



## Systematic review

## Evaluation of the scientific impact of the Ebola epidemic: a systematic review

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## ABSTRACT

**Objectives:** The Ebola outbreak prompted an extensive number of scientific publications, but little attention has been paid to the involvement of local scientists, distribution of research funding and related publications. We sought to systematically review publicly available information on the scientific impact of the Ebola epidemic.

**Methods:** A systematic review of literature on the Ebola outbreak was performed. Extracted information included origins of the authors, type and distribution of funding, and impact factors (IF) of related publications between 6 December 2013, and 22 December 2015.

**Results:** We identified 460 relevant articles out of 3281 references, which were mostly authored by American (46.6%) and European (28.4%) institutions; only 13.4% of authors were affiliated with African institutions. Most IF can be attributed to the Americas and Europe, with 43% (25 030.8 IF) and 34.5% (20 074.2 IF), respectively, compared with 17.9% (10 436.5 IF) in Africa. Funds were provided mainly by the Americas (31.8% of all funded studies) and Europe (17%). American and European funds were also distributed back, mainly to American (77.8%) and European (85.2%) institutions, respectively.

**Conclusions:** The Ebola outbreak had a significant scientific impact and resulted in numerous publications in high IF journals. The main impact could be measured in the Americas and Europe, and was directly related to funding. African researchers were only marginally involved in the scientific processing (86.6% of all researchers were not African), probably because major research centres are located in America and Europe. Our results suggest the importance of promoting closer cooperation between regions. **N.T. Mutters, Clin Microbiol Infect 2018;24:573**

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## Introduction

Ebola virus disease (EVD), also referred to as Ebola haemorrhagic fever, is characterized by its severe, often fatal, outcome. The most recent eruption, starting in December 2013, was unprecedented in its pervasiveness and magnitude. More than 30 000 EVD cases, resulting in over 11 000 deaths, reported in nine different countries can be considered as proof of the grave situation [1]. On 8 August 2014, the World Health Organization (WHO) responded by declaring

Ebola a Public Health Emergency of International Concern, thereby underlining its global significance. This measurement prompted an influx of recommendations and guidelines on disease prevention and management from the WHO itself and other mainly Western countries [2,3]. Additionally, private companies put an unparalleled emphasis on vaccine advancement. Mapp Biopharmaceutical, Inc. (San Diego, CA, USA) and Defyrus Inc. (Toronto, Canada) collaborated to develop the antibody mix ZMapp [4]. Research funding increased significantly compared with the 16 years before the outbreak, eventually resulting in more than US\$435 million spent in 2014 and 2015 [1]. Most of the funding was used for clinical trials (48%) and preclinical research (18.1%) and some was contributed directly to handle the crisis [1]. Despite having a substantial amount of data on the impact of interventions and scientific achievements made

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during the EVD outbreak, little attention has been paid to the scientific impact of the Ebola epidemic and to where the research has come from and which scientific communities were involved. The present review aims to investigate the short-term scientific impact (restricted to 2 years from the start of the outbreak), of the Ebola epidemic analysing the involvement of the local scientists, distribution of funding and related publications.

## Methods

### Information sources and search strategy

Peer-reviewed literature (PubMed) was systematically searched. References from the retrieved articles were also reviewed for potential additional articles. Language was not restricted when English abstracts were available. In cases of absence, the language of publications was limited to Dutch, English, French and German. All available abstracts of studies were reviewed. Search terms included 'Ebola infections' OR 'filovirus infection' AND 'Ebola' OR 'Ebola epidemic' OR 'health worker Ebola infections' OR 'VHF database' AND 'Ebola' OR 'Ebola virus disease epidemic' OR 'EVD epidemic' OR 'Ebola virus disease' OR 'EVD' OR 'Ebola' OR 'EBOV' OR 'Ebola virus' OR 'Ebola fever epidemic' OR 'viral haemorrhagic fever' OR 'VHF' OR 'Ebola virus outbreak' OR 'Ebola haemorrhagic fever' OR 'EHF' OR 'West Africa' AND 'Ebola' OR 'Sierra Leone' AND 'Ebola' OR 'Guinea' AND 'Ebola' OR 'Liberia' AND 'Ebola' OR 'Nigeria' AND 'Ebola' OR 'Mali' AND 'Ebola' OR 'Senegal' AND 'Ebola'. The search was conducted to identify papers that directly addressed the most recent Ebola outbreak in West Africa. The search was restricted to studies published online between 6 December 2013 and 22 December 2015.

