THE EPIDEMIOLOGY OF EBOLA HAEMORRHAGIC FEVER IN ZAIRE, 1976

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INTRODUCTION

The epidemiological investigations attempted to describe the outbreak of Ebola haemorrhagic fever (EbHF) by its distribution in time, in geography and amongst persons. Factors related to spread were also studied. These included possible modes of transmission, the incubation period, secondary attack rates and related risk factors. Serological surveys were undertaken to find evidence of prior Ebola virus disease in the area and asymptomatic infections occurring during the epidemic The cause of the epidemic (1)was searched for by attempts to find the index case and evidence of Ebola virus in some animal and insects (2).

DESCRIPTION OF THE EPIDEMIC AREA

The epidemic focus was in north-central Zaire. It was located in and near the Yambuku Mission, in the Yandongi collectivity (country) of the Bumba Zone of the Equateur Region (Figure 1). This collectivity has about 35 000 persons and the Bumba Zone has about 275 000 persons. Half of the population is less than 15 years of age. Over 75% of the population lives in forest villages of less than 5 000, most in small localities of fewer than 500. The area forms part of the Zaire river basin and is essentially tropical rainforest. The Zaire river forms the southern boundary of the zone and effectively separates geographically the most northern sectors from the remainder of the country. The major ethnic group is Budza and Lingala is the principal language.

Traditionally, the people are hunters and have contact with a wide variety of wild animals. Cash crops are palm oil, rice, some coffee and cocoa. Malaria, filariasis, measles, pneumonia, amoebiasis, bacillary dysentery and goitre are common. There is some poorly controlled movement of palm oil, rice and other staples out of the Equateur into the Central African Empire and the Sudan. These are exchanged for luxury items such as cloth, utensils, transistor radios and other implements of modern technology.

The mission was established in 1935 by Belgian missionaries near Yambuku, a small isolated village 100 km north of Bumba, the administrative capital of the zone. The mission developed a large local following over the next four decades and was involved in education, agricultural development, animal raising, social service and health programmes, as well as religious activities.

By 1976, before the epidemic, the hospital had 120 beds and a medical staff of 17 directed by a Zairian paramedical assistant. Included in the medical staff were three Belgian nursing nuns. The hospital outpatient department drew its clientele essentially from the Yandongi collectivity population, but others from within and even outside the Bumba zone were attracted by the relatively good supply of medicines. Between 6 000 and 12 000 patients per month came to the outpatient clinic for general medical care.

Five syringes and needles were issued to the nursing staff each morning for use at the outpatient department, the prenatal clinic and the inpatient wards. These syringes and needles were sometimes rinsed between patients in a pan of warm water. At the end of the day they were sometimes boiled. The surgical theatre had its own ample supply of instruments, syringes and needles which were kept separately.

FIGURE 1

DEFINITIONS AND METHODS

A probable case of EbHF was a person living in the epidemic area who died after one or more days with two or more of the following symptoms and signs, occurring between 1 September and 5 November 1976: headache, fever, abdominal pain, nausea and/or vomiting, and bleeding; usually a probable case either had an injection or contact within the three preceeding weeks with a probable or proven case of Ebola virus infection and clinically could not be assigned another diagnosis. A proven case of EbHF was a person from whom Ebola virus was isolated or visualized by electron microscopy or who had a fluorescent antibody (IFA) titer of at least 1:64 to Ebola virus within three weeks after onset of symptoms. An Ebola virus infection was deemed to have occurred in persons who had a similar IFA antibody titer, but who reported no illness during the period 30 August to 15 November 1976.

A possible case was a person with at least 24 hours of headache and/or fever, with or without other signs and symptoms, who had contact with a probable or a proven case of EbHF within the previous 3 weeks. These cases were treated with antimalarial drugs, antibiotics and antipyretics to exclude

diseases common to the area. Persons reporting such symptoms retrospectively were bled and their sera were tested for Ebola virus antibodies.

Any case of fever with bleeding, regardless of outcome, reported to the Ministry of Health (MOH) from any part of Zaire was also regarded as a possible case and every effort was made to establish a diagnosis by virological or pathological means.

Infants born to probable cases of EbHF were called neonatal cases if they died within 28 days of birth.

A primary contact was any person having direct face-to-face contact with a probable or a proven case (sleeping in the same room, sharing meals, caring for patients, preparing a cadaver for burial, touching the body at a funeral, etc.). Contact was required from two days prior to onset of symptoms to death or clinical recovery of the patient. The surveillance interval for primary contacts was 21 days from the last such contact. Secondary contacts were persons having face-to-face contact with a primary contact.

