prevention, treatment or control, and for human disease, years lived with disability (YLD) and disability-adjusted-life-year estimates (DALY). Additional measures for animals include losses to production. For many diseases, robust estimates of these measures do not exist. Semi-quantitative and qualitative risk assessments are less demanding of data than quantitative approaches. Nevertheless, they require significant time and physical resources (for example, to obtain parameters and effect sizes from the scientific literature), need updating regularly, and they usually require expert-opinion, adding subjectivity [1,2,3,4,5].

The H-index is an alternative approach to disease prioritisation. It objectively and rapidly provides a quantitative proxy of human disease or pathogen impact [6],(McIntyre, *unpublished*). The H-index captures scientific interest in a disease by deriving a metric from the number of papers published and how many citations each receives. Combining scientific impact (citations) with technical productivity (papers published) is useful as, individually, total papers does not account for the quality of publications, while citation count may be influenced by a small number of seminal

papers or if a disease becomes 'fashionable' briefly. The H-index method is significantly correlated with more comprehensive measures of human infectious disease impact, including DALYs [6], and deaths from disease (McIntyre, *unpublished data*). It can be rapidly obtained at low cost, attained automatically, and repeated regularly to reflect changes in impact, serving as a generic tool to assess the relative bearing of diseases or pathogens, in an easier, timelier manner than traditional risk assessments. While the H-index method undoubtedly has limitations, these tend to be different to those of other approaches; its use could be a step forward in separating high and low priority diseases or pathogens, in combination with other risk assessment methods.

The ENHanCEd Infectious Diseases (EID2) database integrates published data sources on pathogens, their hosts (including vectors) and geographic ranges [7]. By coupling the H-index method with the EID2, the primary aim of this study was to establish priority lists of human and domestic animal pathogens (including zoonoses) present in Europe. We then consider reasons for the omission of some pathogens in our lists from those of other disease prioritisations: the 2010 Global Burden of Disease (GBD) estimates [8], communicable human diseases reportable in the European Community [9], the OIE list of notifiable animal diseases, infections and infestations [10], and the EU FP7 DISCON-TOOLS project [11]. The GBD 2010 study was a large collaborative five year project which used all relevant published and unpublished evidence to create the strongest evidence-based epidemiological assessment of people's infectious and non-infectious health problems around the world [8]. The DISCON-TOOLS project, funded by the European Commission over five years, investigated the impacts of 52 domestic animal diseases, to focus and prioritise future research [11]. As the zoonotic and emerging status of pathogens as well as their taxonomic division could affect the likelihood of their inclusion in surveillance and impact quantification work, these factors were also investigated as reasons for omission from the other disease prioritisations.

The H-index can be obtained in the same way for both human and animal pathogens. It therefore has potential as a single metric for prioritising across both host groups. Its potential as a quantitative One Health indicator (i.e. a single measure applicable to both human and animal diseases) was investigated by comparing scores for human-only, zoonotic, and animal-only pathogen groups, including emerging status as this would likely drive research impact.

Previous work has shown that the H-index is a proxy for human disease impact [6],(McIntyre, *unpublished*). We investigated its value as a proxy for animal disease impact by comparing domestic animal pathogen H-indices with other measures of impact including presence on the OIE list [10], and inclusion in DISCONTOOLS [11].

Methods

EID2 pathogen information

The EID2 database collates data on human and domestic animal pathogens: where, when, and in which hosts there is evidence of their occurrence. The database is built largely using automated procedures to interrogate publicly available databases. An EID2 background has been described previously [7]; here, we used similar criteria to define pathogens, including pathogenic status (frequently pathogenic: a pathogen which frequently causes a clinically pathogenic effect - morbidity or mortality - in humans or domestic animals; non-pathogenic: an organism which causes no clinical signs within any of its hosts; unknown pathogenicity: an organism for which there is insufficient evidence to decide), evidence of pathogens affecting hosts ('host-pathogen interactions': evidence from at least one piece of meta-data uploaded with DNA or RNA sequence information to [12], which describes where, when and from which host the pathogen came, or specific scientific publications [13]), and evidence of pathogens occurring within countries (evidence from at least one piece of meta-data [12], or at least five publications in [13] where pathogen name and a country MeSH-term [14] co-occurred in the title/abstract). Information on host-pathogen interactions was collated when there was evidence of a pathogen occurring in at least one host of interest to the study (including humans and European domestic animals; see Table 1). Further information about each organism, such as their taxonomic division for pathogens (bacteria including rickettsia, fungi - including algal pathogens, helminths including thorny-headed worms and pentastomids, protozoa, and viruses - including prion agents) or their taxonomic rank (genus, species, etc.) is stored using a series of statements. Previously, we examined characteristics of pathogen species [7]; here, we include sub-species, to account for important strains e.g. Escherichia coli O157:H7.

Emerging/zoonotic pathogen status

Information on whether pathogens were zoonotic, non-zoonotic, emerging and not emerging was examined based upon previously published information [15,16]. If not included in earlier work or if their status had changed due to more recent scientific evidence, updated pathogen information was based upon the previous definitions. Zoonotic pathogens were classified as those naturally transmitted between vertebrate (non-human) animals and humans (as the definitive host), not including species which have recently evolved from animal pathogens but are no longer transmitted between animals and humans [15,17]. Emerging pathogens are those that have appeared in a host population for the first time (including newly-evolved strains), or have occurred previously but are increasing in incidence or expanding into areas where they had not previously been reported [15,17]. Pathogens needed to have emerged in several geographically distinct areas to be 'emerging'.

H-index literature search protocol

Information sources. H-index searches were undertaken in January 2012 using Web of Science (WoS) [18]. Previous work established that results of H-index searches for pathogens undertaken using different bibliographic sources (e.g. WoS, SCOPUS, Google Scholar) are not identical but are highly correlated [6].

Eligibility criteria. Searches were restricted to the years 1900 to 2010, inclusive. English is used in WoS, however searches also include foreign-language publication title translations. All literature in the WoS database has been published.

Searches. Searches were undertaken using search phrases specified in quotation marks (""), the 'topic' search field and with no lemmatization. Phrases were compiled including pathogen scientific name, alternative names, synonyms and alternative spellings according to NCBI Taxonomy [19]. H-indices for clinical diseases used clinical terms as well as pathogen phrases for the main pathogens of disease. Virus searches also included synonyms and acronyms from the NCBI Taxonomy database and International Committee on Taxonomy of Viruses [19,20], and the term 'virus', and excluded other entities (viral or non-viral) which shared acronyms. The Boolean operators 'AND', 'OR', and 'NOT' linked multiple search phrases.

Example of a search phrase. ("mycobacterium tuberculosis" OR "bacillus tuberculosis" OR "bacterium tuberculosis" OR **Table 1.** Animal species including humans for which pathogens have been studied, including domestic animals we eat or companion animals we keep as pets, and exotic animals also used as food sources or as pets.

Scientific name	Common name	Scientific name	Common name
Agapornis personata	Masked lovebird	Lama glama	Lama
Agapornis roseicollis	Rosy-faced lovebird	Lama pacos	Alpaca
Anas platyrhynchos	Domestic duck	Meleagris gallopavo	Turkey
Anser anser	Domestic goose	Melopsittacus undulatus	Budgerigar
Bison bison	American bison	Meriones unguiculatus	Mongolian gerbil
Bison bonasus	European bison	Mesocricetus auratus	Syrian golden hamster
Bos indicus	Zebu	Mus musculus	House mouse
Bos taurus	Cow	Mustela putorius furo	Domestic ferret
Camelus dromedarius	Dromedary	Numida meleagris	Helmeted guineafowl
Canis lupus familiaris	Domestic dog	Nymphicus hollandicus	Cockatiel
Capra hircus	Domestic goat	Oryctolagus cuniculus	Domestic rabbit
Capreolus capreolus	Roe deer	Ovis aries	Sheep
Cavia porcellus	Domestic guinea pig	Ovis aries musimon	Mouflon
Cervus elaphus	Red deer	Pavo cristatus	Blue peafowl
Chinchilla lanigera	Chinchilla	Phasianus colchicus	Ring-necked pheasant
Columba livia	Domestic pigeon	Rangifer tarandus	Reindeer
Cricetus cricetus	Common hamster	Rattus norvegicus	Brown rat
Dama dama	Fallow deer	Rattus rattus	Black rat
Equus asinus	Domestic donkey	Rhombomys opimus	Great Gerbil
Equus caballus	Domestic horse	Serinus canaria	Canary
Felis catus	Domestic cat	Struthio camelus	Ostrich
Gallus gallus	Chicken	Sus scrofa	Wild boar
Homo sapiens	Humans	Sus scrofa domesticus	Domestic pig
Lagopus lagopus scotica	Red grouse		

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"mycobacterium tuberculosis typus humanus" OR "mycobacterium tuberculosis var. hominis").

Pathogen prioritisation framework

A full list of human and domestic animal pathogens frequently causing pathogenic effects and for which there was evidence of European occurrence was created using EID2 information [7], and defined criteria, see Figure 1. The relative impact of pathogens in this full list was assessed by calculating H-indices using the specified search protocol; high impact pathogens had the highest H-indices. The list was split according to host-pathogen interaction information, into two directories, one including pathogens with evidence of their occurrence in humans, and the second including domestic animal occurrence; zoonotic pathogens appeared in both lists. Information was manually obtained on whether these pathogens cause diseases featuring in other prioritisation lists [8,10,11], by examining pathogens listed under each disease's details in the NCBI MeSH library [14]; specific lists of diseases had been provided in other work [9,11]. These additional pieces of information are included in the results (Tables 2 and 3). Finally, information on the pathogenic status of each pathogen, whether they frequently occurred in the relevant hosts and in Europe was verified by the study authors using manual literature searches of the scientific literature, for the pathogens with the highest H-indices.

Data analyses

H-indices and previous prioritisations. Pearson's Chisquared tests with Yates' continuity correction and Fisher's Exact Tests (FET) were used to test for differences in counts of pathogens included in previous work [9,10,11], according to outcomes including their taxonomic division, zoonotic and emerging status. Where appropriate, odds ratios (OR) and 95% confidence intervals (CI) are presented.

H-indices for One Health. Differences in H-indices for human-only, zoonotic, and animal-only pathogens were examined using a two-way Analysis of Variance (ANOVA) with log_{10} -transformation of the response, including emerging status as an explanatory covariate. Post-hoc Tukey multiple comparisons of treatments were undertaken using the *HSD.test* [21].

H-indices for domestic animal pathogens. -OIE list. Homogeneity of variances of H-indices for animal-only (and not zoonotic) pathogens included or not within the OIE list of notifiable animal diseases was examined using the Fligner-Killeen (median) test. One-way ANOVA thereafter established differences in the (log₁₀-transformed) H-indices of pathogens included or not in the OIE list. –*DISCONTOOLS*. H-indices and DISCON-TOOLS scores were compared using Spearman's Rank correlations. If more than one pathogen had been included within disease information for the DISCONTOOLS rankings (for *Campylobacter*, Leishmaniasis, and Salmonellosis), the higher H-index score was used for analyses.



Figure 1. Pyramid diagram showing the prioritisation framework for pathogens leading to the use of the quantitative H-index methodology to estimate relative pathogen impact. doi:10.1371/journal.pone.0103529.g001

All analyses were undertaken using the statistical software package R [22], with statistical significance determined by a P-value of less than 0.05.

Results

Priority lists of human and domestic animal pathogens present in Europe

Two lists each including the top 100 human (Table 2) and domestic animal pathogens (Table 3) which cause significant clinical disease and which therefore need consideration from a health and well-being perspective were short-listed using the H-index prioritisation method (for alternative names and synonyms see [19]). When combined, 114 (72.6%) pathogens appeared solely in the human or animal list, and 43 (27.4%) were in both lists. Of the top 100 human pathogens, 66 were classed as zoonotic and 67 were emerging, compared to 67 and 57 for domestic animal pathogens, respectively.

