

Field Epidemiology and containment, Ebola Haemorrhagic Fever

Yambuku Mission Hospital, DRC (Zaire), 1976



Yambuku Mission, DRC, 1976



Nurses, Yambuku Mission Hospital

Maternity, Yambuku Mission Hospital



Deceased health workers, Yambuku Mission Hospital, DRC, 1976



Sœur Beata
missionnaire à Yambuku
awei o Yambuku 19 sept. 1976



Sœur Myriam
missionnaire à Yambuku
awei o Kinshasa 30 sept. 1976

Soko motu akabi bomoi bwa yee mpo ya bandeko; nsuka ya bolingo wana (Yoh. 15,13).

Kristu alobi mpe asali bongo. Amipesi mpo ya bisu tee liwa iya kuruse.

Banyango ba bisu banel: Sr. Beata, Sr. Myriam, Sr. Romana na Sr. Edmonda balandi, bamekoli Kristu. Lilioba liye iya yee likomi bomoi bwa bango. Ut'o bolenge bamipesi mobimba na Kristu na bosalisi bakoni mpe batu ba mawa.

Eleko bomipesi boye boleki ndelu tee bokomi likama iya liwa, bakimi te, bamibendi nsima te kasi batondisi lomoko la bolingani lokola 'te bobongoli mpo ya bango banso banel libonza iya nsuka.

Sikawa o esengo ya yee, Kristu akotanga bango lisusu basaleli te, kasi bandeko.

Banyango ba bolingo, bandeko ba Kristu, bandeko ba bisu bopema na boboto mpe bosambela mpo ya bisu tokoma lokola binu, bamekoli ba solo ba Kristu.



Sœur Romana
missionnaire à Yalosemba
awei o Yambuku 2 oct. 1976



Sœur Edmonda
missionnaire à Yambuku
awei o Kinshasa 14 oct. 1976



VROOM AANDENKEN AAN

Pater Germain LOOTENS

Missionaris van Scheut

geboren te St.-Kruis-Brugge op 30 oktober 1910,
priester gewijd op 18 augustus 1935,
naar Zaïre vertrokken op 14 augustus 1936,
overleden te Yambuku op 2 oktober 1976
als slachtoffer van een zware epidemie.

Ngaliema Hospital, Kinshasa, DRC

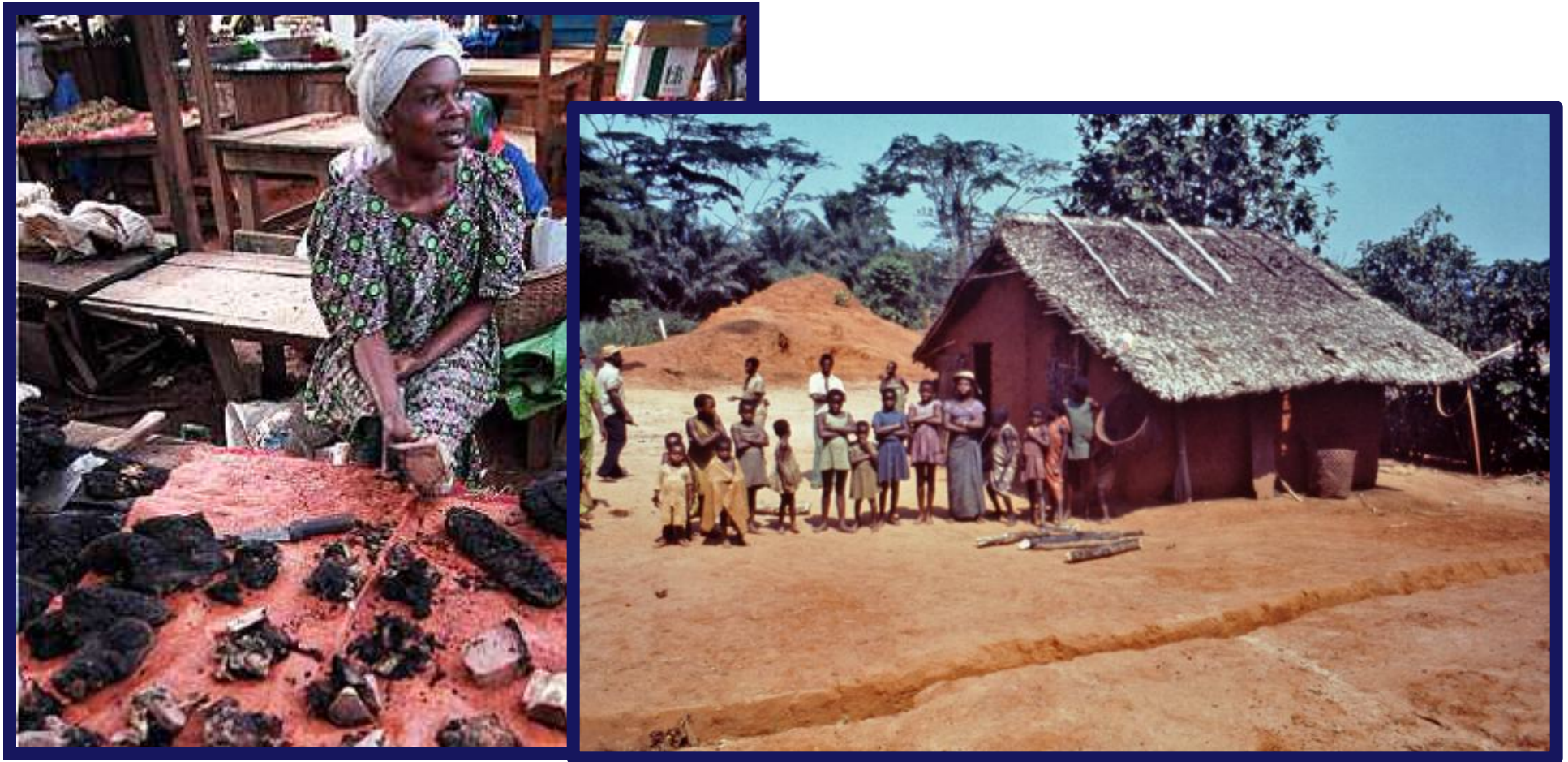


Filoform virus, first identified 1976, CDC (Atlanta) and Porton (UK)