Case investigations were performed by six physician-led teams working with nurseinterpreters and standardized pre-coded forms. The forms had questions on clinical as well as on epidemiological features. Controls were chosen from the same village as a probable case. They were matched as far as possible with cases by sex and age and a member of the same family was chosen if available. One part of the study was done in a restricted zone of 21 villages near Yambuku before the six teams began.

A family was defined as persons using the same kitchen, claiming the same person as the family head, living in contiguous dwellings and sleeping in the village during the time an active case occurred in the family unit.

A case was considered to have acquired his disease by injection if, in the three weeks preceding symptom onset, he received an injection by any medical practitioner in the epidemic area and had no primary contact with a probable or proven case. Person-to-person transmission was designated when a probable case had face-to-face contact with another case within three weeks prior to symptom onset without history of injection receipt. Transmission was classified as both possible if the case had both an injection and face-toface contact with another case within three weeks of symptom onset and one transmission type was not likely by history.

Hospital records were reviewed for the period January 1974 to October 1977. Outpatient records were not kept.

One village with a high attack-rate was studied in greater depth to gain better insight into transmission patterns and subclinical infection. An investigative team mapped every house in the village and censused all cases occurring during the epidemic and remaining residents. Sera were drawn from as many residents as possible.

Serum specimens were taken from family and non-family primary contacts who reported febrile illness during the epidemic, and were possible cases, from other residents of 8 villages where cases occurred, and from residents of 4 villages near the epidemic area where no cases occurred. These were screened for Ebola virus indirect immunofluorescent antibodies (IFA) using a method previously described (4) .

RESULTS

Time. The first known case, a 44-year old male instructor at the Yambuku Mission school, came to the Mission hospital on 26 August 1976 with a febrile illness felt due to malaria. He was given an injection of chloroquine at the dispensary. The fever dropped and remained normal over the next four days but rose to 39.2º on 1 September. The typical syndrome evolved from that day and he died on 8 September with severe haemorrhage.

From I September to 24 October there were 318 cases resulting in 280 deaths the epidemic peaked during the fourth week and then receeded somewhat more gradually over the next 5 weeks (Figure 2). Date of symptom onset was not available for about 10% of cases.

Place. Fifty-five villages of less than 5,000 persons had cases. All infected villages in the epidemic area were within 60 km of Yambuku. This area includes about 100 villages. The larger towns of Abumombazi and Bumba, about 100 km to the north and south, respectively, had imported cases, as did Kinshasa, 1 100 km to the south-west. The large majority of affected villages were along roads running east and west of Yambuku, along which were located more villages than the north-south road. Forty-three of 73 villages in the Yandongi collectivity were affected. This collectivity had an attack rate of 8.0 cases per 1 000 persons.

The epidemic spread relatively slowly in the epidemic area. Within the first two weeks after onset of the epidemic cases were occurring no further than 30 km from Yambuku. Almost another two weeks passed before a sick nursing sister was evacuated to Kinshasa. it was over a month until cases were

imported into Abumombazi and Bumba. The mean duration of active disease was 26 days per locality and ranged from 1 to 55 days.

At the Yambuku Mission Hospital, where all staff members contacted patients or instruments used for treating patients, 13 of 17 hospital employees acquired the disease and 11 died.

Person. All ages and both sexes were affected. Females predominated, mainly in the age groups 5-14 and 15-29 (Table 1). Age-sex specific attack rates, using Yandongi collectivity population as denominator, shows adult females with the highest attack rates (Figure 3). Convalescents were all adults, except for one child of 8 years of age.