H-indices and previous prioritisations

Of the top 100 human pathogens identified, 42 were either included in the GBD [8], or are reportable to the EC [9], or both. Reasons for failure to include pathogens may be that pathogenic agents cause rarely diagnosed disease (e.g. Human T-lymphotropic Virus 1, Lymphocytic Choriomeningitis Virus, and Moraxella *catarrhalis*), or because disease agents are diverse, e.g. pneumonia or other lung infections (Aspergillus niger, Chlamydophila pneumonia, Cryptococcus neoformans, Klebsiella pneumonia, and Mycoplasma pneumoniae) and gastro-intestinal (GI) symptoms or GI-tract infections (Aeromonas hydrophila, Bacillus cereus, Bacteroides fragilis, Clostridium species, Vibrio parahaemolyticus, and Yersinia enterocolitica). The impact of chronic disease or diseases causing low morbidity may be difficult to quantify or seen as less important (Bartonella henselae, Borrelia burgdorferi, Human Enterovirus C, Human Herpesvirus group, Human Papillomavirus, Human Parvovirus b19, Mycobacterium bovis, Mycobacterium avium, and Mycoplasma genitalium). In addition, some pathogens may generally be commensals or natural biota (Aggregatibacter actinomycetemcomitans, Candida species, Enterobacter, Enterococcus, Staphylococcus species, Candida tropicalis, Helicobacter pylori, and Porphyromonas gingivalis) or species existing in the environment (Acinetobacter baumannii, Burkholderia cepacia, Candida glabrata, Entamoeba histolytica, Fusarium oxysporum, Gibberella moniliformis, Proteus mirabilis, Pseudomonas species, Rhizopus oryzae, Serratia marcescens, Staphylococcus aureus, and Stenotro*phomonas maltophilia*) causing opportunistic infections in immunecompromised individuals (including those young, old or pregnant); their impact upon the general population may not be quantified.

Of the top 100 domestic animal pathogens described, 76 were either notifiable according to the OIE [10], or included in DISCONTOOLS [11], or both. Reasons for failure to include may be similar to for human pathogens (only pathogens not previously mentioned are cited: multiple disease symptoms or lack of diagnosis - Ascaris suum, Feline Immunodeficiency Virus, Feline Leukemia Virus, Gallid Herpesvirus 2, Haemonchus contortus, and Yersinia pseudotuberculosis; causes of specific disease being diverse, for respiratory infection - Feline Calicivirus, and GI symptoms - Campylobacter fetus, Cryptosporidium parvum, and Listeria monocytogenes,; and existing in the environment and opportunistic - Pseudomonas aeruginosa). In addition, some omitted pathogens may be production issues with impact difficult to quantify (Streptococcus agalactiae causing Mastitis in cattle and Neospora caninum causing abortion in cattle and dogs) and some may be issues of pets (Canine Parvovirus, Neospora caninum, and Parainfluenza Virus 5).

For human pathogens in our list (Table 2), fungi and helminths are particularly under-represented in GBD assessments (percentage included in GBD: bacteria, 25%; fungi, 0%; helminths, 0%; protozoa, 60%; viruses, 42.3%; FET, P = 0.046). There was no difference between taxonomic divisions in the percentage reportable to the EC (FET, P = 0.109). Human pathogens classed as emerging (compared to not emerging) were statistically more likely to have GBD estimates (FET, P < 0.001, OR = 10.27, CI = 2.28– 95.77) and be EC reportable (FET, P < 0.001, OR = 16.00, CI = 3.49–144.92), but not more likely to have GBD estimates or be EC reportable if they were zoonotic compared to nonzoonotic (Pearson's χ^2 , P = 0.219 and FET, P = 0.745, respective-ly).

For domestic animal pathogens in our list (Table 3), fungi were particularly under-represented in the OIE list (percentage included in OIE: bacteria, 20%; fungi, 0%; helminths, 33.3%, protozoa, 33.3%, viruses, 52.5%; FET, P = 0.014). By contrast, viruses are particularly under-represented in DISCONTOOLS (percentage included in DISCONTOOLS: bacteria, 55.6%; fungi, 100%; helminths, 33.3%; protozoa, 33.3%; viruses, 25%; FET, P = 0.008). Animal pathogens classed as zoonotic (compared to non-zoonotic) were (of borderline statistical significance) less likely to be included in the OIE list (Pearson's χ^2 , P = 0.055, effect size(ϕ) = 0.22, OR = 0.39) but there was no difference in the percentage included in DISCONTOOLS, (Pearson's χ^2 , P = 0.309) nor any effect of being emerging (versus not emerging)
 Table 2. Top 100 human pathogens in Europe, prioritised according to the H-index methodology [6].

Pathogen name	H-index score	Taxonomic division	Pathogen name	H-index score	Taxonomic division
Escherichia coli, _{Z, E, A, GBD}	524	Bacteria	Streptococcus pyogenes, _{Z, E}	113	Bacteria
Human Immunodeficiency Virus 1, _{NZ, E, GBD, EC}	410	Viruses	Bacillus cereus, _{Z, NE, A}	111	Bacteria
Human Immunodeficiency Virus 2, _{NZ, E, GBD, EC}	399	Viruses	Aspergillus niger, _{Z, NE}	110	Fungi
Hepatitis C Virus, _{NZ, E, GBD, EC}	289	Viruses	Burkholderia cepacia, _{NZ, NE}	107	Bacteria
Staphylococcus aureus, _{Z, E, A}	271	Bacteria	Clostridium botulinum, _{Z, E, A, EC}	106	Bacteria
Human Herpesvirus 4, _{NZ, NE}	257	Viruses	Encephalomyocarditis Virus, _{Z, NE, A}	105	Viruses
Helicobacter pylori, _{Z, NE, A}	246	Bacteria	Yersinia pestis, _{Z, E, A, EC}	105	Bacteria
Hepatitis B Virus, _{NZ, E, GBD, EC}	246	Viruses	Streptococcus mutans, _{NZ, NE}	104	Bacteria
Pseudomonas aeruginosa, _{Z, E, A}	243	Bacteria	Aggregatibacter actinomycetemcomitans, z, NE	101	Bacteria
Mycobacterium tuberculosis, _{Z, E, GBD, EC}	238	Bacteria	Clostridium perfringens, _{Z, NE, A}	101	Bacteria
Human Papillomavirus, _{NZ, E}	235	Viruses	Serratia marcescens, _{Z, E}	100	Bacteria
Bacillus subtilis, _{Z, NE}	219	Bacteria	Yersinia pseudotuberculosis, _{Z, NE, A, EC}	99	Bacteria
Listeria monocytogenes, _{Z, E, A, EC}	207	Bacteria	Entamoeba histolytica, _{Z, NE, A}	98	Protozoa
Streptococcus pneumoniae, _{Z, E, GBD, EC}	199	Bacteria	Leishmania donovani, _{Z, E, A, GBD}	98	Protozoa
Candida albicans, _{Z, E, A}	181	Fungi	Bacteroides fragilis, _{Z, NE, A}	97	Bacteria
Human Herpesvirus 1, _{NZ, E}	171	Viruses	Gibberella moniliformis, _{NZ, E}	97	Fungi
Respiratory Syncytial Virus, NZ, NE, GBD	164	Viruses	West Nile Virus, _{Z, E, A, EC}	97	Viruses
Human Herpesvirus 5, _{NZ, E}	159	Viruses	Human Herpesvirus 2, _{NZ, E}	96	Viruses
Haemophilus influenzae, NZ, E, GBD, EC	148	Bacteria	Rabies Virus, Z, E, A, GBD, EC	96	Viruses
Lymphocytic Choriomeningitis Virus, _{Z, NE, A}	148	Viruses	Hepatitis A Virus, _{Z, E, GBD, EC}	95	Viruses
Toxoplasma gondii, _{Z, E, A, EC}	148	Protozoa	Human Herpesvirus 6, _{NZ, NE}	94	Viruses
Klebsiella pneumoniae, _{Z. E. A}	146	Bacteria	Fusarium oxysporum, _{NZ. E}	93	Fungi
Vibrio cholerae, NZ, E, GBD, EC	145	Bacteria	Mycoplasma pneumoniae, _{NZ, NE}	93	Bacteria
Borrelia burgdorferi, _{Z. E. A}	144	Bacteria	Cryptosporidium parvum, z. E. A. GBD. EC	92	Protozoa
Chlamydophila pneumoniae, _{Z. NE. A}	143	Bacteria	Enterobacter cloacae, _{Z. NE. A}	90	Bacteria
Shigella flexneri, z. NE. GBD. EC	142	Bacteria	Aeromonas hydrophila, _{Z. F. A}	89	Bacteria
Human Herpesvirus 8, _{NZ, F}	140	Viruses	Acinetobacter baumannii, _{NZ, NE, A}	88	Bacteria
Escherichia coli o157:h7, z. E. EC	138	Bacteria	Candida glabrata, _{Z. F}	87	Fungi
Human T-lymphotropic Virus 1, _{NZ, F}	137	Viruses	Moraxella catarrhalis, _{NZ, NE}	87	Bacteria
Neisseria gonorrhoeae, _{NZ, E, GBD, EC}	136	Bacteria	Salmonella enterica subsp. enterica serovar enteritidis, _{Z, E, A, GBD, EC}	87	Bacteria
Influenza A Virus, _{Z, E, A, GBD, EC}	135	Viruses	Treponema pallidum, _{NZ, E, GBD, EC}	87	Bacteria
Legionella pneumophila, _{NZ, E, EC}	133	Bacteria	Trichomonas vaginalis, _{NZ, E, GBD}	87	Protozoa
Enterococcus faecalis, _{Z, E}	132	Bacteria	Rhizopus oryzae, _{z. NE}	86	Fungi
Mycobacterium bovis, _{Z, E, A}	132	Bacteria	Hepatitis E Virus, _{Z, E, GBD}	83	Viruses
Campylobacter jejuni, _{Z, E, A, GBD, EC}	130	Bacteria	Human Parvovirus b19, _{NZ, E}	81	Viruses
Neisseria meningitidis, _{NZ, E, GBD, EC}	130	Bacteria	Proteus mirabilis, _{Z, NE, A}	80	Bacteria
Chlamydia trachomatis, _{Z, E, GBD, EC}	129	Bacteria	Shigella dysenteriae, _{Z, E, GBD, EC}	80	Bacteria
Clostridium difficile, _{Z, E, A}	127	Bacteria	Stenotrophomonas maltophilia, _{NZ, NE}	80	Bacteria
Cryptococcus neoformans, _{Z, E, A}	126	Fungi	Bacillus licheniformis, _{Z, NE, A}	78	Bacteria
Yersinia enterocolitica, _{Z, E, A}	126	Bacteria	Mycoplasma genitalium, _{NZ, NE}	78	Bacteria
Mouse Mammary Tumor Virus, _{Z, E, NS}	125	Viruses	Trichinella spiralis, _{Z, E, A, EC}	78	Helminths
Mycobacterium avium, _{Z. E}	125	Bacteria	Bartonella henselae, _{Z. NE. A}	77	Bacteria
Bacillus anthracis, _{Z, E, A, EC}	122	Bacteria	Salmonella enterica subsp. enterica serovar typhimurium, _{Z, E, A, GBD, EC}	77	Bacteria
Bordetella pertussis, _{NZ, E, GBD, EC}	122	Bacteria	Brucella abortus, _{Z, E, A, EC}	76	Bacteria
Measles Virus, _{Z, E, GBD, EC}	119	Viruses	Candida tropicalis, _{z, NE}	76	Fungi
Human Enterovirus C, _{NZ. NE}	118	Viruses	Pseudomonas stutzeri, _{NZ. NE}	76	Bacteria
Enterococcus faecium, _{Z, E}	116	Bacteria	SARS coronavirus, _{Z, E, NS, EC}	76	Viruses
Staphylococcus epidermidis, _{Z, E, A}	114	Bacteria	Enterobacter aerogenes, _{Z, NE, A}	75	Bacteria

Table 🛛	2. Cont.
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Pathogen name	H-index score	Taxonomic division	Pathogen name	H-index score	Taxonomic division
Human Herpesvirus 3, _{NZ, E, GBD}	113	Viruses	Francisella tularensis, _{Z, E, A, EC}	74	Bacteria
Porphyromonas gingivalis, _{Z, NE}	113	Bacteria	Vibrio parahaemolyticus, _{Z, E}	74	Bacteria

Pathogens include those which are zoonotic (Z), non-zoonotic (NZ), emerging (E) and not emerging (NE) [15,16], or given a new status (NS) in this work. Pathogens also included in the list of top 100 animal pathogens are noted (A). The major pathogens causing diseases included within the 2012 Global Burden of Disease (GBD) report are noted [8,31], as are those reportable in the EC (EC) [9].

