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Review

Ebola virus disease in Africa: epidemiology and nosocomial transmission

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SUMMARY

The 2014 Ebola outbreak in West Africa, primarily affecting Guinea, Sierra Leone, and Liberia, has exceeded all previous Ebola outbreaks in the number of cases and in international response. There have been 20 significant outbreaks of Ebola virus disease in Sub-Saharan Africa prior to the 2014 outbreak, the largest being that in Uganda in 2000, with 425 cases and a mortality of 53%. Since the first outbreaks in Sudan and Zaire in 1976, transmission within health facilities has been of major concern, affecting healthcare workers and acting as amplifiers of spread into the community. The lack of resources for infection control and personal protective equipment are the main reasons for nosocomial transmission. Local strategies to improve infection control, and a greater understanding of local community views on the disease, have helped to bring outbreaks under control. Recommendations from previous outbreaks include improved disease surveillance to enable more rapid health responses, the wider availability of personal protective equipment, and greater international preparedness.

Introduction

The current 2014 extensive outbreak of Ebola virus disease (EVD) in West Africa has resulted in more cases and deaths than all previous EVD outbreaks combined. There has been a particularly high transmission to, and mortality in, healthcare workers (HCWs).

Nosocomial transmission has been a major cause of morbidity and mortality in EVD since the first outbreaks described in Sudan and Zaire (now Democratic Republic of the Congo, DRC) in 1976.[1,2] Despite the increased understanding of Ebola transmission and the availability of clear and structured guidelines by the World Health Organization (WHO) and other agencies, by the end of 2014 (31st December 2014 data) the current outbreak in West Africa had led to documented infection in 660 health staff with 375 deaths.[3–6] In addition, nosocomial transmission may occur to family attendants, in both healthcare and community settings.[7]

Person-to-person transmission of Ebola virus is by direct contact with the body fluids of a symptomatic case; there is no confirmed evidence of aerosol transmission during outbreaks, though this has been demonstrated in animal studies.[8,9] The incubation period is 2–21 days. EVD clinical features include fever, fatigue, headache, myalgia, gastrointestinal symptoms, and abdominal pain. Not all patients develop haemorrhagic symptoms, but infectivity may begin from the onset of symptoms by body fluids other than blood. Infective contact may occur during patient care in a health facility or in the community, and during burial rituals of a deceased case.[10]

The animal reservoir of Ebola virus has not been definitively proven, but the fruit bat (*Hypsignathus monstrosus* and

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Epomops franqueti) is now regarded as the probable primary host.[11] Non-human primates, infected by fruit bats, slaughtered or eaten as bush meat, have been shown to be the beginning of human infection chains in most outbreaks, with subsequent human-to-human transmission in the community and health facilities.[12] All areas in which EVD outbreaks have occurred are characterized by poor health infrastructure, in most cases remoteness from the more developed areas of the countries, and limited resources for infection control and patient isolation.

Five strains of Ebola virus have been described: Ebola Zaire, occurring in outbreaks in the DRC, Gabon, and the Republic of the Congo, Ebola Sudan, occurring in southern Sudan and Uganda, Ebola Bundibugyo, occurring in Uganda and DRC, Ebola Tai Forest, occurring in a single case in Côte d'Ivoire, and Ebola Reston, which has occurred in non-human, laboratory primates linked to the Philippines, with a small number of asymptomatic human cases.

Table I lists the documented EVD outbreaks that have occurred between 1976 and 2012, prior to the 2014 West Africa outbreak.

The current review has two major aims: (i): to describe published data on documented EVD outbreaks listed in Table I and the current situation in West Africa, to ascertain the evidence for nosocomial transmission; (ii) to consider the control strategies that have been implemented, and how previous recommendations may contribute to reducing Ebola transmission in future outbreaks.

