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# World Influence of Infectious **Diseases from Wikipedia Network** Analysis

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Abstract We consider the network of 5 416 537 articles of English Wikipedia extracted in 2017. 9 Using the recent reduced Google matrix (REGOMAX) method we construct the reduced network of 10 230 articles (nodes) of infectious diseases and 195 articles of world countries. This method 11 generates the reduced directed network between all 425 nodes taking into account all direct and 12 indirect links with pathways via the huge global network. PageRank and CheiRank algorithms are 13 used to determine the most influential diseases with the top PageRank diseases being Tuberculosis. 14 HIV/AIDS and Malaria. From the reduced Google matrix we determine the sensitivity of world 15 countries to specific diseases integrating their influence over all their history including the times of 16 ancient Egyptian mummies. The obtained results are compared with the World Health 17 Organization (WHO) data demonstrating that the Wikipedia network analysis provides reliable 18 results with up to about 80 percent overlap between WHO and REGOMAX analyses. 19

Introduction 21 Infectious diseases account for about 1 in 4 deaths worldwide, including approximately two-thirds of all 22 deaths among children vounger than age 5 (NIH, 2018). Thus the understanding of the world influence 23 of infectious diseases is an important challenge. Here we apply the mathematical statistical 24 methods originated from computer and network sciences using the PageRank and other Google 25 matrix algorithms developed at the early stage of search engines development (Brin and Page, 26 **1998:** Langville and Mever, 2012). These methods are applied to English Wikipedia edition which 27 is considered as a directed network generated by hyperlinks (citations) between articles (nodes). 28 Nowadays, the free online encyclopedia supersedes old ones such as Encyclopaedia Britannica 29 (2018) in volume and in quality of articles devoted to scientific topics (Giles, 2005). For instance, 30 Wikipedia articles devoted to biomolecules are actively maintained by scholars of the domain 31 (Butler, 2008: Callaway, 2010). The academic analysis of information contained by Wikipedia finds 32 more and more applications as reviewed in *Reagle Ir. (2012): Nielsen (2012)*. 33 The Google matrix analysis, associated to the PageRank algorithm, initially invented by Brin and 34 Page to efficiently rank pages of the World Wide Web (Brin and Page, 1998), allows to probe the 35 network of Wikipedia articles in order to measure the influence of every articles. The efficiency of 36 this approach for Wikipedia networks has been demonstrated by ranking historical figures on a scale 37 of 35 centuries of human history and by ranking world universities (Zhiroy et al., 2010: Fom et al., 38 2015; Lages et al., 2016; Katz and Rokach, 2017; Coguidé et al., 2018). This approach produced also reliable results for the world trade during last 50 years reported by the UN COMTRADE database 40

and other directed networks (Ermann et al., 2015).

42 Recently, the reduced Google matrix method (REGOMAX) has been proposed using parallels

<sup>43</sup> with quantum scattering in nuclear physics, mesoscopic physics, and quantum chaos (*Frahm and* 

44 Shepelyansky, 2016; Frahm et al., 2016). This method allows to infer hidden interactions between

a set of  $n_r$  nodes selected from a huge network taking into account all indirect pathways between

these  $n_r$  nodes via the huge remaining part of the network. The efficiency of REGOMAX has been demonstrated for analysis of world terror networks and geopolitical relations between countries

demonstrated for analysis of world terror networks and geopolitical relations between countries from Wikipedia networks (*El Zant et al., 2018a*,b). The efficient applications of this approach to

- the global biological molecular networks and their signaling pathways are demonstrated in (*Lages*
- 50 et al., 2018).

In this work we use REGOMAX method to investigate the world influence and importance of

<sup>52</sup> infectious diseases constructing the reduced Google matrix from English Wikipedia network with all

<sup>53</sup> infectious diseases and world countries listed there.

The paper is constructed as follows: the data sets and methods are described in Section II, Results are presented in Section III and discussion is given in Section IV; Appendix contains Tables 1, 2, 3, 4, 5; additional data are presented at *Wiki4InfectiousDiseases* (2018).

57 Description of data sets and methods

#### 58 English Wikipedia Edition network

<sup>59</sup> We consider the English language edition of Wikipedia collected in May 2017 (*Frahm and Shepelyan*-

<sup>60</sup> *sky*, *2017*) containing N = 5416537 articles (nodes) connected through  $n_l = 122232932$  hyperlinks

between articles. From this data set we extract the  $n_d = 230$  articles devoted to infectious diseases

(see Tab. 1, Tab. 2) and the  $n_c = 195$  articles devoted to countries (sovereign states, see Tab. 3). The

<sup>63</sup> list of infectious diseases is taken from *Wikipedia* (2018d) and the list of sovereign states of 2017 is

taken from *Wikipedia* (2017). Thus the size of the reduced Google matrix is  $n_r = n_d + n_c = 425$ . This

subset of  $n_r$  articles is embedded in the global Wikipedia network with N nodes. All data sets are

66 available at Wiki4InfectiousDiseases (2018).

#### 67 Google matrix construction

<sup>68</sup> The construction of Google matrix G is described in detail in Brin and Page (1998); Langville and

<sup>69</sup> Meyer (2012); Ermann et al. (2015). In short, the Google matrix G is constructed from the adjacency

matrix  $A_{ij}$  with elements 1 if article (node) j points to article (node) i and zero otherwise. The Google

matrix elements take the standard form  $G_{ij} = \alpha S_{ij} + (1 - \alpha)/N$  (Brin and Page, 1998; Langville

<sup>72</sup> and Meyer, 2012; Ermann et al., 2015), where *S* is the matrix of Markov transitions with elements <sup>73</sup>  $S_{ij} = A_{ij}/k_{out}(j)$ . Here  $k_{out}(j) = \sum_{i=1}^{N} A_{ij} \neq 0$  is the out-degree of node *j* (number of outgoing links)

and  $S_{ii} = 1/N$  if j has no outgoing links (dangling node). The parameter  $0 < \alpha < 1$  is the damping

<sup>75</sup> factor. For a random surfer, jumping from one node to another, it determines the probability  $(1 - \alpha)$ 

to jump to any node; below we use the standard value  $\alpha = 0.85$  (*Langville and Mever, 2012*).

The right eigenvector of *G* satisfies the equation  $GP = \lambda P$  with the unit eigenvalue  $\lambda = 1$ . It gives the PageRank probabilities P(j) to find a random surfer on a node *j* and has positive elements  $\sum_{j} P(j) = 1$ . All nodes can be ordered by decreasing probability *P* numbered by PageRank index K = 1, 2, ...N with a maximal probability at K = 1 and minimal at K = N. The numerical computation of P(j) is efficiently done with the PageRank algorithm described in **Brin and Page (1998)**; **Langville and Meyer (2012)**.

<sup>83</sup> It is also useful to consider the network with inverted direction of links. After inversion the <sup>84</sup> Google matrix  $G^*$  is constructed within the same procedure with  $G^*P^* = P^*$ . This matrix has its own <sup>85</sup> PageRank vector  $P^*(j)$  called CheiRank (*Chepelianskii, 2010*) (see also *Zhirov et al. (2010*); *Ermann* <sup>86</sup> *et al. (2015*)). Its probability values can be again ordered in a decreasing order with CheiRank <sup>87</sup> index  $K^*$  with highest  $P^*$  at  $K^* = 1$  and smallest at  $K^* = N$ . On average, the high values of  $P(P^*)$ 

se correspond to nodes with many ingoing (outgoing) links (*Ermann et al., 2015*).

#### 89 Reduced Google matrix analysis

Reduced Google matrix is con-90 structed for a selected subset 91 of nodes (articles) following the 92 method described in Frahm and 93 Shepelyansky (2016); Frahm et al. 94 (2016); Lages et al. (2018). It is 95 based on concepts of scattering 96 theory used in different fields in-97 cluding mesoscopic and nuclear 98 physics, and quantum chaos (see 99 Refs. in Frahm and Shepelyan-100 **sky** (2016)). It captures in a n<sub>r</sub>-101 by-n. Perron-Frobenius matrix the 102 full contribution of direct and in-103 direct interactions happening in 104 the full Google matrix between 105 the  $n_{\rm e}$  nodes of interest. Also the 106 PageRank probabilities of selected 107  $n_{\rm m}$  nodes are the same as for the 108 global network with N nodes, up 109 to a constant multiplicative factor 110 taking into account that the sum 111 of PageRank probabilities over  $n_{\rm r}$ 112 nodes is unity. The elements of re-113



**Figure 1.** Subnetwork of the 425 articles devoted to countries and infectious diseases in 2017 English Wikipedia. The bulk of the other Wikipedia articles is not shown. Articles devoted to countries are presented by empty nodes with country codes (see Tab. 3). Articles devoted to infectious diseases are presented by colored nodes with the following color code: **bacterial diseases**, **viral diseases**, **parasitic diseases**, **fungal diseases**, **prionic diseases**, **diseases with multiple origins**, and **other kind of diseases** (see Tab. 1. Tab. 2). Network drawn with Cytoscape (*Shannon et al., 2003*).

duced matrix  $G_{\rm p}(i, j)$  can be interpreted as the probability for a random surfer starting at web-page 114 *i* to arrive in web-page *i* using direct and indirect interactions. Indirect interactions refer to paths 115 composed in part of web-pages different from the  $n_r$  ones of interest. The intermediate computation 116 steps of  $G_{\rm R}$  offer a decomposition of  $G_{\rm R}$  into matrices that clearly distinguish direct from indirect 117 interactions:  $G_{\rm R} = G_{\rm rr} + G_{\rm pr} + G_{\rm ar}$  (Frahm et al., 2016). Here  $G_{\rm rr}$  is given by the direct links between 118 selected  $n_r$  nodes in the global G matrix with n nodes. In fact,  $G_{or}$  is rather close to the matrix in 119 which each column is given by the PageRank vector  $P_{r}$ , ensuring that PageRank probabilities of  $G_{\rm P}$ 120 are the same as for G (up to a constant multiplier). Thus  $G_{pr}$  doesn't provide much information 121 about direct and indirect links between selected nodes. The component playing an interesting role 122 is  $G_{ar}$ , which takes into account all indirect links between selected nodes appearing due to multiple 123 paths via the global network nodes N (see Frahm and Shepelyansky (2016); Frahm et al. (2016)). 124 The matrix  $G_{arr} = G_{ard} + G_{arnd}$  has diagonal ( $G_{ard}$ ) and non-diagonal ( $G_{arnd}$ ) parts. Thus  $G_{arnd}$  describes 125 indirect interactions between nodes. The explicit formulas as well as the mathematical and nu-126 merical computation methods of all three components of  $G_{R}$  are given in *Frahm and Shepelyansky* 127 (2016); Frahm et al. (2016); Lages et al. (2018). 128

