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The 2014 Ebola Outbreak: Preparedness in West African Countries and its Impact on the Size of the Outbreak

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Abstract

The recent Ebola virus outbreak in West Africa was the first that reached epidemic size resulting in more than 28,000 suspected and confirmed cases and more than 11,000 deaths. Here, we performed a meta-analysis to determine the role of preparedness in the course of the epidemic. Relevant research articles were identified using the search terms "Ebola 2014 preparedness", "Ebola 2014 treatment and diagnosis", "Ebola 2014 isolation", "Ebola 2014 culture", and "Ebola 2014 Health Care Workers" in PubMed. 21 relevant original articles in English were identified and analysed. Results revealed that a lack of preparedness substantially contributed to the scale of the Ebola epidemic in West Africa. Studies consistently reported on shortcomings in the availability and use of personal protective equipment, transportation and communication systems, surveillance, patient isolation and treatment, training of healthcare workers, and public awareness and perception in the affected West African countries. Effective surveillance and patient isolation enabled outbreak control. In conclusion, effective health care systems and procedures for early detection and containment of outbreaks, in combination with education of the population will be needed to better control future Ebola outbreaks and outbreaks of other (novel) pathogens for which no effective treatment is available.

Introduction

Ebolaviruses have since their discovery in 1976 been known to cause severe disease including haemorrhagic fever with high fatality rates in humans [1,2]. Until recently, *Ebolaviruses* only caused sporadic outbreaks of limited size affecting a maximum of a few hundreds of patients [3]. However, between 2013 and 2016 an unprecedented Ebola virus outbreak occurred predominantly in Guinea, Liberia, and Sierra Leone with few cases in Nigeria, Mali, and Senegal. The disease was also exported to the UK, the US, Spain, and Sardinia and resulted as of 8th May 2016 in 28,657 suspected and confirmed cases and 11,325 confirmed deaths (www.who.int), although this is probably an underestimation [4].

It remains incompletely understood why the recent Ebola virus outbreak reached epidemic size. Here, we performed a meta-analysis of the available evidence in order to determine the contribution of a lack of preparedness and societal factors such as cultural behaviour and beliefs to the extent of the outbreak.

Methods

Identification of relevant research articles

Relevant research articles were identified by a Pubmed (http://www.ncbi.nlm.nih.gov/pubmed) search using the search terms "Ebola 2014 preparedness", "Ebola 2014 Treatment and Diagnosis", "Ebola 2014 Isolation", "Ebola 2014 Culture", "Ebola 2014 Health Care Workers", Ebola 2014 Personal Protective Equipment", "Ebola 2014 perception", "Ebola 2014 Resistance", and "Ebola 2014 Transportation". Additionally, the reference list of the selected articles was used to identify further relevant research articles.

The inclusion criteria for articles were that they are published in English and that they report on original research focussed on the West African countries, Guinea, Sierra Leone and Liberia, and their neighbouring countries Ghana and Nigeria.

Results

Identification of relevant research articles

The results of the article search are presented in table 1. Since some articles were identified in more than one category, this resulted in 21 relevant original articles in English that were included in this study (Table 2).

Availability and use of personal protective equipment and supplies

A number of studies agreed that lack of sufficient personal equipment and lack of knowledge of its proper usage contributed to the problems to control the 2014 West African Ebola virus outbreak.

One study focused on four rural counties in Liberia (Grand Cape Mount, Grand Bassa, Rivercess, Sinoe), reported on limited supplies of ambulances, essential drugs, and personal protective equipment as well as on inadequate training on the safe removal of personal protective equipment [5]. Furthermore, a lack of protective clothing, masks, and boots as well as disinfectants such as chlorine was reported in two prefectures in Guinea [6]. In Ghana, the majority of healthcare workers