Source: CDC

Animal market, near Yambuku, DRC



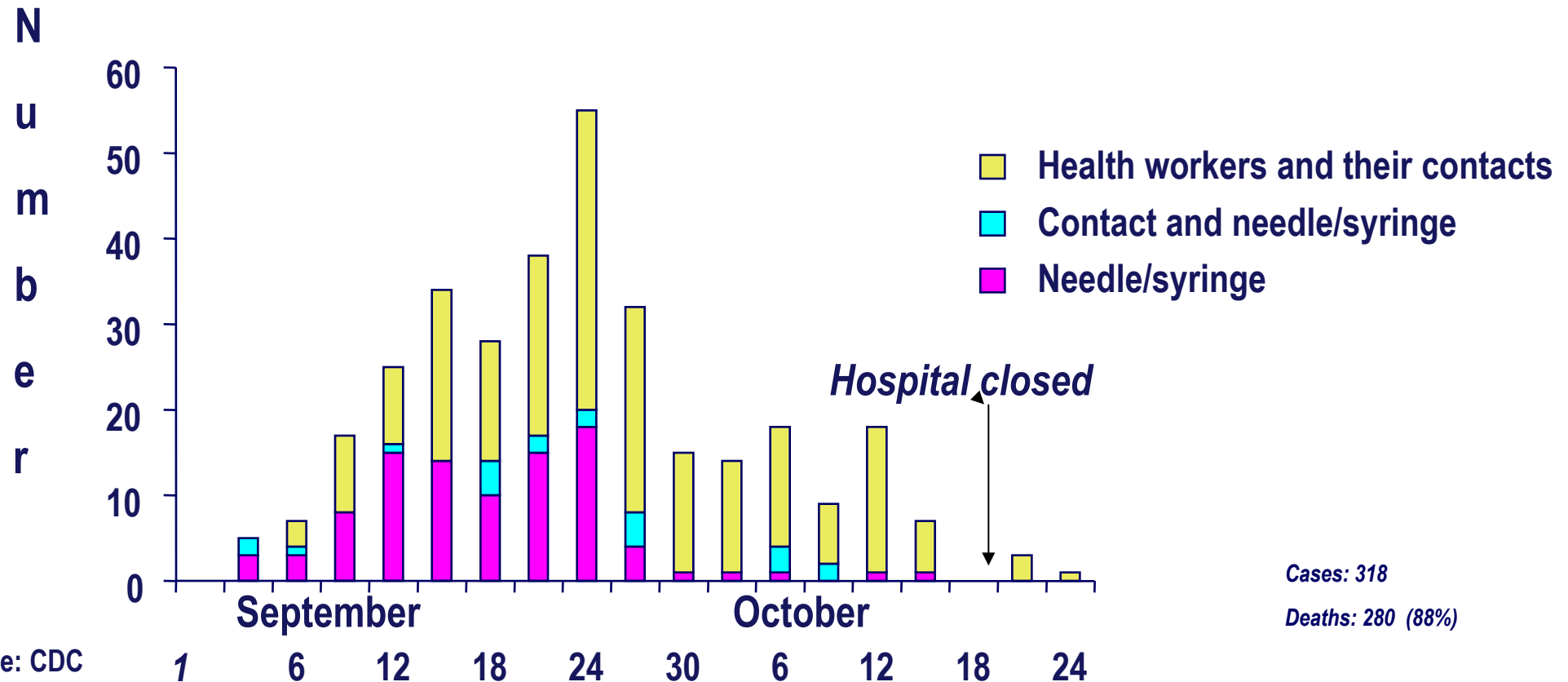
Patient record, outpatient department, Yambuku Hospital, DRC, August 1976

2348	Mapoba Alima	♀	Bosanga	Lilongo	Helminthiasis	27/8	31/8	4	-
2349	Alila Liwangu	♀	Bodaba	Shimbi	Blebo + Ankylo	27/8	31/8	4	-
2350	Mandungu Otundu	♀	yatuwa mabe	Mouzamboli	Ascariidiosis	27/8	31/8	4	p.
2351	Seembo Dombe	♀	yaongo	B/yowa	Blebo + Ankylostomiasis	27/8	31/8	4	-
2352	Ampidobolo Baka	♂	- 11 -	- 11 -	HI double	27/8	31/8	4	-
2353	Monzia Kokeka Gaga	♀	Boupo Lu	Lilongo	Ca Ankylostomiasis	27/8	31/8	4	-
2354	Quipia Lidele	♀	yambawo	Mouzamboli	HI D.	27/8	31/8	5	-
2355	Makilo Alita	♂	yandoupi	yandoupi *	epitaxin + dysentery	28/8	30/8	2	fur
2356	Koloupi Kombesa	♀	Katank	Lilongo	Blebo + Ascariidiosis	28/8	31/8	3	-
2357	Kanza K. Mubunzu	♂	yakolo	Mouzamboli	Contusion	30/8	31/8	1	-
2358	Batayo - Malike	♂	yaketu	Moluwa	Anemia + Ankylo	29/8	31/8	2	-
2359	Bunda Otapi	♂	yambonzo	B/yowa	Malaria	30/8	31/8	1	-
2360	Opawa Dosi	♀	yakai	Kwanza	Ankylost.	29/8	31/8	2	-
2361	Mapulola Mapula	♂	Celza jaketu	yandoupi	Ankylostomiasis	30/8	31/8	1	-
2362	Kebolo Ambena	♂	yamoleka	- 11 -	HI Double	30/8	31/8	1	-
2363	Atinandunga Amiba	♀	yalokila	Mouzamboli	Observation	28/8	31/8	3	-
2364	Mondele Mohiwambi	♀	yapombi	- 11 -	Blebo + Ankylo	28/8	31/8	3	-
2365	Maleme - Likonde	♀	yakoleka	yandoupi	Aspothesis	28/8	31/8	3	-
2366	Eglogbo - Atale	♂	yapbo	Mouzamboli	Bronchite + Ascariid	29/8	31/8	2	-
2367	Ambena Saja	♂	yandoupi	Mouzamboli		30/8	31/8	1	-
2368	Boza - Makoma	♂	Benzadi	yandoupi	Blessure plaie	30/8	31/8	1	-
2369	Apapla M. Luaga	♀	yakombo	Mouzamboli	Ankylostomiasis	30/8	31/8	1	-
2370	Likuya Soki	♀	yakombo	- 11 -	Helminthiasis	30/8	31/8	1	-
2371	Zoda Mabambu	♀	- 11 -	- 11 -	Helminthiasis	30/8	31/8	1	-
2372	Mangondo Mambo	♀	Bombanga	yandoupi	Avortement	30/8	31/8	1	-

