

The following is the submitted version of an article eventually published as:
Schneider, William H. "Origins of the HIVs and the AIDS Outbreaks," *eLS*, Vol 2: 1–6,
2022. DOI: 10.1002/9780470015902.a0028032
[<https://onlinelibrary.wiley.com/doi/book/10.1002/047001590x>]

Origins of the HIVs and the AIDS Outbreaks

William H. Schneider, Professor emeritus of History and Medical Humanities
Indiana University Purdue University Indianapolis
Cavanaugh Hall 441,
425 University Blvd.,
Indianapolis, IN 46202, USA

Abstract:

The AIDS pandemic was caused by human immunodeficiency virus type 1 group M (HIV-1M). It is not widely appreciated that there are three other HIV outbreaks that emerged independently in different regions of Africa during the last century. To date, 13 HIVs have been discovered, but only four of which became major outbreaks to varying degrees. HIV-1M is responsible for 90% of over 35 million deaths, and the other three epidemic HIVs are estimated to have infected from 25,000 to 750,000 people each. A handful of key determinants explain how and why this happened, including human interaction with the simian sources from which the HIVs emerged, but much more important were new ways that people spread the viruses to one another. The latter included population movement and urbanization, changes in sexual relations, war, and above all new medical procedures (unsterile injections and inadequately tested blood transfusions). The emergence of the viruses and their epidemic spread were not the result of a random mutation, but rather depended upon the combination of specific circumstances at different places and times. The AIDS pandemic was not a chance, natural occurrence; it is much more accurately described as a (hu)man-made disaster.

Key words:

AIDS, emerging viruses, HIV, serial passage

Key Concepts:

- The global AIDS pandemic was caused by multiple human immunodeficiency viruses.
- The HIVs emerged from different simian immunodeficiency viruses independently in two widely separated regions and at different times, mainly during the early and mid-twentieth century.
- Broader understanding of historical, social, and cultural circumstances is necessary to explain how and why these viruses emerged and became pandemic.

- The most important new circumstances causing the emergence of HIV epidemic viruses in the twentieth century were those that facilitated passage of pathogens between humans.
- In addition to population movement, urbanization and changing sexual relations, the most ubiquitous new developments increasing the possibility of adapting viruses to humans were blood transfusions and injections against diseases or for mass vaccination campaigns with insufficiently sterilized needles which were contaminated with as yet undiscovered viruses.

Glossary:

- Molecular clock: A tool for estimating the phylogeny of viruses based on extrapolating their rate of mutation
- Serial passage: An explanation of the mechanism by which SIVs adapted to become HIVs only in the twentieth century when passage of viruses between humans was greatly facilitated
- Simian immunodeficiency virus: Viruses found in over 40 simian species in sub-Saharan Africa, and from two of which the human immunodeficiency viruses adapted in the twentieth century.

Introduction:

The AIDS pandemic is widely recognized as one of the worst medical disasters in the past century. In addition to the enormous death toll of tens of millions who have died, the disease was identified near the height of the "miracle" medical discoveries following the Second World War that established overwhelming confidence in modern medicine. (Brandt 2000, LeFanu 1999, Burnham 1982) These included the discovery and mass production of penicillin, dramatic advances in heart surgery and transplantation, and thanks in part to advances in vaccinations, an unprecedented reduction in infectious diseases. The first cases of what we now call AIDS were identified in 1981, only a few years after the eradication of smallpox and all that it promised. As a result, the AIDS pandemic shook the health field to its core. Despite success in identifying, testing and treating AIDS, the emergence of HIVs and their epidemic spread proved to be precursors of other viral outbreaks such as Ebola and Zika, well before the COVID-19 pandemic. They have eroded confidence in modern medicine that is not likely to be fully restored soon. (Snowden 2008) DOI:

10.1038/npg.els.0002238

Much has been discovered about AIDS since it was first recognized, most notably the long period of incubation of the virus generally 10 to as long as 20 years in rare cases, during

which time many of those infected are asymptomatic but still able to silently transmit the virus to others. This greatly increased the spread of the virus without any awareness of the transmission. The result was to heighten fear and suspicion about who was infected, especially before the virus was identified in 1983 and tests were developed two years later that could screen for those who were infected but asymptomatic. It took another 10 years to find an effective anti-viral treatment, which along with preventive behavioural and public health measures finally began to reduce anxiety and help bring the spread of the disease under some control in most parts of the higher socio-demographic index countries in the early 2000s. (UNAIDS 2017) Most writings on the history of AIDS have focused on the search to understand its cause and find an effective treatment or prevention. As a result, many other features of the disease agent and circumstances that enabled these pandemic and epidemic outbreaks have been relatively neglected, including a clear understanding of the mechanisms that produced this new virus and the process by which it emerged in different places in a relatively short period of time.

The Full Scope Explanation of HIVs Emergence

Explanations of the emergence of HIVs are based on the extraordinary work of researchers beginning with the recognition that it attacks the immune system, which eventually allows opportunistic infections when immunity is compromised. (Curran 2011) Soon after the identification of the virus in 1983 by the Montagnier and Barré-Sinoussi group at the Pasteur Institute (also reported a year later by the Gallo group at NIH), a test was developed and made available in 1985. This helped confirm another feature crucial to understanding its spread; the long period of low viral load before the immune system was eventually compromised and unable to prevent opportunistic infections.

In the late 1980s and early 1990s, additional HIVs with genetically distinct lineages were discovered in West Africa 2,000 miles away from the first HIV found in central Africa. The two pathogens were accordingly named HIV-1 and HIV-2 (Clavel 1986). Another key discovery was that HIV-1 had evolved from a simian immunodeficiency virus in chimpanzees in central Africa. (Peeters 1989, Huet 1990) This was followed very soon by discovery of the SIV source of the West African HIV-2 (Hirsch 1989), in a different simian species: Sooty Mangabey monkeys. (Hirsch 1989) Careful testing and DNA mapping of phylogenetic trees, subsequently showed that three other HIV-1 groups had crossed over from central African simians. (Simon 1998, Plantier 2009) Likewise, as Figure 1 shows, the same was found to have occurred in nine cases with the HIV-2 strains.

Figure 1 HIVs discovered to date

Virus	Geogr. origin	Est. date	No. of Infections (estimates)
HIV - 1			
Group M	Cameroon	1909-33	77,000,000

Group N	Cameroon	1948-67	20**
Group O	Cameroon	1903-48	100,000
Group P	Cameroon		2**
HIV-2			
Subtype A	Cape Verde Islands, Guinea Bissau	1928-47	750,000
Subtype B	Ivory Coast	1931-59	750,000
Subtype C	Liberia		1*
Subtype D	Liberia		1*
Subtype E	Sierra Leone		1*
Subtype F	Sierra Leone		2**
Subtype G	Ivory Coast		1*
Subtype H	Ivory Coast		1**
Subtype I	Ivory Coast		1*

*Cases reported so far

** Including outside Africa

Sources: Faria 2012, 2014; Wertheim 2009; Lemey 2003; UNAIDS 2022

Several means were utilized to estimate the age of these viruses, including retrospective diagnoses of previously reported cases and a world-wide search and testing of stored tissue and serum samples. Somewhat later, beginning in 2000, researchers applied a new technique of phylogenetic analysis, based on HIV mutation rates called molecular clocks, to estimate the timing of the most recent common ancestor of HIV samples whose DNA was mapped. (Kumar 2005) Edward Hooper's book, *The River*, remains the most extensive effort to track down possible cases of unknown deaths that had likely been caused by undetected AIDS, and he concluded that the virus emerged quite recently, in mid-twentieth century. The search for physical samples that could be tested for HIV antibodies found that the earliest for HIV-1 was from a man in Leopoldville (in the Belgian Congo) who took part in a 1959 study of genetic diseases. (Nahmias 1986) Shortly thereafter, samples that tested positive for HIV-2 dating from the mid-1960s in the Ivory Coast and neighboring West African countries were found stored in a WHO serum databank. (LeGuenno 1989, Kawamura 1989).