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on inclusion in either list (Pearson's χ^2 , P = 0.633 and P < 0.99, respectively).

H-indices for One Health

There was a statistically significant difference between the Hindices of zoonotic, human-only or animal-only pathogens (Twoway ANOVA, $F_{2,152} = 24 \cdot 40$, P < 0.001); H-indices were significantly higher for human-only (untransformed mean = 132.39±6.14 and lower for animal-only pathogens (68.11±6.06) compared to zoonotic (100.83±9.93). H-indices were higher (with borderline statistical significance) for emerging (106.61±10.19) compared to not emerging (86.91±8.14) pathogens (Two-way ANOVA, $F_{1,152} = 3.78$, P = 0.054). The interaction between zoonotic and emerging factors was not significant (P = 0.25).

H-indices for domestic animal pathogens

-OIE list. There was no difference in the H-indices of animalonly pathogens included or not within the OIE list (ANOVA F(1, 31) = 0.005, MSE < 0.001, P = 0.943; variances not significantly different by Fligner-Killeen (median) test.

-DISCONTOOLS. There were significant correlations between H-indices and DISCONTOOLS estimates of public (human) health (zoonotic and animal pathogens) and impact on wider society (animal-only pathogens), and a further relationship of borderline significance between H-indices and the DISCON-TOOLS overall result; no other correlations were significant (Table 4).

Discussion

The European Commission has outlined measures to strengthen coordinated approaches to health security at EU level, including monitoring, early warning and combating specific threats of a cross-border nature. These measures could be for climate change resilience [23] or for biosecurity, particularly for infectious diseases including communicable diseases, antimicrobial resistant and healthcare-associated infections related to communicable diseases, and biotoxins or other biological agents [24]. In this study, we implement a number of previously defined actions [25], including presenting a quantitative evaluation for the impact of infectious pathogens affecting human health and well-being (via effects upon domestic animals) [24]. The work is unique, starting with all known infectious pathogens, and then objectively and systematically deciding which occur in relevant hosts in Europe using a transparent process. The study establishes priority lists of human and domestic animal pathogens (including zoonoses) present in Europe, using the H-index as a proxy measure for impact.

Previous work suggests that higher H-indices indicate higher impact for a pathogen relative to lower H-indices [6], (McIntyre, *unpublished material*). The H-index method has both strengths and weaknesses. The strengths include that it is much more evidence-based and objective than semi-quantitative and qualitative approaches, and the results provide an easily understood quantitative estimate of impact. H-indices estimates can be simply and rapidly calculated, and they can therefore be repeatedly obtained to reflect changes in status, with the potential for automation of this process. The results are available for all pathogens at a global scale, and the scores reflect the wider scientific interest that would be expected to follow from a pathogen being either zoonotic or emerging [6]. Most importantly, within a study of 27 human diseases, H-indices were correlated with DALY estimates [6], (McIntyre, unpublished material). DALYs are an accepted measure of true disease burden in humans which accounts for the years of healthy life lost as a result of poor health or disability as well as the potential years of life lost due to premature death [26]. In further work, H-indices were also correlated with the number of human deaths (McIntyre, unpublished material).

The weaknesses of the H-index method include that calculations need some manual oversight, as false positives can occur for instance when pathogens are used as model organisms; biases in results may happen because of trends in interest in specific pathogens, diseases or research fields or in certain regions; and estimates are subject to biases in funding (McIntyre, unpublished material) and research publication. H-indices are likely to underestimate the contribution of scientific literature published in non-English languages, although after translation some publications are included in WoS and consequently in our calculations of H-indices. The literature searching method also doesn't account for the quality of publications in which pathogen names appear and the typical number of citations within different fields, and all bibliographic software packages incorporate newly published literature from different literature sources into their databases at different rates. Finally, H-indices are only a proxy for impact, with the results susceptible to a lag in time-to-publication, and newly emerging pathogens likely to be under-represented.

As the strengths and weaknesses of using the H-index method are different to those of other prioritisation methods, it is probably best used in combination with other approaches, for example, to shortlist a set of pathogens for more detailed risk assessment relying on expert opinion or qualitative data. It may also be used to prioritise diseases for which formal risk assessments are not possible because of data gaps.

Our priority lists of pathogens enabled investigation of why infectious pathogens are omitted from disease surveillance and impact quantification work [8,9,10,11]. We considered several reasons for exclusion, including lack of diagnosis or misdiagnosis [27], because the impact of particularly chronic infections is difficult to quantify or they are seen as less important, and because some pathogens are commensals or natural biota causing opportunistic infections in immune-compromised individuals; their
 Table 3. Top 100 domestic animal pathogens in Europe, prioritised according to the H-index methodology [6] with the same emerging and zoonotic definitions as for Table 2.