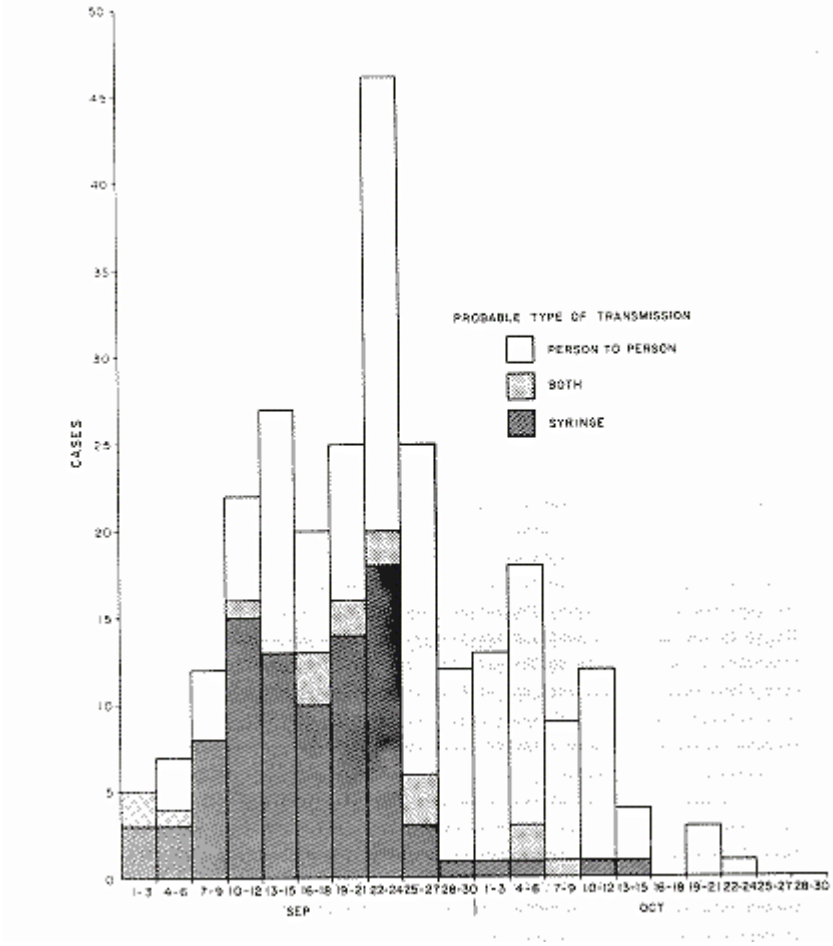

Fig.2 Cases of Ebola Hemorrhagic Fever, by day of onset, Equateur Region, Zaire, Africa, Sept. 1 - Oct. 30, 1976

TABLE 1

AGE AND SEX DISTRIBUTION OF EbHF CASES, ZAIRE, 1976

	Male		Female		Total	
Age	n	%	n	%	n	%
Newborn & Infant	10	3.1	14	4.4	24	7.5
1-14 yrs.	18	5.7	22	6.9	40	12.6
15-29	31	9.7	60	19.0	91	28.8
30-49	57	17.9	52	16.4	109	34.3
50 or >	23	7.2	26	8.2	49	15.5
Unknown	2	0.6	3	0.9	5	1.6

Total	141	44.2	177	56.0	318	100

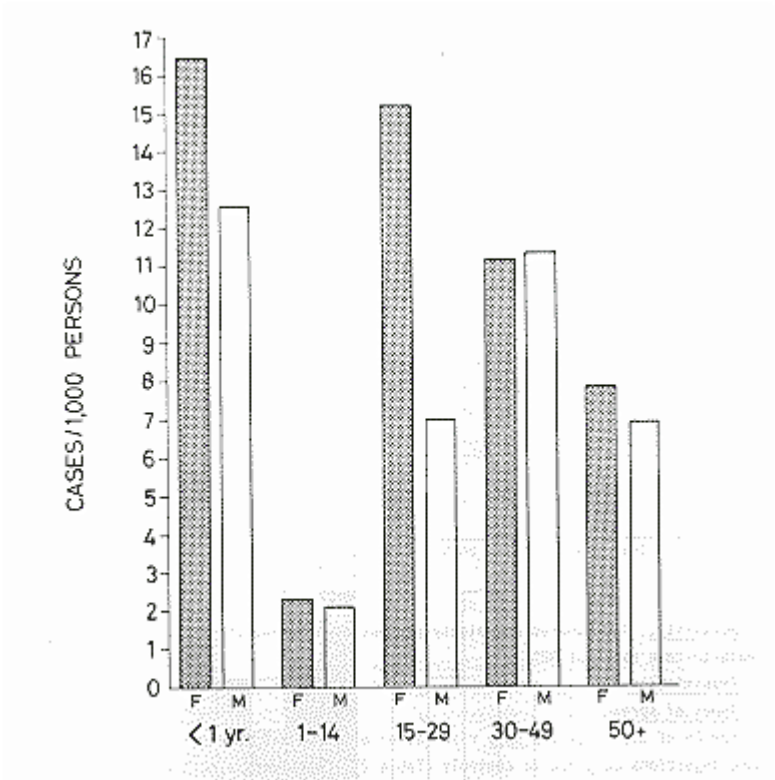

Fig. 3 Attack rates of Ebola Haemorrhagic Fever by age and sex, Yandongi collectivity, Bumba Zone, Equateur Region, Zaire, 1976.

Mortality, Two hundred and eighty persons died during the epidemic, a death-to-case ratio of 88%.