### Eligibility criteria

Two authors (VM and NM) independently assessed the inclusion criteria (original papers, reviews and guidance documents referring to the Ebola outbreak in West Africa) and exclusion criteria (papers not addressing the Ebola outbreak between 2014 and 2015, opinions, comments, news, editorials, papers from journals without IF and inability to retrieve full copies). Included references were abstracted systematically according to number of authors,

geographical location of authors' affiliated institutions (Africa, Americas, Asia, Australia and Europe) and IF of the journal (based on the IF calculated by Journal Citation Reports of Thomson Reuters, accessed October 2016). The retrieved IF number was assigned to the article and to each of the authors of the article. In cases of authors with multiple affiliations from different geographical regions, one affiliation per region was counted. In cases of funded guidance documents and original works, the source of funding per geographic region was assessed if funding was acknowledged.

### Statistics

For descriptive purposes, the arithmetic mean value, standard deviation, median, interquartile range and cumulative frequencies were calculated as appropriate. All statistical comparisons were conducted with a significance level of 0.05. Statistical analysis was performed using the SPSS statistical package (SPSS v. 21.0, Chicago, IL, USA).

## Results

Our literature review identified 3281 references of which 744 were considered potentially relevant. After a full-text review, a total of 460 studies were included (Fig. 1). Those comprised 240 (52.2%) original papers, 151 (32.8%) reviews and 69 (15%) guidance documents. The 460 studies were authored by 3807 authors in total. Most authors came from the Americas, 46.6% (1775/3807), and only 13.4% of all authors were from Africa (Table 1). All authors amounted in total to 58 271.2 IF and a mean of 15.3 IF ( $\pm 18.1$  SD) per author. The majority of total IF were attributed to the Americas and Europe, with 43% and 34.5%, respectively, and only 17.9% could be attributed to Africa (Table 1). Most of the original works and reviews were carried out in one geographical region (92.6%;  $n = 426/460$ ), whereas only 7.4% were collaboration papers between geographical regions. Only three studies were co-funded by both an African nation and another country from a different geographical region. Geographical regions were defined as the European, African, American and Asian continents, respectively.

The IF depicted as mean per article reached 8.5 ( $\pm 12.9$  SD) and totalled 3897.1 IF for all 460 studies. Of all studies, 38.8% gave no

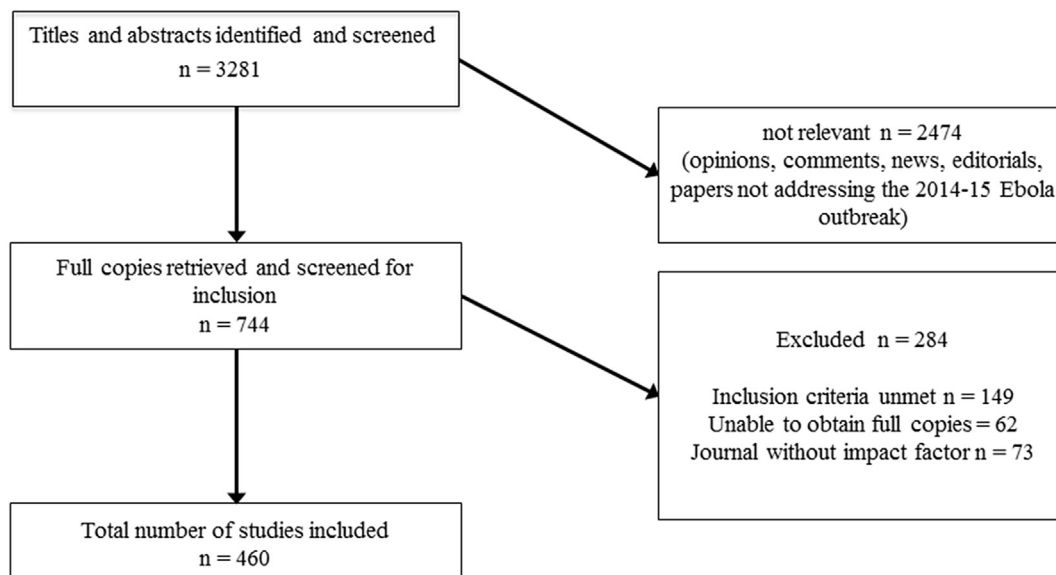


Fig. 1. Search flow diagram.