After obtaining the matrix  $G_{\rm p}$  and its components we can analyze the PageRank sensitivity in 129 respect to specific links between  $n_c$  nodes. To measure the sensitivity of a country c to a disease d 130 we change the matrix element  $G_{\mathbb{P}}(d \to c)$  by a factor  $(1 + \delta)$  with  $\delta \ll 1$ , we renormalize to unity the 131 sum of the column elements associated with disease  $d_{i}$  and we compute the logarithmic derivative 132 of PageRank probability P(c) associated to country c:  $D(d \rightarrow c, c) = d \ln P(c)/d\delta$  (diagonal sensitivity). 133 It is also possible to consider the nondiagonal (or indirect) sensitivity  $D(d \rightarrow c, c') = d \ln P(c')/d\delta$ 134 when the variation is done for the link from d to c and the derivative of PageRank probability 135 is computed for another country c'. This approach was already used in **El Zant et al.** (2018a.b) 136 showing its efficiency. 137



**Figure 2.** Adjacency matrix of the subnetwork of the 425 articles devoted to countries and infectious diseases in 2017 English Wikipedia. White (black) pixels represent existing (absent) links. In horizontal and vertical axis the articles are ordered by continent for countries (AM for Americas, EU for Europe, AS for Asia, AF for Africa, and OC for Oceania) and by disease type for diseases (**BA** for bacterial, **VI** for viral, **PA** for parasitic, **FU** for fungal, **MU** for multiple type, **PR** for prionic, and **OT** for other type). Inside each block of continent and disease type the articles are ordered according to PageRank algorithm (see Tabs. 1 and 3). From top left to bottom right: block diagonal elements corresponding to intra-continent links are delimited by light gray squares. Also block diagonal elements corresponding to intra-disease type links are delimited by squares with color contour. Off diagonal blocks indicates links between diseases of different type, links between countries of different continent, or links between diseases and countries.

#### 138 Results

#### **Network of direct links**

For the reduced Google matrix analysis we have  $n_r = 425$  selected nodes of countries (195) and 140 infectious diseases (230). The diseases are attributed to 7 groups corresponding to the standard 141 disease types as it is given in Tab. 1, Tab. 2. These  $n_r$  nodes constitute a subnetwork embedded 142 in the huge global English Wikipedia network with more than 5 million nodes. This subnetwork 143 is shown in Fig. 1 which has been generated with Cytoscape software (Shannon et al., 2003). In 144 Fig. 1 black arrow links represent the nonzero elements of adjacency matrix between the selected 145  $n_{\rm r}$  nodes. The image of this adjacency matrix is shown in Fig. 2 where white pixels depicted a link 146 between two nodes. In this picture, nodes are ordered with respect to the PageRank order in each 147 subgroup: American countries, European countries, Asian countries, African countries, Oceanian 148 countries, bacterial diseases, viral disease, parasitic diseases, fungal diseases, multiple origins 149 diseases, prionic diseases and other kind of disease origins. There are visibly more links inside 150 subgroups but links between groups are also significant. Fig. 1 gives us the global view of network 151 of direct links, shown in Fig. 2, corresponding to the component  $G_{\rm rr}$  of the reduced Google matrix. 152 We see that countries are located in the central part of the network of Fig. 1 since they have many 153 ingoing links. While it is useful to have such a global view it is clear that it does not take into account 154



**Figure 3.** Density of articles of English Wikipedia 2017 on PageRank *K* – CheiRank *K*\* plane. Data are averaged over a  $100 \times 100$  grid spanning the  $(\log_{10} K, \log_{10} K^*) \in [0, \log_{10} N] \times [0, \log_{10} N]$  domain. Density of articles ranges from very low density (purple tiles) to very high density (bright yellow tiles). The cells without articles are represented by black tiles. The superimposed white (colored) circles give the positions of countries (infectious diseases) listed in Tab. 3 (Tab. 1). The color code for infectious diseases is the same as in Fig. 1.

the indirect links appearing between  $n_r$  nodes due to pathways via the complementary network part with a huge number of nodes  $N - n_r \simeq N$ . The indirect links emerging between  $n_r$  from this indirect pathways are analyzed in the frame of REGOMAX method below.

#### PageRank and CheiRank of the reduced network nodes

At first we compute the PageRank and CheiRank probabilities for the global network with N nodes 159 attributing to each node PageRank and CheiRank indexes K and K\*. For selected n, nodes the 160 results of PageRank are shown in Tab. 2. As usual (see Zhirov et al. (2010); Ermann et al. (2015)). 161 the countries are taking the top PageRank positions with US, France, Germany, etc at K = 1, 2, 3, etc 162 as shown in Tab. 3. In the list of n nodes the infectious diseases start to appear from K = 106 with 163 Tuberculosis (Tab. 2). If we consider only infectious diseases ordered by their disease PageRank 164 index  $K_d$  then we obtain at the top Tuberculosis, HIV/AIDS, Malaria, Pneumonia, Smallpox at first 165 positions with  $K_d = 1, 2, 3, 4, 5$  (see Tab. 2). It is clear that PageRank order gives at the top positions 166 severe infectious diseases which are (were for Smallpox) very broadly spread worldwide. 167

In Fig. 3 we show the location of selected  $n_r$  nodes on the global ( $K, K^*$ ) plane of density of Wikipedia articles (see details of this representation in *Zhirov et al.* (2010); *Ermann et al.* (2015)). Here the positions of countries are shown by white circles and diseases by color circles. The countries are taking the top positions since they have many ingoing links from variety of other articles. The infectious diseases are located on higher values of  $K, K^*$  even if some diseases are overlapping with the end list of countries (see Tab. 2).

All  $n_r = 425$  selected articles can be ordered by their local PageRank and CheiRank indexes  $K_r$ and  $K_r^*$  which range from 1 to  $n_r = 425$ . Their distribution in the local PageRank-CheiRank plane is



**Figure 4.** Distribution of the articles devoted to infectious diseases (colored circles) and to countries (white circles) in the PageRank  $K_r$  – CheiRank  $K_r^*$  plane. The color code for infectious diseases is the same as in Fig. 1.

shown in Fig. 4. As discussed previously, countries are at the top  $K_r$ ,  $K_r^*$  positions. The names of top PageRank diseases are marked on the figure. The most communicative articles of infectious

diseases are those with top  $K_r^*$  positions. Thus the top CheiRank disease is Burkholderia due to

<sup>179</sup> many outgoing links present in this article. The next ones are Malaria and HIV/AIDS.

#### 180 Reduced Google matrix

To study further the selected subset of 425 nodes we use the reduced Google matrix approach and 181 compute numerically  $G_{\rm R}$  and its three components  $G_{\rm or}$ ,  $G_{\rm rr}$ ,  $G_{\rm ar}$ . It is convenient to characterize 182 each component by its weight defined as the sum of all elements divided by the matrix size  $n_r$ . By 183 definition we have the weight  $W_R = 1$  for  $G_R$  and we obtain weights  $W_{pr} = 0.91021$ ,  $W_{rr} = 0.04715$ , 184  $W_{qr} = 0.04264$  (with nondiagonal weight  $W_{qrnd} = 0.02667$ ) respectively for  $G_{pr}$ ,  $G_{rr}$ ,  $G_{qr}$  ( $G_{qrnd}$ ). The 185 weight of  $G_{\rm pr}$  is significantly larger than others but this matrix is close to the matrix composed 186 from equal columns where the column is the PageRank vector (see also discussions in Frahm et al. 187 (2016); El Zant et al. (2018a); Lages et al. (2018)). Due to this reason the components  $G_{\rm rr}$  and  $G_{\rm or}$ 188 provide an important information about interactions of nodes. Since the weights of these two 189 components are approximately equal we see that the direct and indirect (hidden) links have a 190 comparable contribution. 191

As an illustration we show in Fig. 5 a close up on African countries and viral diseases sectors of the full  $n_r \times n_r$  reduced Google matrix  $G_R$  is shown (there are 55 African countries and 60 viral diseases shown in fig5). Detailed presentations of the  $G_R$  matrix components for the complete subset of  $n_r = 425$  countries and infectious diseases are given in *Wiki4InfectiousDiseases (2018)*. In Fig. 5,  $G_R$  and its components are composed of diagonal blocks corresponding to country  $\rightarrow$  country and disease  $\rightarrow$  disease effective links, and off-diagonal blocks corresponding to disease  $\rightarrow$  country (upper off-diagonal block) and country  $\rightarrow$  disease (lower off-diagonal block) effective links.



**Figure 5.** Reduced Google matrix  $G_R$  (top left panel) and three of its components,  $G_{qrnd}$  (top right panel),  $G_{rr}$  (bottom left panel), and  $G_{rr} + G_{qrnd'}$  associated to the subnetwork of articles (bottom right) devoted to countries and infectious diseases in 2017 English Wikipedia. For the sake of clarity, here we show only matrix entries corresponding to the subset of articles devoted to African countries and viral diseases (see *Wiki4InfectiousDiseases (2018)* for the full subnetwork constituted by the  $n_r = 425$  articles devoted to all countries and all infectious diseases). Here lines and columns corresponding to African countries (viral diseases) are ordered as in Tab. 3 (Tab. 1). Horizontal and vertical tics on close-ups are placed every 10 entries.