Schechla coll, k_{1,k_1,k_2,m_2} S24 Bacteria Sampholocours aurus, y_{2,k_1,k_2,m_2} 71 Bacteria Staphylocours aurus, y_{2,k_1,m_1} 271 Bacteria Browloader deopens, y_{2,k_1,m_1} 72 Bacteria Additionation aurus, y_{2,k_1,m_1} 243 Bacteria Proncellal burlewis, y_{2,k_1,m_1} 74 Bacteria Additionation aurus, y_{2,k_1,m_1} 243 Bacteria Proncellal burlewis, y_{2,k_1,m_1} 74 Helminthy Additionation aurus, y_{2,k_1,m_1} 243 Bacteria Proncellal burlewis, y_{2,k_1,m_1} 74 Helminthy Candido albitantis, z_{1,k_1,m_2} 184 Viruses Domposition y_{2,k_1,m_1} 70 Bacteria Samphologong (2, k_1, k_1, k_1, k_1, k_1, k_1, k_1, k_1	Pathogen name	H-index score	Taxonomic division	Pathogen name	H-index score	Taxonomic division
StophyCocccs survey, p. r. 1271BacteriaBrocefia oborthy, p. r. 1, nor.74BacteriaHelkoboter groupinez, p. e. 1, nor.74BacteriaEnterboter groupinez, p. e. 1, nor.74BacteriaHelkoboter groupinez, p. e. 1, nor.77BacteriaFrancaella tuberatis, p. e. 1, nor.74HelminitsKiereia manosytigeres, p. e. 1, nor.181FungaiComport Vinter, p. e. 1, nor.71VinuesCandido dirácm, p. g. e. 1, nor.181FungaiComport Vinter, p. e. 1, nor.71VinuesCandido dirácm, p. e. 1, nor.181ProtoraComboter Herpervinte, J. e. 1, nor.71VinuesSamphorupito, Chanismeningito Vinte, g. e., no184BacteriaFeline Lackernia Vinte, y. e. 1, nor.71VinuesBartela burgdoring, r. e. 1, nor.184BacteriaFactola Pagetoria, r. e. 1, nor.71BacteriaChangdoring pagetor, r. e. 1, nor.183VinuesCalabetard Vinte, y. e. 1, nor.71BacteriaChangdoring pagetoria, r. e. 1, nor.183VinuesReciclabetard Vinte, y. e. 1, nor.71BacteriaChangdoring pagetoria, r. e. 1, nor.183VinuesReciclabetard Vinte, y. e. 1, nor.71BacteriaChangdoring pagetoria, r. e. 1, nor.183BacteriaReciclabetard Vinte, y. e. 1, nor.71BacteriaChangdoring pagetoria, r. e. 1, nor.183BacteriaReciclabetard Vinte, y. e. 1, nor.71BacteriaChangdoring pagetoria, r. e. 1, nor.183BacteriaRe	<i>Escherichia coli</i> , _{Z, E} , н, _{DISC}	524	Bacteria	Salmonella enterica subsp. enterica serovar typhimurium, _{Z, E, H, DISC}	77	Bacteria
Heinchadter gylori, 2, H. H. Doc 246 Bacteria Preudamonskip, 2, H. H. Doc 75 Bacteria Peudamonskie aruginska, 2, H. H. Doc 243 Bacteria Preudamonskie, 7, H. H. Doc 74 Bacteria Deudamonskie aruginska, 2, H. Doc 184 Vituses Neespore caninum, X., H. NR 74 Wituses Gandda allkann, 2, H. Soc 184 Vituses Boorine Herpewinks J, H. NK, Soc 70 Wituses Springhocytic Chorhomeningits Vitus, 2, H. Soc 146 Bacteria Corobacter Freundit, X. E. H. Soc 70 Wituses Bornish bargdorferi, 2, H. H. Soc 146 Bacteria Predicola Macrita, Y. H. NK, Soc 60 Wituses Bornish bargdorferi, 2, H. H. Soc 143 Bacteria Macrial Macrita, Y. H. NK, Toc 61 Wituse Absorder Macrita, F. L. H. Soc 120 Bacteria Macrial Macrita, W. M. NK, Toc 61 Wituse Charnydophrilis preumonishe J. N. NK, NK, M. NK,	Staphylococcus aureus, _{z, e, н}	271	Bacteria	Brucella abortus, _{Z, E, H, OIE}	76	Bacteria
Pacudomos aeruginoso, 2 m, H243BacteriaPronocolo Autorento, 2 m, N74BacteriaIbleria monocytogens, 2 m, N271BacteriaHoemonchus controtto, 1 m, N, N, N, N74HelmintsIbleria monocytogens, 2 m, N181ViruseNeopore controtto, 1 m, N, N, N, N, N71ViruseCandida dinkam, 2 m, N181FinagiCoopox Virus, 2 m, N71ViruseLymphotytic Donormeningits Virus, 2 m, N181ProtozoaCarobacter freurdit, N, M, N, M, N, N81ViruseBacteriaAdde SacteriaFinale Larkenia Virus, N, M, N,	Helicobacter pylori, z, NE, H, DISC	246	Bacteria	Enterobacter aerogenes, Z, NE, H, DISC	75	Bacteria
Listeria monocycogorene, z.e. n. 207 Bezeria Hermonchus construits, w.e. m. w. 74 Herminchus Murine Leukemia Viruk, z.e. n. 184 Viruxes Noopora contumun, w.g. n.e. n.e. 72 Protozoa Campido Discorra, z.e. n.oc 184 Viruxes Borine Herpesvirus 1, w.m. n.c. os 70 Viruses Lymphonycit, Choriomeningitis Virus, z.e. n.g. 148 Protozoa Compositie Herpesvirus 1, w.m. n.c. os 70 Viruses Borelia bazadari, z.e. n.soc 146 Bazteria Feline Leukemia Virus, y.g. n.g. n.c. os 88 Hermithy Alabdalia prozumanide, z.g. H. noc 143 Bazteria Relational contentity, N.g. n.g. n.c. os 60 Wiruses Contradium Moord, z.g. H. noc 132 Bazteria Manheimia hermolytica, z.e. n.g. os 67 Bazteria Mycobacterium Moord, z.g. H. noc 122 Bazteria Rehabello oprice, J. n.g. n.g. os 66 Wiruses Captrodorar of prodorar of prodoraro of prodorar	Pseudomonas aeruginosa, _{Z, E, H}	243	Bacteria	Francisella tularensis, _{Z, E, H, OIE}	74	Bacteria
Murine Luxemia Muxis 2, k, k, Dace 184 Visues Nonsport Continuum, Ma, Ma, HA, MA, CA, HA, MA, MA, HA, HA, HA, MA, MA, HA, HA, HA, HA, MA, MA, HA, HA, HA, HA, HA, HA, HA, HA, HA, H	Listeria monocytogenes, _{Z, E, H}	207	Bacteria	Haemonchus contortus, _{NZ, NE, NS}	74	Helminths
Candda abkans, 2, E, M, DOC 181 Fungi Cowpox Virus, 2, M 71 Viruses Lymphocytic. Choriomeningits Virus, 2, ME, H 148 Viruses Bovine Harpesvirus 1, NZ, NE, HE, DUE 70 Viruses Kebsidi preumonike, 2, E, N, DMC 146 Bacteria Feline Leukemia Virus, 52, M, NE, MC 69 Viruses Borrelia burgdorfari, 2, E, N, DMC 143 Bacteria Rectuodordorbeliosis Virus, ME, ME, MC 68 Helminths Chordydophia mumorike, 2, E, H, OGC 135 Viruses Coxelia burrelli, 2, E, N, DMC 67 Bacteria Mycobacterium boxis, 2, E, H, OGC 130 Bacteria Infectious Bonchits Virus, N, M, N, DMC 66 Viruses Clastradium difficilit, 2, E, H 126 Bacteria Bacteria Bacteria Bacteria Bacteria Borine Leukemia Virus, N, M, N, DMC 65 Viruses Staphylococcus endormaris, 2, E, H 126 Bacteria Borine Leukemia Virus, N, M, N, DMC 65 Viruses Staphylococcus endormaris, 2, E, H, Soc 106 Bacteria Porainfleera Virus, N, M, N, DMC 65 Viruses	Murine Leukemia Virus, _{Z, E, NS}	184	Viruses	Neospora caninum, _{NZ, NE, NS}	72	Protozoa
Lymphopytic Chaiomeninghits Virus, 2, Mie, M. 148 Viruses Bovine Herpevirus 1, N.E. N.E. NG. 70 Viruses Dataplasma gandil, 2, E. N. Gosc 148 Patoboa Cirobacter freundil, N.E. E. N. Gosc 70 Batteria Barrelia burgdorfel, 2, E. N. Ensc 144 Batteria Felle Leuenhal Virus, X.E. N.E. NG. 68 Helminths Chainrydophili g neuronnike, 2, E. N. Ensc 143 Batteria Reticuloendotheliosis Virus N.M. M.S. DOC 68 Wiruses Inhuenza A Viruse, 2, E. N. Ginc 130 Batteria Infectious Bronchink Ortes, N.E. M.S. DOC 66 Batteria Corputationationality, 2, E. N. Ginc 130 Batteria Kebelali opationator, N.E. M.S. DOC 65 Heinenths Corputationationation, 2, E. N. DOC 130 Batteria Borna Disease Virus, 2, M. N.E. DOC 65 Viruses Corputationationation, 2, E. N. DOC 136 Fungi Accaris suum, 2, M. N.B. DOC 65 Viruses Status antimator, 2, E. N. DOC 136 Batteria Complobacter ool, X.M. N.S. DEC. NO.DOC 65 Viruses Status antimator 111 <td< td=""><td>Candida albicans, _{Z, E, H, DISC}</td><td>181</td><td>Fungi</td><td>Cowpox Virus, _{Z, E, NS}</td><td>71</td><td>Viruses</td></td<>	Candida albicans, _{Z, E, H, DISC}	181	Fungi	Cowpox Virus, _{Z, E, NS}	71	Viruses
Tacaghana gondh, z. E. H. BDC 148 Potozoa Grobhacter freundil, w. Z. H. SDC 70 Bacteria Kiebsleila preumonike, z. H. BDC 146 Bacteria Feline Leukemia Virus, w. H. KS 69 Viruses Kiebsleila preumonike, z. H. BDC 144 Bacteria Fecina Leukemia Virus, w. H. KS 69 Viruses Chanydophila preumonike, z. H. H. DSC 133 Bacteria Reticuleendorheliois Virus, N. K. HS, DSC 68 Viruses Koobacteri bright, z. L. H. DSC 132 Bacteria Monthelini brannylicitor, S. M. KN, DSC 66 Viruses Coprodoctar independenting, z. L. H. DSC 130 Bacteria Infectious Bronchritis Virus, N. R. KN, DSC 66 Bacteria Coprodoctar independenting, z. L. H. DSC 120 Bacteria Borna Disease Virus, z. E. KD, DSC 65 Wiruses Staphylococccar independenting, z. H. H. DSC 106 Bacteria Comproheacter Media Virus, N. M. KD, DSC 65 Wiruses Bacteria Comproheacter Media Virus, N. M. KD, DSC 65 Wiruses Social Bacteria Viruses Staphylococcccar independenting, z. H. H. DSC	Lymphocytic Choriomeningitis Virus, _{Z, NE, H}	148	Viruses	Bovine Herpesvirus 1, NZ, NE, NS, OIE	70	Viruses
Schebiella preumonida, 2, E, N, DOC 146 Bacteria Feline Leukemia Virus, NE, NE, DOC 69 Viruses Borelia burgdorfer, X, E, H, Noc 144 Bacteria Facciola hapárcir, Z, M, N, DOC 68 Helminths Influenza A Virus, Z, E, H, Noc 135 Viruses Coxiella burnetii, Z, L, M, OBC 67 Bacteria Mycobacterium boxis, Z, E, H, Noc 130 Bacteria Manhemia hazmodytica, Z, M, N, Soc. 67 Bacteria Groupbobacteri (Bint), Z, E, N, Noc 130 Bacteria Manhemia hazmodytica, Z, M, N, Soc. 66 Wiruses Clostridum difficite, Z, E, H 127 Bacteria Manhemia hazmodytica, Z, M, N, Soc. 66 Niruses Stabilis anthaze, X, E, H, Noc 122 Bacteria Bornalis Bornalis Stabilis anthaze, X, M, Noc. 65 Viruses Stabilis anthaze, X, L, H, Noc 106 Bacteria Parainfluenza Virus, X, M, Noc. 65 Viruses Stabilis anthaze, X, M, Noc 106 Viruses Parainfluenza Virus, X, M, Noc. 65 Viruses Stabilis preprivirus Y, N, Noc, M, L, Noc 105	Toxoplasma gondii, _{Z, E, H, DISC}	148	Protozoa	Citrobacter freundii, _{NZ, E, NS, DISC}	70	Bacteria
Barrelia burgdorfari, J., L. H., DOC 144 Bacteria Fasciala hepatica, J., L. H., DOC 68 Helminths Chiamydophila pneumonica, J., M. H., DOC 135 Wrusse Coxilia burgetti, J., L. H., DOC 67 Bacteria Informata, A. Yun, S., D., Co. 132 Bacteria Mannheimia hemonyika, J., M., K., DOC 66 Wrusse Compribadeter iptini, J., E. H., DOC 130 Bacteria Infectious Bronchitis Virus, N.R., N.R., DOC 66 Bacteria Contridium difficile, J., E. H., DOC 126 Fungi Accors sum, J., M., S., DOC 65 Viruses Doptococccs mediamedimants, J., E. H., DOC 126 Bacteria Bornia Dissase Virus, J., M. K., DOC 65 Viruses Bacilias creuds, J., H., H., DOC 126 Bacteria Compribodeter in U., M.K., BOC 65 Viruses Bacilias creuds, J., H., H., DOC 126 Bacteria Controlidum bitilium, T.K., H., NOC 65 Viruses Bacteria Compribodeter in U., M.K., Son 111 Bacteria Controlidum bitilium, T.K., M.K., Son 65 Viruses Suid Herpexitrus, J., M.K., Son 10	Klebsiella pneumoniae, _{Z, E, H, DISC}	146	Bacteria	Feline Leukemia Virus, _{NZ, NE, NS}	69	Viruses
Chlanydophla pneumoniae 2, ME, H, DISC 143 Bacteria Reticuloendotheliosis Virus, MZ, ME, NG, DISC 68 Viruses Minuses Coxiella burnelii, Z, L. NG, OIE 135 Viruses Coxiella burnelii, Z, L. NG, OIE 67 Bacteria Mycobacteri julin, Z, L. NG, OIE 130 Bacteria Infectious Bronchits Virus, MZ, ME, NG, OIE 66 Viruses Clastridium difficile, Z, L. H 127 Bacteria Mebiella oxytoca, NZ, ME, NG, OIE 66 Bacteria Clastridium difficile, Z, L. H 126 Bacteria Borna Disease Virus, NZ, ME, NG, OIE 65 Viruses Bacitria Bacteria Borna Disease Virus, Z, ME, NG, OIE 65 Niruses Staphylococcus epidemidis, Z, L. H, OIE 114 Bacteria Camplobacter Coli, Z, ME, NG, OIE 65 Niruses Bacteria Camplobacter Coli, Z, ME, NG, OIE 65 Viruses Partimine Parvovirus, Z, ME, NG, OIE 65 Viruses Staphylococcus epidemidis, Z, L. M, DISC 106 Viruses Partimine Parvovirus, Z, ME, NG, OIE 65 Viruses Staphylococicus epidemidis, Z, L. M, DISC 10	Borrelia burgdorferi, _{Z, E, H, DISC}	144	Bacteria	Fasciola hepatica, _{Z, E, NS} , DISC	68	Helminths