Search term	Hits	Original articles	Relevant original articles
Ebola 2014 preparedness	81	74	9
Ebola 2014 Treatment and Diagnosis	187	146	5
Ebola 2014 Isolation	205	176	9
Ebola 2014 Culture	37	36	4
Ebola 2014 Health Care Workers	87	82	8
Ebola 2014 Personal Protective Equipment	48	36	6
Ebola 2014 perception	12	11	3
Ebola 2014 Resistance	14	12	1
Ebola 2014 Transportation	21	19	2

Table 1: Results of the literature research

Authors	Journal
Ajelli et al.	BMC Med. 2015 Nov 26;13:281.
Blackley et al.	MMWR Morb Mortal Wkly Rep. 2015 Feb 27; 64(7):175-8.
Chowell et al.	Lancet Infect Dis. 2015 Feb;15(2):148-9.
Dixon et al.	Emerg Infect Dis. 2015 Nov;21(11):2022-8.
Gidado et al.	PLoS Curr. 2015 Apr 8;7. pii: ecurrents. outbreaks.0b805cac244d700a47d6a3713ef2d6db.
Gleason et al.	MMWR Morb Mortal Wkly Rep. 2015 Oct 9;64(39):1108-11.
Greiner et al.	Int J Infect Dis. 2015 Dec;41:53-5.
Grinnell et al.	MMWR Morb Mortal Wkly Rep. 2015 Oct 2;64(38):1083-7
Kilmarx et al.	MMWR Morb Mortal Wkly Rep. 2014 Dec 12;63(49):1168-71.
Kouadio et al.	PLoS Curr. 2015 May 6;7. pii: ecurrents. outbreaks.9681514e450dc8d19d47e1724d2553a5.
Kucharski et al.	Proc Natl Acad Sci U S A. 2015 Nov 17;112(46):14366-71.
Manguvo and Mafuvadze	Pan Afr Med J. 2015 Oct 10;22 Suppl 1:9.
Musa et al.	Pan Afr Med J. 2015 Aug 31;21:331.
Nyarko et al.	Global Health. 2015 Feb 26;11:7.
Pellechia et al.	Pan Afr Med J. 2015 Oct 10;22 Suppl 1:9.
Oladimeji et al.	Trop Med Int Health. 2015 Sep;20(9):1162-1170.
Summers et al.	MMWR Morb Mortal Wkly Rep. 2014 Dec 19;63(50):1202-4.
Tambo et al.	Infect Dis Poverty. 2014 Aug 5;3:29.
Tartari et al.	Antimicrob Resist Infect Control. 2015 Jun 8;4:22.
Thiam et al.	Pan Afr Med J. 2015 Oct 11;22 Suppl 1:22.
Victory et al.	MMWR Morb Mortal Wkly Rep. 2015 Apr 17;64(14):386-8.

Table 2: Articles that were analysed in this study

raised concerns over the lack of personal protective equipment and there is anecdotal evidence of healthcare workers abandoning a ward and patients after being confronted with a patient that was suspected to have been in contact with an Ebola patient and that displayed Ebola virus disease-like symptoms [7]. The apprehensions of health care workers with regard to their individual risks seem to be justified given that incidence of Ebola virus infection in health care workers was 42-fold higher compared to non-health care workers in Guinea [8] and up to 103-fold higher in Sierra Leone [9].

The importance of sufficient supplies for controlling the outbreak was illustrated by a mathematical model of disease transmission developed to assess the effect of addition of hospital beds on Ebola virus transmission rates between June 2014 and February 2015 in 12 districts of Sierra Leone [10]. 56,600 (reported and unreported) Ebola cases were estimated to have been prevented as of 2nd February 2015 as a direct result of increased numbers of treatment beds. The simulation also concluded that a further 12,500 cases would have been prevented if more beds had been available a month earlier. This demonstrates that the lack of preparedness at hospital level directly escalated the size of this epidemic. More beds might have been sufficient to result in an early stop to the entire outbreak or at least to dramatically reduce its size [10]. In this context, an uneven distribution of resources in the affected areas may have contributed to the scale of the outbreak [3,5].