**Figure 6.** Infectious diseases friendship network. Top panel: we consider the set of top PageRank infectious disease for each of the seven type of infectious diseases, i.e., tuberculosis for bacterial type, HIV/AIDS for virus type, malaria for parasitic type, candidiasis for fungal type, pneumonia for multiple type, Creutzfeldt–Jakob for prionic type, and Desmodesmus for other type (see Tab. 1). From each one of these top PageRank diseases (placed along the main grey circle) we determine the two best linked diseases in  $G_{rr} + G_{qr}$ , e.g., from tuberculosis the two best linked diseases are leprosy and HIV/AIDS. If not already present in the reduced network, we add these best linked diseases along secondary circles centered on the previous diseases. Then from each one of the new added diseases we determine the two best linked diseases, and so on. At the fourth iterations of this process no new diseases can be added. The arrows represent the links between diseases (1st iteration: plain line; 2nd iteration: dashed line; 3rd iteration: dashed-dotted line; 4th iteration: dotted line). Black arrows correspond to links existing in the adjacency matrix, red arrows are purely hidden links absent from adjacency matrix but present in  $G_{qr}$  component of the reduced Google matrix  $G_R$ . The color code for infectious diseases is the same as in Fig. 1. Bottom panel: same reduced network as in the top panel but at each iteration also the best linked countries are determined. At each iteration no new links are determined from the newly added countries. Countries are represented by ring shape nodes with red color for countries from Americas, gold for African countries, cyan for Asian countries, blue for European countries, and orange for Oceanian countries. Network drawn with Cytoscape (*Shannon et al., 2003*).

#### 199 Friendship network of nodes

We use the matrix of direct and indirect transition  $G_{rr} + G_{or}$  to determine the proximity relations 200 between 230 nodes corresponding to diseases and to all  $n_{e} = 425$  nodes of diseases and countries. 201 We call this the friendship networks being shown in Fig. 6. For each of 7 disease groups (see Tab. 2) 202 we take a group leader as a disease with highest PageRank probability inside the group. Then 203 on each step (level) we take 2 best friends define them as those nodes to which a leader has two 204 highest transition matrix elements of  $G_{rr} + G_{qr}$ . This gives us the second level of nodes below the 205 7 leaders. After that we generate the third level keeping again two better friends of the nodes 206 of second level (those with highest transition probabilities). This algorithm is repeated until no 207 new friends are found and the algorithm stops. In this way we obtain the network of 17 infectious 208 diseases shown in the top panel of Fig. 6. The full arrows show the proximity links between disease 209 nodes. The red arrows mark links with dominant contribution of  $G_{ar}$  indirect transitions while the 210 black ones mark the links with dominance of G<sub>rr</sub> direct transitions. Full arrows are for transitions 211 from group leaders to nodes of second level, etc (see Fig. 6 caption for details). The obtained 212 network is drawn with the Cytoscape software (Shannon et al., 2003). 213 In Fig. 6 top panel, four of the leader diseases are well connected; nodes corresponding to 214

In Fig. 6 top panel, four of the leader diseases are well connected; hodes corresponding to
 Tuberculosis (bacterial disease), HIV/AIDS (viral disease), Malaria (parasitic disease), Pneumonia
 (multiple origin disease) have 6 or more degrees. Nodes of Creutzfeldt-Jakob disease (prion disease)
 and of Desmodesmus (other origin disease) are more isolated. Focusing on first level friendship
 links (solid arrows), we retrieve several well known interactions between infectious diseases such
 as:

the Tuberculosis–HIV/AIDS syndemic (see e.g. *Pawlowski et al., 2012; Kwan and Ernst, 2011*)
 which is here represented by a closed loop between the two diseases,

• the interaction between HIV/AIDS and Syphilis (see e.g. *Karp et al., 2009*) which is a typical example of syndemic between AIDS and sexually transmitted diseases,

the Candidiasis interaction with HIV/AIDS, since the former is a very common opportunistic fungal infection for patients with HIV/AIDS (see e.g. *Armstrong-James et al., 2014*), and the Candidiasis interaction with Sepsis<sup>1</sup> since e.g. invasive Candidiasis which in some rare cases can lead to fulminant sepsis with an associated mortality exceeding 70% (see e.g. *Pappas et al., 2018*),

the Pneumonia to Sepsis interaction or the Malaria to Sepsis interaction, the first interaction reflects the fact that Sepsis is one of the possible complications of Pneumonia, the second interaction reflects that symptoms of Malaria resemble to those of Sepsis *Auma et al.* (2013),

the closed loop interaction between Tuberculosis and Leprosy reflecting that these two
 diseases are caused by two different species of mycobacteria (see e.g. *Wikipedia, 2018e*),

the relation between Pneumonia and Tuberculosis, two severe pulmonary diseases (see e.g. *WHO*, 2018),

the Creutzfeldt–Jakob disease pointing to Pneumonia since patient infected by this prion disease develop a fatal Pneumonia due to impaired coughing reflexes (see e.g. *Al Balushi et al., 2016*),

the closed loop interaction between Kuru and Creutzfeldt–Jakob diseases since these two diseases are representatives of transmissible spongiform encephalopathies (see e.g. *Sikorska and Liberski, 2012*).

<sup>242</sup> Taking into account also the other 2nd to 4th friendship levels, peculiar features appear such as:

- the cluster of bacterial diseases Tuberculosis–Leprosy–Syphilis; since there were a confusion
- 244 between Leprosy and Syphilis in diagnosis before XXth century (see e.g. *Leprosy and Syphilis*,
- 1890; Syphilis and Leprosy, 1899), and false positives can occur with Tuberculosis for patients
- with Syphilis (see e.g. *Shane, 2006*),

<sup>1</sup>Even if most of the Sepsis are bacterial, it can also be fungal or viral

- the mosquito diseases cluster grouping Malaria, Yellow fever, Dengue fever and West Nile
   fever,
- the Meningitis–Sepsis closed loop since the Sepsis is usually developed at early stage by patient with Meningitis (see e.g. *CDC*, *2018*).

Red arrows in Fig. 6 indicate pure indirect links between infectious diseases: Desmodesmus and
 Malaria are both waterborne diseases (see e.g. *Wikipedia, 2018f*), Desmodesmus and HIV/AIDS
 are related by a Wikipedia page devoted to immunocompetence (see e.g. *Wikipedia, 2018b*), and
 Kuru in Papua New Guinea Foré language possibly means to shiver from cold (see e.g. *Liberski and Ironside, 2015*).

From the above analysis we observe that the wiring between infectious diseases is meaningful 256 guaranteeing that information encoded in the reduced Google matrix  $G_{p}$ , and more precisely in 257 its  $G_{rr} + G_{ar}$  component, is reliable, and can be used to infer possible relations between infectious 258 diseases and any other subjects contained in Wikipedia such as e.g. countries, drugs, proteins, etc. 259 In the bottom panel of Fig. 6 we analyze the proximity between diseases of top panel with the 260 world countries. Thus we add the two better "friend" countries being those to which a given disease 261 has most strong matrix elements in  $G_{rr} + G_{qr}$  (there is no next iterations for country nodes). The 262 friend countries (or proximity countries) are Egypt and Swaziland for Tuberculosis: Cameroon and 263 Cote d'Ivoire for HIV/AIVS: Peru and Thailand for Malaria: Liberia and Uganda for Pneumonia: United 264 Kingdom (UK)<sup>2</sup> and Papua New Guinea for Creutzfeldt-lakob disease and others. These strong links 265 from an infectious disease to a given country well correspond to known events involving a disease 266 and a country, like e.g. UK and Creutzfeldt-Jakob disease. We will see this in a more direct way using 267

<sup>268</sup> the sensitivity analysis presented in the next subsection.

#### 269 World country sensitivity to infectious diseases

We also preform analysis of the sensitivity  $D(d \rightarrow c, c')$  of country node c' to the variation of the link 270  $d \rightarrow c$ , where d denotes a disease node and c a country node. The diagonal sensitivity  $D(d \rightarrow c, c)$  of 271 world countries to Tuberculosis and HIV/AIDS are shown in Fig. 7. The most sensitive countries to 272 Tuberculosis are Swaziland (SZ), Egypt (EG) and New Zealand (NZ), Indeed, in 2007 SZ had the highest 273 estimated incidence rate of Tuberculosis as it is described in the corresponding Wikipedia article. 274 Egypt also appears in this article since tubercular decay has been found in the spine of Egyptian 275 mummy kept in the British Museum. NZ is present in this article since this country had a relatively 276 successful effort to eradicate bovine tuberculosis. Thus Tuberculosis has direct links to these three 277 countries (in agreement with two close country friends shown in the network of Fig. 6) that results 278 in their high sensitivity to this disease. Of course, the origins of this sensitivity are different for SZ. 279 EG. NZ. Thus Wikipedia network integrates all historical events related to Tuberculosis including 280 ancient Egyptian mummy and recent years of high incidence rate in S7. It can be discussed how 28 important are these rather different types of links between disease and counties. Of course, a 282 simplified network view cannot take into account all richness of historical events and describe them 283 by a few number of links. However this approach provides a reliable global view of the interactions 284 and dependencies between a disease and world countries. 285

The sensitivity of countries to HIV/AIDS is shown in the top panel of Fig. 7. The most sensitive countries are Botswana (BW), Senegal (SN) and Cote d'Ivoire (CI). This happens since HIV/AIDS article directly points that estimated life expectancy in BW dropped from 65 to 35 years in 2006; SN and CI appears since the closest relative of HIV-2 exists in monkey living in coastal West Africa from SN to CI. The friendship network in Fig. 6 indeed marks the countries close to HIV/AIDS as CI and Cameroon (CM). The sensitivity map in Fig. 7 also shows that CM has high sensitivity to HIV/AIDS since HIV-1 appears to have originated in southern Cameroon.

The case of two diseases considered in Fig. 7 demonstrates that the REGOMAX approach is able to reliably determine the sensitivity of world countries to infectious diseases taking into account

<sup>&</sup>lt;sup>2</sup>Noted GB in Fig. 6 and Tab. 3.



**Figure 7.** Country PageRank sensitivity to the variation of the reduced Google matrix HIV→country link (upper panel) and to the variation of the reduced Google matrix Tuberculosis→country link (bottom panel). The color categories are obtained using the Jenks natural breaks classification method (*Wikipedia, 2018c*).



**Figure 8.** Country PageRank sensitivity to the variation of the reduced Google matrix HIV  $\rightarrow$  USA link (top panel) and to the variation of the reduced Google matrix HIV  $\rightarrow$  Cameroon link (bottom panel). The color categories are obtained using the Jenks natural breaks classification method (*Wikipedia*, 2018c).



**Figure 9.** Overlap  $\eta(j) = j_c/j$  between the ranking of countries obtained from the REGOMAX PageRank sensitivity computation and the ranking of countries obtained from WHO data (Tab. 4 for Tuberculosis and Tab. 5 for HIV/AIDS). Here,  $j_c$  is the number of common countries in the top j of the two rankings. Green curve is for the HIV/AIDS disease, and red curve is for the Tuberculosis disease.

their relations on a scale of about 3 thousands of years.