Transmission

Types of spread

For 85 of 318 cases the only risk factor elicited was receipt of one or more injections compared to controls (Table 2). These were almost all given at the outpatient service or on the general medical wards at the Yambuku mission hospital. Less than 1% of the controls had contact with the hospital during the epidemic (p 0.0001). History of injection receipt away from the Yambuku mission hospital occurred in only 2 instances. One case had an injection at the dispensary in Kwaédza, near several villages where cases were occurring. Another case was alleged to have received an injection at the Modjambuli dispensary out of the epidemic zone, and known to be closed at the time.

TABLE 2

DISTRIBUTION OF CASES OF AFRICAN HEMORRHAGIC FEVER IN ZAIRE BY TRANSMISSION TYPE

	Cases		Survivors	
Transmission type	No	%	No	%
Injection	85	26.7	0	0
Person-to-person	149	46.9	30	78.9
Both possible	43	13.5	4	10.5
Unknown	30	8.9	0	10.5
"Neonatal"	11	3.5	0	0
Total	318	100.0	38	99.9

One hundred and forty-nine persons acquired their disease following contact with patients. These contacts occurred, for the most part, at the villages after injected patients returned home in September and when family and friends came to visit these sick persons at the hospital.

In 43 instances, cases could have acquired disease either by injection or contact. Eleven cases were possibly "neonatal" infections. The remaining cases lived in the epidemic area and had probable case or hospital contact. However, the details were not specific enough to class in the three other groups.

All survivors were infected by person-to-person contact, excepting four where both transmission types were possible and four where the transmission type was unknown (Table 2). Seventeen persons, whose home village was not Yambuku, had contact with cases at Yambuku. It is possible that this group had an injection without reporting this to the family.

The distribution of age and sex by transmission type in the 21 village stud is shown in Table 3. Twenty-two females in the 15-29 year old group acquired their disease by injection compared to only two males in this group.

Those acquiring the disease by contact had a variety of close associations with possible cases (Table 4). However, the only type of contact more associat with the disease, when compared to controls, was aiding in the delivery of a pregnant woman with EbHF. Several persons had multiple contacts before becoming ill, especially medical personnel working at the Yambuku mission hospital.

Figure 2 shows onset of cases throughout the epidemic by transmission type. During the first two weeks of the epidemic over two-thirds of the cases were acquired by injection. This type of spread almost completely terminated when the mission hospital closed at the end of September.

Other factors, such as exposure to foods, domestic and wild animals, and travel outside the epidemic zone did not appear to be related to disease transmission.

TABLE 3

AGE AND SEX DISTRIBUTION OF 145 EBOLA HAEMORRHAGIC FEVER CASES IN 21 VILLAGES CLOSE TO YAMBUKU ACCORDING TO TRANSMISSION TYPE

Age Group	Transmission Type				Total	
	Injection		Case Contract			
	Male	Female	Male	Female	Male	Female
< 15 yrs.	3	6	4	3	7	9
15-29 yrs.	2	22	16	16	18	38
30-49 yrs.	7	7	21	13	28	20
50 or > yrs.	7	2	6	8	13	10
Total	19	37	47	42	66	79

TABLE 4

FACTORS ASSOCIATED WITH PERSON-TO-PERSON SPREAD CONTROLS FOR CASES AND FAMILY

Risk factor	P to P cases		Family controls		P
	No	% Yes	No	% Yes	
Touched case	126	85.7	91	83.5	n.s.
Attended funeral	126	85.7	98	85.7	n.s.
Care for case	119	70.6	84	71.4	n.s.
Slept in same room	116	69.0	86	66.3	n.s.
Prepared cadaver	116	87	57.5	n.s.	
Aided in delivery of child of sick patient	104	18.3	74	9.5	p<0.001

n.s. = not significant.

Secondary attack rates

Five consecutive transmission generations of EbHF cases were documented. Sporadic, apparently spontaneous, probable cases simply were not recorded. When "family" was defined as all persons living in contiguous housing and sharing common eating facilities, attack rates for secondary case generations one through four never exceeded eight percent. However, when 92 families affected in the 21 villages surveyed along an east-west axis close to Yambuku were examined, contact infection rates were 16.7, 3.6 and 9.0 percent in three successive generations. Moreover, there were marked differences in secondary contact transmission related to both sex of the primary case and blood and marital relationships within households. The secondary attack rate was 27.3% among spouses, between brothers and sisters and between parents and children but only 8.0% to all other relatives. Among the high risk relatives 10 of 60 (17%) contacts became ill when the primary case was male and 27 infections occurred among 75 such contacts (36%) of female primary cases. Although the precise factors involved were impossible to determine, direct care of cases and intimate family contact, including sexual intercourse, possibly were the important variables.