Outbreaks before 2014: occurrence and epidemiology

The first recorded outbreaks of EVD occurred in June 1976 in southern Sudan (now South Sudan) and in July 1976 in the vicinity of a mission hospital in Yambuku, Zaire (DRC).[1,2,30] Although the outbreaks occurred at a similar time and in the same geographical area of central Africa (Yambuku is ~500 km from Nzara), no definite link between them was established, and later virological studies demonstrated differences between the two strains, subsequently described as the Sudan and Zaire strains.[31,32]

The Sudan outbreak began in the town of Nzara, 400 km from the regional capital Juba, and affected workers in a cotton-processing factory. A symptomatic case was transferred to the district hospital of Maridi, where explosive nosocomial transmission occurred. Within four weeks, one-third of the 220 hospital staff had acquired infection, and 41 had died. At this time, there was no knowledge of the mode of transmission of this 'new' disease, and no effective infection control activities or personal protective equipment (PPE) were available. Maridi hospital acted as an amplifier for cases in the community, and by the end of the outbreak in October there had been 284 cases and 151 deaths.

Two months after the first case in Nzara, a similar disease became apparent in a mission hospital in Yambuku, Zaire. The initial infections occurred in patients who had attended the outpatient clinic of the hospital. Parenteral injections with syringes not sterilized between patients, from an initial unsuspected index case, were presumed to be the route of transmission. Subsequent transmission then occurred within the hospital and from infected patients into the community. A total of 318 known cases occurred, with 280 deaths, a case fatality rate of 88%. Eleven of the 17 nursing/clinical staff of the hospital died. No patient whose contact was exclusively parenteral injection survived. Investigations indicated that the index case had eaten bush meat during recent forest travel.

Following the 1976 Sudan and Zaire outbreaks, there have been 18 documented EVD outbreaks in central Africa prior to

Table I
Ebola virus disease outbreaks 1976–2012

Year	Country	Strain	Reported cases	CFR (%)	Situation[a]	Reference
1976	Sudan	Sudan	284	53	2	1
1976	Zaire (DRC)	Zaire	318	88	2	2
1979	Sudan	Sudan	34	65	3	13
1994	Gabon	Zaire	52	60	1	14
1994	Côte d'Ivoire	Tai Forest	1	0	1	15
1995	DRC	Zaire	315	81	2	16
1996 (i)	Gabon	Zaire	37	57	1	14
1996 (ii)	Gabon	Zaire	60	74	1	14
2000–2001	Uganda	Sudan	425	53	2	17
2001–2002	Gabon	Zaire	65	82	1	18
2001–2002	Republic of the Congo	Zaire	57	75	1	19
2002–2003	Republic of the Congo	Zaire	143	89	1	20
2003	Republic of the Congo	Zaire	35	83	1	21
2004	Sudan	Sudan	17	41	3	22
2005	Republic of the Congo	Zaire	12	80	1	23
2007	DRC	Zaire	264	71	1, 3	24
2007–2008	Uganda	Bundibugyo	149	25	3	25
2008–2009	DRC	Zaire	32	47	1	26
2012	Uganda	Sudan	11	36	3	27
2012	DRC	Bundibugyo	36	36	1, 3	28
2012–2013	Uganda	Sudan	6	50	3	29

CFR, case fatality rate; DRC, Democratic Republic of the Congo.
[a] Epidemiological situation: (1) forest/remote area; (2) hospital-centred, with community spread; (3) community and hospital.

the 2014 West Africa outbreak, and one isolated case in Côte d'Ivoire (in 1994). Epidemiologically, these outbreaks fall into three main groups: those occurring in remote forest areas, linked directly to bush meat consumption, and usually with relatively few cases; those centred around and within regional hospitals, with considerable hospital transmission, spreading into the community; and those occurring in populated rural areas, with mainly community transmission but some transmission in local health facilities.