A part of the sensitivity relations between diseases and countries can be visible from the 296 friendship network as those in the bottom panel of Fig. 6. However, the REGOMAX approach can 297 handle also indirect sensitivity  $D(d \rightarrow c, c')$  which is rather hard to be directly extracted from the 298 friendship network. The examples of indirect sensitivity are shown in Fig. 8. Thus the variation 299 of link from HIV/AIDS to Cameroon (CM) (Fig. 8 bottom panel) mainly affects Equatorial Guinea 300 (GQ), Central African Republic (CF) and Chad (TD). The variation of link HIV/AIDS to USA (Fig. 8 top 301 panel) produces the strongest sensitivity for Federal States of Micronesia (FM). Marshall Islands 302 (MH) and Rwanda (RW). These countries are not present in the Wikipedia article HIV/AIDS and the 303 obtained sensitivity emerges from a complex network interconnections between HIV/AIDS, USA (or 304 Cameroon) to these countries. Thus the REGOMAX analysis allows to recover all network complexity 305 of direct and indirect interactions between nodes. 306

#### 307 Comparison of REGOMAX and WHO results

It is important to compare the results of REGOMAX analysis with those of World Health Organization 308 (WHO) or other sources on number of infected people. With this aim we extract from WHO reports 309 (WHO, 2008, 2018) the number of Tuberculosis incidences per 100000 population of a given country. 310 and the number of new HIV/AIDS infections per 1000 uninfected population. The ranking of 311 countries by the number of incidences is presented in Tab. 4 for Tuberculosis and the ranking of 312 countries by new infections is presented in Tab. 5 for HIV/AIDS. We also analyze WHO 2004 data 313 (WHO, 2008) for the number of deaths caused by each disease in 2004 complemented by the data 314 reported in *Wikipedia* (2018a). The resulting ranking of diseases is given in Tab. 6. 315 We compare these official WHO ranking results with those obtained from REGOMAX analysis. 316 Thus we determine the ranking of countries by their sensitivity to Tuberculosis and to HIV/AIDS 317

for top 100 countries (these ranking lists are given in *Wiki4InfectiousDiseases* (2018)). The overlap  $\eta(j)$  of these REGOMAX rankings with those of WHO from Tab. 4 and Tab. 5 are shown in Fig. 9. We obtain the overlap of 50% for Tuberculosis and 79% for HIV/AIDS for the top 100 countries. These





numbers are comparable with overlaps obtained for top 100 historical figures found from Wikipedia
 and historical analysis (see *Eom et al. (2015*)) and for top 100 world universities determined by
 Wikipedia and Shanghai ranking (see *Lages et al. (2016*); *Coquidé et al. (2018*)).

Another comparison is presented in Fig. 10. Here we take the infectious diseases ordered by 324 their PageRank index and compare them with the ranking list of diseases ordered by the number of 325 deaths caused by them in 2004 (see Tab. 6). The obtained overlap is shown in Fig. 10 with an overall 326 of 100% for top 4 deadliest diseases (which from Tab. 6 are 1 Pneumonia, 2 HIV/AIDS, 3 Tuberculosis, 327 4 Malaria) and 54% for the whole list of 31 considered diseases. In addition the REGOMAX analysis 328 allows to determine the world map of countries with the highest sensitivity to the top list of 7 329 diseases. Such maps are shown in Fig. 11. We see the world dominance of Tuberculosis (top panel) 330 while after it (or in its absence) we find the world dominance of HIV/AIDS (bottom panel). The 331 geographical influence of Malaria and Diarrheal diseases are also well visible. 332

Thus the performed comparison with WHO data shows that the Google matrix analysis of Wikipedia network provides us a reliable information about world importance and influence of infectious diseases.

#### 336 Discussion

In this work we presented the reduced Google matrix (or REGOMAX) analysis of world influence of 337 infectious diseases from the English Wikipedia network of 2017. This method allows to take into 338 account all direct and indirect links between the selected nodes of countries and diseases. The 339 importance of diseases is determined by their PageRank probabilities. The REGOMAX analysis allows 340 to establish the network of proximity (friendship) relations between the diseases and countries. 341 The sensitivity of world countries to a specific disease is determined as well as the influence of link 342 variation between a disease and a country on other countries. The comparison with the WHO data 343 confirms the reliability of REGOMAX results applied to Wikipedia network. 344



**Figure 11.** Maps of the maximal sensitivity of diseases. Each country is colored according to the disease giving the maximal sensitivity: Tuberculosis (blue), HIV/AIDS (red), Malaria (cyan), Diarrheal diseases (magenta), Dengue, Meningitis, Hepatitis. Top panel shows the maximal sensitivity for the 7 diseases, and bottom panel for 6 of these diseases (Tuberculosis is not taken into account). Gray color indicates countries for which the maximal sensitivity to these diseases is less than 1/8 (1/4) of the greatest maximal sensitivity for any country. Note that Dengue, Meningitis and Hepatitis never gives the maximal sensitivity for any country.

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**Appendix 1 Table 1.** List of infectious diseases ordered by type (82 of bacterial type, 60 of viral type, 52 of parasitic type, 24 of fungal type, 6 of multiple types, and 2 of other types) then by PageRank of the corresponding article in English edition of Wikipedia (*Frahm and Shepelyansky*, **2017**). The  $n_d = 230$  elements of this list have been extracted from the *list of infectious diseases* article in 2017 English Wikipedia (*Wikipedia, 2018d*; *Wiki4InfectiousDiseases, 2018*).

Inf	ectious diseases						
Ba	cterial type	Ba	cterial type (Cont.)	Vir	al type (Cont.)	Ра	rasitic type (Cont.)
1	Tuberculosis	61	Prevotella	38	CCHF <sup>e</sup>	37	Anaplasmosis
2	Cholera	62	Ehrlichiosis	39	Caliciviridae	38	Baylisascaris
3	Typhoid fever	63	Vibrio vulnificus	40	PML <sup>f</sup>	39	Fasciolopsiasis
4	Syphilis	64	Actinomycosis	41	Rift Valley fever	40	Head lice infestation
5	Bubonic plague	65	Ureaplasma urealyticum	42	Lassa fever	41	Angiostrongyliasis
6	Leprosy	66	Melioidosis	43	Astrovirus	42	Isosporiasis
7	Sensis	67	Granuloma inguinale	44	Fifth disease	43	Diphyllobothriasis
8	Meningitis	68	Buruli ulcer	15	VEF	11	Cyclosporiasis
0	Plaque (disease)	60	Varsinia psoudotuborculosis	45	Molluscum contagiosum	45	Balantidiasis
10	Turphus	70	Kingolla kingao	40	MEDCh	45	Plastacystocic
10	Diabtharia	70		47	Mankaunau	40	Diastocystosis
11	Diprimena	71	H. granulocytic anaplasmosis	48	Workeypox	47	Dientamoediasis
12	Anthrax	72	Pheumococcal Inf.	49	Hand, foot, and mouth disease	48	Gnatnostomiasis
13	Helicobacter pylori	73	Nocardiosis	50	Bolivian nemorrhagic tever	49	Capillariasis
14	Lyme disease	74	Bartonellosis	51	H. metapneumovirus	50	Metagonimiasis
15	Staphylococcus	75	Group B streptococcal inf.	52	HFRS	51	Pediculosis corporis
16	Haemophilus influenzae	76	Pasteurellosis	53	LCM <sup>j</sup>	52	Free-living Amoebozoa inf.
17	Tetanus	77	Carrion's disease	54	BK virus	fui	ngal type
18	Gonorrhea	78	Yersiniosis	55	Colorado tick fever	1	Candidiasis
19	Pertussis	79	Mycoplasma pneumonia	56	Argentine hemorrhagic fever	2	Histoplasmosis
20	Botulism	80	HME <sup>a</sup>	57	Heartland virus	3	Athlete's foot
21	Chlamydia inf.	81	Ehrlichiosis ewingii inf.	58	Venezuelan hemorrhagic fever	4	Coccidioidomycosis
22	Rickettsia	82	A. haemolyticum <sup>b</sup>	59	Brazilian hemorrhagic fever	5	Chytridiomycosis
23	Brucellosis	Vir	al type	60	H. bocavirus	6	Pneumocystis pneumonia
24	Leptospirosis	1	HIV/AIDS	Pai	rasitic type	7	Cryptococcosis
25	Pelvic inflammatory disease	2	Smallpox	1	Malaria	8	Onvchomycosis
26	Cellulitis	3	Influenza	2	Schistosomiasis	9	Aspergillosis
27	Legionnaires' disease	4	Measles	3	African trypanosomiasis	10	Tinea versicolor
22	Clostridium difficile inf	5	Vellow fever	1	Toxonlasmosis	11	Tinea cruris
20	Pocky Mountain spotted fever	6	Poliomyolitic	5	Opchocorciasis	12	Paracoccidioidomycosis
29		7	CADEG	6	Cashies	12	Tippo compario
30	Enterococcus Restaurial varia esia	/	SARS <sup>2</sup>	0	Scaples	13	Risets and a size
31	Bacterial vaginosis	8	Hepatitis C	/	Chagas disease	14	
32	Bacterial pneumonia	9	Hepatitis B	8	Filariasis	15	
33	Epidemic typnus	10	Ebola virus disease	9	Hookworm inf.	16	linea capitis
34	Irachoma	11	Common cold	10	Leishmaniasis	17	linea manuum
35	Salmonellosis	12	Rabies	11	Trichinosis	18	Sporotrichosis
36	Tularemia	13	Dengue fever	12	Giardiasis	19	Tinea barbae
37	Kawasaki disease	14	Chickenpox	13	Amoebiasis	20	Tinea nigra
38	Bacteroides	15	H. papillomavirus inf.	14	Trichomoniasis	21	Chromoblastomycosis
39	Acinetobacter	16	West Nile fever	15	Cryptosporidiosis	22	White piedra
40	Chlamydophila pneumoniae	17	Herpes simplex	16	Myiasis	23	Black piedra
41	Q fever	18	Rubella	17	Dracunculiasis	24	Geotrichosis
42	Shigellosis	19	Hepatitis A	18	Lymphatic filariasis	Мι	Itiple types
43	Gas gangrene	20	Cytomegalovirus	19	Echinococcosis	1	Pneumonia
44	Bacillus cereus	21	Mumps	20	Cysticercosis	2	Foodborne illness
45	Group A streptococcal inf.	22	Infectious mononucleosis	21	Babesiosis	3	Hemolytic-uremic syndrome
46	Meningococcal disease	23	Shingles	22	Pinworm inf.	4	Keratitis
47	Burkholderia	24	Norovirus	23	Ascariasis	5	Neonatal conjunctivitis
48	Relapsing fever	25	Rotavirus	24	Strongyloidiasis	6	Mycetoma
49	Glanders	26	Hantavirus	25	Toxocariasis	Pri	onic type
50	Psittacosis	27	H respiratory syncytial virus	26	Anisakis	1	Creutzfeldt-lakob disease
51		∠/ 28	Marburg virus	20 27	Easciolosis	2	Kuru (disaasa)
57	Rickettsialnov	20 20	Phinovirus	∠/ 20	Paragonimiasis	2	Fatal familial incompia
52	Campulabactariasia	∠⊅ 20	Entorovirus	20 20	Cutapoous Janes missore	2	
ک د د		3U 21	Chilungunua	29	Cutaneous larva migrans	4	ددی
54	Naegieriasis	31		3U 21		Ut	ner types
55	Murine typhus	32	Hepatitis D	31	Hymenolepiasis	1	Desmodesmus
56	Fusobacterium	33	Viral pneumonia	32	Clonorchiasis	2	Rhinosporidiosis
57	Chancroid	34	Hepatitis E	33	Pediculosis pubis		
58	Cat-scratch disease	35	SSPEa	34	Microsporidiosis		
59	Staphylococcal inf.	36	Roseola	35	Opisthorchiasis		
60	Vibrio parahaemolyticus	37	H. parainfluenza viruses	36	Taeniasis		