Hospital Implements , Yambuku, 1976



Ebola Haemorrhagic Fever by mode of transmission, Yambuku DRC, 1976



Mission Hospital, Tandala Zaire (DRC), 1977

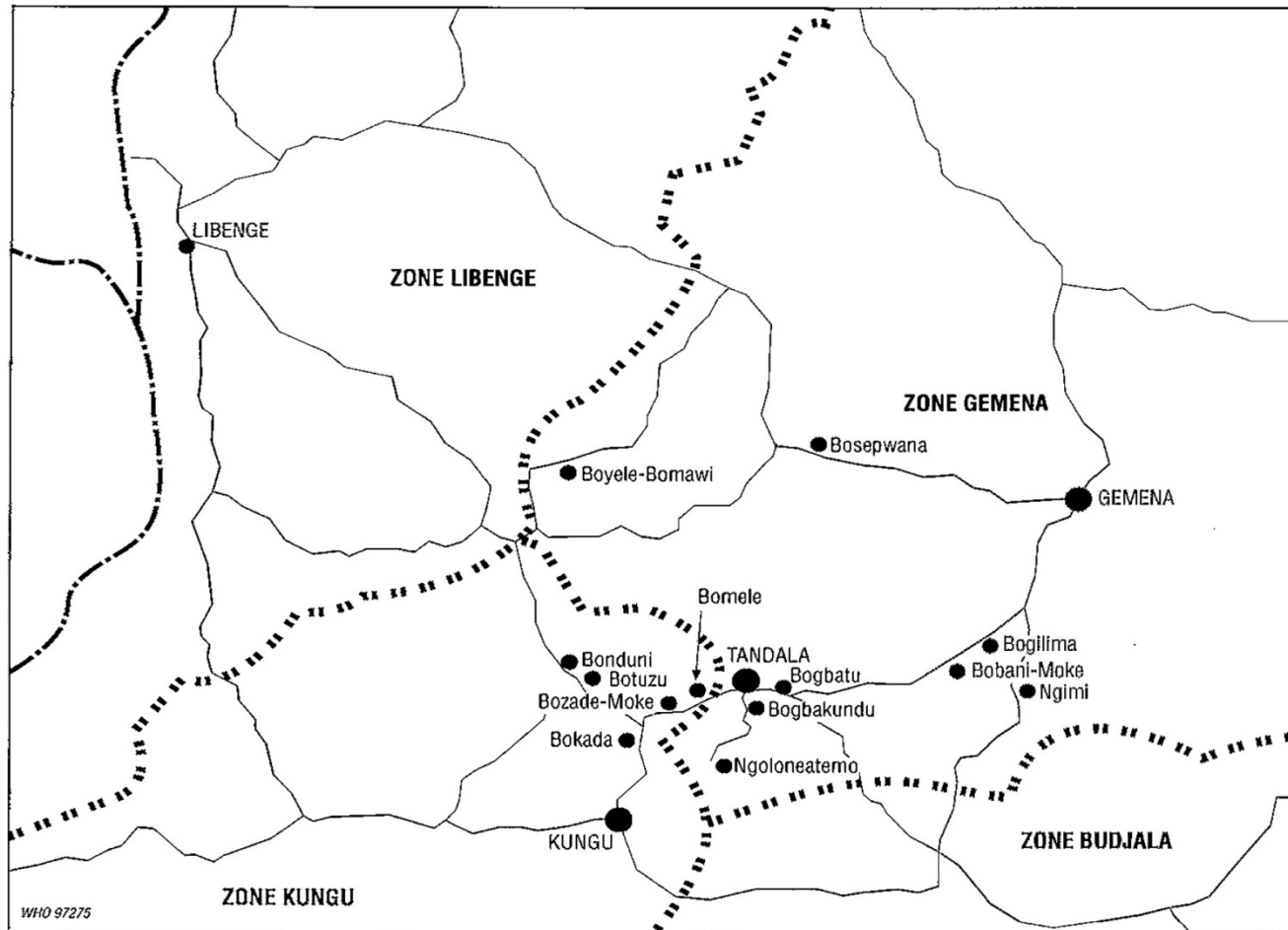


1 clinical case/died

1 contact (sister) fit possible case definition/survived



Ebola haemorrhagic fever surveillance, Tandala Zaire, 1981–1985



Ebola haemorrhagic fever surveillance, Zaire, 1981–1985: IFA in reported clinical cases

Case definition	1981 (<i>n</i> = 0)	1982 (<i>n</i> = 4)	1983 (<i>n</i> = 36)	1984 (<i>n</i> = 27)	1985 (<i>n</i> = 31)	1981–1985 (<i>n</i> = 98)
Possible	0	0	0	1	2	3
Clinical	0	1	4	2	4	11
Probable	0	2	5	0	0	7
Total	0	3	9	3	6	21

NOTE. *n* = no. of surveillance reports investigated.