Influenza A Virus, z. p. H. Ge 135 Viruses Coxiella burnetil, z. p. N. Ge 67 Bacteria Mycobacter jum bork, z. p. H. Ge 132 Bacteria Manheimia haemolytico, z. N. M. NGC 67 Bacteria Campylobacter jum bork, z. p. H. GE 130 Bacteria Infectious Bronchits Virus, y. N. M. GO 66 Viruses Costridium difficle, z. p. H. GE 127 Bacteria Bacteria Bacteria 65 Helminths Cyptococcus neoformans, z. c. H. GOC 126 Fungi Ascaris sum, z. N. N. SC 65 Viruses Salius anthracis, z. s. H. GOC 128 Bacteria Borna Dissaev Virus, z. g. N. N. SC 65 Viruses Salius anthracis, z. s. H. OBC 114 Bacteria Campylobacter coli, z. M. N. SOC 65 Viruses Salius anthracis, z. s. N. N. SOC 106 Bacteria Campylobacter colin, z. M. N. SOC 65 Viruses Salius anthracis, z. M. N. SOC 106 Viruses Pasturella multodadi, z. m. N. SOC 65 Bacteria Bacteria Campylobacter colin, z. M. N. SOC 65 Viruses	Chlamydophila pneumoniae, _{Z, NE, H, DISC}	143	Bacteria	Reticuloendotheliosis Virus, _{NZ, NE, NS, DISC}	68	Viruses
Mycobacterium bovis, z, E, H, GBC 132 Bacteria Monnheimia hoemolytica, z, E, H, SGC 67 Bacteria Compyblacter jejunt, z, E, H, GBC 130 Bacteria Infectious Bronchitis Virus, x, H, RS, GBC 66 Wruses Clostridium difficile, z, E, H 127 Bacteria <i>Riebsiello oxytoca, Ha, Ha, SD, GBC</i> 65 Bacteria Clostridium difficile, z, E, H 126 Bacteria Borna Disease Virus, z, E, NS, DGC 65 Viruses Bodilus anthrock, z, E, H, GBC 112 Bacteria Borna Disease Virus, z, E, NS, DGC 65 Viruses Staphylococcus epideminis, z, E, H, GBC 114 Bacteria Campylobacter coli, z, ME, NS, DBC 65 Viruses Staphylococcus epideminis, z, NE, H, DBC 106 Bacteria Parainfluenza Virus S, Z, HK, NS, DBC 65 Viruses Solid Herpsvirus, J, H, S, NE, NS, OB 105 Viruses Pasteurill multicolda, z, NE, NS, OBC 65 Viruses Bowine Spongiform Encephalopathy agent, P, K, NS, OB 101 Viruses Bateeria 64 Viruses Bowine Spongiform Encephalopathy agent, P, NS, OB 101 Viruses Buetongue Virus, MZ, E, NS, OB 63 Bacteria Encephalomycardiffor Encephalopathy agent, P, NS, OB 98 Protozoa Enterococus dipalotita, E, E, NS,	Influenza A Virus, _{Z, E} , H, OIE	135	Viruses	Coxiella burnetii, _{Z, E, NS, OIE}	67	Bacteria
Campylobacter jejuni, 2, E, H, DSC 130 Bacteria Infectious Bronchitis Virus, NZ, NE, NS, OBC 66 Wiruses Costridium difficile, 2, E, H, DSC 126 Fungi Ascaris suum, 2, NE, NS, OBC 65 Helminths Cryptococcus neoformans, 2, E, H, OBC 126 Fungi Ascaris suum, 2, NE, NS, DBC 65 Viruses Bacillus anthracis, 2, E, H, OBC 122 Bacteria Bowine Leukemia Virus, NZ, NE, NS, DBC 65 Bacteria Staphylobacter of U, S, NE, NS, DBC 05 Bacteria Camipe Parvovirus, NZ, NE, NS, DBC 65 Viruses Stadi Herpesvinus 1, NZ, NE, NS, OBC 106 Bacteria Parainfluenzy Virus 5, Z, NE, NS 65 Viruses Suid Herpesvinus 1, NZ, NE, NS, OBC 106 Viruses Parainfluenzy Virus 5, Z, NE, NS 65 Viruses Suid Herpesvinus 1, NZ, NE, NS, OBC 105 Viruses Parcine Ciccovirus, NZ, E, NS, OBC 65 Viruses Syndrome Virus, NZ, L, NS, OBC 105 Wiruses Syndrome Virus, NZ, E, NS, OBC 63 Bacteria Bovine Sponglform Encephalopathy agent, 2, L, N, DBC 101 Viruses	Mycobacterium bovis, _{z, e, н, оle}	132	Bacteria	Mannheimia haemolytica, _{Z. NE, NS, DISC}	67	Bacteria
Clostridlum difficile, Z, E, H 127 Bacteria Klebsiella oxytoca, KZ, KE, KS, DOC. 66 Bacteria Coptococcus neoformans, Z, E, H, DBC 126 Fungi Ascaris suum, Z, NE, NS, DOC. 65 Viruses Bacillus anthracis, Z, E, H, DBC 126 Bacteria Borna Disease Virus, Z, E, NS, DOC. 65 Viruses Staphylococcus epidermidis, Z, E, H, DBC 114 Bacteria Davine Euclewinal Virus, NZ, NE, NS, DOC. 65 Viruses Bacillus anthracis, Z, E, H, DBC 111 Bacteria Campylobacter coli, Z, NE, NS, DOC. 65 Viruses Bacillus anthracis, Z, E, K, DBC 106 Bacteria Parainfluenza Virus, S, Z, NE, NS, DOC. 65 Viruses Suid Herpesvirus 1, NZ, NE, NS, OBC 106 Viruses Parainfluenza Virus, S, Z, NE, NS, DOC. 65 Viruses Buvine Spongiform Encephalopathy agent, S, Z, E, K, DBC 105 Viruses Syndrome Virus, NZ, E, NS, DBC. 63 Bacteria Clostridium perfingens, Z, NE, H 101 Bacteria Chlomydophila abortus, Z, E, NS, DBC. 63 Bacteria Clostridum perfingens, Z, NE, H 101 Bacteria Chlomydophila abortus, Z, E, NS, DBC. 63	Campylobacter jejuni, _{Z. E. H. DISC}	130	Bacteria	Infectious Bronchitis Virus, NZ, NE, NS, OIE	66	Viruses
Cyptococcus neoformans, z, E, H, DBC 126 Fungli Ascaris sumi, z, NE, NS 65 Helminths Yersinia enterocolitica, z, E, H, DBC 126 Bacteria Borna Disease Virus, z, E, NS, DBC 65 Wiruses Bacillus anthracis, z, E, H, OBC 112 Bacteria Borine Leukemia Yurus, XE, KS, DBC 65 Wiruses Bacillus cereus, z, NE, H, DBC 114 Bacteria Cannipolocater coli, z, NE, NS, DBC 65 Wiruses Suid Herpesvirus 1, NE, NS, DB 106 Viruses Pasteurella multorida, Z, NE, NS, DBC 65 Wiruses Suid Herpesvirus 1, NE, NS, DB 106 Viruses Pasteurella multorida, Z, NE, NS, DBC 65 Wiruses Suid Herpesvirus 1, NE, NS, DB 105 Viruses Porcine ficrovirus, NZ, E, NS, DBC 65 Viruses Bovine Spongiform Encephalopathy agent, Z, E, NS, DBC 101 Viruses Buctoria 63 Bacteria Prisnia pestis, z, E, H, DBC 98 Protozoa Enterococcus hirae, z, NE, NS, DBC 63 Bacteria Editindin donovari, z, E, H, DBC 97 Bacteria Anaplasma phagocytophilun, z, E, NS, DBC 63 Bacteria Entarooba hiso	Clostridium difficile, z, E, H	127	Bacteria	Klebsiella oxytoca, _{NZ. NE. NS.} DISC	66	Bacteria
Yersinia enterocolitica, Z, E, H.126BacteriaBorna Disease Virus, Z, E, HS, DNC65VirusesBacillus anthracis, Z, E, H, OE122BacteriaBovine Leukemia Virus, NZ, NE, NS, DNC65WirusesStaphylobaccurs epidermidis, Z, E, H, DNC111BacteriaCampylobacter colit, Z, IR, NS, DNC65WirusesOctoridum borum, Z, E, H, DNC106BacteriaParainfluenza Virus, S, Z, NE, NS, OS65WirusesSuid Herpesvirus 1, NZ, NE, NS, OS106VirusesParainfluenza Virus, S, Z, NE, NS, OS65VirusesSuid Herpesvirus 1, NZ, NE, NS, OS106VirusesParainfluenza Virus, S, R, NS, OSC65VirusesBovine Spongiform Encephalopathy agent, Z, E, NS, ONC105VirusesPorcine Agropoductive and Respiratory Syndrome Virus, NZ, E, NS, ONC63BacteriaBovine Spongiform Encephalopathy agent, Z, E, NS, ONC01VirusesBluetongue Virus, NZ, ENS, ONC63BacteriaClostridium perfingens, Z, NE, H101BacteriaChlamydophila abortus, Z, E, NS, ONC63BacteriaEntamoeba histolytica, Z, NE, H, DNC98ProtozoaEnterococcus hirae, Z, NE, NS, ONC63BacteriaBacteria da anonyni, Z, E, H, ONC97BacteriaAnaplasma phagocytophilum, Z, E, NS, ONC62BacteriaBacteria digilis, Z, NE, H, DNC95VirusesEquine Infectious Anemia Virus, NZ, NE, NS, ONC62WirusesBacteria da anonyni, Z, E, H, ONC97BacteriaAnaplasma phagocytophilum, Z, E, NS, ONC62 <td>Cryptococcus neoformans, Z. E. H. DISC</td> <td>126</td> <td>Fungi</td> <td>Ascaris suum, z. NE. NS</td> <td>65</td> <td>Helminths</td>	Cryptococcus neoformans, Z. E. H. DISC	126	Fungi	Ascaris suum, z. NE. NS	65	Helminths
Bacillus anthracis, Z., E. H., Diec 122 Bacteria Bovine Leukemia Virus, R.Z., R.K., Disc 65 Viruses Staphylococcus epidemidis, Z., E. H., Disc 114 Bacteria Campylobacter coli, Z., NE, NS, Disc 65 Bacteria Bacillus cereus, Z., KE, H., Disc 111 Bacteria Canine Parvovirus, NZ, NE, NS 65 Viruses Clostridium botulinum, Z. E. H., Disc 106 Bacteria Parainfluenza Virus, Z., NE, NS, OE 65 Viruses Suid Herpesvirus 1, NZ, NE, NS, OIE 105 Viruses Porcine circovirus, NZ, RE, NS, Disc 65 Viruses Sourine Spongiform Encephalopathy agent, Z., K., NG, OIE 105 Bacteria Porcine Reproductor, NS, OIE 64 Viruses Bovine Spongiform Encephalopathy agent, Z., NK, NG 101 Viruses Buetongue Virus, NZ, E. NS, OIE 63 Bacteria Persina pestifs, Z., KE, H. 101 Bacteria Chlamydophila pittaci, Z., E. NS, DISC 63 Bacteria Persina pesudotuberulosis, Z., KE, H. 101 Bacteria Chlamydophila pittaci, Z., E. NS, DISC 63 Bacteria Persina pesudotuberulosis, Z., KE, H. 103 Bacteria Anaplasma phagocytophilar, N.K., So 63 Bacteria Persina pesudotuberulosis, Z., KE, NDISC 98 Protozoa Gallid Her	Yersinia enterocolitica, _{7 E H}	126	Bacteria	Borna Disease Virus, z F NS DISC	65	Viruses
Staphylococcus pidermidis, z, E, H, DBC114BacteriaCampylobacter coli, z, NE, NS, DBC65BacteriaBacillus cereus, z, NE, H, DBC111BacteriaCanine Parvovirus, NZ, NE, NS65VirusesClostridium botulinum, z, E, H, DBC106BacteriaParainfluenza Virus 5, z, NE, NS65VirusesSuid Herpesvirus 1, NZ, NE, NS, ORE106VirusesParainfluenza Virus, S, Z, NE, NS, ORE65BacteriaEncephalomyocarditis Virus, z, NE, H, DBC105VirusesPorcine Reproductive and Respiratory65VirusesYersinia pestis, z, E, H, DBC101VirusesButeongue Virus, NZ, E, NS, ORE64VirusesSolvie Spongiform Encephalopathy agent, z, E, NS, ORE101BacteriaChamydophila botrus, z, E, NS, ORE63BacteriaClostridium perfingens, z, NE, H101BacteriaChamydophila botrus, z, E, NS, ORE63BacteriaClostridium perfingens, z, NE, H101BacteriaChamydophila botrus, z, E, NS, ORE63BacteriaLeishmania donovani, z, E, H, ORE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacteria/Leishmania donovani, z, E, H, ORE97BacteriaAnaplasma phagocytophilum, z, E, NS, ORE62BacteriaBabies Virus, z, E, H, ORE96VirusesStreptococcus brane, z, E, NS, ORE61VirusesBabies Virus, z, E, H, ORE97VirusesEquine Infectious Anemia Virus, NZ, E, NS, ORE62BacteriaBovine Papillomavirus, NZ, E, H, ORE<	Bacillus anthracis, 7 F H OF	122	Bacteria	Bovine Leukemia Virus, NZ NE NS DISC	65	Viruses
Backlus cereus, z., NE, H. DISC111BacteriaCanine Parvovirus, NZ, NE, NS65VirusesClostridium botulinum, z., E. H., DISC106BacteriaParainfluenza Virus 5, Z., NE, NS65VirusesSuid Herpesvirus 1, NZ, NE, NS, OIE106VirusesPasteurella multocida, z., NE, NS, OIE65BacteriaEncephalomyocarditis Virus, z., NE, H., DISC105VirusesParaine Reproductive and Respiratory65VirusesVersinia pestis, z., E. H., DISC105BacteriaPorcine Reproductive and Respiratory65VirusesBovine Spongiform Encephalopathy agent, z. E. NS, OIE101VirusesBluetongue Virus, NZ, E. NS, OIE63BacteriaClostridium perfringens, z., NE, H101BacteriaChlamydophila abortus, z. E. NS, OISC63BacteriaClostridium perfringens, z., NE, H101BacteriaChlamydophila psittoci, z. E. OIS, OISC63BacteriaEntamoeba histofytica, z., NE, H, DISC98ProtozoaEnterococcus hirae, z. NE, NS, OISC63BacteriaEntamoeba histofytica, z., NE, H, DISC97BacteriaAnaplasma phagocytophilum, z. E. NS, OISC62BacteriaBacteriodes fragilis, z., NE, H, OISC97VirusesEquine Infectious Anemia Virus, NZ, E. NS, OIE61VirusesRabies Virus, z., E. H, OISC95VirusesStreptococcus graanulosus, z. E. NS, OIE61VirusesRobies Papillomavirus, NZ, E. NS, OIE91VirusesEquine Anterinis Virus, NZ, E. NS, OIE60Viruses<	Staphylococcus epidermidis, z E H DISC	114	Bacteria	Campylobacter coli, z NE NS DISC	65	Bacteria