Abbreviations H. and inf. stand for Human and infection. <sup>a</sup>HME: Human monocytotropic ehrlichiosis. <sup>b</sup>A. haemolyticum: Arcanobacterium haemolyticum. <sup>c</sup>SARS: Severe acute respiratory syndrome. <sup>d</sup>SSPE: Subacute sclerosing panencephalitis. <sup>e</sup>CCHF: Crimean-Congo hemorrhagic fever. <sup>f</sup>PML: Progressive multifocal leukoencephalopathy. <sup>g</sup>VEE: Venezuelan equine encephalitis virus. <sup>h</sup>MERS: Middle East respiratory syndrome. <sup>i</sup>HFRS: Hantavirus hemorrhagic fever with renal syndrome. <sup>j</sup>LCM: Lymphocytic choriomeningitis. <sup>k</sup>GSS: Gerstmann-Sträussler-Scheinker syndrome. **Appendix 1 Table 2.** Ranking of infectious diseases and countries in English Wikipedia 2017 according to PageRank algorithm. The color code distinguishes type of infectious diseases: **bacterial**, **viral**, **parasitic**, **fungal**, **prionic**, **multiple origin**, and **other origin**.

Rank	Disease or country	Rank	Disease or country	Rank	Disease or country	Rank	Disease or country
1	United States	228	Haemophilus influenzae	294	Cysticercosis	360	Bolivian hemorrhagic fever
		229	Tetanus	295	Babesiosis	361	Blastomycosis
105	Sudan	230	H. papillomavirus inf.	296	Bacteroides	362	Cutaneous larva migrans
106	Tuberculosis	231	West Nile fever	297	Pneumocystis pneumonia	363	H. metapneumovirus
107	Uganda	232	Schistosomiasis	298	Viral pneumonia	364	Zygomycosis
		233	Herpes simplex	299	Cryptococcosis	365	Trichuriasis
114	Somalia	234	Gonorrhea	300	Hepatitis E	366	Granuloma inguinale
115	HIV/AIDS	235	Pertussis	301	Acinetobacter	367	Hymenolepiasis
116	lvory Coast	236	African trypanosomiasis	302	Chlamydophila pneumoniae	368	Clonorchiasis
		237	Rubella	303	Q fever	369	HFRS <sup>g</sup>
128	Fiji	238	Hepatitis A	304	Pinworm inf.	370	Buruli ulcer
129	Malaria	239	Cytomegalovirus	305	Shigellosis	371	LCM <sup>h</sup>
130	Mali	240	Botulism	306	Gas gangrene	372	Yersinia pseudotuberculosis
		241	Mumps	307	Bacillus cereus	373	Pediculosis pubis
140	Oman	242	Creutzfeldt–Jakob disease	308	Kuru (disease)	374	BK virus
141	Pneumonia	243	Toxoplasmosis	309	SSPE <sup>b</sup>	375	GSS <sup>i</sup>
142	Smallpox	244	Candidiasis	310	Group A streptococcal inf.	376	Kingella kingae
143	Suriname	245	Chlamydia inf.	311	Roseola	377	H. granulocytic anaplasmosis
		246	Rickettsia	312	Meningococcal disease	378	Microsporidiosis
162	Malawi	247	Infectious mononucleosis	313	H. parainfluenza viruses	379	Pneumococcal inf.
163	Cholera	248	Onchocerciasis	314	Burkholderia	380	Opisthorchiasis
164	Тодо	249	Scabies	315	Onychomycosis	381	Nocardiosis
		250	Brucellosis	316	Aspergillosis	382	Taeniasis
185	San Marino	251	Chagas disease	317	CCHF <sup>c</sup>	383	Bartonellosis
186	Influenza	252	Shingles	318	Relapsing fever	384	Anaplasmosis
187	Saint Lucia	253	Filariasis	319	Ascariasis	385	Tinea capitis
188	Measles	254	Hookworm inf.	320	Strongyloidiasis	386	Colorado tick fever
189	Palau	255	Leishmaniasis	321	Glanders	387	Baylisascaris
190	Typhoid fever	256	Leptospirosis	322	Psittacosis	388	Fasciolopsiasis
191	Marshall Islands	257	Pelvic inflammatory disease	323	Listeriosis	389	Group B streptococcal inf.
192	Equatorial Guinea	258	Norovirus	324	Caliciviridae	390	Pasteurellosis
193	Dominica	259	Cellulitis	325	PML <sup>d</sup>	391	Head lice infestation
194	Guinea-Bissau	260	Trichinosis	326	Rickettsialpox	392	Angiostrongyliasis
195	Syphilis	261	Rotavirus	327	Tinea versicolor	393	Isosporiasis
196	Comoros	262	Hantavirus	328	Campylobacteriosis	394	Argentine hemorrhagic fever
197	Djibouti	263	Legionnaires' disease	329	Naegleriasis	395	Diphyllobothriasis
198	Yellow fever	264	Histoplasmosis	330	Murine typhus	396	Heartland virus
199	Bubonic plague	265	Clostridium difficile inf.	331	Tinea cruris	397	Cyclosporiasis
200	Fed. States of Micronesia	266	<b>Rocky Mountain spotted fever</b>	332	Fusobacterium	398	Carrion's disease
201	Poliomyelitis	267	Enterococcus	333	Rift Valley fever	399	Balantidiasis
202	Tuvalu	268	Bacterial vaginosis	334	Lassa fever	400	Tinea manuum
203	Leprosy	269	Giardiasis	335	Chancroid	401	Sporotrichosis
204	Sepsis	270	Bacterial pneumonia	336	Cat-scratch disease	402	Venezuelan hemorrhagic fever
205	Nauru	271	Amoebiasis	337	Neonatal conjunctivitis	403	Blastocystosis
206	St. Vincent & Grenadines	272	H. respiratory syncytial virus	338	Toxocariasis	404	Tinea barbae
207	Meningitis	273	Athlete's foot	339	Astrovirus	405	Yersiniosis
208	Kiribati	274	Trichomoniasis	340	Fifth disease	406	Tinea nigra
209	Plague (disease)	275	Epidemic typhus	341	Staphylococcal inf.	407	Chromoblastomycosis
210	Saint Kitts and Nevis	276	Hemolytic-uremic syndrome	342	Vibrio parahaemolyticus	408	Dientamoebiasis
211	Typhus	277	Marburg virus	343	Prevotella	409	Brazilian hemorrhagic fever
212	Antigua and Barbuda	278	Trachoma	344	Fatal familial insomnia	410	Gnathostomiasis
213	São Tomé & Príncipe	279	Rhinovirus	345	Anisakis	411	Mycoplasma pneumonia
214	Diphtheria	280	Salmonellosis	346	Ehrlichiosis	412	Capillariasis
215	SARS <sup>a</sup>	281	Coccidioidomycosis	347	VEE <sup>e</sup>	413	White piedra
216	Anthrax	282	Cryptosporidiosis	348	Molluscum contagiosum	414	HME
217	Hepatitis C	283	Myiasis	349	MERS	415	Metagonimiasis
218	Foodborne illness	284	Enterovirus	350	Monkeypox	416	Pediculosis corporis
219	Hepatitis B	285	Chytridiomycosis	351	Fasciolosis	417	Black piedra
220	Ebola virus disease	286	Tularemia	352	Paracoccidioidomycosis	418	H. bocavirus
221	Common cold	287	Kawasaki disease	353	Hand, foot, and mouth disease	419	Ehrlichiosis ewingii inf.
222	Rabies	288	Chikungunya	354	Vibrio vulnificus	420	Desmodesmus
223	Dengue fever	289	Hepatitis D	355	Actinomycosis	421	Rhinosporidiosis
224	Helicobacter pylori	290	Dracunculiasis	356	Ureaplasma urealyticum	422	Free-living Amoebozoa inf.
225	Lyme disease	291	Keratitis	357	Tinea corporis	423	Geotrichosis
226	Chickenpox	292	Lymphatic filariasis	358	Melioidosis	424	A. haemolyticum <sup>k</sup>
227	Staphylococcus	293	Echinococcosis	359	Paragonimiasis	425	Mycetoma

Abbreviations H. and inf. stand for Human and infection. <sup>a</sup>SARS: Severe acute respiratory syndrome. <sup>b</sup>SSPE: Subacute sclerosing panencephalitis. <sup>c</sup>CCHF: Crimean-Congo hemorrhagic fever. <sup>d</sup>PML: Progressive multifocal leukoencephalopathy. <sup>c</sup>VEE: Venezuelan equine encephalitis virus. <sup>f</sup>MERS: Middle East respiratory syndrome. <sup>8</sup>HFRS: Hantavirus hemorrhagic fever with renal syndrome. <sup>b</sup>LCM: Lymphocytic choriomeningitis. <sup>1</sup>GSS: Gerstmann-Sträussler-Scheinker syndrome, <sup>1</sup>HME: Human monocytotropic ehrlichosis. <sup>k</sup>A. haemolyticum: Arcanobacterium haemolyticum. **Appendix 1 Table 3.** List of countries ordered by PageRank of the corresponding article in English Wikipedia 2017. Here the countries correspond to the  $n_c = 195$  sovereign states listed in (*Wikipedia, 2017*). The country code (CC) is given for each country.

