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Review article

Ebola hemorrhagic fever outbreaks: strategies for effective epidemic management, containment and control

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ABSTRACT

Ebola hemorrhagic fever, caused by the highly virulent RNA virus of the *filoviridae* family, has become one of the world's most feared pathogens. The virus induces acute fever and death, often associated with hemorrhagic symptoms in up to 90% of infected patients. The known sub-types of the virus are *Zaire*, *Sudan*, *Taï Forest*, *Bundibugyo* and *Reston* Ebola viruses. In the past, outbreaks were limited to the East and Central African tropical belt with the exception of Ebola Reston outbreaks that occurred in animal facilities in the Philippines, USA and Italy. The on-going outbreak in West Africa that is causing numerous deaths and severe socio-economic challenges has resulted in widespread anxiety globally. This panic may be attributed to the intense media interest, the rapid spread of the virus to other countries like United States and Spain, and moreover, to the absence of an approved treatment or vaccine.

Informed by this widespread fear and anxiety, we analyzed the commonly used strategies to manage and control Ebola outbreaks and proposed new approaches that could improve epidemic management and control during future outbreaks. We based our recommendations on epidemic management practices employed during recent outbreaks in East, Central and West Africa, and synthesis of peer-reviewed publications as well as published "field" information from individuals and organizations recently involved in the management of Ebola epidemics.

The current epidemic management approaches are largely "reactive", with containment efforts aimed at halting spread of existing outbreaks. We recommend that for better outcomes, in addition to "reactive" interventions, "pre-emptive" strategies also need to be instituted. We conclude that emphasizing both "reactive" and "pre-emptive" strategies is more likely to lead to better epidemic preparedness and response at individual, community, institutional, and government levels, resulting in timely containment of future Ebola outbreaks.

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Introduction

Ebola hemorrhagic fever (EHF) or Ebola virus disease (EVD) is the human disease caused by infection of the single stranded RNA viruses of the genus '*Ebola*' and family '*Filoviridae*'. Ebola virus was discovered in 1976, following coinciding outbreaks in Zaire, now Democratic Republic of the Congo (DRC), and Sudan.[1,2] EVD usually begins with an acute fever, causing death following hemorrhagic symptoms in up to 90% of cases depending on the viral species.[1,2] The known species include *Bundibugyo Ebolavirus* (*BEBOV*), *Sudan Ebolavirus* (SEBOV), Zaïre *Ebolavirus* (*ZEBOV*), Reston *Ebolavirus* (*REBOV*) and *Côte D'Ivoire Ebolavirus* (*CIEBOV*), also known as, *Taï Forest Ebolavirus* (*TAFV*). The *REBOV* strain has caused no human deaths so far, but has been lethal to chimpanzees, gorillas and monkeys.[3,4]

In terms of pathogenicity, SEBOV strain leads to case fatality rates of 40–60%, *ZEBOV* rates range from 60% to 90%, while the *BEBOV* strain is associated with fatality rates of 25%. The *CIEBOV* subtype has been implicated in a single non-fatal human case.[2,4] Generally, this high fatality rate, the international spread of the virus across borders, including the possible use of the viral isolates as a possible tool for bioterrorism make EVD an important public health concern of global proportions. Consequently, Ebola outbreaks lead to widespread fear, anguish and hysteria, locally and internationally, due to media attention, commerce, travel and tourism.[3,5]

Typically, EVD leads to rapid suppression of the immune system, triggering systemic inflammatory response causing impaired vascular, coagulation and immune systems functioning, resulting in multiple organ failure, hypovolemic shock and death.[2,5] Since its discovery in 1976, no effective vaccine or post-exposure treatment exists to date. Hence, the current disease management plan consists of supportive therapy to revive infected patients, minimizing infection transmission, and calming anxious populations.[2,3] These interventions often require interdisciplinary efforts instituted at both community and healthcare institutions.

In this paper, we discuss the epidemiology, clinical features and mode of transmission of Ebola virus. We also highlight epidemic response efforts instituted in recent outbreaks in East, Central and West Africa. We recommend strategies for improved epidemic management during and in-between outbreaks. The paper is based on synthesis of original research and review papers indexed in MEDLINE, Scopus, PubMed, CINAHL, Science Direct, and Google Scholar databases, published between January 2000 and September 2014, as well as data collected during a doctoral research study conducted in Uganda between June and July 2013.

To reflect current practices and highlight specific aspects of epidemic management, we have also included substantial amounts of recent "field" information from individuals and organizations involved in the recent outbreaks, in the form of online resources, newspaper articles, press releases and clinical guidelines. The resources and publications used were obtained from data bases using combinations of the Medical Subject Headings (MeSH) and related search terms, "Ebola hemorrhagic fever"; "Ebola virus disease"; "filoviridae infections"; "Ebola epidemics"; "communicable disease control"; "case management"; "disease surveillance"; "epidemiology" and "disease management". Peer-reviewed articles published in the last decade in English that focused on Ebola and Marburg was prioritized.

Focus of the study

This article briefly introduces the reader to Ebola virus disease, the various strains and the common signs and symptoms of the disease, including current epidemic management strategies. The paper ends with recommendations for improved epidemic management strategies based on the lessons learnt from outbreaks in East, Central Africa and West Africa.

Mode of transmission

The exact transmission mode of Ebola viruses from their natural reservoir to humans or non-human primates remains largely unknown,[2,6] although most outbreaks appear to be zoonotic. In laboratory animals, the virus can initiate infection following ingestion, inhalation or passage through breaks in the skin.[4,7] In non-human primates, experiments have also shown that transmission can occur through droplet inoculation of the viruses into the mouth or eyes.[8]

In humans, outbreaks usually occur following person-to-person transmission involving direct contact with the mucous membranes or broken skin with contaminated blood, vomitus, urine, feces, and semen from infected persons.[7,9] During outbreaks, it has been shown that direct contact among humans occurs during funerals, as part of ritual handling of corpses, as a major mode of interfamilial transmission.[8,10] In addition, healthcare workers are at risk of infection if they care for Ebola patients without appropriate protective measures due to shortages and poor infrastructure or following exposure to patients with unrecognized Ebola virus disease.[5,11]

Contrary to the belief that the Ebola virus is confined to the rain forest of Central Africa, the on-going outbreak in West Africa[3,11] has shown that the virus can spread rapidly and widely, covering large areas, in this case Guinea, Liberia, Sierra Leone, Nigeria, Senegal, Mali, and USA. The factors implicated in this spread are fear, denial, misinformation, mistrust, concealment, and rumor. These resulted in contacts and infected persons to avoid or escape from surveillance systems or treatment centers,[3,11] or relatives hiding symptomatic family members or taking them to traditional healers. Such unregulated movement of infected persons across borders amplifies Ebola epidemics, exacerbated by inadequate surveillance systems and medical isolation centers,[11,12] and persistent high-risk cultural practices like consumption of bush meat and funeral rituals where physical contact occurs with the deceased patient.[2,13]

In addition to human to human contact, direct contact with infected wild animals such as gorillas or chimpanzees during hunting, butchering and while preparing meat has been a significant source of infection to humans especially in the DRC, Gabon, and Uganda.[2,13] Apart from contact with infected non-human primates, human exposure to bat secretions or excretions has also been demonstrated to be a potential route