Forest area outbreaks have occurred in Gabon, Republic of the Congo and DRC.[18–20,23,33,34] With the exception of two large, extended, outbreaks in Republic of the Congo and DRC, reported case numbers ranged from 12 to 65, and case fatality rates from 57% to 83%. One outbreak in DRC was closely associated with fruit bat migration and consumption.[35,36]

Two large outbreaks have occurred linked to regional hospitals, in DRC in 1995 and in Uganda, 2000.[16,17,37–41] The outbreak in DRC occurred in Kikwit, a 350-bed regional hospital, resulting in infection in 80 healthcare workers (though some may have been infected in the community), and subsequent spread to other hospitals following patient transfer.[42,43] The Uganda outbreak, in Gulu district, was centred around two hospitals, and the surrounding communities. There were 425 cases and 224 deaths, including 17 hospital staff. Many of the community cases were associated with attendance at burials. The outbreak spread to another area 150 km distant when a patient was transferred to another hospital.[44]

Outbreaks in rural communities with some health facility involvement have occurred in South Sudan and Uganda with case numbers ranging from six to 34 except for an extended outbreak in DRC.[13,22,27,29,45,46] In 2007 a new strain of Ebola virus was isolated in an outbreak in Bundibugiyo district of Uganda, resulting in 147 reported cases, but a lower case fatality rate than with Zaire or Sudan strains.[25,47,48] An outbreak caused by the same strain (now termed the Bundibugyo strain) occurred in DRC in 2012, though no links were discovered between the two areas.[28]

An isolated case of Ebola infection occurred in Côte d'Ivoire in 1994, the only reported case of human Ebola infection in West Africa prior to the 2014 epidemic.[15] The infection occurred in an expatriate zoologist after undertaking an autopsy on a chimpanzee in the Tai forest area. The zoologist was repatriated and survived. Virology studies showed the strain to be different from those of Sudan and Zaire, and was designated Ebola Tai forest strain.[49]

Exposure risk and disease transmission

Whereas it is accepted that disease transmission, in both health facilities and the community, is by direct contact with body fluids of a symptomatic case, there are limited data on the exposure risks of different body fluids or of different types of contact. An unanswered question in the current 2014 epidemic is why, despite wearing PPE and having some degree of infection control, so many healthcare workers have acquired infection. For local staff, some may have acquired infection in the community, but apparently transmission is also occurring in health facilities. Bausch *et al*. investigated specimens in an isolation ward from 26 laboratory-confirmed cases of EVD in the 2000 Uganda outbreak during the acute phase of the illness.[50] Ebola virus was detected by culture or PCR in saliva, stool, semen, breast milk, tears, and nasal blood, both in patients who subsequently died and in survivors. Apart from the nasal swab, only two specimens visibly contained blood. Environmental sampling was also undertaken. Only two sites were positive, both having visible blood present. The study demonstrated that body fluids other than blood are infectious in symptomatic patients, and that patients do not need to be haemorrhagic to be infectious. Importantly, their results suggested that risk of transmission from fomites in the isolation ward was low. A study by Formenty *et al*. during an outbreak in the Republic of the Congo demonstrated virus-positive saliva in symptomatic cases, which correlated with blood levels.[51] Several studies have demonstrated higher blood Ebola viral loads in fatal compared to non-fatal cases during the course of disease — a finding that has also been demonstrated during the 2014 epidemic suggesting an increased risk of infectivity in patients who subsequently die.[52–54] A detailed study during the Uganda 2000 outbreak demonstrated the presence of viral RNA in patients as soon as clinical symptoms appeared, and a review of Ebola and Marburg cases concluded that there is no evidence that patients are viraemic during the incubation period.[53,55] The above studies, although all on small groups of patients, provide some virological evidence for understanding transmission risks, and it is likely that more robust findings will result from studies during the 2014 epidemic.

A review by Ftika *et al*. has considered the amplifying role of healthcare facilities in the evolution of Ebola outbreaks.[56] Analysing data from the 1976 Sudan outbreak, they demonstrated that unprotected nursing of a patient had an attack rate of 81%, limited physical contact (not described in detail) an attack rate of 23%, and no transmission occurred in visiting a room with a symptomatic case and having no physical contact.