1         United States         US         66         Morocco         M.         132         Gyrana         GY           3         Germany         DF         68         Algeria         D2         133         Timilad and Tobago         TT           4         United Kingdom         GF         68         Algeria         D2         133         Timilad and Tobago         TT           6         India         IN         71         Saudi Arabia         GC         135         Suitana         MU           6         Canada         CA         72         Lithuania         IT         137         Oman         OM           8         Australia         AU         73         Echana         D         138         Suriname         SR           9         China         China         China         D         72         Suriname         SR         SR           11         Japan         JP         76         Erhopia         Celana         D         140         Berra         Berra         SR         Suriname         SR         Si         Suriname         SR         Si         Suriname         SR         Suriname         SR         Si         Suriname<	Rank	Country	сс	Rank	Country	сс	Rank	Country	сс
2         France         FR         67         Cuba         CU         132         Strikido and Tobágo         TT           4         United Kingdom         GB         68         Bosnia and Herregovina         BA         134         Munituids and Tobágo         TT           4         Inited Kingdom         GB         69         Bosnia and Herregovina         BA         134         Munituids and Tobágo         TT           6         India         IN         71         Saudi Arabia         SA         136         Monaco         MU           7         Canada         CA         72         Linbania         IN         137         German         OM           8         China         CN         74         Folovina         CI         137         Soman	1	United States	US	66	Morocco	MA	131	Kyrgyzstan	KG
3         Germany         DE         68         Ageria         D2         13         Munitolity         MU           5         Iran         R6         63         Sonia and Heresona         R4         Mu         Mu           5         Iran         R7         Ecuador         C6         135         Financo         Mu           6         India         CA         72         Lithuania         L         137         Orman         OM           6         Antstratia         CA         72         Lithuania         L         138         Surinarce         SR           9         China         CN         74         Boliva         E         141         Sisterance         SR           11         Japan         P         76         Ethopia         Combit of the Congo         C         142         Brutan         Sisterance         Sisteranc	2	France	FR	67	Cuba	CU	132	Guyana	GY
4         United Kingdom         GB         6 Bernia and Herregovina         BA         11 Maurituiz         Mu           5         Irain         IR         70         Ganda         IS         Tajistrain         T           6         India         IN         71         Saudi Arabia         IS         ISS         Tajistrain         MC           7         Canada         AC         72         Iubavia         IS         ISS         Tajistrain         MC           8         Australia         AU         73         Ieeland         IS         ISS         Tajistrain         IS           10         Italy         T         75         Fanzania         TZ         IAU         Solomon Islands         IS           11         Japan         P         76         Ethopia         TZ         IAU         Solomon Islands         IS           13         Brazial         RU         77         Cencador         MA         IAU         Vatican         IS           14         Supain         RU         74         Madagascar         MC         IAU         IS         Babadas         IS         Marciau         MU         IS         Is         Is	3	Germany	DE	68	Algeria	DZ	133	Trinidad and Tobago	TT
5         iran         IR         70         Ecuador         EC         135         Angono         MC           6         India         IN         71         Saudi Arabia         LT         135         Ornan         OM           7         Canada         CA         72         Libuania         LT         135         Suriance         SR           9         China         CN         74         Bolivia         EC         138         Suriance         SR           9         China         CN         74         Bolivia         ET         141         Sizera         SR           11         Japan         JP         76         Ethiopia         ET         141         Sizera         SR           12         Ruxsia         RU         77         Democratic Republic of the Congo         CM         142         Bhutan         SR           13         Brazal         RW         87         Madagascar         MG         143         The Sanda         RW           14         Pationa         RC         85         Sandarania         RC         144         Sattan         RW         150         Berina         Bita         Sattan	4	United Kingdom	GB	69	Bosnia and Herzegovina	BA	134	Mauritius	MU
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7       Canada       CA       72       Lithania       LT       137       Oman       OMA         8       Australia       AU       73       Iecland       IS       183       Suriname       SR         9       China       CN       74       Bolivia       BO       133       Uberia       Lith         10       Italy       TT       75       Tanzaria       TT       143       Suriname       SR         11       Japan       IT       75       Enthopia       ET       141       Suriname       SR         12       Russia       RU       77       Democratic Republic of the Congo       142       Butan       BT         13       Brazin       ES       79       Armenia       MI       144       Standor       VA         14       Butan       ES       69       Armenia       KI       145       Barbados       BB         15       Necico       MX       83       Controlinitation       KI       145       Barbados       BB         15       Mexico       MX       83       Controlinitation       KI       150       Beinai       BB         15       Mexico	6	India	IN	71	Saudi Arabia	SA	136	Monaco	MC
8         Auxtralia         AU         73         Iceland         IS         IS         Suriname         SR           9         Chan         CN         74         Bolain         D0         139         Lebria         LR           10         Italy         T7         75         Tarchinja         T2         140         Solomon Islands         SB           11         Japan         T9         To Encoratic Republic Of the Congo         CD         14         Buhanans         BS           13         Brazil         BU         TS         Madagascan         MD         14         Vational Lebranans         BS           14         Spain         RU         RS         Australian         MD         17         Succhanics         RS           15         Netherlands         NL         RS         Cepantanics         RS         144         Vational Lebranans         BH           16         Poland         PL         RS         Cepantanics         RS         145         Subaranans         BH         155         Netherlands         BH           17         Succhanics         RS         Pananana         PA         150         Beninanas         BN         250	7	Canada	CA	72	Lithuania	LT	137	Oman	ОМ
9         China         Control         CA         Bolivia         BO         13         Lberia         Lberia <td< td=""><td>8</td><td>Australia</td><td>AU</td><td>73</td><td>Iceland</td><td>IS</td><td>138</td><td>Suriname</td><td>SR</td></td<>	8	Australia	AU	73	Iceland	IS	138	Suriname	SR
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13       Brazil       BR       7.9       Madagascar       MG       1.43       The Bahramas       BS         14       Spain       ES       7.9       Armenia       AM       1.44       Vata City       Via         15       Netherlands       NL       80       Lebanon       LB       145       Bahrain       BH         16       Foland       PL       81       Cyprus       CY       146       Bahrain       BH         17       Sweden       SZ       Kazikhstan       KZ       147       Folswana       EW         18       Mexico       MX       83       Georgia (country)       GE       148       Navana       EW         19       Furkey       TR       84       Latvia       LV       149       Furkerstan       TM         20       Romania       RO       85       Panama       PA       150       Bernin       BJ         21       Norway       NO       84       Balvain       AL       155       Gold       GA         23       Norway       NO       84       Pausition       AL       154       Belize       BJ         24       Sutria       AT<	12	Russia	RII	70	Democratic Republic of the Congo	CD	147	Bhutan	BT
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26       Austria       AT       91       United Arab Emirates       AE       150       Chalawi       TD         27       Belgium       BE       92       Uruguay       UY       157       Malawi       MW         28       Pakistan       PK       93       North Korea       KP       158       Togo       TG         29       Argentina       AR       94       Yemen       YE       159       Lichtenstein       Li         30       Indonesia       DD       95       Costa Rica       CR       160       Samoa       WS         31       Greece       GR       96       Malta       MT       161       Burundi       BI         32       Denmark       DK       97       Truisia       TT       162       South Sudan       S1         33       South Korea       IK       98       Jamaica       JM       163       Republic of the Congo       CG         34       Israel       IL       99       Zimbodua       KH       165       Cape Verde       CV         35       Hungary       HU       100       Cameroon       CM       HA       Republic Of Macotona       MN       167 <td>25</td> <td>Philippines</td> <td>PH</td> <td>90</td> <td>Ghana</td> <td>GH</td> <td>155</td> <td>Guinea</td> <td>GN</td>	25	Philippines	PH	90	Ghana	GH	155	Guinea	GN