Within all family units, the overall secondary attack rates were generally low amongst members who contacted cases acquiring their disease by both injection and by person-to-person transmission (Table 5). There is a significant difference (p 0.1) in secondary attack rates subsequent to contact with an "injected" case compared to others. However, there is no difference in attack rates caused by persons of different subsequent infection generations, all having secondary attack rates of less than 5%.

Spread within villages

Approximately one-third of the villages affected had one case and another third had between 2 and 5 cases (Table 6). Only two villages had more than 30 cases, Yambuku and Yandongi, the nearby administrative capital of the collectivity. The mean number of cases per village was 5.

Incubation period

The mean incubation period for cases due to injection was 6.3 days following the first injection (Figure 4). This ranged from I to 15 days. The incubation period for person-to-person spread was 9.5 days when the first day of contact was considered date of infection acquisition. This is imprecise as infection could have occurred at any time during the contact period, which at times covered up to 3 weeks. There were 17 instances where only 1 or 2 days of person-to-person contact was documented; the mean incubation period of these cases was 6.3 days, with a range of 1 to 21 days.

In one well-documented case a single contact occurred within 48 hours of symptom onset in that contact.

TABLE 5

FAMILY CONTACT ATTACK RATE BY GENERATION OF ILLNESS

Generation	No. Families of Cases	No. Family Exposures	No. Subsequent Cases	Attack Rate (%)
1x	61	498	38	7.6
2	62	459	20	4.4
3	18	117	3	2.6
4	5	29	1	3.4
TOTAL	146	1103	62	5.6

(x) persons acquiring disease by injection; subsequent generations acquired disease by person-to-person contact.

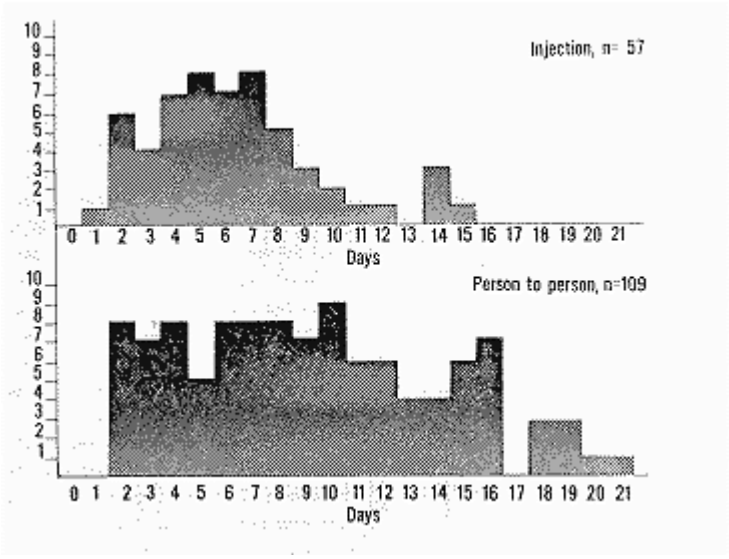

Fig. 4. Time of onset of Ebola Haemorrhagic Fever by transmission type (after initial contact with source) Zaire, 1976.

TABLE 6

DISTRIBUTION OF CASE NUMBERS IN VILLAGES

Number of Cases	Number of Villages	% of Villages	Cumulative %
1	17	30.9	30.9
2 - 5	18	32.7	63 .6
6 - 9	12	21.8	85.4
10 -14	4	7.3	92.7
15 -19	1	1.8	94.5
20 -29	1	1.8	96.3
30+	2	3.7	100.0
Total	55		