Costridium boulinum, Z., E. H., DOSC106BacteriaParainfluenza Virus S., Z. NE, NS, ONE65VirusesSuid Herpesvirus 1, NZ, NE, NS, ONE106VirusesPasteurella multocida, Z. NE, NS, ONE65BacteriaEncephalomyocarditis Virus, Z., NE, NS, ONE105VirusesPorcine circovirus, NZ, E. NS, ONE65VirusesYersinia pestis, Z., E. H., DISC105BacteriaPorcine Reproductive and Respiratory65VirusesBovine Spongiform Encephalopathy agent, Z., E. NS, ONE101VirusesBluetongue Virus, NZ, E. NS, ONE63BacteriaPersinia pseudotuberculosis, Z., NE, H101BacteriaChlamydophila psittaci, Z. E. ONE, NS63BacteriaPersinia pseudotuberculosis, Z., NE, H101BacteriaChlamydophila psittaci, Z. E. ONE, NS63BacteriaLeishmania donovani, Z. E., H, ONE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacteriaies fragilis, Z., NE, H, ONE97BacteriaAnaplasma phagocytophilum, Z. E. NS, ONE62VirusesBovine Papillomavirus, NZ, E., H, ONE96VirusesStreptococcus agalactaer, Z. E. NS, ONE61HelminthsNewcastle Disease Virus, Z., E., H, ONE93VirusesEquine Arteritis Virus, NZ, E. NS, ONE61VirusesRabie Virus, Z. E., H, ONE94VirusesEchinococcus granulosus, Z. E. NS, ONE61VirusesRabie Virus, Z. E., H, ONE95VirusesEquine Arteritis Virus, NZ, E. NS, ONE61VirusesRabi	Bacillus cereus, z NE H DISC	111	Bacteria	Canine Parvovirus, NZ NE NS	65	Viruses
Solid Herpesvirus 1, NZ, ME, NS, OBE106VirusesPasteurella multocida 2, ME, NS, OBE65BacteriaEncephalomyocarditis Virus, 2, ME, H, DSC105VirusesPorcine circovirus, NZ, E, NS, OBE65VirusesBevine Sponjform Encephalopathy agent, 2, E, NS, OBE101VirusesBluetongue Virus, NZ, E, NS, OBE64VirusesBovine Sponjform Encephalopathy agent, 2, E, NS, OBE101VirusesBluetongue Virus, NZ, E, NS, OBE63BacteriaClostridium pefringens, Z, NE, H101BacteriaChlamydophila abortus, Z, E, NS, DBC63BacteriaClostridium pefringens, Z, NE, H101BacteriaChlamydophila abortus, Z, E, NS, DBC63BacteriaEntamoeba histolytica, Z, NE, H, DBC98ProtozoaGallid Herpesvirus 2, NZ, NE, NS, DBC63BacteriaEstimania donovani, Z, E, H, OBE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacteriades fragilis, Z, NE, H, DBC97BacteriaAnaplasma phagocytophilum, Z, E, NS, OBE62BacteriaWest Nile Virus, Z, E, H, OBE96VirusesStreptococcus agalactiae, Z, E, NS, OBE61HelminthsNewcastE Disease Virus, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, OBE61VirusesBovine Papillomavirus, Z, KE, NS, OBE95VirusesEquine Infectious Anemia Virus, NZ, E, NS, OBE61VirusesEnterobacter Disease Virus, Z, KE, NS, OBE93VirusesEquine Arteritis Virus, NZ, E, NS, OBE60Viruses <td>Clostridium botulinum, z E H DISC</td> <td>106</td> <td>Bacteria</td> <td>Parainfluenza Virus 5, z NE NS</td> <td>65</td> <td>Viruses</td>	Clostridium botulinum, z E H DISC	106	Bacteria	Parainfluenza Virus 5, z NE NS	65	Viruses
InterventionProductionProcessor<	Suid Herpesvirus 1, NZ NE NE OF	106	Viruses	Pasteurella multocida, z NE NS OF	65	Bacteria
Yersinia pestis, z, E, H, DDC105BacteriaPorcine Reproductive and Respiratory Syndrome Virus, NZ, E, NS, OIE65VirusesBovine Spongiform Encephalopathy agent, z, E, NS, OIE101VirusesBluetongue Virus, NZ, E, NS, OIE64VirusesBovine Spongiform Encephalopathy agent, z, E, NS, OIE101BacteriaChlamydophila abortus, z, E, NS, OIE63BacteriaClostridium perfringens, z, NE, H101BacteriaChlamydophila psittaci, z, E, NS, DISC63BacteriaClostridium perfringens, z, NE, H, DISC98ProtozoaEnterococcus hirae, z, NE, NS, OIE63BacteriaEntamoeba histolytica, z, NE, H, DISC98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacteriaAnaplasma phagocytophilany, z, E, NS, OIE62BacteriaLeishmania donovani, z, E, H, OIE97BacteriaAnaplasma phagocytophiluny, z, NS, OIE62BacteriaBovine Papillomavirus, NZ, E, NS, DISC95VirusesEtriptococcus agalactica, z, E, NS, OIE61HelminthsNewcastle Disease Virus, z, E, H, OIE93VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, z, E, H90BacteriaCanine Distemper Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, z, E, H92ProtozoaMaedi Visna Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, z, E, H90BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesAeromonas hydroph	Encephalomyocarditis Virus, z NE H DISC	105	Viruses	Porcine circovirus, NZ E NS DISC	65	Viruses
Bovine Spongiform Encephalopathy agent, 2, E, NS, OIE101VirusesBluetongue Virus, NZ, E,NS, OIE64VirusesClostridium perfringens, Z, NE, H101BacteriaChlamydophila abortus, Z, E, NS, DISC63BacteriaYersinia pseudotuberculosis, Z, NE, H99BacteriaChlamydophila psittaci, Z, E, OE, NS63BacteriaEntamoeba histolytica, Z, NE, H, DISC98ProtozoaEnterococcus hirae, Z, NE, HS, DISC63BacteriaLeishmania donovani, Z, E, H, OIE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacteria/stragilis, Z, NE, H, DISC97BacteriaAnaplasma phagocytophilum, Z, E, NS, OIE62BacteriaBacteria/stragilis, Z, E, H, OIE97VirusesEquine Infectious Anemia Virus, NZ, E, NS, OIE62BacteriaBovine Papillomavirus, NZ, E, H, OIE96VirusesStreptococcus agalactiae, Z, E, NS, OIE61HelminthsNewcastle Disease Virus, Z, NE, NS, DISC93VirusesEquine Anteritis Virus, NZ, E, NS, OIE61VirusesEnterobacter cloacae, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z, NE, MS, OIE89VirusesEquid Herpesvirus 1, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, NZ, E, MS, OIE89VirusesEquid Herpesvirus 1, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica servoar87BacteriaInfectious Bursal Disease Virus, NZ, E, NS, OIE60<	Yersinia pestis, _{Z, E, H, DISC}	105	Bacteria	Porcine Reproductive and Respiratory Syndrome Virus, _{NZ, E, NS, OIE}	65	Viruses
Clostridium perfringens, Z. NE, H101BacteriaChlamydophila abortus, Z. E. NS, DISC63BacteriaYersinia pseudotuberculosis, Z. NE, H, DISC98ProtozoaEnterococcus hirae, Z. NE, NS, DISC63BacteriaEntamoeba histolytica, Z. NE, H, DISC98ProtozoaGallid Herpesvirus 2, NZ, NE, NS, DISC63BacteriaLeishmania donovani, Z. E, H, OIE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS, DISC63BacteriaBacterioles fragilis, Z. NE, H, DISC97BacteriaAnaplasma phagocytophilum, Z. E, NS, OIE62BacteriaWest Nile Virus, Z. E, H, OIE97VirusesEquine Infectious Anemia Virus, NZ, NE, NS, OIE62BacteriaRabies Virus, Z. E, H, OIE96VirusesStreptococcus agalactiae, Z. E, NS, OIE61HelminthsNewcastle Disease Virus, Z. NE, NS, DISC95VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z. E, H90BacteriaCanine Distemper Virus, NZ, E, NS, OIE61VirusesEnterobacter cloacae, Z, NE, H90BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z. E, H, OISC89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z, NE, NS, OIE89VirusesEquid Herpesvirus 1, NZ, E, NS, OIE60VirusesSalmenbla cherica subsp. enterica serovar enteritidis, Z, E, H, OISC88BacteriaInfectious Bursal Disease Virus, NZ, NE, NS, OIE </td <td>Bovine Spongiform Encephalopathy agent, z, e, ns, oie</td> <td>101</td> <td>Viruses</td> <td>Bluetongue Virus, _{NZ, E,NS, OIE}</td> <td>64</td> <td>Viruses</td>	Bovine Spongiform Encephalopathy agent, z, e, ns, oie	101	Viruses	Bluetongue Virus, _{NZ, E,NS, OIE}	64	Viruses
Yersinia pseudotuberculosis, Z., NE, H.99BacteriaChlamydophila psittaci, Z., E., OE, NS63BacteriaEntamoeba histolytica, Z., NE, H., DISC98ProtozoaEnterococcus hirae, Z., NE, NS, DISC63BacteriaLeishmania donovani, Z., E. H., OIE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS, DISC63VirusesBacteroides fragilis, Z., NE, H., DISC97BacteriaAnaplasma phagocytophilum, Z., E, NS, OIE62BacteriaWest Nile Virus, Z., E. H., OIE97VirusesEquine Infectious Anemia Virus, NZ, NE, NS, OIE62BacteriaRabies Virus, Z., E. H., OIE96VirusesStreptococcus agalactiae, Z., E, NS61HelminthsNewcastle Disease Virus, Z., E. NS, OIE95VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z., E, H90BacteriaCanine Distemper Virus, NZ, E, NS, OIE60VirusesEnterobacter cloacae, Z., NE, H90BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z., E, H, DISC89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z., E, H, DISC88BacteriaInfectious Bursal Disease Virus, NZ, E, NS, OIE60VirusesSalmenella enterica subsp. enterica serovar enteritidis, Z., E, H, DISC88BacteriaInfectious Bursal Disease Virus, NZ, E, NS, OIE60VirusesSalmella enterica subsp. enterica serovar enteritidis, Z., E, H, DISC80 <t< td=""><td>Clostridium perfringens, _{Z, NE, H}</td><td>101</td><td>Bacteria</td><td>Chlamydophila abortus, _{Z, E, NS, DISC}</td><td>63</td><td>Bacteria</td></t<>	Clostridium perfringens, _{Z, NE, H}	101	Bacteria	Chlamydophila abortus, _{Z, E, NS, DISC}	63	Bacteria
Entamoeba histolytica, Z, NE, H, DISC98ProtozoaEnterococcus hirae, Z, NE, NS, DISC63BacteriaLeishmania donovani, Z, E, H, OIE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacterides fragilis, Z, NE, H, DISC97BacteriaAnaplasma phagocytophilum, Z, E, NS, OIE62BacteriaWest Nile Virus, Z, E, H, OIE97VirusesEquine Infectious Anemia Virus, NZ, NE, NS, OIE62VirusesRabies Virus, Z, E, H, OIE96VirusesStreptococcus agalactiae, Z, E, NS, OIE61HelminthsNewcastle Disease Virus, NZ, E, NS, OIE95VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z, E, H92ProtozoaMaedi Visna Virus, NZ, E, NS, OIE61VirusesEnterobacter cloacae, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z, NE, H, DISC89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z, NE, H, DISC88BacteriaInfectious Bursal Disease Virus, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica serovar enteridis, Z, E, H, DISC84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, OIE60VirusesClassical Sime Fever Virus, NZ, E, NS, OIE84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, OIE59BacteriaBovine Viral Diarrhea Virus I, NZ, E, NS, OIE80VirusesFeline Calicivirus, Z, E	Yersinia pseudotuberculosis, _{Z, NE, H}	99	Bacteria	Chlamydophila psittaci, _{Z, E, OIE, NS}	63	Bacteria
Leishmania donovani, Z, E, H, OIE98ProtozoaGallid Herpesvirus 2, NZ, NE, NS63VirusesBacteriaAnaplasma phagocytophilum, Z, E, NS, OIE62BacteriaWest Nile Virus, Z, E, H, OIE97VirusesEquine Infectious Anemia Virus, NZ, NE, NS, OIE62VirusesRabies Virus, Z, E, H, OIE96VirusesStreptococcus agalactiae, Z, E, NS62BacteriaBovine Papillomavirus, NZ, E, NS, DISC95VirusesEchinococcus granulosus, Z, E, NS, OIE61HelminthsNewcastle Disease Virus, Z, KE, NS, OIE93VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z, E, H92ProtozoaMaedi Visna Virus, NZ, E, NS, OIE61VirusesEnterobacter cloacae, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z, NE, H, OISC89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica serovar enteritidis, Z, E, H, DISC88BacteriaInfectious Bursal Disease Virus, NZ, NE, NS, OIE60VirusesClassical Swine Fever Virus, NZ, NE, NS, OIE84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, DISC59BacteriaBovine Viral Diarrhea Virus I, NZ, E, NS, OIE80VirusesActinobacillus pleuropneumoniae, NZ, E, NS, DISC59BacteriaClassical Swine Fever Virus, NZ, E, NS, OIE80VirusesFeline Calicivirus, Z, E, NS, OIE59Viruses <tr<< td=""><td>Entamoeba histolytica, _{Z, NE, H}, _{DISC}</td><td>98</td><td>Protozoa</td><td>Enterococcus hirae, Z, NE, NS, DISC</td><td>63</td><td>Bacteria</td></tr<<>	Entamoeba histolytica, _{Z, NE, H} , _{DISC}	98	Protozoa	Enterococcus hirae, Z, NE, NS, DISC	63	Bacteria
