Title
Magnitude of Ebola relative to other causes of death in Liberia, Sierra Leone, and Guinea

Journal
The Lancet Global Health, 3(5)

ISSN
2572-116X

Authors
Helleringer, Stephane
Noymer, Andrew

Publication Date
2015-05-01

DOI
10.1016/s2214-109x(15)70103-8

Peer reviewed

Magnitude of Ebola relative to other causes of death in Liberia, Sierra Leone, and Guinea

With more than 20 000 cases reported, the outbreak of Ebola virus disease (EVD) in west Africa is by far the largest in recorded history. Despite the scale of the current outbreak, EVD is often perceived as a "small-scale killer".[1] By comparison, malaria caused an estimated 854 000 deaths worldwide in 2013.[2] However, although limited at the global level, the impact of EVD on mortality could be substantial in countries with intense transmission. We thus aimed to compare EVD with other causes of death in Liberia, Sierra Leone, and Guinea in 2014.

We did an uncertainty analysis of EVD mortality (see appendix), based on two parameters: the extent of under-reporting of EVD cases and the case fatality rate (CFR)—ie, the proportion of EVD cases who die. Similar to other analyses of EVD spread,[3] we hypothesised that there were up to 2·5 times more EVD cases than reported. This factor derives from a mathematical model, which compared the reported number of EVD cases to the number of beds in use in Ebola treatment units in August, 2014.[4] We assumed that the CFR varied between 60% and 85%. The lower rate corresponds to CFRs seen among hospitalised EVD patients with known disease outcomes.[5] Lower CFRs have been documented, but only in Ebola treatment units that implement non-standard treatment protocols.[6] The upper rate corresponds to CFRs seen in non-hospitalised EVD patients.[5]

We estimated the number of EVD deaths as the product of (1) the reported number of EVD cases, (2) the under-reporting factor and (3) the CFR. Based solely on confirmed and probable EVD cases, the number of EVD deaths in 2014 ranged from 2928 to 10 372 in Liberia, from 4468 to 15 824 in Sierra Leone, and from 1739 to 5548 in Guinea.

We used the most recent (2013) national estimates of non-EVD mortality,[2,7] together with projections of population growth, to calculate the expected number of deaths from non-EVD causes in Liberia, Sierra Leone, and Guinea in 2014. For all combinations of model parameters, we mapped how the estimated number of EVD deaths ranked relative to the expected number of deaths from non-EVD causes.

In Liberia, for virtually all model parameters, EVD deaths exceeded the expected number of deaths due to the leading non-EVD cause of death (figure). In Sierra Leone, a broad range of model parameters also indicated that EVD might have killed more people in 2014 than the leading non-EVD cause of death (ie, malaria). In other sets of model parameters, EVD still killed more people than the second