Source: WHO

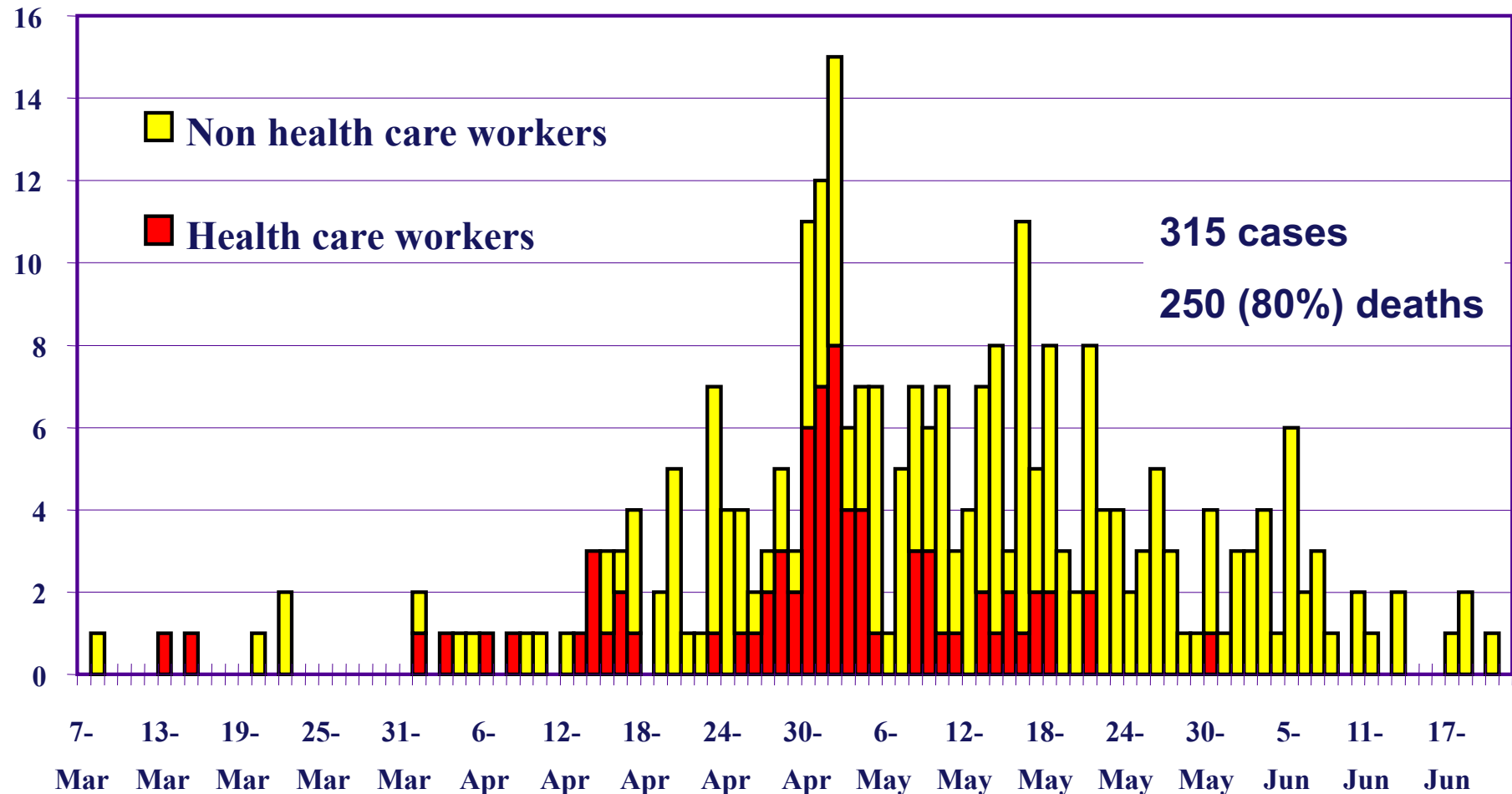
Kikwit General Hospital, Zaire, 1995



Nursing sisters, Kikwit General Hospital, Zaire, 1995

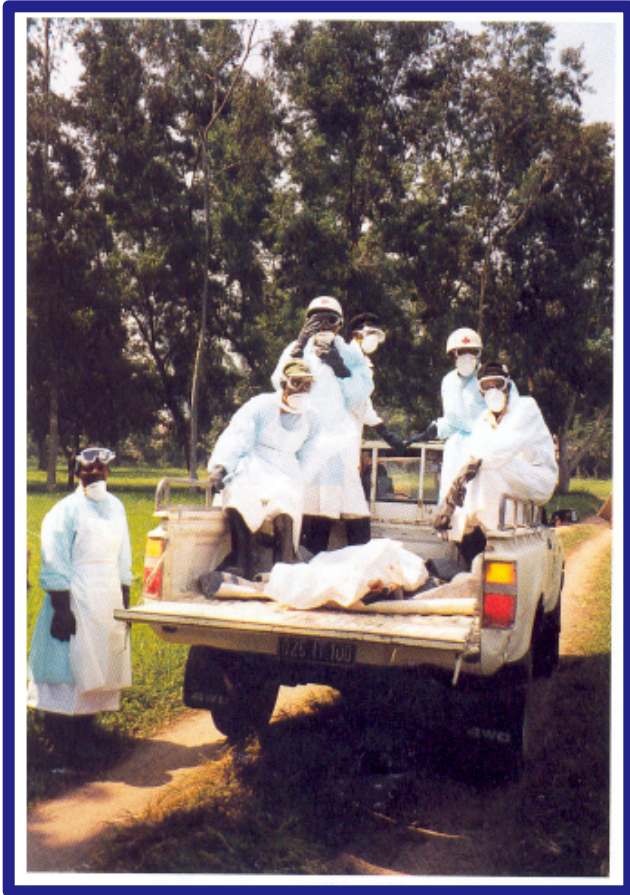


Ebola Haemorrhagic Fever by mode of transmission, Kikwit Zaire, 1995

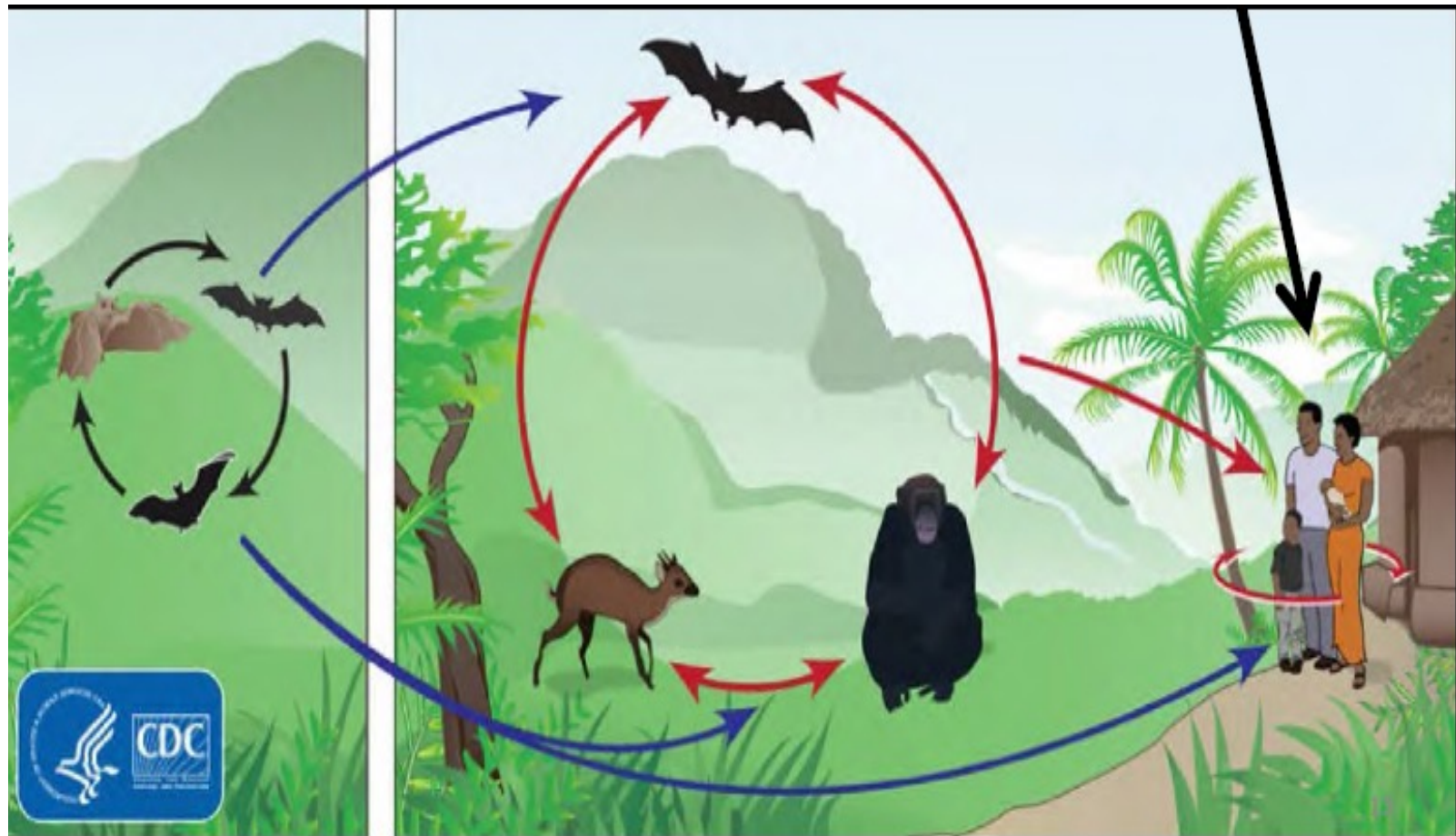


Source: WHO/CDC

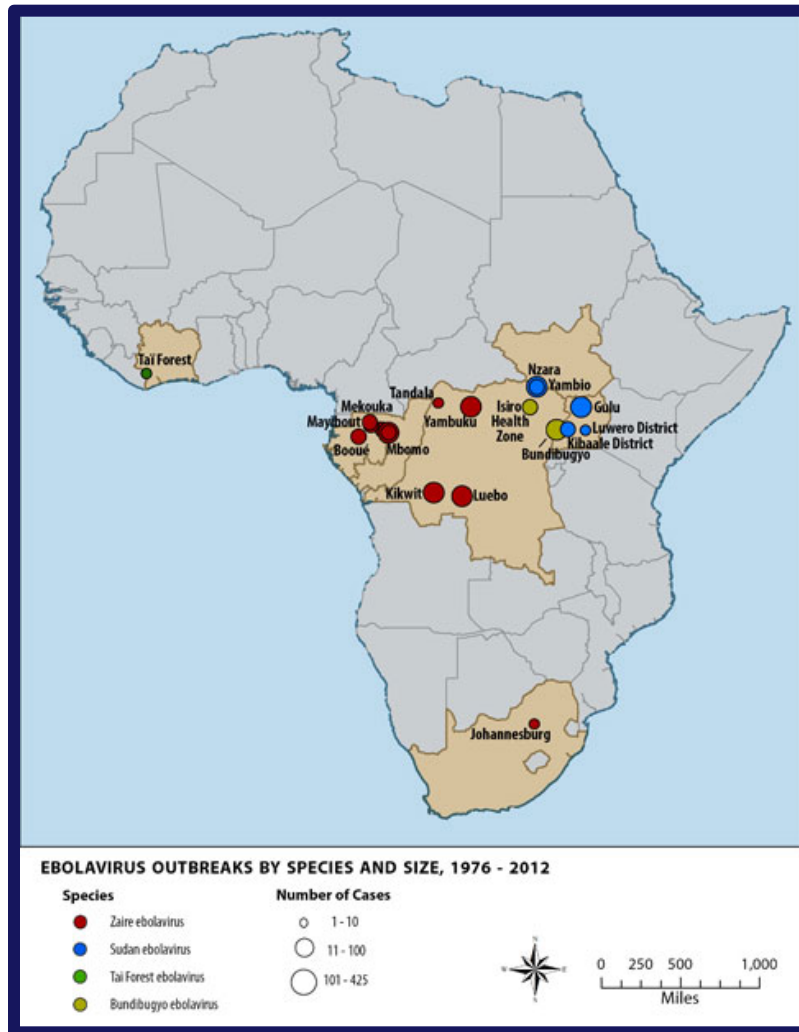
Contact with patients and funeral practices transmit in communities, Kikwit 1995