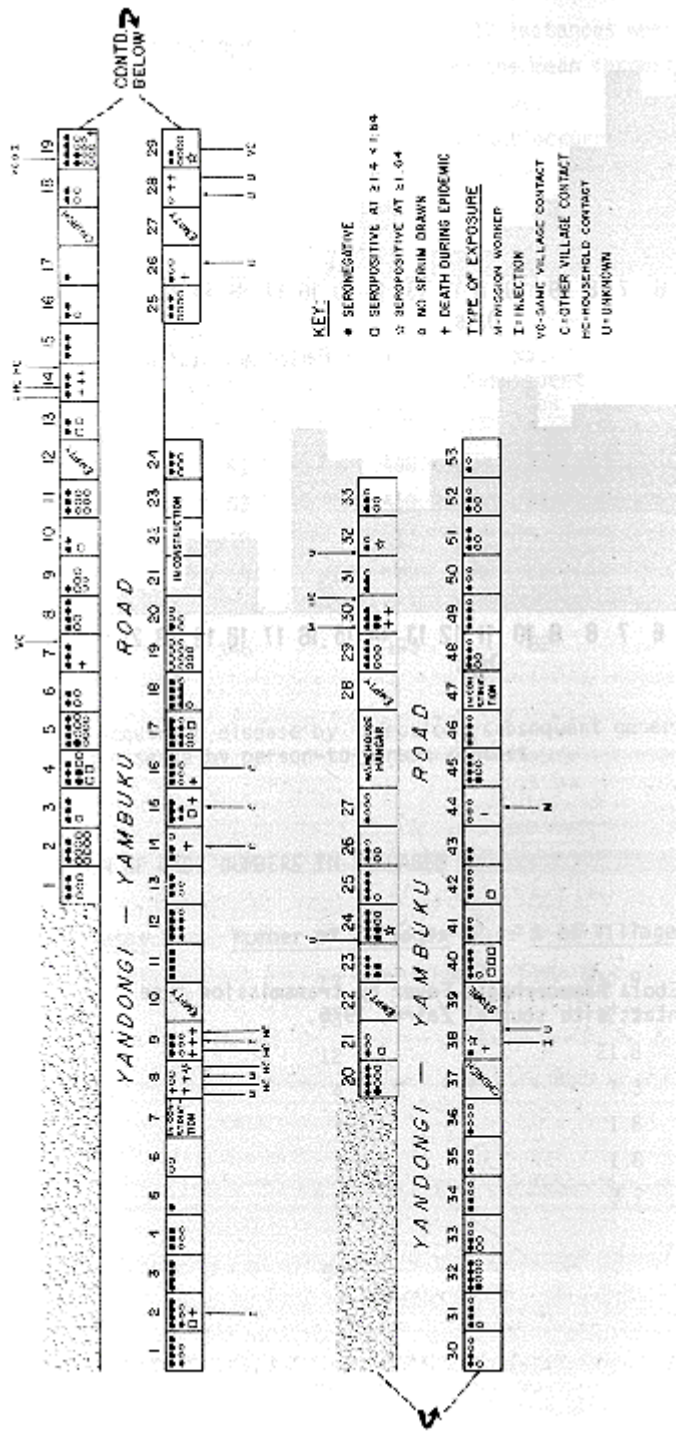

Fig 5. Ebola Haemorrhagic Fever, by household with individual inhabitants, Yamolembia, Zaire, September - October 18, 1976

Epidemic Disease in the Village of Yamolembia I.

This village, located five kilometers from Yambuku, was chosen for detailed analysis of disease transmission. The town was mapped and a door to door census revealed that 415 persons were resident in 71 households prior to the epidemic (Figure 5). Between 4 September and 18 October 1976, 24 persons developed probable or confirmed cases of EbHF. The first case was a 27 year old man who received an injection at YMH outpatient clinic on 29 August. Within six days, four more persons with a shitory of injection at the Yambuku Mission Hospital became ill. During this same period two nurses, a medical assistant and a catechist contracted the disease. These persons had all been in frequent contact with patients at the hospital, but had not received injections. By mid-October 15 additional villagers

had sickened, 12 of these secondary close contact with patients in this or other villages. Seven of these contacts occurred in the home of a neighbour, and three were contacts of sick relatives in other villages. Information on three cases was lacking.

Ten cases were among males, 14 among females. Adults of 15-45 years were most commonly affected. Only two persons survived, both contact infections. Cases occurred in 15 of the 71 households (21%) with 98 members. Four had secondary cases and one other had more than one case but could not be documented sufficiently to arrive at a conclusion as to transmission mode. There were six secondary and three tertiary cases giving transmission rates of 7.2% and 4.0%. Households with cases were scattered through the villages and no pattern of disease transmission other than very close patient contact was established.

In December 1976 and January 1977, sera were sought from as many people as possible. A total of 236 serum samples were obtained. Three persons, two of them in clinically non-infected households, who had not had symptoms during or since the epidemic, were found to have Ebola virus IFA titres of at least 1:64. All three had experienced contact with fatal cases. Extrapolating to the entire population two more silent infections might be expected. Thus it appeared that 29 people (7%) in the village had been infected, clinical illness ensued in 83% with an infection mortality rate of 76%.

Source of the epidemic

Although the first case began his symptoms six days after receiving an injection in Yambuku, it is of interest to follow his movements in the threeweek period preceeding his illness.