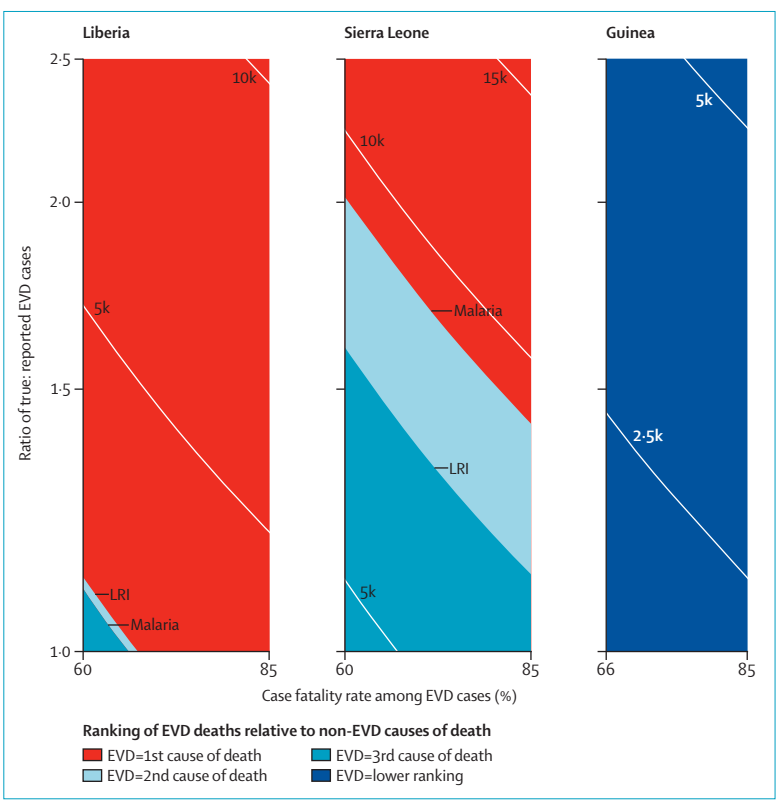

Figure: **Comparison of Ebola virus disease (EVD) deaths and expected deaths from non-EVD causes in Liberia, Sierra Leone, and Guinea in 2014**

LRI=lower respiratory infections. White contours represent estimated number of EVD deaths in 2014 for specific combinations of model parameters (where 2·5k = 2500 deaths, etc). Calculations of number of EVD deaths, and comparisons with other causes of death, are described in the appendix. Range of possible case fatality rates (CFRs) is narrower in Guinea than in the other two countries because a higher percentage of EVD deaths was recorded in that country among reported EVD cases. Lower bound of CFR is thus set at level estimated by surveillance data in that country. To aid figure interpretation, we illustrate the case of Sierra Leone. In the red area, there are more EVD deaths than we expect deaths from the leading non-EVD cause of death in that country—ie, malaria. Hence, in this region of the parameter space, EVD would be the first cause of death. In the light blue area, there are fewer EVD deaths than deaths from the leading non-EVD cause of death, but there are more EVD deaths than deaths from the second non-EVD cause of death (ie, LRI). Hence EVD would be the second cause of death in that region of the parameter space. In the slightly darker blue area at the bottom of the graph, there are fewer EVD deaths than deaths from LRI, but more than deaths from HIV/AIDS—ie, the third leading non-EVD cause of death (see appendix). EVD would thus be the third leading cause of death in that region of the parameter space. The boundary between the red and light blue areas (marked "malaria") represents combinations of model parameters where the number of EVD deaths is equal to the expected number of malaria deaths. The boundary between the light blue and the darker blue areas (marked "LRI") represents combinations for which the number of EVD deaths is equal to the expected number of LRI deaths. In Guinea, the entire graph is dark blue because the number of EVD deaths is lower than the expected number of deaths from the third non-EVD cause of death in the country for all model parameters.

See Online for appendix

(ie, lower respiratory infections) or the third (ie, HIV/AIDS) leading causes of death. In Guinea, EVD never ranked higher than the top three non-EVD causes of death (figure). The highest estimate of EVD deaths was slightly lower than the expected number of deaths from diarrhoeal diseases—ie, the fifth leading non-EVD cause of death in that country (see appendix).

Our analyses have limitations. First, we do not account for increases in non-EVD deaths due to lower health-care use during the outbreak.[8] Second, the estimates of non-EVD mortality are based largely on imprecise survey or census data.[2] Despite statistical corrections,[9] they might underestimate the number of non-EVD deaths.[10] Third, the range of model parameters we considered might be too broad. In one study of EVD viral sequences collected in June, 2014, in Sierra Leone, there were only up to 1·7 times more cases than reported.[11] Case reporting might also have improved in the autumn of 2014, as new Ebola treatment units were opened. Fourth, we only include confirmed and probable EVD cases, whereas EVD deaths might also be common among suspected cases (ie, cases without laboratory or clinical data).