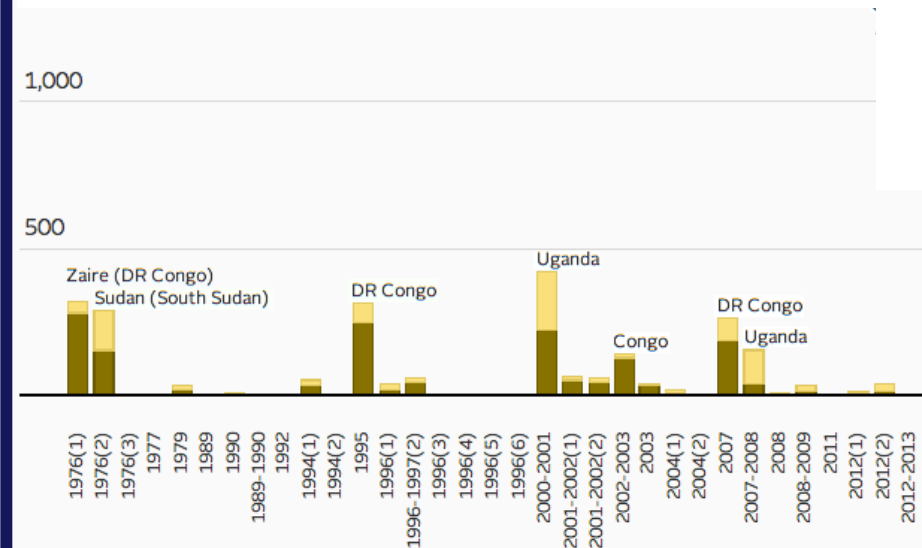
Ebola emergence: current hypotheses



Ebola outbreaks and virus strains, 1976 - 2013



Ebola, 1976 - 2014



Source: CDC, WHO



Known Ebola outbreaks, 1976 - 2013

ARTICLE IN PRESS

Table 1. Previous Ebola outbreaks/infection in humans. Table adapted from CDC website [6].

2

year	countries	no. outbreaks	no. cases	no. deaths	viral strain
1970–1979	Zaire, 1976 ^a	2	319	281	Zaire
	Sudan, 1976 ^b	2	318	173	Sudan
	United Kingdom, 1976	1	1	0	Sudan
1980–1989	Philippines, 1989–1990	1	3 ^c	0	Reston
1990–1999	USA, 1990	1	4 ^c	0	Reston
	Gabon, 1994	3	149	97	Zaire
	Côte d'Ivoire, 1994	1	1	0	Tai Forest
	DRC, 1995	1	315	250	Zaire
	South Africa, 1996	1	2	1	Zaire
	Russia, 1996	1	1	1	Zaire
	Uganda, 2000–2001	2	574	261	Sudan/Bundibugyo
2000–2009	Gabon, 2001–2002	1	65	53	Zaire
	Republic of Congo, 2001–2002	3	235	200	Zaire
	Sudan ^b , 2004	1	17	7	Sudan
	Russia, 2004	1	1	1	Zaire
	DRC, 2007	2	296	202	Zaire
	Philippines, 2008	1	6 ^c	0	Reston
	Uganda, 2011–2013	3	18	8	Sudan
2010–2013	DRC, 2012	1	36	13	Bundibugyo

^aNow Democratic Republic of Congo (DRC).

^bNow South Sudan.

^cAsymptomatic infection.