This person had been on a touristic visit to Mobaye-Bongo Zone in the northern part of the Equateur Region from 10-22 August 1976 with six other mission employees travelling in a mission vehicle. During this period he visited a number of larger towns (Abumombazi, Yakoma, Katokoli, Wapinda) along the road from Yambuku to Badolité which is very close to the Central African Empire frontier. He never arrived at Badolité because a bridge was out of use a few kilometers before Badolité. On his return to Yambuku on 22 August, he bought some freshly killed, and some smoked, antelope, and another traveller in the group bought some freshly killed, and some smoked, monkey from a local market along the route. His wife dried and stewed the antelope upon his return and this was consumed by his entire family. He had no contact with the monkey after his return to the village. The only possible animal contacts at the household were with two ducks. This person left to work in his nearby banana plantation a few days following his return. No unusual event occurring during the trip or in the fields upon his return was reported to the patient's wife.

During the search through the hospital records from January 1974 to the beginning of the epidemic, there was only one case resembling EbHF. This person was an adult male who was hospitalized on 20 August 1976 with "epistaxis and diarrhoea". The person left against medical advice on 30 August; he could not be found despite an active search during the investigations.

DISCUSSION

The cause of the epidemic was not identified until six weeks had passed and over 95% of cases had occurred. This was due to the similarity of clinical Ebola virus disease (3) to yellow fever (5), Lassa fever (6) and to a lesser extent to typhoid fever (7), one of the earliest diagnoses made by local investigators (8).

However, none of the patients responded who were treated with chloramphenicol. Jaundice was not an important clinical feature of the disease. All five of the expatriates who died had been vaccinated against yellow fever. Lassa fever has a higher frequency of pulmonary symptoms and bleeding is less common. Person-to-person spread is very uncommon and spread to a third generation is rare. Much of the early confusion could have been resolved if specimens would have been promptly collected and sent directly to the appropriate laboratory.

The epidemic curve resembled a common source infection and the peak occurred after 24-28 days had passed. The people in the community had already associated the mission hospital with the epidemic and had stopped coming to the outpatient department. Several patients with EbHF left the hospital for their villages in the second fortnight of September. The hospital staff, themselves severely affected by the epidemic, closed the hospital at the end of the month. This essentially stopped injection-transmitted disease and the epidemic shortly terminated.

The geographical distribution of cases was related to the hospital catchment area and the customs of the people. The epidemic zone was restricted to being quite near the mission hospital because the villagers in that area, during the beginning of the rice harvest, did not appear to stray too far from home. Several of the cases returned to their parents' homes when they became ill and these villages were for the most part also close to the hospital. The exportations of cases out of the epidemic zone to Bumba and Kinshasa illustrate how special circumstances can endanger large population centres. In

both of these instances injected persons had begun symptoms before leaving Yambuku. Because they were of the more favoured class they had the means to travel swiftly out of the epidemic zone hoping to find effective treatment at a larger medical centre. With the rather constant clinical presentation, incubation period and strict quarantine measures in the large cities, it became easy to identify cases and limit spread rapidly.

The women in the epidemic area were most severely affected. The group of women in the child-bearing age, between 15 and 29, went to the active prenatal clinic at the hospital. Although there are no data from hospital outpatient records to compute the rates of attendance by each age and sex group compared to the general population, other data show that adult females were more frequently hospitalized than males. Adult females also traditionally care for the sick. When death occurs, they are charged with washing and dressing the body for burial. When birth occurs in the village, it is the women of this group who assist the traditional midwife, especially when a complication occurs. Girls from 5 to 14 have taken on many of the duties of older females and are assumed to have also been in closer contact with cases while caring for them.

The contention that transmission by contaminated syringe and needle was the major mode of spread is based on good histories from at least 85 families that persons received injections within the three week period prior to illness onset whereas less than 1% of unaffected family members received injections. It is known that Ebola virus viraemia exists for at least 13 days past symptom onset and haematogenous spread of this disease has been confirmed (8). The manner in which the syringes and needles were cleaned and the technique for giving injections in this setting was conducive to transmission by this means.

Spread by close contact, mainly at the villages, could have been through the vehicle of contaminated body fluids (blood or excreta) entering open cuts or scratches. Although a sore mouth and throat were frequently reported, this was not often associated with cough or other respiratory signs which might have promoted spread.

Although it could not be completely ruled out, animals and insects appeared to have no role in transmission during the epidemic (2). Most families in the epidemic zone had the same type of contact with wild and domestic animals and those with cases did not differ from others. Although most adult men in the epidemic zone were hunters, the first known case was not.