Baron *et al*. analysed family contacts and disease risk related to exposure in a 1979 southern Sudan Ebola outbreak.[13] In a study of 86 contacts of cases, 24 of 36 who provided nursing care developed disease, but disease occurred in only three of 23 contacts who had physical contact but no history of nursing care (odds ratio: 5.1; 95% confidence interval: 1.31–15.48).

Several studies from the 1995 Kikwit outbreak have investigated the risks in different degrees of exposure/contact with a known case. Dowell *et al*. showed that in 173 household contacts of a primary case, 28 (16%) developed EVD.[57] All of these secondary cases had direct contact, and exposure to body fluids conferred additional risk. Roels *et al*. investigated risk factors for patients without known exposure to a primary EVD case.[58] Admission to a hospital, and visiting a person with fever and bleeding, were the primary risk factors. Rowe *et al*. investigated the possible seroconversion of contacts following the Kikwit outbreak.[59] The study showed a small number of antibody-positive, non-symptomatic contacts, suggesting that mild forms of the disease may exist, though the role of such cases in transmission is uncertain.

Francesconi *et al*. investigated exposure history of cases in Gulu hospital in the 2000 Uganda outbreak.[60] Contact with body fluids ($P < 0.001$) and participating in funeral rites ($P < 0.02$) were the most significant risk factors for infection. Shared meals with a sick patient, or sharing the same room were not significantly associated with risk of infection.

An important conclusion from these exposure studies is that airborne transmission appears unlikely, as sharing a room, or patient proximity but not direct nursing care, has a much lower

risk of infection. Whereas these studies are valuable in confirming the role of body fluids and nursing care in transmission, there are uncertainties in the actual process of transmission, particularly in determining which procedures/contacts are most risk-prone and what are the routes of entry if not through unbroken skin.

Nosocomial transmission and infection control in EVD outbreaks

From the first recorded EVD outbreaks in Sudan and Zaire in 1976, nosocomial transmission of Ebola infection has been an important cause of morbidity and mortality, among healthcare workers and family attendants. The high rates of nosocomial transmission in these two outbreaks must be put into context. This was a completely unknown disease with high mortality, with an initially unknown mode of transmission, occurring in remote areas of countries with very limited health resources and means of communication. What is of relevance for all outbreaks after 1976 is that the mode of transmission was now known, the fundamental role of isolation and PPE in interrupting nosocomial transmission was established, and the international health agencies were aware of the existence of Ebola virus.

The difficulties of implementing infection control activities in under-resourced areas of the tropics, including in relation to bloodborne viruses, have been described in several reviews.[61–65]

However, there have been effective strategies reported from several EVD outbreaks. In the 1995 DRC (Kikwit) outbreak, setting up of isolation wards and introduction of PPE, supervision of burials by local Red Cross volunteers, and home care and infection control for patients in the community contributed to the ending of the outbreak.[43,66,67]

Studies from other viral haemorrhagic fever outbreaks in Africa can contribute to understanding strategies for appropriate infection control.[68] Effective isolation and infection control was described in a Marburg haemorrhagic fever (MHF) outbreak in north-eastern DRC in 1998–1999.[69] Two isolation units were created and protective equipment was distributed to healthcare workers and family members caring for patients. A detailed account of patient management and infection control in an MHF outbreak in Uige, Angola, in 2005 describes both hospital and community strategies for reducing disease transmission.[70,71] The community strategy was particularly relevant. This response included community epidemiological surveillance, clinical assessment and isolation of patients with MHF, safe burials and disinfection, home-based risk reduction, peripheral health facility support, psychosocial support, and information and education campaigns. During an MHF outbreak in Watsa health zone, DRC, in 1999, a detailed study was undertaken of the risk procedures undertaken by healthcare workers, the use of PPE, and risk of disease transmission.[72] For non-invasive procedures (taking temperature, measuring blood pressure, etc.) only 19% of staff always used PPE. For invasive procedures, 29% always used PPE, but 60% reported not using PPE. The reasons given for inconsistent use of PPE included insufficient availability of equipment, adherence to traditional explanations of the disease (that it was related to poisoning rather than to a transmissible agent) and visiting sick colleagues without wearing PPE.