Nonetheless, our analyses identify a large discrepancy between the high impact of EVD on mortality in Liberia and Sierra Leone (and to a lesser extent Guinea), and its low impact on mortality at global or continental levels. Since assessments of the burden of disease should inform the allocation of health investments,[12] this discrepancy could create conflicting priorities among actors of the health sector in these countries. External actors operating across multiple countries and regions (eg, donors, non-governmental organisations) might emphasise tackling diseases more common throughout sub-Saharan Africa than EVD.[13] National governments, on the other hand, might stress the need to prevent future EVD outbreaks. The emergence of EVD will thus require increased coordination between national and external actors to ensure that important components of the disease burden do not go unaddressed. Focusing on building high-quality health systems, capable of addressing a broad range of diseases including EVD, could help overcome this tension.[14]

We thank Bruno Masquelier and Jemima A Frimpong for comments. We declare no competing interests.

*Stephane Helleringer, Andrew Noymer
sheller7@jhu.edu

Johns Hopkins University Bloomberg School of Public Health, Baltimore, MD 21205, USA (SH); and Department of Population Health and Disease Prevention, University of California, Irvine, CA, USA (AN)

1 Anon. Fever rising. *Economist* Aug 16, 2014. http://www.economist.com/news/international/21612157-spread-ebola-west-africa-deeply-troubling-region-and-world-fever (accessed March 10, 2015).

2 Murray CJ, Ortblad KF, Guinovart C, et al. Global, regional, and national incidence and mortality for HIV, tuberculosis, and malaria during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014; **384:** 1005–70.

3 Drake JM, Kaul RB, Alexander LW, et al. Ebola cases and health system demand in liberia. *PLoS Biol* 2015; **13:** e1002056.

4 Meltzer MI, Atkins CY, Santibanez S, et al. Estimating the future number of cases in the ebola epidemic—Liberia and Sierra Leone, 2014–2015. *Morb Mortal Wkly Rep* 2014; **63:** 1–14.

5 WHO Ebola Response Team. Ebola virus disease in West Africa—the first 9 months of the epidemic and forward projections. *N Engl J Med* 2014; **371:** 1481–95.

6 Ansumana R, Jacobsen KH, Sahr F, et al. Ebola in Freetown area, Sierra Leone—a case study of 581 patients. *N Engl J Med* 2015; **372:** 587–88.

7 GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015; **385:** 117–71.

8 Bolkan H, Bash-Taqi D, Samai M, Gerdin M, Von Schreeb J. Ebola and indirect effects on health service function in Sierra Leone. *PLoS Curr Outbreaks* 2014; published online Dec 19. http://dx.doi.org/10.1371/currents.outbreaks.0307d588df619f9c9447f8ead5b72b2d.

9 Obermeyer Z, Rajaratnam JK, Park CH, et al. Measuring adult mortality using sibling survival: a new analytical method and new results for 44 countries, 1974–2006. *PLoS Med* 2010; **7:** e1000260.

10 Helleringer S, Pison G, Masquelier B, et al. Improving the quality of adult mortality data collected in demographic surveys: validation study of a new siblings' survival questionnaire in Niakhar, Senegal. *PLoS Med* 2014; **11:** e1001652.

11 Scarpino SV, Iamarino A, Wells C, et al. Epidemiological and viral genomic sequence analysis of the 2014 Ebola outbreak reveals clustered transmission. *Clin Infect Dis* 2014; published online Dec 15. http://dx.doi.org/10.1093/cid/ciu1131.

12 Dieleman JL, Haakenstad A. The complexity of resource allocation for health. *Lancet Glob Health* 2015; **3:** e8–9.

13 Ljomborg B. Ebola kills far fewer than Aids, TB and malaria. What should we prioritise? *Guardian* Jan 19, 2015. http://www.theguardian.com/global-development-professionals-network/2015/jan/19/ebola-kills-fewer-aids-tb-malaria-attention (accessed March 10, 2015).

14 Boozary AS, Farmer PE, Jha AK. The Ebola outbreak, fragile health systems, and quality as a cure. *JAMA* 2014; **312:** 1859–60.