Bacteroides fragilis, z, NE, H, DISC97BacteriaAnaplasma phagocytophilum, z, E, NS, OIE62BacteriaWest Nile Virus, z, E, H, OIE97VirusesEquine Infectious Anemia Virus, NZ, NE, NS, OIE62VirusesRabies Virus, z, E, H, OIE96VirusesStreptococcus agalactiae, z, E, NS, OIE62BacteriaBovine Papillomavirus, NZ, E, NS, DISC95VirusesEchinococcus granulosus, z, E, NS, OIE61HelminthsNewcastle Disease Virus, z, NE, NS, OIE93VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, z, E, H92ProtozoaMaedi Visna Virus, NZ, E, NS, OIE61VirusesEnterobacter cloacae, z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, DISC60VirusesFoot and Mouth Disease Virus, z, NE, OIE89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica serovar87BacteriaTransmissible Gastroenteritis Virus, NZ, NE, NS, OIE60VirusesClassical Swine Fever Virus, NZ, NE, NS, OIE84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, OIS59BacteriaBovine Viral Diarrhea Virus 1, NZ, E, NS, OIE80VirusesFeline Calicivirus, Z, E, NS, OIE59VirusesFeline Immunodeficiency Virus, NZ, E, NS, OIE80VirusesMyxoma Virus, NZ, NE, NS, OIE59VirusesProteus mirabilis, z, NE H, DISC80BacteriaMyxoma Virus, NZ, NE, NS, OIE59Viruses<	Leishmania donovani, _{z, e, н, оle}	98	Protozoa	Gallid Herpesvirus 2, _{NZ, NE, NS}	63	Viruses
West Nile Virus, Z, E, H, OIE97VirusesEquine Infectious Anemia Virus, NZ, NE, NS, OIE62VirusesRabies Virus, Z, E, H, OIE96VirusesStreptococcus agalactiae, Z, E, NS62BacteriaBovine Papillomavirus, NZ, E, NS, DISC95VirusesEchinococcus granulosus, Z, E, NS, OIE61HelminthsNewcastle Disease Virus, Z, NE, NS, OIE93VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z, E, H92ProtozoaMaedi Visna Virus, NZ, NE, NS, OIE61VirusesEnterobacter cloace, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, DISC60VirusesFoot and Mouth Disease Virus, Z, NE, OIE89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica serovar enteritidis, Z, E, H, DISC88BacteriaInfectious Bursal Disease Virus, NZ, NE, NS, OIE60VirusesClassical Swine Fever Virus, NZ, NE, NS, OIE84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, DISC59BacteriaBovine Viral Diarrhea Virus 1, NZ, E, NS, OIE80VirusesFeline Calicivirus, Z, E, NS, OIE59VirusesFeline Immunodeficiency Virus, NZ, E, NS, OIE80VirusesMyxoma Virus, NZ, NE, NS, OIE59VirusesProteus mirabilis, Z, NE H, DISC80BacteriaEncenhalitozoan cuniculi, Z, E, NS, OIE59VirusesProteus mirabilis, Z, NE H, DISC80BacteriaHoriboacilus pleuropneumoniae, NZ, E, NS, OIE	Bacteroides fragilis, _{Z, NE, H} , DISC	97	Bacteria	Anaplasma phagocytophilum, _{Z, E, NS, OIE}	62	Bacteria
Rabies Virus, Z, E, H, OIE96VirusesStreptococcus agalactiae, Z, E, NS62BacteriaBovine Papillomavirus, NZ, E, NS, DISC95VirusesEchinococcus granulosus, Z, E, NS, OIE61HelminthsNewcastle Disease Virus, Z, NE, NS, OIE93VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z, E, H92ProtozoaMaedi Visna Virus, NZ, NE, NS, OIE61VirusesEnterobacter cloacae, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, DISC60VirusesAeromonas hydrophila, Z, E, H, DISC89BacteriaChicken Anemia Virus, NZ, E, NS, OIE60VirusesFoot and Mouth Disease Virus, Z, NE, OIE89VirusesEquid Herpesvirus 1, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica serovar enteritdis, Z, E, H, DISC87BacteriaTransmissible Gastroenteritis Virus, NZ, NE, NS, OIE60VirusesSoline Viral Diarrhea Virus 1, NZ, E, NS, OIE84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, DISC59BacteriaBovine Viral Diarrhea Virus 1, NZ, E, NS, OIE80VirusesFeline Calicivirus, Z, E, NS, OIE59VirusesFeline Immunodeficiency Virus, NZ, E, NS, OIE80VirusesMyxoma Virus, NZ, NE, NS, OIE59VirusesProteus mirabilis, Z, NE, H DISC80BacteriaEncenbalitozoon cuniculi, Z, E, NS, OIE59Viruses	West Nile Virus, _{Z, E, H, OE}	97	Viruses	Equine Infectious Anemia Virus, _{NZ, NE, NS, OIE}	62	Viruses
Bovine Papillomavirus, NZ, E, NS, DISC95VirusesEchinococcus granulosus, Z, E, NS, OIE61HelminthsNewcastle Disease Virus, Z, NE, NS, OIE93VirusesEquine Arteritis Virus, NZ, E, NS, OIE61VirusesCryptosporidium parvum, Z, E, H92ProtozoaMaedi Visna Virus, NZ, E, NS, OIE61VirusesEnterobacter cloacae, Z, NE, H90BacteriaCanine Distemper Virus, NZ, E, NS, DISC60VirusesAeromonas hydrophila, Z, E, H, DISC89BacteriaChicken Anemia Virus, NZ, E, NS, DISC60VirusesFoot and Mouth Disease Virus, Z, NE, OIE89VirusesEquid Herpesvirus 1, NZ, E, NS, OIE60VirusesSalmonella enterica subsp. enterica serovar enteritdis, Z, E, H, DISC88BacteriaInfectious Bursal Disease Virus, NZ, NE, NS, OIE60VirusesClassical Swine Fever Virus, NZ, NE, NS, OIE84VirusesActinobacillus pleuropneumoniae, NZ, E, NS, DISC59BacteriaBovine Viral Diarrhea Virus 1, NZ, E, NS, OIE80VirusesFeline Calicivirus, Z, E, NS, OIE59VirusesFeline Immunodeficiency Virus, NZ, E, NS80VirusesMyxoma Virus, NZ, NE, NS, OIE59VirusesProteus mirabilis, Z, NE, H, DISC80BacteriaEncephalitozoon cuniculi, Z E NE, OIE59Viruses	Rabies Virus, Z. E. H. OIE	96	Viruses	Streptococcus agalactiae, Z. E. NS	62	Bacteria
Newcastle Disease Virus, z, NE, NS, OIE 93 Viruses Equine Arteritis Virus, NZ, E, NS, OIE 61 Viruses Cryptosporidium parvum, z, E, H 92 Protozoa Maedi Visna Virus, NZ, NE, NS, OIE 61 Viruses Enterobacter cloacae, z, NE, H 90 Bacteria Canine Distemper Virus, NZ, E, NS, DISC 60 Viruses Aeromonas hydrophila, z, E, H, DISC 89 Bacteria Chicken Anemia Virus, NZ, E, NS, DISC 60 Viruses Foot and Mouth Disease Virus, Z, NE, H, DISC 89 Viruses Equid Herpesvirus 1, NZ, E, NS, OIE 60 Viruses Salmonella enterica subsp. enterica serovar enteritidis, z, E, H, DISC 88 Bacteria Infectious Bursal Disease Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS, OIE 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H DISC 80 Bacteria Ence	Bovine Papillomavirus, _{NZ. E. NS. DISC}	95	Viruses	Echinococcus granulosus, Z. E. NS. OIE	61	Helminths
Cryptosporidium parvum, z, E, H 92 Protozoa Maedi Visna Virus, NZ, NE, NS, OIE 61 Viruses Enterobacter cloacae, z, NE, H 90 Bacteria Canine Distemper Virus, NZ, E, NS, DISC 60 Viruses Aeromonas hydrophila, z, E, H, DISC 89 Bacteria Chicken Anemia Virus, NZ, E, NS, DISC 60 Viruses Foot and Mouth Disease Virus, Z, NE, OIE 89 Viruses Equid Herpesvirus 1, NZ, E, NS, OIE 60 Viruses Acinetobacter baumannii, NZ, NE, H, DISC 88 Bacteria Infectious Bursal Disease Virus, NZ, NE, NS, OIE 60 Viruses Salmonella enterica subsp. enterica serovar enteritidis, z, E, H, DISC 87 Bacteria Transmissible Gastroenteritis Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS, OIE 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H DISC 80 Bacteria	Newcastle Disease Virus, Z. NF. NS. OIF	93	Viruses	Equine Arteritis Virus, NZ, F. NS, OF	61	Viruses
Enterobacter cloacae, z, NE, H 90 Bacteria Canine Distemper Virus, NZ, E, NS, DISC 60 Viruses Aeromonas hydrophila, z, E, H, DISC 89 Bacteria Chicken Anemia Virus, NZ, E, NS, DISC 60 Viruses Foot and Mouth Disease Virus, Z, NE, OIE 89 Viruses Equid Herpesvirus 1, NZ, E, NS, OIE 60 Viruses Acinetobacter baumannii, NZ, NE, H, DISC 88 Bacteria Infectious Bursal Disease Virus, NZ, NE, NS, OIE 60 Viruses Salmonella enterica subsp. enterica serovar enteritidis, z, E, H, DISC 87 Bacteria Transmissible Gastroenteritis Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS, OIE 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Bacteria Encenhalitozoon cuniculi, Z E NS DISC 58 Funoi	Cryptosporidium parvum, z. F. H	92	Protozoa	Maedi Visna Virus, NZ, NE, NS, OIE	61	Viruses
Aeromonas hydrophila, z, E, H, DISC 89 Bacteria Chicken Anemia Virus, NZ, E, NS, DISC 60 Viruses Foot and Mouth Disease Virus, z, NE, OIE 89 Viruses Equid Herpesvirus 1, NZ, E, NS, OIE 60 Viruses Acinetobacter baumannii, NZ, NE, H, DISC 88 Bacteria Infectious Bursal Disease Virus, NZ, NE, NS, OIE 60 Viruses Salmonella enterica subsp. enterica serovar enteritidis, z, E, H, DISC 87 Bacteria Transmissible Gastroenteritis Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS, OIE 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H, DISC 80 Bacteria Encenhalitozoon cuniculi, Z, E, NS, OIE 59 Viruses	Enterobacter cloacae, 7 NF H	90	Bacteria	Canine Distemper Virus, NZ E NS DISC	60	Viruses
Foot and Mouth Disease Virus, z, NE, OIE 89 Viruses Equid Herpesvirus 1, NZ, E, NS, OIE 60 Viruses Acinetobacter baumannii, NZ, NE, H, DISC 88 Bacteria Infectious Bursal Disease Virus, NZ, NE, NS, OIE 60 Viruses Salmonella enterica subsp. enterica serovar enteritidis, z, E, H, DISC 87 Bacteria Transmissible Gastroenteritis Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Bacteria Encenhalitozoon cuniculi, z E NS DISC 58 Funci	Aeromonas hvdrophila, z E H DISC	89	Bacteria	Chicken Anemia Virus, NZ ENS DISC	60	Viruses
Acinetobacter baumannii, NZ, NE, H, DISC 88 Bacteria Infectious Bursal Disease Virus, NZ, NE, NS, OIE 60 Viruses Salmonella enterica subsp. enterica serovar enteritidis, Z, E, H, DISC 87 Bacteria Transmissible Gastroenteritis Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS, OIE 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H, DISC 80 Bacteria Encenhalitozoon cuniculi, Z, E, NS, OIE 59 Viruses	Foot and Mouth Disease Virus, 7 NE OF	89	Viruses	Equid Herpesvirus 1, NZ E NS OF	60	Viruses
Salmonella enterica subsp. enterica serovar enteritidis, z, e, H, DISC 87 Bacteria Transmissible Gastroenteritis Virus, NZ, NE, NS, OIE 60 Viruses Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H, DISC 80 Bacteria Encenhalitozoon cuniculi, Z, E, NS, OIE 58 Funci	Acinetobacter baumannii. NZ NE H DISC	88	Bacteria	Infectious Bursal Disease Virus, NZ NE NE OF	60	Viruses
Classical Swine Fever Virus, NZ, NE, NS, OIE 84 Viruses Actinobacillus pleuropneumoniae, NZ, E, NS, DISC 59 Bacteria Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H, DISC 80 Bacteria Encenhalitozoon cuniculi, Z, ENS DISC 58 Funci	Salmonella enterica subsp. enterica serovar enteritidis, z. E. H. DISC	87	Bacteria	Transmissible Gastroenteritis Virus,	60	Viruses
Bovine Viral Diarrhea Virus 1, NZ, E, NS, OIE 80 Viruses Feline Calicivirus, Z, E, NS 59 Viruses Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NS, OIE 59 Viruses Proteus mirabilis, Z, NE, H, DISC 80 Bacteria Encenhalitozoon cuniculi, Z, E, NS, DISC 58 Funci	Classical Swine Fever Virus, NZ NE NS OF	84	Viruses	Actinobacillus pleuropneumoniae, NZ E NS DISC	59	Bacteria
Feline Immunodeficiency Virus, NZ, E, NS 80 Viruses Myxoma Virus, NZ, NE, NS, OIE 59 Viruses Proteus mirabilis, Z, NE H, DISC 80 Bacteria Encephalitozoon cuniculi, Z, E, NS, DISC 58 Funci	Bovine Viral Diarrhea Virus 1, NZ E NG OF	80	Viruses	Feline Calicivirus, 7 E NIS	59	Viruses
Proteus mirabilis, z NE H DISC 80 Bacteria Encenhalitozoon cuniculi, z ENS DISC 58 Fundi	Feline Immunodeficiency Virus, NZ E NS	80	Viruses	Myxoma Virus, NZ NE NE OF	59	Viruses
	Proteus mirabilis, z NE H DISC	80	Bacteria	Encephalitozoon cuniculi, z r his picc	58	Fungi