Traditional beliefs and community activities affecting the implementation of EVD control programmes

Whereas lack of resources and equipment are major constraints in reducing EVD transmission, local cultural and traditional views of disease, and particularly of EVD, may have a major influence on how technical and medical inputs are followed. A detailed study during the 2001 Gulu, Uganda, outbreak investigated why some communities were not following the health programme recommendations.[73] The community in this area of northern Uganda had three explanations for disease: *Yat*, where disease is explained by ingestion of poisons or other harmful substances, managed by traditional healers, with no link to a medical model; *Gemo*, where disease is explained by bad spirits, managed by traditional healers, but where there are some connections with a medical model, e.g. isolation of the patient, a survivor can care for an infected relative, houses with ill patients should be identified by branches or poles; and the biomedical model, which fits into the medical approach to EVD prevention and management. This study showed three particularly relevant findings. First, that unless traditional views of disease are taken into account – however unscientific they may seem – the effect of medical staff, both national and international, will be limited. Second, that cultural and traditional interpretations of disease may not be irrelevant, and may have components that can be incorporated into the health programme. Third, whereas many in the community initially followed the biomedical model, when deaths increased, particularly in the treatment centres, people began to return to traditional models and beliefs. A similar study was undertaken during an Ebola epidemic in the Republic of the Congo in 2003.[74] The authors described that while local volunteers undertook extensive health education regarding contact with patients including participation in burials, it was only after greater understanding of traditional beliefs that, as with the *Gemo* traditions in Uganda, it became clear that traditional practices could be incorporated into the medical model, leading to a more effective programme. The community aspects of Ebola outbreaks also involve the attitudes of local healthcare workers to infection control methods, the use of local volunteers, and how local media cover the outbreak. Several studies were taken during the Uganda 2000 outbreak. A study in Masindi showed that local staff were concerned about the lack of cultural sensitivity of many infection control methods.[75] One suggestion given was to have body bags with viewing windows, so that relatives could see the face of the deceased at the time of burial. Another study described the role of local Red Cross volunteers in health education, case detection, and in giving support to discharged patients, who were often regarded with uncertainty and suspicion when they returned to their villages.[76] The response of local media also plays a role in how the community responds to the outbreak. A study in Uganda investigated how the 2000 outbreak was portrayed in articles, editorials, letters and cartoons in the two main English language daily newspapers.[77] The responses to the outbreak included confusion, anger, stigma in affected communities, and a climate of fear within many communities. The study conclusions suggest that a careful balance is necessary for the media to inform about the seriousness of the outbreak,

but not to create disproportionate panic. In the 2014 epidemic, it may be necessary to consider the role of social media in this context.

The 2014 West Africa outbreak

On March 21, 2014, the Guinea Ministry of Health reported the outbreak of an illness characterized by fever and severe diarrhoea, with a case fatality rate of 59% in the first 49 cases notified. Specimens from 15 of the patients tested were positive for Ebola virus, Zaire strain.[78] By March 30th, cases were reported in a neighbouring area of Liberia, and in May, the first cases in Sierra Leone occurred. By the middle of June, the outbreak had become the largest EVD outbreak ever reported, with a total of 528 cases and 337 deaths. By August 8th, there had been a total of 1848 cases and 1013 deaths, spread between the three countries and a small travel-related cluster in Nigeria, and an international public health emergency was declared by WHO.[79]