The difficulty of person-to-person transmission of Ebola virus along with the high mortality rate indicates that the agent is probably an animal virus or has some other source in nature. The Marburg outbreak in 1967 was associated with Cercopithecus aethiops monkeys imported from Uganda and the illness produced has been popularly called "Green Monkey disease" (9). This is misleading as these groups of monkeys associated with the 1967 epidemic had an extremely high mortality rate while grouped in animal care areas at the laboratories which may indicate the monkeys contracted the disease from another source. Furthermore, these monkeys had contact with 48 species of other wild animals while en route from Africa to Europe (11). No investigations of the other animal species were done. Serologic studies done in East Africa among animals captured in the wild showed that several different primate species had antibodies to Marburg virus but the specificity of the test used has since been questioned. No source could be identified for the outbreak of Marburg virus disease occurring in South Africa in 1975 although the first of three cases received an "insect bite" a week before the disease onset (13).

The source of this epidemic, although not determined exactly, probably originated in the Sudan. The Sudan epidemic began in late June and was already known to have extended to the important regional centre of Maridi by August (11) Travel is not extensive between the Bumba Zone and the Sudan or the Central African Empire. However, many of these international exchanges are illegal and details are difficult to get. It was found that someone could travel from the infected zone in Southern Sudan to Bumba Zone in four days, well within the incubation period.

The origin of the cases in the Sudan is still obscure. This epidemic was also associated with a hospital. It is very likely that if these hospitals would not have served as "amplifiers" and disseminators, the epidemics may not have come to the attention of health authorities. The best way to ensure rapid diagnosis and necessary control measures is to develop an awareness of this disease among peripheral health workers, provide them with instruction and materials for taking specimens and proper equipment for protecting themselves if an outbreak of this or similar disease should occur.

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DISCUSSION

Bastian : In your presentation you mentioned some customs, can we have some more information on the customs to which you referred ?

J.G. Breman : The custom that at this time of the year, which is the rice harvest, people stayed very close to the epidemic area. Distant travel outside the zone, except in the well-noted and well-studied instances, did not occur. That epidemiologically is really the most important factor.

J.A. Bryan : How many midwives were there in the area and did everyone of these people become ill or none of them ?

J.G. Breman : In Yambuku interestingly enough, there were three midwives, all of them working at the hospital during the time of the epidemic, none of them had clinical symptoms and none had Ebola virus antibodies. In the village of the fifteen or so instances where there was a relation to a birth, and there were several stillborns which were not counted as neonatal disease, about half of the midwives there, were infected.

K.M. Johnson : I think the kind, intensity and duration of contact were important in the transmission. Are there any indications from the answers to the non-quantitative set of questions that were asked to the people, to define those individuals within the families who were at a considerable higher than 5% risk of getting the infection ?

J.G. Breman : There were two studies. One performed late October early November in a group of villages along the east-west road, and the second study beginning late November when people would not recall as well. Data on age, sex. names corresponded in over 90% of instances. In the early study it was found that when spouses were compared to parents and children or sibs, the secondary attack rates were upwards of 20%. When males were compared to females, the secondary attack rate was of the order of 16% for males and 27% for females, indicating that just asking if someone was a member of the family was not enough to define this high-risk group.

S. van Nieuwenhove : I just want to add something to the question of the slowing down of the epidemic. Normally burial involves a lot of physical contact with the corpse. But as time went on the population became very suspicious and did not touch the corpses any more, not even to bury them. That is probably why person-to-person transmission in the end slowed down very quickly.

A.A. Arata : The question that we still have not come to is, I think, where did the virus really come from ?

J.G. Breman : Retrospectively, what else could we have done or done differently in our investigations ? We had a long list of animal contacts, domestic and wild, but most of them were animals that were commonly seen by all. But there are a few very unusual species and varieties. It might have been helpful to find out if someone had this type of contact. Undoubtedly with the low contact rate and the high mortality rate this is probably a zoonosis.

I.W. Pinkerton : Was any information obtained from older people, as to the past occurrence of such epidemics ?

J.G. Breman : A lot of interviews early on were carried out with village elders, specifically regarding past epidemics of this type of syndrome. It was so unique to the villagers that they easily could reply. People over sixty years old had never seen anything like this. A good portion of these were bled as were the sisters who had been at the Mission for more than twenty or thirty years and none of them had antibodies.

C.E. Gordon Smith : Would you expect to detect antibodies from far distance infections ?

J.G. Breman : if that would have been twenty or thirty years ago, I don't know, but Dr. Isaacson brought us some titer from Marburg with a 1/8 titer after art acute in 1975 that certainly could have been detected.

K.M. Johnson : I don't think that anybody knows what the endpoint is by any method in terms of disappearance of antibodies. A small sample of people infected with Marburg virus in were rebled and retested in our laboratory in late 1975 early 1976 all are still positive titers were low but they all could be recognized as having antibodies. I suspect that we will find that the majority of survivors from epidemics will still be positive for a number of years. If you wanted to go to twenty or thirty years, I would hesitate clearly to make any statement at the moment.