Table 3. Cont.

Pathogen name	H-index score	Taxonomic division	Pathogen name	H-index score	Taxonomic division
Mycobacterium avium subsp. paratuberculosis,	79	Bacteria	Rotavirus A, _{Z, E, NS, DISC}	58	Viruses
NZ, E, NS, OIE					
Scrapie agent, _{NZ, NE, NS, OIE}	79	Viruses	Campylobacter fetus, _{Z, E, NS}	57	Bacteria
Bacillus licheniformis, _{Z, NE, H}	78	Bacteria	Fowlpox Virus, _{NZ, NE, NS, DISC}	57	Viruses
Trichinella spiralis, _{Z, E, H, OIE}	78	Helminths	Leishmania infantum, _{Z, E, NS, OIE}	57	Protozoa
Bartonella henselae, _{Z, NE, H, DISC}	77	Bacteria	Trichostrongylus colubriformis, _{Z, NE, NS, DISC}	57	Helminths

Pathogens also included in the list of top 100 human pathogens are noted (H). The major pathogens causing diseases included within the OIE list of notifiable terrestrial and aquatic animal diseases (OIE) are noted [10], as are those included in the DISCONTOOLS project (DISC) [11].

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impact upon the general population may therefore not be quantified. Recently discovered pathogens may be under-represented as a sufficient body of evidence for their impact may not have been accrued within the literature, for example Norovirus infection does not appear within the top 100 human pathogens. In addition, domestic pet pathogens, particularly if non-zoonotic or easily controlled, may not be included. Further analysis suggests that pathogens fail to be included dependent upon their taxonomic division (perhaps due to diagnostic issues) and for human pathogens, if they are not emerging, perhaps as a result of the 'Matthew effect' ('the rich get richer and the poor get poorer'); equally, they may simply have less long-term impact. The effect of emerging status is unsurprising, given this focus in surveillance work and despite a lag in time-to-publication leading to their likely under-representation in H-index calculations [6]; for some animal pathogens, this is the first time that emerging status has been examined.

Methods to assess disease impacts use metrics capturing either human or animal host effects; they neither measure the magnitude in all hosts nor take account of scientific knowledge and tools for control. It is hard to prioritise human and animal diseases, because of the different metrics used (health or societal impacts versus welfare or economic impacts). Significant differences between Hindices mean values for human-only, zoonotic, and animal-only pathogens provide evidence that this single measure may have some use as a One Health metric accounting for such factors. For example values for zoonotic pathogens were higher than for animal-only, suggesting that they account for human as well as animal-impact. Higher values for human-only compared to other pathogen groups suggests that zoonoses may be under-represented due to underestimation of their global burden [28,29], or research impact [6], or because of biases in research impact and funding for chronic human pathogens [29]. In addition, lower animal-only Hindices may be due to funding biases.

Finally, there was limited evidence that the H-index method is a reasonable proxy for the impact of animal pathogens; animal pathogen H-indices were significantly positively correlated with subsections of DISCONTOOLS [11], including impact on public (human) health and overall results (borderline significance). If animal-only (not zoonotic) diseases were included, there was a significant positive relationship with impact on wider society. As the more animal-focussed subsections (disease knowledge, impact on animal health and welfare, impact on trade, and available control tools) were not correlated with H-indices, and H-indices were not affected by inclusion in the OIE list [10], this suggests a human-centric bias in H-indices; for example, a pathogen causing little impact in animals may nevertheless have a high H-index if zoonotic.

The priority lists presented in this work should be used by agencies and research organisations in combination with other risk assessment methods to identify gaps in working for priority setting. It has been suggested that zoonoses must be dealt with at the interface of human and animal health using all available information [30]; this work, combining the EID2 and H-index technique, demonstrates such 'big-data' approaches.

Table 4. Results of Spearman's Rank correlations between H-indices and the DISCONTOOLS prioritisation of major animal diseases

 [11].

Zoonotic and an	nimal-only pathogens	Animal-only pathogens	
S rho	P value	S rho	P value
0.004	0.987	-0.180	0.699
-0·048	0.830	0.309	0.500
0.449	0.032	0.586	0.166
0.081	0.713	-0.775	0.041
0.200	0.360	-0·216	0.641
0.170	0.438	0.093	0.842
0.379	0.074*	>0.001	<0.999
	Zoonotic and an S rho 0·004 -0·048 0·449 0·081 0·200 0·170 0·379	Zoonotic and animal-only pathogens S rho P value 0·004 0·987 -0·048 0·830 0·449 0·032 0·081 0·713 0·200 0·360 0·170 0·438 0·379 0·074*	Zoonotic and animal-only pathogens Animal-only pathogens S rho P value S rho 0·004 0·987 -0·180 -0·048 0·830 0·309 0·449 0·032 0·586 0·081 0·713 -0·775 0·200 0·360 -0·216 0·170 0·438 0·093 0·379 0·074* >0·001

Notations include Spearman's Rank correlation value (S rho) and P values for the correlation. P values of significance are shown in bold, and a relationship of borderline significance is marked *.

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Author Contributions

Conceived and designed the experiments: KMM SM AM MB. Performed the experiments: KMM CS PH. Analyzed the data: KMM. Contributed reagents/materials/analysis tools: KMM CS. Contributed to the writing of the manuscript: KMM MB.

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