27BelgiumBE92UrguayUY157MalawiMW28PakistanPK93North KoreaKP158TogoTG30IndonesiaID95Costa RicaCR160SamoaWS31GreeceGR96MaltaMT161BurundiBl32DenmarkDK97TunisiaTN162South SudanSS33South KoreaKR98JamaicaJM163Republic of the CongoCG44IsraelIL99ZimbabweZW164East TimorTL35HungaryHU100CambodiaKH165Cape VerdeCV36FinlandFI101CameroonCM166EritreaER37EgyptEG102MongoliaMN167MauritaniaMR38PortugalPT103Burkina FasoBF168Central African RepublicCF39UkraineUA104JordanJO169MaldivesMV4040Sri LankaLK105SudanSD170TongaTO41Czech RepublicCZ106UgandaUG171AndorraAD42MalaysiaMY107Republic of MacedoniaMK172VanatuVU43PeruPE108GuatemalaGT17	26	Austria	AT	91	United Arab Emirates	AE	156	Chad	TD
28       Pakistan       PK       93       North Korea       KP       158       Togo       TG         29       Argentina       AR       94       Yemen       YE       159       Licchtenstein       Li         30       Indonesia       D       95       Costa Rica       CR       160       Samoa       WS         31       Greece       GR       96       Malta       MT       161       Burundi       Bl         32       Denmark       DK       97       Tunisia       TN       162       Samoa       CG         34       Israel       IL       99       Zimbabwe       ZW       164       East Timor       TL         35       Hungary       HU       100       Cameroon       CM       166       Eritrea       ER         37       Egypt       EG       102       Mongolia       MN       167       Mauritania       MR         38       Portugal       PT       103       Burkina Faso       BF       168       Central African Republic       CF         39       Ukraine       LK       104       Jordan       UG       171       Andara       AD         40	27	Belgium	BE	92	Uruguay	UY	157	Malawi	MW
29ArgentinaAR94YemenYE159LickhtensteinLI30IndonesiaID95Costa RicaCR160SamoaWS31GreeceGR96MaltaTN161BurundiBI32DenmarkDK97TunisiaTN162South SudanSS33South KoreaKR98JamaicaJN163Republic of the CongoGG34IsraelIL99ZimbabweZW164East TimorTL35HungaryHU100CambodiaKH165Cape VerdeCV36FinlandFI101CameroonCM166FirtreaRR37EgyptEG102MongoliaMN167MauritaniaMK38PortugalPT103Burkina FasoBF168Central African RepublicCF39UkraineUK104JordanD0169MaldivesMV40Sri LankaLK105SudanSD171AndorraAD42MalaysiaMY107Republic of MacedoniaMK172VanuatuVU43PeruPE108GuatemalaGT173State of PalestinePS44ThaliandTH109LibyaLY174LesothoLS45ColombiaCO110Dominican Republic <t< td=""><td>28</td><td>Pakistan</td><td>ΡK</td><td>93</td><td>North Korea</td><td>KP</td><td>158</td><td>Тодо</td><td>TG</td></t<>	28	Pakistan	ΡK	93	North Korea	KP	158	Тодо	TG
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31GreeceGR96MaltaMT161BurundiBl32DenmarkDK97TunisiaTN162South SudanSS33South KoreaKR98JamaicaTN162South SudanSS34IsraelIL99ZimbabweZW164East TimorTL35HungaryHU100CambodiaKH165Cape VerdeCV36FinlandF1101CameroonCM166EritreaER37EgyptEG102MongoliaMN167MauritaniaMR38PortugalPT103Burkina FasoBF168Central African RepublicCF39UkraineUA104JordaJO169MaldivesMV40Sri LankaLK105SudanSD170TongaTO41Czech RepublicCZ106UgandaUK172VanutuVU43PeruPE108GuatemalaGT173State of PalestinePS44ThailandTH109LibaLY174LesothoLS45ColombiaCO110Dominican RepublicD175The GambiaGM46BugariaBG111HatiHT176SwazilandSZ47ChileCLLL20MoldovaMD177<	30	Indonesia	ID	95	Costa Rica	CR	160	Samoa	WS
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35       HUngary       HU       100       Cambodia       KH       165       Cantonia       CV         36       Finland       FI       101       Cameroon       CM       166       Firtrea       ER         37       Egypt       EG       102       Mongolia       MN       167       Mauritania       MR         38       Portugal       PT       103       Burkina Faso       BF       168       Central African Republic       CF         39       Ukraine       UA       104       Jordan       JO       169       Maldives       MV         40       Sri Lanka       LK       105       Sudan       SD       170       Tonga       Tonga       TO         41       Czech Republic       CZ       106       Uganda       UG       171       Andorra       AD         42       Malaysia       MY       107       Republic of Macedonia       MK       172       Vanuatu       VU         43       Peru       PE       108       Guatemala       GT       173       State of Palestine       PS         44       Hailysia       LY       174       Lesotho       LS       Aste of Palestine       Sa	34	Israel		99	Zimbabwe	7W	164	Fast Timor	TI
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37EgyptEG100Cunctor <t< td=""><td>36</td><td>Finland</td><td>FI</td><td>101</td><td>Cameroon</td><td>CM</td><td>166</td><td>Fritrea</td><td>ER.</td></t<>	36	Finland	FI	101	Cameroon	CM	166	Fritrea	ER.
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45ColombiaCO110Dominican RepublicDO175Ine GambiaGM46BulgariaBG111HaitiHT176SwazilandSZ47ChileCL112MoldovaMD177SeychellesSC48Republic of IrelandIE113SomaliaSO178GrenadaGD49SingaporeSG114Ivory CoastCI179San MarinoSM50SerbiaRS115NamibiaNA180Saint LuciaLC51AzerbaijanAZ116ParaguayPY181PalauPW52VietnamVN117AngolaAO182Marshall IslandsMH53NepalNP118UzbekistanUZ183Equatorial GuineaGQ54EstoniaEE119MontenegroME184DominicaDM55CroatiaHR120KuwaitKW185Guinea-BissauGW56NigeriaNG121LaosLA186ComorosKM57AfghanistanAF122MozambiqueMZ187DijboutiDj58IraqIQ123NicaraguaNI188Federated States of MicronesiaFM59BangladeshBD124QatarQA189TuvaluTV60SyriaSY125Senegal </td <td>44</td> <td>Inalland</td> <td>IH</td> <td>109</td> <td>Libya</td> <td>LY</td> <td>174</td> <td>Lesotho</td> <td>LS</td>	44	Inalland	IH	109	Libya	LY	174	Lesotho	LS
46BulgariaBG111HaitiHT176SwazilandSZ47ChileCL112MoldovaMD177SeychellesSC48Republic of IrelandIE113SomaliaSO178GrenadaGD49SingaporeSG114Ivory CoastCl179San MarinoSM50SerbiaRS115NamibiaNA180Saint LuciaLC51AzerbaijanAZ116ParaguayPY181PalauPW52VietnamVN117AngolaAO182Marshall IslandsMH53NepalNP118UzbekistanUZ183Equatorial GuineaGQ54EstoniaEE119MontenegroME184DominicaDM55CroatiaHR120KuwaitKW185Guinea-BissauGW56NigeriaNG121LaosLA186ComorosKM57AfghanistanAF122MozambiqueMZ187DibuotiDj58IraqIQ123NicaraguaNI188Federated States of MicronesiaFM59BangladeshBD124QatarQA189TuvaluTV60SyriaSY125SenegalSN190NauruNR61MyanmarMM126FijiFj191	45	Colombia	co	110	Dominican Republic	DO	1/5	The Gambia	GM
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57ArghanistanAF122MozambiqueMZ187DjiboutiDj58IraqIQ123NicaraguaNI188Federated States of MicronesiaFM59BangladeshBD124QatarQA189TuvaluTV60SyriaSY125SenegalSN190NauruNR61MyanmarMM126FijiFJ191Saint Vincent and the GrenadinesVC62KenyaKE127MaliML192KiribatiKI63SlovakiaSK128HondurasHN193Saint Kitts and NevisKN64VenezuelaVE129ZambiaZM194Antigua and BarbudaAG65SloveniaSL130El SalvadorSV195São Tomé and PríncineST	56	Nigeria	NG	121	Laos	LA	186	Comoros	KM
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59BangladeshBD124QatarQA189TuvaluTV60SyriaSY125SenegalSN190NauruNR61MyanmarMM126FijiFJ191Saint Vincent and the GrenadinesVC62KenyaKE127MaliML192KiribatiKI63SlovakiaSK128HondurasHN193Saint Kitts and NevisKN64VenezuelaVE129ZambiaZM194Antigua and BarbudaAG65SloveniaSI130El SalvadorSV195São Tomé and PríncineST	58	Iraq	IQ	123	Nicaragua	NI	188	Federated States of Micronesia	FM
60SyriaSY125SenegalSN190NauruNR61MyanmarMM126FijiFJ191Saint Vincent and the GrenadinesVC62KenyaKE127MaliML192KiribatiKI63SlovakiaSK128HondurasHN193Saint Kitts and NevisKN64VenezuelaVE129ZambiaZM194Antigua and BarbudaAG65SloveniaSI130El SalvadorSV195São Tomé and PríncipeST	59	Bangladesh	ВĎ	124	Qatar	QA	189	Tuvalu	ΤV
61MyanmarMM126FijiFJ191Saint Vincent and the GrenadinesVC62KenyaKE127MaliML192KiribatiKI63SlovakiaSK128HondurasHN193Saint Kitts and NevisKN64VenezuelaVE129ZambiaZM194Antigua and BarbudaAG65SloveniaSI130El SalvadorSV195São Tomé and PríncipeST	60	Svria	SY	125	Senegal	SN	190	Nauru	NR
62     Kenya     KE     127     Mali     ML     192     Kiribati     KI       63     Slovakia     SK     128     Honduras     HN     193     Saint Kitts and Nevis     KI       64     Venezuela     VE     129     Zambia     ZM     194     Antigua and Barbuda     AG       65     Slovenia     SL     130     El Salvador     SV     195     São Tomé and Príncipe     ST	61	Myanmar	MM	126	Fiii	FI	191	Saint Vincent and the Grenadines	VC
62     KL     12     KL     12     KL     KL       63     Slovakia     SK     128     Honduras     HN     193     Saint Kitts and Nevis     KN       64     Venezuela     VE     129     Zambia     ZM     194     Antigua and Barbuda     AG       65     Slovenia     SI     130     El Salvador     SV     195     São Tomé and Príncipe     ST	62	Kenva	KF	127	Mali	MI	197	Kiribati	KI
64         Venezuela         VE         129         Zambia         ZM         194         Antigua and Barbuda         AG           65         Slovenia         SI         130         El Salvador         SV         195         São Tomé and Príncipe         ST	62	Slovakia	SK	178	Honduras	HN	192	Saint Kitts and Nevis	KN
65 Slovenia SI 130 El Salvador SV 195 São Tomé and Príncipe ST	64	Venezuela	VE	170	Zambia	714	10/	Antigua and Barbuda	AG
	65	Slovenia	SI	130	El Salvador	SV	195	São Tomé and Príncine	ST