A number of studies have investigated the possible origin of the outbreak. It was established that the first case, linked through a chain to the cases reported in Guinea on March 21st, was a child in the Gueckedou region of south-eastern Guinea who died on December 6th, 2013.[80] Virology studies have subsequently confirmed that the virus is the Zaire strain, with 97% homology with earlier strains from DRC and Gabon.[81] The question for many epidemiologists was 'how did this strain "suddenly" appear in West Africa?'[82] The only previously reported case of human EVD in West Africa had been the case in Côte d'Ivoire in 1994, caused by a different strain, designated the Tai Forest strain. The possibility of a human, asymptomatic carrier introducing the Zaire strain from central Africa to a remote rural area of Guinea is unlikely. The distance is >2000 km, land communication is difficult, and there is little regular travel or trade between the two areas. A possibility seriously considered is fruit bat migration from central Africa to the initial epicentre of the new outbreak. What is not clear is whether this strain had been circulating zoonotically in Guinea for some considerable time before human cases appeared, or were reported. Although closely related to the Zaire strain, it is defined as a separate clade.[81] Current virological studies, that have sequenced the strain and compared it to earlier Ebola Zaire isolates, suggest that the outbreak strain has been circulating zoonotically in West Africa since 2004.[83] From early August, the number of cases in the three main affected countries continued to increase sharply, and the limited treatment centres run by local health resources and international teams were overwhelmed. There are several likely reasons for the extent and continuation of the outbreak. Many of these are mirrored in the situation in previous outbreaks: the relative remoteness of and poor health infrastructure in the affected areas, lack of community and local health staff awareness of this new disease, transmission from cases to relatives at village level, transmission during traditional burial practices, and lack of sufficient treatment centres with adequate isolation facilities in the affected areas.[84–87] However, the current epidemic entered a steeply accelerating phase in August and September when urban transmission, which had become established in Liberia's capital, Monrovia, in June, began to grow exponentially. By late September, the estimated reproduction numbers were 1.81 for Guinea, 1.51 for Liberia, and 1.38 for Sierra Leone. The corresponding doubling times were 15.7, 23.6, and 30.2 days, respectively.[80] At December 31st, 2014, the total reported case number for Guinea, Sierra Leone, and Liberia was 20,171, and 7890 deaths.[6] The overall case fatality rate among all cases for whom a definitive outcome is known is 71%. Nosocomial transmission to health staff has been of particular concern.[88] On December 31st, 2014, excluding Nigeria, 660 healthcare workers were reported to have been infected, of whom 375 had died (Table II).[6] Whereas it is thought that many of the infections among healthcare workers occurred due to exposure to infection in health centres and hospitals, in some cases associated with lack of PPE or breaches in infection prevention and control, it is also likely that HCWs were at risk of unprotected exposure to infection when caring for symptomatic but unconfirmed Ebola cases in the community. A detailed study of Ebola infection in HCWs in Sierra Leone emphasized the lack of PPE, lack of delineation between low- and high-risk areas in treatment centres, a lack of standard operating procedures for infection control, and lack of handwashing and disinfectant facilities.[89] An assessment of infection and prevention control needs in six districts of Sierra Leone demonstrated the lack of infection control leads or co-ordinators, lack of staff training, problems of transport of infected patients, as well as the lack of PPE and other resources.[90]

The US Centers for Disease Control and Prevention, Atlanta, developed an Ebola response modelling tool to predict the possible number of cases if the outbreak continued at its rate in September 2014, and the possible effect of control measures.[91] The pessimistic prediction was >21,000 cases by November 2014, and between 0.5 and 1.4 million cases by January 2015 according to current trends. However, the model suggested that the epidemic would begin to decrease if ~70% of Ebola cases were managed in Ebola treatment centres, and if safe burials were undertaken.

The massive United Nations-supported international response that began in October 2014 had a strategy of '70:70:60', i.e. 70% of all patients in treatment centres and 70% of all burials using safe practices, within 60 days. Although this specific target has not been achieved, it is hoped that the massive response will contribute to bringing the outbreak under control.