Transportation and communication systems

There is evidence that shortcomings in the transport and communication infrastructure contributed to the size of the Ebola outbreak in West Africa [5,7,10,11]. In Liberia, roads were blocked during the rainy seasons and investigation teams had to walk up to 8 hours and cross rivers to reach remote affected areas to distribute information on safe behaviour (in particular safe burials) and contact tracing. This also affected the transport of necessary laboratory equipment and supplies, and specimens/samples as well as patient transport to Ebola treatment units [5]. Moreover, the distribution of information (in particular on suspected cases and test results) was impaired by poor telephone network coverage in Liberia and Sierra Leone [5,10]. A study in Ghana suggested that the communication and transport infrastructure in this country was also not prepared to cope with a substantial Ebola virus disease outbreak [7].

Surveillance and contact tracing

Effective surveillance including contact tracing is necessary to identify susceptible individuals and closely monitor them for a minimum of 21 days to break the transmission chain [12]. The analysis of a contact database in two prefectures in Guinea showed that only about 30% of the patients were documented as contacts before the disease was diagnosed. Moreover, more than 60% of newly diagnosed cases did not have registered contacts [13]. Similar gaps indicating insufficient training of contact tracers were identified in Sierra Leone, Ghana, and Liberia [5,7,14,15].

Isolation and treatment

Efficient isolation is critical for diseases for which no treatment exists. A recent simulation indicated that isolation of 50% of individuals within three days after Ebola virus disease onset does not change the course of an outbreak while effective isolation of 65% of patients was predicted to result in epidemic control [16]. All affected West African countries have been reported to lack adequate isolation facilities [6,17-20]. An analysis that assessed the impact of control measures in Pujehun, Sierra Leone concluded that the number of available beds in qualified isolation units is critical for the control of Ebola virus outbreaks [18]. In the Bombali district in Sierra Leone, the establishment of a new isolation unit resulted in an immediate and drastic reduction in the number of new cases [20].

With regard to treatment of Ebola patients, a lack of appropriate intensive care units was reported [6,17,20-22]. In particular, facilities that offer renal replacement therapy, which is required for critically ill Ebola virus disease patients are very limited [17].

Healthcare worker knowledge and training

A number of studies reported a lack of knowledge and training of health care workers in West African countries [5,6,19]. In Coyah and Forecariah, two prefectures in Guinea, only one to two staff members per facility underwent Ebola training for three days at the prefecture level and were expected to implement procedures in their home institutions without further support [6]. Among four counties in Sierra Leone, only Grand Bassa reported to have teams trained in case investigation and contact tracing in place when the first case was reported. Only Grand Bassa and Grand Cape Mount reported having a functioning ambulance. However, health care workers from Grand Cape Mount were reported not to have received training on the transport of potential Ebola patients. Moreover, corpses were transported by untrained individuals [5]. In addition, there was an absence (Guinea) or lack (Sierra Leone) of lab technicians that had received training on the handling of specimens from suspected Ebola patients [5]. In Lagos, Nigeria, a majority of health care workers demonstrated sufficient knowledge on Ebola virus disease, but the implementation of this knowledge into clinical practice remained very poor [19].

Public Awareness and Perception

Ebola virus transmission occurs via direct contact, usually direct touching [23]. It was shown that the number of community deaths rapidly declined after the initiation of community intervention [24].In this context, the number of community deaths was an important parameter in the Ebola WHO situation reports to monitor public awareness, which was critical for the efficacy of control measures, in particular contact tracing (www.who.int/csr/disease/ebola/situation-reports/archive/en/). In many African countries, burial procedures include touching, cleaning, and

washing of the deceased, which is known to be a route of viral transmission [25]. In Liberia, cremation was suggested to decrease transmission. However, this resulted in secret, unsafe burials [26].