rsb.royalsocietypublishing.org Phil. Trans. R. Soc. B 20160297

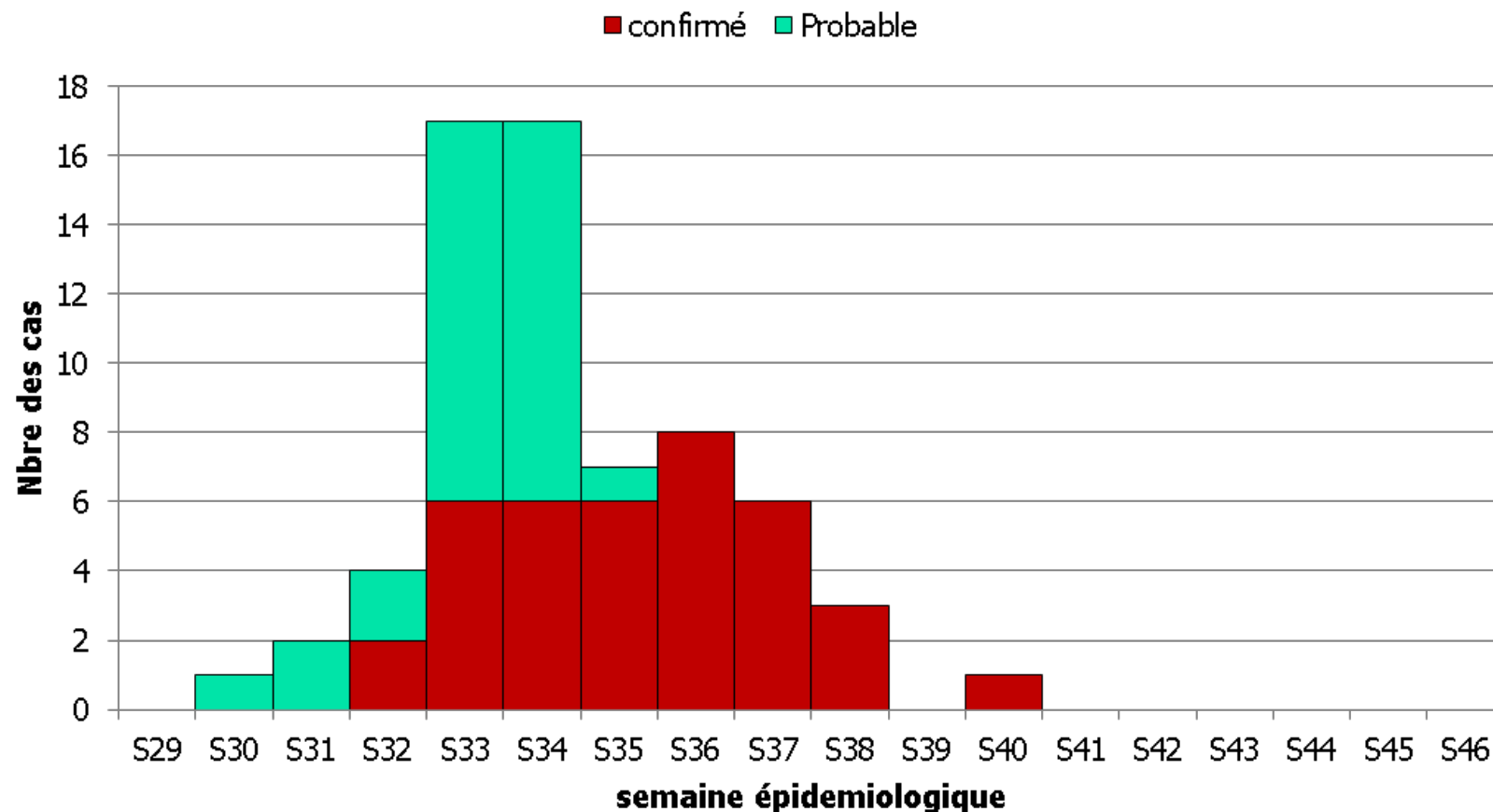
Ebola outbreak, Boende, DRC, 2014



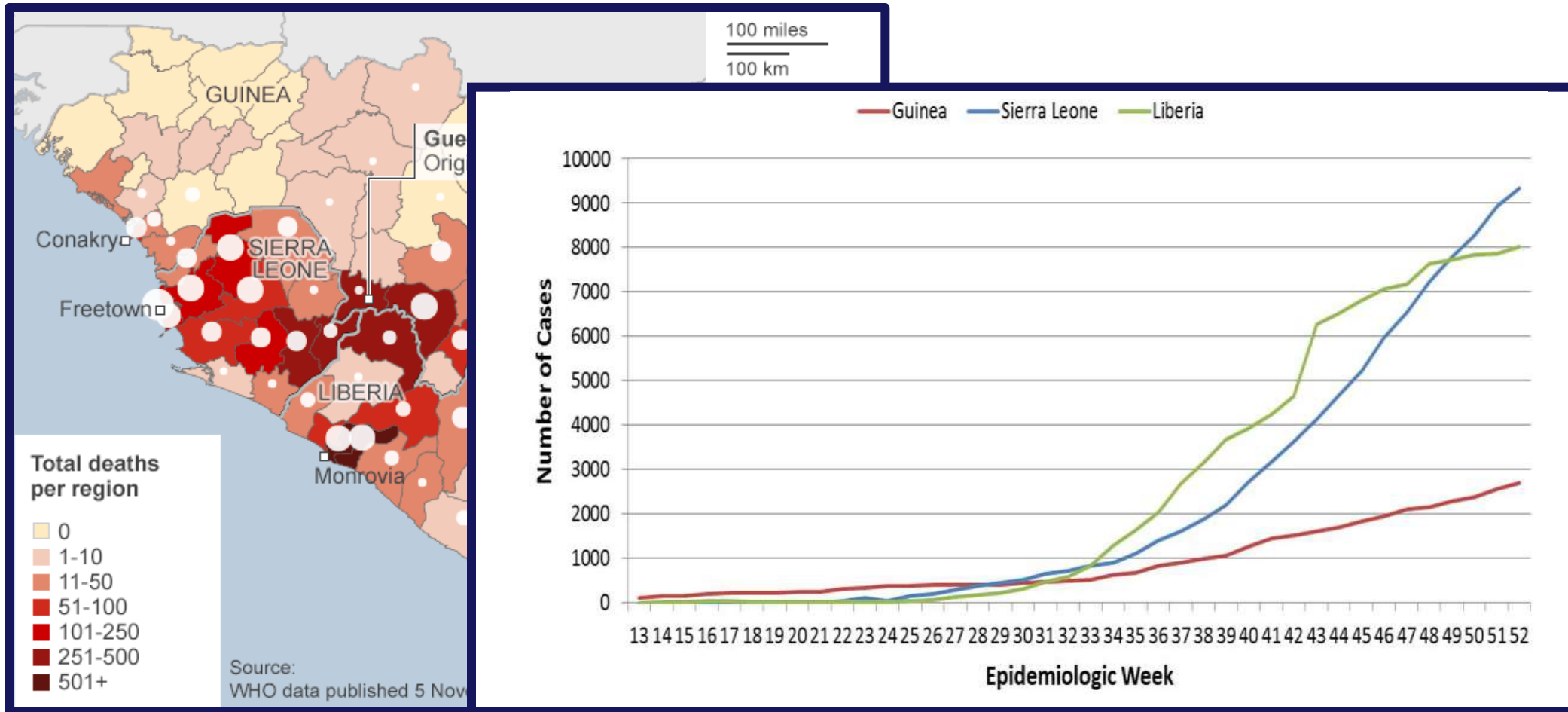
● Cases:	66
● Deaths:	49 (74%)
● Health workers:	8

Ebola outbreak, Boende, DRC, 2014

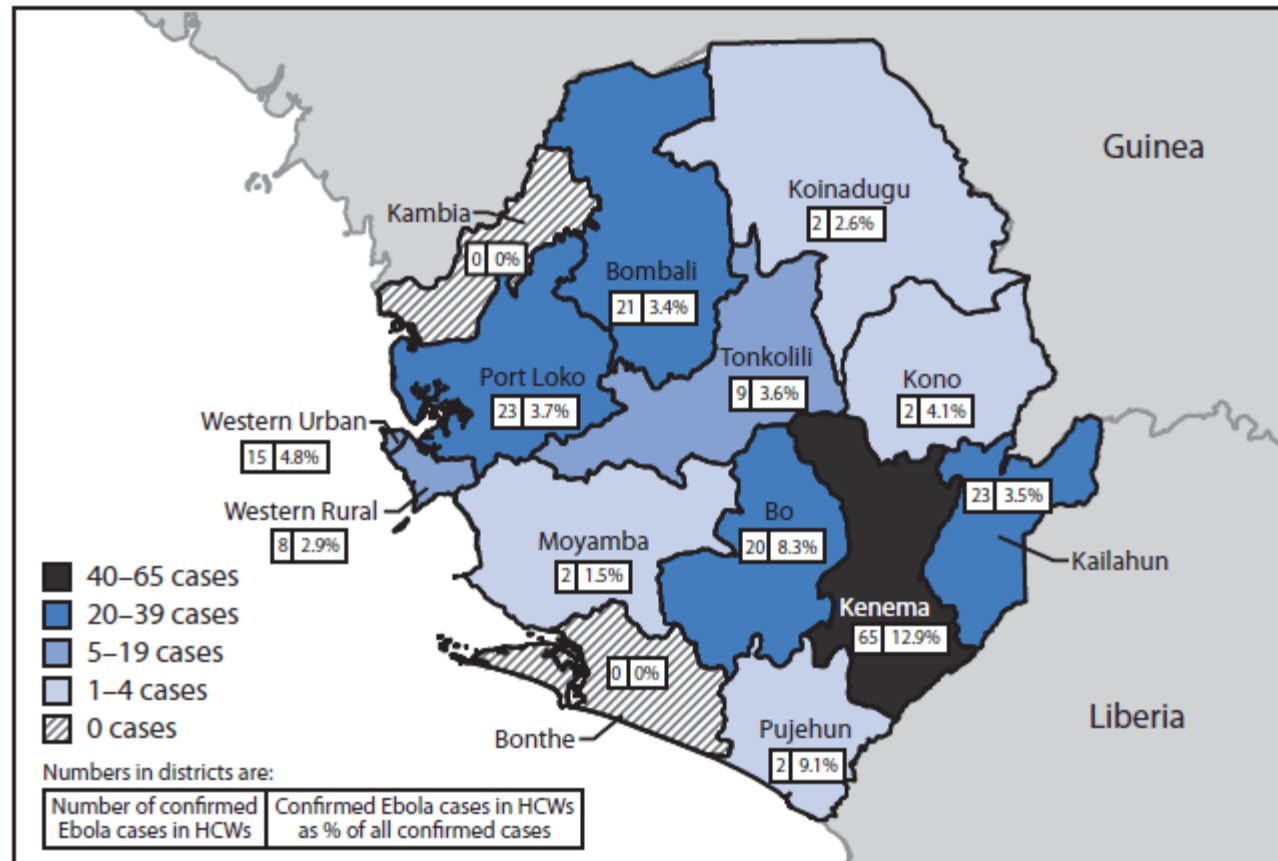
Evolution hebdomadaire des cas confirmés et probables selon la semaine de debut de symptome , MVE BOENDE, S30-46,2014