The global dimension of the West Africa outbreak has been demonstrated by the transmission of infection to healthcare workers in hospitals in Europe and the USA, from index cases repatriated from Liberia.[92,93]

Discussion and future strategies in EVD control

The 2014 West Africa EVD outbreak is a public health catastrophe that, even when controlled, will have long-lasting

Table II
Ebola virus disease cases, West Africa outbreak, at December 31st, 2014

Country	All cases[a]		Healthcare workers[a]	
	Cases	Deaths	Cases	Deaths
Guinea	2707	1709	148	87
Sierra Leone	9446	2758	143	110
Liberia	8018	3423	369	178
Total	20,171	7890	660	375

Source: World Health Organization.[6]
[a] Includes confirmed, probable and suspected cases.

effects on both the social fabric and the economy of the countries affected. There are many reasons, as described above, that have made early and effective intervention difficult in Guinea, Sierra Leone and Liberia. It is relevant that as well as the poor health infrastructure and lack of development, all three countries have in the recent past been disrupted by civil war and political insecurity. There have, however been 20 previous outbreaks of EVD in tropical Africa, where lessons for surveillance, interruption of community transmission, infection control in treatment centres, and the need for urgent coordinated international response have been proposed.[94,95]

Several effective Ebola surveillance programmes have been previously implemented in DRC. Jezek *et al*. described a five-year surveillance programme (1981—1985) in the Sud-Ubangi region of northern DRC, following previous sporadic reports of possible EVD cases.[96] The programme included surveillance agents at remote health facilities, simple case definitions and involvement of village leaders and traditional healers. A similar surveillance programme was set up following the Kikwit DRC outbreak in 1995.[97] An example of a hospital-based surveillance programme in West Africa for viral fevers is described in a study from Ghana, which included 18 hospitals in the northern and central regions.[98] Whereas no cases of viral haemorrhagic fevers occurred, the study demonstrated the feasibility of setting up such a hospital-based surveillance system over a wide area.

A detailed review of the lessons learned from the 2007 Ebola Bundibugyo outbreak in Uganda has been described by MacNeil *et al*. with recommendations for future outbreaks.[99] These include the importance of having broad surveillance definitions complemented by rapid diagnostic capacity to correctly identify EVD patients, and enable control and management programmes to be concentrated where needed. The study described the long lag period that occurred in the Bundibugyo outbreak between the retrospectively recognized initial cases, and subsequent outbreak declaration, two months in the case of this outbreak, and between 1.5 and four months in most previous outbreaks. As noted earlier, the lag time in the West Africa outbreak was from early December 2013 to March 2014. This lag time allows community transmission to occur before any control measures are implemented. The results of poor infection control practices leading to nosocomial transmission in viral haemorrhagic fevers other than Ebola or Marburg have been described for Lassa in Nigeria and Crimean—Congo haemorrhagic fever in Sudan.[100—102]

A major recommendation for improving disease surveillance and public health action at the local level, and enhanced international response preparedness, was provided following the 1995 Kikwit, DRC outbreak.[103] This report provided comprehensive guidelines for preparation for, and management of, large EVD outbreaks, including action at the local level and the responsibilities of WHO. A major recommendation, as well as stockpiling of protective equipment and supplies and effective laboratory support, was the deployment of field epidemiologists to support field investigations and control activities. There are networks and information resources that can be used to provide support and information in the field, examples being the African Field Epidemiology Network and the web-based Global Infectious Disease and Epidemiology Network (GIDEON).[104,105]

As is clear from the 2014 West Africa outbreak, putting lessons from past outbreaks into practice at an early stage of a new outbreak has many difficulties, though it is evident that there were delays, both locally and internationally, in implementing appropriate responses in the early stages of the outbreak. Of additional concern is the possibility of an EVD outbreak occurring in a region in a state of conflict or civil war.[106,107] Because of such a possibility, it is essential that the lessons from earlier EVD outbreaks, and the lessons that will no doubt come out of the 2014 West Africa outbreak, are formally documented and incorporated into national and international strategies for Ebola control.

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