**Table 1**  
Distribution of authors and impact factor per region

Region	No. (%) of authors	IF, mean ( $\pm$ SD)	Total IF (%)
Americas	1775 (46.6)	14.1 ( $\pm$ 16.4)	25 030.8 (43.0)
Europe	1081 (28.4)	18.6 ( $\pm$ 19.7)	20 074.2 (34.5)
Africa	510 (13.4)	20.5 ( $\pm$ 21.6)	10 436.5 (17.9)
Asia	425 (11.2)	6.2 ( $\pm$ 10.6)	2620.0 (4.5)
Australia	16 (0.4)	6.9 ( $\pm$ 8.6)	109.7 (0.2)
Total	3807 (100)	15.3 ( $\pm$ 18.1)	58 271.2

Abbreviations: IF, impact factor; SD, standard deviation.

information about funding, and 4.2% stated that they did not receive any funding. Of all studies who reported funding, 31.8% were funded by American, 17% by European, 5.8% by Asian and 2.3% by African institutions. However, although Europe and the Americas provided most of the research funds, they were also distributed back mainly to American and European institutions; that is, American funding was mainly distributed to American authors (77.8%) and European funding was mainly distributed to European authors (85.2%)

## Discussion

With a high median IF per article (4.0 IF; interquartile range 5.0 IF), the Ebola outbreak was at the centre of scientific debate (the usual median IF for virology and infectious diseases are 2.6 and 2.5, respectively) [5]. However, research on EVD was scarce before the West African outbreak and the size of the epidemic as well as the related public attention might have opened the doors to high IF journals. Our review shows most scientific processing involved little involvement from African researchers. On-site involvement of African personnel in most of the high IF original works, such as clinical trials (mean IF per article  $25.9 \pm 20.1$  SD) did not result in many authorships. Considering authorship criteria, establishing satellite laboratories and research facilities in affected areas could have allowed on-site personnel to be more integrated into the scientific part of the outbreak, nourishing a more long-term cooperation between institutions and better preparing the global scientific community in case of another outbreak. Considering that EVD requires strict laboratory containment and environmental controls to avoid accidental exposure and laboratory/healthcare worker infections, few laboratories are adequately equipped in Africa to fulfil those safety requirements. Additionally, those that were equipped were mainly designed to perform diagnostics and not research, which might have impacted our results. Unfortunately, the absence of research activity subsequently impedes the development of research capacity that could be driving potential scientists away from a career in academic science in African countries [6]. Research needs not only money but also time and trained personnel, which are rare in some parts of Africa, and especially West Africa, where the outbreak happened. Hence, to improve inter-regional cooperation among researchers, funding mechanisms need to be changed. Although funding is mostly provided to individual research groups rather than strategically on a large scale, strategic funding is required for inter-pandemic research, pre-pandemic research and established pandemic research [1]. One relevant driving force of research is competition, and researchers poorly adapt to soft values such as equality between regions if not forced to do so by funding mechanisms. Strategic inter-pandemic and pre-pandemic funding would be one solution to build up capacity in under-funded regions. Foreign investment alone cannot replace the long-term public funding of research. National policies must adhere to the government's leading role in fostering its own research institutions. One national

approach to broaden access to tertiary institutions is reflected in Beijing's low university tuition fees and national scholarship programmes, such as tax-free loans and free admission. As a result, more science PhDs are currently graduating in China than in any other country [7]. Yet the complexity of African and foreign historical, political and economic relations can certainly be accredited with the current conditions [6].

There are some drawbacks to our study. First, the amount of money actually received was not disclosed. Hence, the proportion of funded studies per region might not be strictly correlated with the actual amount of money. Still, as the statistical proportions are clear (of all funded studies, only 15.5% were African studies compared with 73.8% American and European studies), the amount of money actually received will probably be concordant. Furthermore, well-equipped research facilities are more frequently found in developed regions. Hence, some studies could only have been performed there and not in Africa, which impedes the attribution of authorship. Authorship of a scientific paper requires contributions to experimental conception and design, data analysis and interpretation as well as drafting of the article. A trans-continently conducted study would therefore make it difficult for everyone to contribute to all aspects and hence gain a right to authorship. Furthermore, the outbreak itself resulted in limited human resources, with many qualified African specialists trying to contain the outbreak, leaving no time for research. Lastly, we used the IF as a marker for scientific performance, which has major limitations such as, creating the so-called 'impactitis'; however, it remains the most frequently used marker for scientific excellence and was therefore also chosen in this review [8].

Although some of the Ebola research has fostered meaningful trans-continental cooperation, further improvements are necessary to reach equality in international research collaborations. Extending the involvement of African research institutions to study planning, especially clinical trials, as well as data analysis and interpretation could act as a fulcrum for education. Through investment in the local scientific infrastructure locally conducted research could give African researchers more responsibility and oversight in joint scientific projects. Such long-term investment into the African scientific community can lead to gains in skills and autonomy, creating a more prosperous research collaboration that both parties would benefit from and eventually promote closer cooperation between regions, which sometimes appear not only geographically but also politically separated. After all, infectious diseases will always ignore international boundaries and continue to spread between continents.

## Transparency declaration

All authors report no conflicts of interest.

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