Safe procedures require trained burial teams fully protected by personal protective equipment, timely burial of Ebola victims, the placing of dead bodies in leak-proof bags, and burying them at least two metres deep [27]. However, there were shortcomings in the implementation of such measures, although the extent of these shortcomings is not entirely clear [18,27]. In addition, community members felt insufficiently informed, insisted on religious practices, and/ or opposed to unmarked graves. The resulting conflicts and misunderstandings further hampered the implementation of safe procedures [6,27]. In this context, 85 new Ebola virus disease cases were documented to arise from a single traditional funeral ceremony [28].

Studies also demonstrated substantial gaps in the knowledge of Ebola virus disease with regard to the causes, symptoms, and mode of transmission, resulting in a lack of understanding of the necessity and adequacy of the introduced preventative measures [6,29]. In Lagos, Nigeria, less than half of assessed individuals had satisfactory understanding of the mode of transmission and preventative measures to avoid the disease. Only 2% followed advice on hygiene measures and more than 50% believed they could not contract the disease [29].

Nine communities in Guinea showed reluctance to implement control measures, because initial information distributed by the authorities had stated that diseased patients would inevitably die [6]. Such exaggerated messages that had been intended to increase compliance also resulted in the stigmatisation of individuals who were suspected to be infected but tested negative or survived [6]. Other misconceptions included that control measures were just a way of making money and/ or that healthcare workers would distribute Ebola virus during disinfection sessions [6]. Due to misconceptions, some Ebola patients were hiding from officials [30].

Discussion

Here, we present a meta-analysis of the contribution of a lack of preparedness to the unprecedented size of the recent Ebola virus outbreak in West Africa, an area that had not previously been affected by Ebola virus outbreaks [3]. Our results indicate that a lack of preparedness substantially contributed to the scale of the epidemic. A range of studies (Table 2) consistently reported on shortcomings in the availability and use of personal protective equipment, transportation and communication systems, surveillance, patient isolation and treatment, training of healthcare workers, and public awareness and perception in the affected West African countries.

While there is clear evidence that a lack of preparedness critically contributed to the size of the Ebola epidemic, the extent of its contribution cannot be conclusively quantified. Molecular studies did (despite initial concern about potentially increased mutation rates) not suggest a difference in Ebola virus properties or evolution between the West Africa outbreak and previous outbreaks [31-37]. Similarities observed between the West Africa outbreak and previous outbreaks, including reproductive number, serial time, symptoms and incubation period suggest that the virus transmissibility and virulence was unchanged [38]. Hence, the scale of the outbreak has been attributed to environmental factors rather than virus properties [38].

Some studies suggested that efficient identification and isolation of patients and their contacts are sufficient to control Ebola virus outbreaks [10,16,18]. Awareness and preparedness may have avoided a larger outbreak in Nigeria [39]. This re-emphasises the need for effective surveillance systems, appropriate facilities, and well-trained healthcare staff. However, studies suggest that gaps in the preparedness are not limited to less developed countries but are prevalent globally [17,21,40,41]. The development of Ebola virus vaccines and anti-Ebola virus drugs is under way [42,43] and will hopefully enable the more efficient control of future Ebola virus outbreaks. However, (novel) pathogens for which no causative treatment exists remain a critical threat, as illustrated by examples such as Zika virus [44] and Dengue virus [45]. Even well-known pathogens can re-emerge as a threat because of the sudden emergence of novel variants like in the case of influenza viruses [46] or the development of resistance to available drugs like in the case of multi-drug resistant bacteria [47]. In the case of influenza, even best case scenarios predict a delay of at least five to six months from the identification and isolation of a novel pandemic virus strain and to the availability of vaccines [46]. Therefore, functioning health care systems that can effectively deal with pathogens for which no causative treatment exists remain of crucial importance.

In conclusion, a lack of preparedness and efficient epidemic control substantially contributed to the magnitude of the recent Ebola virus outbreak in West Africa. Due to global interconnectedness, local outbreaks always also pose a global threat, as illustrated by the export of the disease to UK, the US, Spain, and Sardinia [4]. This should be a wake-up call for the development of effective global structures that enable the early identification and effective management of outbreaks of (novel) diseases.

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