#### Appendix 1 Table 4. List of countries ordered by Tuberculosis incidences in 2016 (per 100000 population per year; taken from WHO (2018))

Rank	Country	Incidence	Rank	Country	Incidence	Rank	Country	Incidence
1	South Africa	781.0	65	Mauritania	102.0	129	Portugal	20.0
2	Lesotho	724.0	66	Moldova	101.0	130	Serbia	19.0
3	Kiribati	566.0	67	São Tomé and Príncipe	99.0	131	Turkey	18.0
4	Philippines	554.0	68	Niger	93.0	132	Trinidad and Tobago	18.0
5	Mozambique	551.0	69	Guvana	93.0	133	Poland	18.0
6	North Korea	513.0	70	Malavsia	92.0	13/	Montenegro	16.0
7	Fast Timor	409.0	70		02.0	125	lanan	16.0
/	Cabaa	496.0	71	Georgia (country)	92.0	135	Japan	10.0
8	Gabon	485.0	/2	Ukraine	87.0	136	Estonia	16.0
9	Namibia	446.0	73	Tajikistan	85.0	137	Chile	16.0
10	Papua New Guinea	432.0	74	Solomon Islands	84.0	138	Albania	16.0
11	Marshall Islands	422.0	75	Sudan	82.0	139	Seychelles	15.0
12	Central African Republic	407.0	76	South Korea	77.0	140	Iran	14.0
13	Swaziland	398.0	77	Uzbekistan	76.0	141	Egypt	14.0
14	Indonesia	391.0	78	Romania	74.0	142	Malta	13.0
15	Republic of the Congo	378.0	79	Eritrea	74.0	143	Lebanon	12.0
16	Zambia	376.0	80	Algeria	70.0	144	Croatia	12.0
17	Guipea Bissau	374.0	Q1	Kazakhetan	67.0	1/15	Babrain	12.0
17	Augusta Sau	374.0	01	Razakiistaii	07.0	145	Caraia	12.0
18	Angola	370.0	82	Russia	66.0	146	spain	10.0
19	Myanmar	361.0	83	Brunei	66.0	147	Saudi Arabia	10.0
20	Kenya	348.0	84	Azerbaijan	66.0	148	Belgium	10.0
21	Cambodia	345.0	85	Sri Lanka	65.0	149	United Kingdom	9.9
22	Djibouti	335.0	86	China	64.0	150	Costa Rica	9.5
23	Botswana	326.0	87	Turkmenistan	60.0	151	Oman	9.0
24	Democratic Republic of the Congo	323.0	88	El Salvador	60.0	152	Hungary	8.8
25	Liberia	308.0	89	Dominican Republic	60.0	153	Tonga	8.6
26	Sierra Leone	304.0	90	Fiii	59.0	154	Sweden	8.0
20	Tanzania	297.0	01	Ponin	50.0	154	Austria	0.2
27		287.0	91	Benin	59.0	155	Austria	8.2
28	Somalia	270.0	92	vanuatu	56.0	156	Germany	8.1
29	Pakistan	268.0	93	Mali	56.0	157	Switzerland	7.8
30	Madagascar	237.0	94	Panama	55.0	158	Dominica	7.8
31	Bangladesh	221.0	95	Lithuania	53.0	159	Samoa	7.7
32	Nigeria	219.0	96	Belarus	52.0	160	France	7.7
33	India	211.0	97	Singapore	51.0	161	New Zealand	7.3
34	Zimbabwe	208.0	98	Burkina Faso	51.0	162	Republic of Ireland	7.1
35	Tuvalu	207.0	99	Rwanda	50.0	163	Cuba	6.9
36	Cameroon	207.0	100	Ecuador	50.0	164	Slovenia	6.5
20	Uganda	203.0	100	Maldivez	30.0	104	Sioverna	0.5
37	Uganda	201.0	101	Maidives	49.0	165	Grenada	6.4
38	Afgnanistan	189.0	102	Yemen	48.0	166	Saint Vincent and the Grenadines	6.3
39	Haiti	188.0	103	Nicaragua	48.0	167	Norway	6.1
40	Mongolia	183.0	104	Тодо	46.0	168	Italy	6.1
41	Equatorial Guinea	181.0	105	Armenia	44.0	169	Denmark	6.1
42	Bhutan	178.0	106	Iraq	43.0	170	Australia	6.1
43	Federated States of Micronesia	177.0	107	Paraguav	42.0	171	Andorra	6.0
44	Ethiopia	177 0	108	Brazil	42.0	172	Slovakia	59
45	Guinea	176.0	100	Libva	40.0	173	Netherlands	5.9
45	Laos	170.0	110	Hondurac	40.0	174	Luxombourg	5.5
40	Laus The Couchie	173.0	110	Turisis	40.0	174	Luxembourg	5.6
4/		1/4.0	111	runisia	38.0	1/5	Jordan	5.6
48	Thailand	172.0	112	Belize	38.0	176	Cyprus	5.6
49	Malawi	159.0	113	Latvia	37.0	177	Canada	5.2
50	Ghana	156.0	114	Comoros	35.0	178	Czech Republic	5.0
51	Nepal	154.0	115	Venezuela	32.0	179	Finland	4.7
52	lvorv Coast	153.0	116	Colombia	32.0	180	lamaica	4.5
53	Chad	153.0	117	Bosnia and Herzegovina	32.0	181	Greece	4.4
54	South Sudan	146.0	118		29.0	182	Israel	35
55	Kyrgyzstap	145.0	110	Bulgaria	25.0	192	Antigua and Barbuda	3.5
	Conogal	140.0	120	Surjaama	27.0	104	United States	J.4 7 4
56	Seriegal	140.0	120	Sui IIIdiile	26.0	184		3.1
57	cape verde	137.0	121	The Banamas	26.0	185	iceiand	2.1
58	Vietnam	133.0	122	Kuwait	24.0	186	Saint Lucia	1.9
59	Palau	123.0	123	Guatemala	24.0	187	Barbados	1.2
60	Burundi	118.0	124	Argentina	24.0	188	United Arab Emirates	0.79
61	Peru	117.0	125	Qatar	23.0	189	San Marino	0.0
62	Bolivia	114.0	126	Mexico	22.0	190	Saint Kitts and Nevis	0.0
62	Nauru	112.0	127	Mauritius	22.0	191	Monaco	0.0
6/	Morocco	102.0	120	Svria	22.0	101		0.0
		105.0	120	Syria	21.0			

#### Appendix 1 Table 5. List of countries ordered by new HIV/AIDS infections in 2017 (per 1000 uninfected population; taken from WHO (2018))

Rank	Country	New infections	Rank	Country	New infections	Rank	Country	New infections
1	Lesotho	12.68	44	Ethiopia	0.33	87	Azerbaijan	0.1
2	Swaziland	9.37	45	Cape Verde	0.31	88	Spain	0.09
3	South Africa	5.58	46	Trinidad and Tobago	0.29	89	Peru	0.09
4	Botswana	5.52	47	Cuba	0.29	90	Niger	0.09
5	Namibia	4.37	48	Georgia (country)	0.28	91	Lithuania	0.09
6	Zambia	4.08	49	Chile	0.28	92	France	0.09
7	Mozambique	3.63	50	Dominican Republic	0.24	93	Armenia	0.09
8	Zimbabwe	3.03	51	Brazil	0.24	94	Senegal	0.08
9	Equatorial Guinea	2.71	52	Latvia	0.23	95	Albania	0.08
10	Malawi	2.29	53	Myanmar	0.22	96	Sweden	0.06
11	Central African Republic	1.8	54	Venezuela	0.21	97	Nicaragua	0.06
12	Republic of the Congo	1.65	55	Paraguay	0.2	98	Malta	0.06
13	Uganda	1.5	56	Burundi	0.2	99	Italy	0.06
14	Kenya	1.46	57	Malaysia	0.19	100	Republic of Ireland	0.06
15	Cameroon	1.39	58	Indonesia	0.19	101	Iran	0.06
16	South Sudan	1.35	59	Costa Rica	0.19	102	India	0.06
17	Nigeria	1.23	60	Burkina Faso	0.19	103	Australia	0.05
18	Tanzania	1.19	61	Madagascar	0.18	104	Yemen	0.04
19	Angola	0.94	62	Luxembourg	0.18	105	Romania	0.04
20	Gabon	0.92	63	Guatemala	0.18	106	Czech Republic	0.04
21	Sierra Leone	0.86	64	Somalia	0.17	107	Cambodia	0.04
22	Ivory Coast	0.86	65	Democratic Republic of the Congo	0.17	108	Bahrain	0.04
23	Ghana	0.78	66	Kazakhstan	0.16	109	Tunisia	0.03
24	Haiti	0.77	67	El Salvador	0.16	110	Sri Lanka	0.03
25	Guyana	0.77	68	Uruguay	0.15	111	Slovenia	0.03
26	Belize	0.75	69	Tajikistan	0.15	112	Serbia	0.03
27	Guinea-Bissau	0.72	70	Eritrea	0.15	113	Netherlands	0.03
28	Rwanda	0.7	71	Sudan	0.13	114	Nepal	0.03
29	Guinea	0.67	72	Kyrgyzstan	0.13	115	Morocco	0.03
30	Liberia	0.66	73	Argentina	0.13	116	Bulgaria	0.03
31	The Gambia	0.65	74	Vietnam	0.12	117	Afghanistan	0.03
32	Jamaica	0.63	75	Mauritania	0.12	118	Slovakia	0.02
33	Suriname	0.62	76	Fiji	0.12	119	Saudi Arabia	0.02
34	Тодо	0.59	77	Ecuador	0.12	120	Qatar	0.02
35	Djibouti	0.58	78	Colombia	0.12	121	Lebanon	0.02
36	Barbados	0.58	79	Philippines	0.11	122	Kuwait	0.02
37	Ukraine	0.38	80	Montenegro	0.11	123	Egypt	0.02
38	Moldova	0.38	81	Honduras	0.11	124	Croatia	0.02
39	Papua New Guinea	0.37	82	Thailand	0.1	125	Algeria	0.02
40	Panama	0.34	83	Pakistan	0.1	126	Mongolia	0.01
41	Chad	0.34	84	Mexico	0.1	127	Jordan	<0.01
42	Benin	0.34	85	Laos	0.1	128	Comoros	<0.01
43	Mali	0.33	86	Bolivia	0.1	129	Bangladesh	<0.01

**Appendix 1 Table 6.** List of diseases ordered by the number of deaths caused by each disease during the year 2004 in the world. Data are taken from *WHO* (2008). For 8 of these diseases (tagged by a star \*), the number of deaths are estimated using English Wikipedia edition (*Wikipedia, 2018a*).

Rank	Diseases	Deaths (×10 <sup>3</sup> )
1	Pneumonia*	4000
2	HIV/AIDS	2040
3	Tuberculosis	1464
4	Malaria	889
5	Shigellosis*	700
6	Measles	424
7	Foodborne illness*	420
8	Influenza*	375
9	Meningitis	340
10	Salmonellosis*	268
11	Pertussis	254
12	Norovirus*	200
13	Tetanus	163
14	Typhoid fever*	149
15	Hepatitis B	105
16	Syphilis	99
17	Cholera*	68
18	Hepatitis C	54
19	African trypanosomiasis	52
20	Leishmaniasis	47
21	Schistosomiasis	41
22	Dengue fever	18
23	Japaness encephalitis	11
24	Chagas disease	11
25	Chlamydia infection	9
26	Leprosy	5
27	Diphtheria	5
28	Trichuriasis	2
29	Ascariasis	2
30	Poliomyelitis	1
31	Gonorrhea	1