Ebola outbreaks, West Africa, 2014



Ebola outbreak and health workers, Sierra Leone, May–October 2014



Ebola outbreak, 2014-2015

28,637

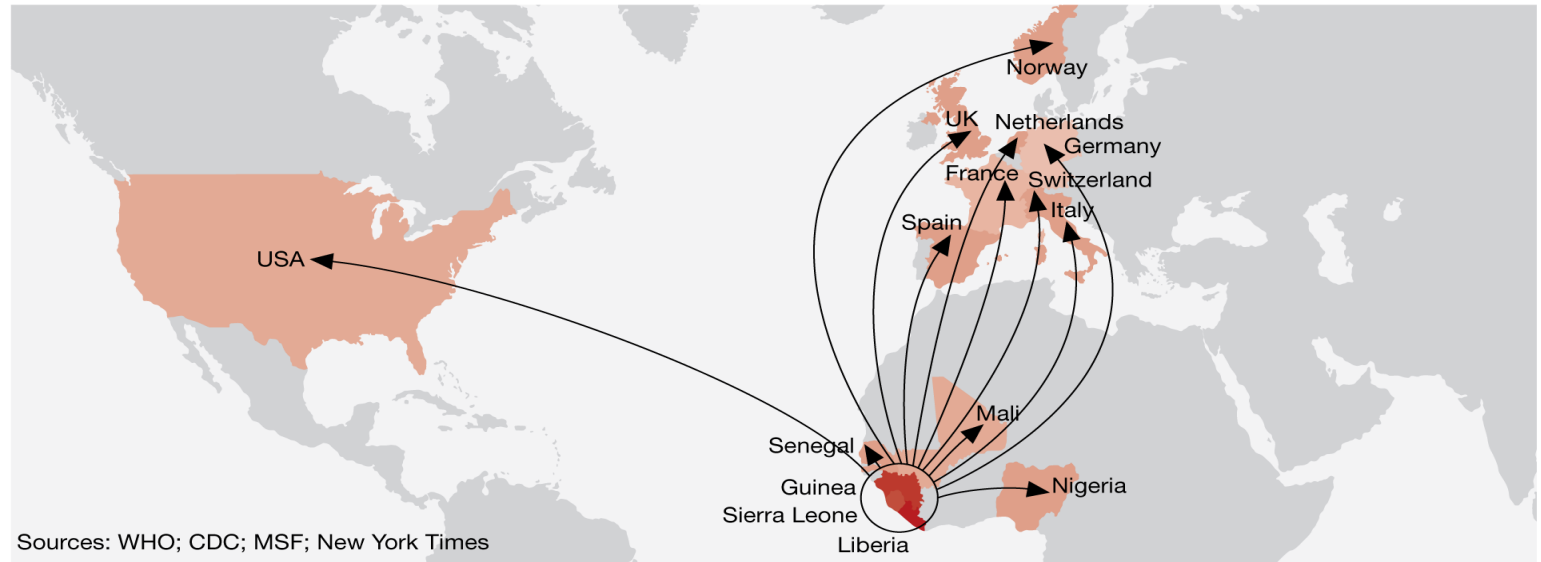
Infected people
from 12 countries

11,315

Deaths in Liberia, Guinea,
Sierra Leone, Nigeria, USA,
Mali, Spain and Germany

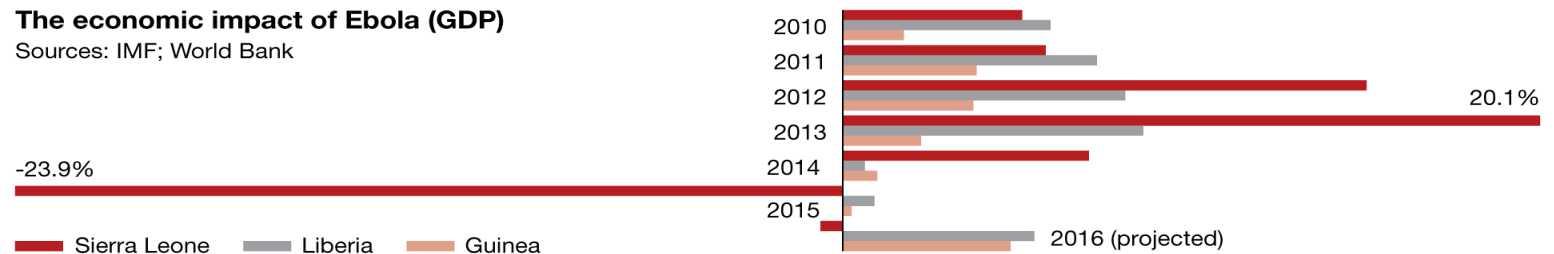
\$4.3bn

Cumulative pledges
to Guinea, Liberia and
Sierra Leone



The economic impact of Ebola (GDP)

Sources: IMF; World Bank



Ebola managed in Europe and North America



Cases of Ebola Outside of West Africa

As of Jan. 5, 2015

United States	Arrival date	
Aid worker	Aug. 2	Recovered
Missionary	Aug. 2	Recovered
Doctor	Sept. 5	Recovered
Doctor	Sept. 9	Recovered
Visitor	Sept. 30*	Died
NBC Cameraman	Oct. 6	Recovered
Nurse	Oct. 11*	Recovered
Nurse	Oct. 15*	Recovered
Doctor	Oct. 23*	Recovered
Doctor	Nov. 15	Died
Spain		
Priest	Aug. 7	Died
Missionary	Sept. 22	Died
Nurse	Oct. 6*	Recovered
Britain		
Nurse	Aug. 24	Recovered
Nurse	Dec. 29*	Recovered

France	Arrival date	
Nurse	Sept. 19	Recovered
Medical worker	About Nov. 2	In treatment
Germany		
Doctor	Aug. 27	Recovered
Physician	Oct. 3	Recovered
U.N. medical official	Oct 9	Died
Norway		
Aid worker	Oct. 6	Recovered
Switzerland		
Doctor	Nov. 21	Recovered
Italy		
Doctor	Nov. 25	Recovered
Netherlands		
Peacekeeper	Dec. 6	Recovered

*Date of Ebola diagnosis.

RT-PCR testing of semen samples provided by Ebola survivors, West Africa, 2015 - 2017

Table 1: Summary of findings of analysis of RT-PCR testing of semen samples provided by survivors of the West African outbreak

Study	Program	Location	Total no. of participants*	Positive RT-PCR, by interval since disease onset
Deen, 2015	Unnamed pilot study	Sierra Leone	93	2–3 months: 9/9 (100%) 4–6 months: 26/40 (65%) 7–9 months: 11/43 (26%)
Fallah, 2016	Partnership for Research on Ebola Virus in Liberia (PREVAIL)	Liberia	76	Any (≥ 1 positive finding): 28/76 (37%)
Keita, 2016	Postebogui cohort	Guinea	188	Any (≥ 1 positive finding): 15/188 (8%)
Knust, 2016	Sierra Leone Ebola Virus Persistence Study	Sierra Leone	92	Any (≥ 1 positive finding): 15/92 (16%)
Sissoko, 2017	Unnamed longitudinal study	Guinea	26	Initial sample (median 55 days post-onset): 19/26 (73%)
Soka, 2016	Men's Health Screening Program	Liberia	429	Any (≥ 1 positive finding): 38/429 (9%) Of which >12 months: 24/38 (63%)

Note: Data are shown reflect most recently published results; * Providing ≥ 1 semen sample

Ebola virus transmission clusters after outbreaks declared over, West Africa, 2016

Table 2: Summary of EBOV clusters that occurred after the West African country outbreaks had been declared over

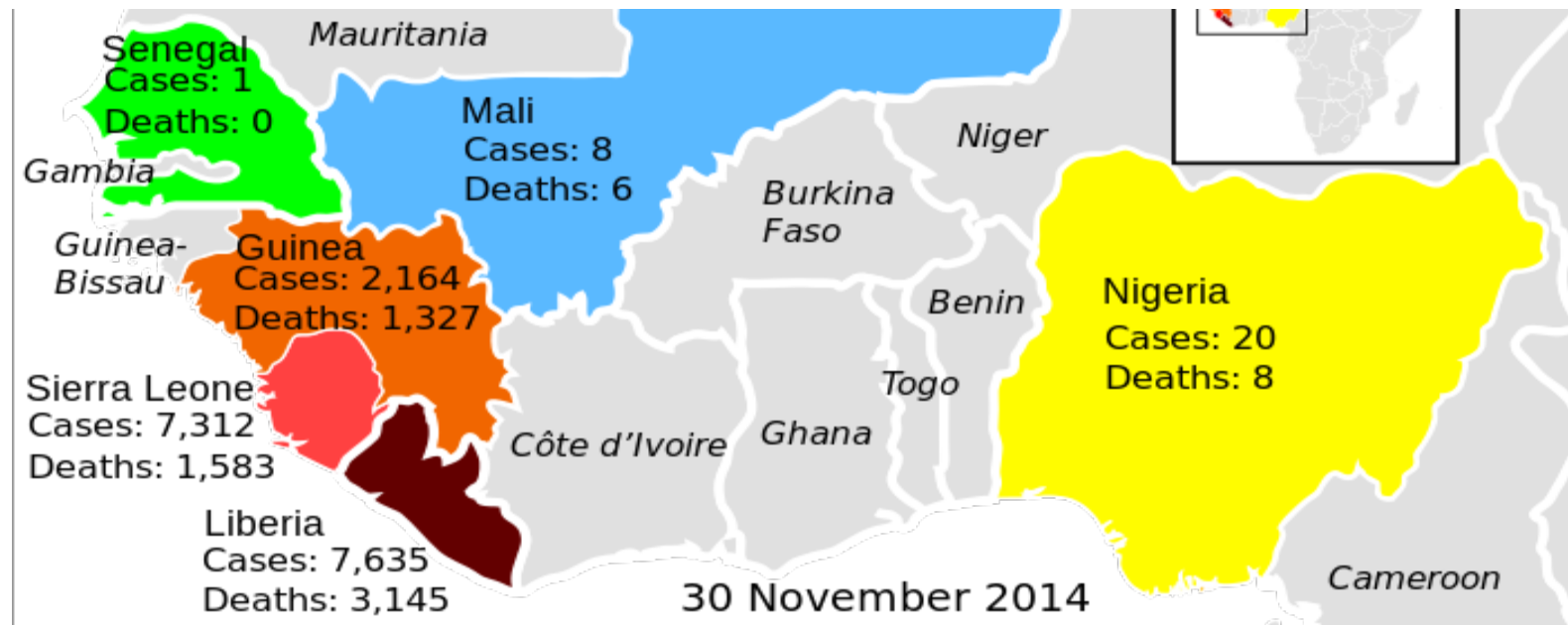
Study	Location	Date cluster identified	Cluster size	Estimated interval from disease onset in survivor to contact with index case (days)
Alpren, 2016	Sierra Leone	January 2016	2	Unknown [‡]
Arias, 2016	Sierra Leone	August 2015	7	14–55*
Blackley, 2016	Liberia	June 2015	6	Unknown [‡]
Christie, 2016	Liberia	March 2015	1	199*
Diallo, 2016	Guinea	March 2016	13 [§]	482*

*Days from onset of symptoms in survivor to sexual contact with cluster index case

[‡]Flare-up likely to have originated from an unidentified persistently infected source

[§]Including three cases that occurred in Liberia linked to the Guinea cluster

Ebola spread within Africa, 2014: major Ebola outbreaks were prevented



Ebola outbreaks can be stopped: Kikwit, 1995

- Hospital infection control/health worker protection
- Patient identification, management and isolation
- Surveillance/contact tracing and fever surveillance with rapid diagnosis and isolation
- Community understanding with safe patient and body transport systems, safe burial and household/environmental decontamination
- **Vaccine – fortuitous pipeline**

Ebola vaccine possibly suited for primary prevention

- **One dose, multi-antigen, long-lasting immunity**
 - **Protection against emergence - vaccinate population at risk (if populations can be identified)**
 - **Protection against amplification - vaccinate health workers/others (Red Cross/Red Crescent) in Ebola belt**

Ebola vaccine possibly suited for outbreak control

- **Immunogenic after one dose, antigen-specific**
 - Ring vaccination strategy to prevent tertiary infections
 - Vaccination of contacts and/or contacts of contacts
 - Vaccination of health workers and other front line workers
- **Needed for successful strategy**
 - Rapid diagnosis of cases – is clinical diagnosis sufficient once an outbreak has begun, understanding there may be over-use of vaccinations
 - Contact tracing and community census

Challenges in designing a vaccine clinical trial to be implemented in outbreaks

- **Site, size and duration of outbreaks unpredictable**
- **Clinical trial design must accommodate proven control measures**
- **Operational readiness required with rapid deployment to outbreak site**
- **Pooling of standardised data across sites and time periods**
- **International collaboration and methodological standardization on standby**
- **Ethical clearance and agreements must be in place - lessons from the Mechanisms of Severe Acute Influenza Consortium (MOSAIC) project**
- **Expedited ethical approval, single template for material transfer agreements, pre-existing approved research and development approvals available to roll out**