The molecular clock estimates pushed back the emergence dates of the earliest HIVs as many as 30 to 40 years before the earliest date of tested samples. (Korber 2000, Lemey 2003, Faria 2012, 2014) There was still general agreement that these HIVs were very recent in origin compared to the apparently much older simian viruses. These SIVs are very widespread across sub-Saharan Africa, in over 40 species of apes and monkeys (Locatelli 2012), which indicates a long evolutionary period. Likewise, they are asymptomatic in simians which also strongly suggests a long period of endemic evolution. More direct evidence to confirm this came from a recent study of monkeys on Bioko Island off the coast

of Equatorial Guinea which became isolated when seawaters rose 30,000 years ago. They were found to have the same type of SIV as their mainland relatives. (Worobey 2010).

Limited Scope explanations to Date

The explanation to date of the emergent HIVs and the subsequent AIDS pandemic raises two questions. First, if SIVs are ancient and human-simian interaction is widespread and long standing, why did HIVs emerge only in the twentieth century? The second question is that if the pandemic was not the result of a one-time random mutation, then why did multiple HIVs emerge, only some of which became epidemic, and one pandemic? Explanations to date have focused mostly on the HIV-1M strain which is responsible for 90% of infections in the world. These explanations, unfortunately, ignore the questions of what produced multiple HIVs by the middle of the twentieth century as well as why some became epidemic and some did not. Moreover, even the explanations for HIV-1M have been incomplete and usually not generalizable for the other HIV-1 groups.

The earliest and most controversial explanation was by Hooper. Beginning with the 1959 date for the first samples with identifiable cases of AIDS or HIV antibodies, he concluded that the production in the Belgian Congo of a polio vaccine using chimpanzee kidneys in the mid-1950s was responsible for the virus and epidemic. Hooper was quickly challenged for a number of reasons, perhaps most compellingly because it did not explain the emergence of the other HIVs. In addition, tests of the polio vaccine showed that it used rhesus monkey kidneys (Weiss 2001); and even if additional local animals were used from the Kisangani site of production (colonial Stanleyville, Belgian Congo), the chimpanzees of that region were found to have a different SIV than the ones in southeastern Cameroon from which HIV-1M adapted (Worobey 2004, Keele, et al. 2006). A final criticism came from new molecular clock estimates of the timing of the crossover which were 20-30 years earlier than the polio vaccine program. (Wertheim 2009) Researchers quickly turned to another explanation first suggested at a meeting in London in 2000 to review the Hooper thesis. (Martin 2001) A summary of the new explanation is that a hunter in Cameroon was infected from a cut while butchering a chimp with SIV. He then made his way down the Sangha River to the Congo, where the urban setting of Leopoldville (later renamed Kinshasa) became the “epicenter” of the AIDS epidemic. In the capital of the Belgian Congo, this view concludes, the demographic and other features of colonial rule provided the possibility for evolution and epidemic spread of HIV-1M. (Hahn 2000, Pepin 2011, Timberg and Halperin 2012, Quammen 2015).

Broader Interdisciplinary Perspective

The features of the “cut hunter/ Kinshasa epicenter” explanation are plausible but limited in focus and in some cases misleading either because they lack sufficient evidence or

proponents have misread key colonial historical documents and cultural practices. But more important is that they have not been tested to see if they can explain the other HIVs and epidemics. A much more useful explanation of the HIV-1M pandemic should also account for the emergence of all the HIVs and the multiple epidemics caused by some of them. To achieve this, a broader interdisciplinary perspective is necessary not only to understand in more depth the emergence and epidemic spread of HIV-1M in southeastern Cameroon and Kinshasa but also to account for the emergence of the other HIV-1 groups, including the epidemic spread of group O as well as the emergence of the multiple HIV-2s and the epidemic spread of two of them.

Examining the first matter begins with the question of human-simian interaction in southeastern Cameroon. Recent anthropological fieldwork in the Sangha River basin (Rupp 2016) found that hunting was only one of many kinds of contact there between the people and non-human primates both historically and to the present day. Many baby chimps had been taken as pets, villagers often chased apes from their fields, and they competed in harvesting wild fruits from the forest. Marx et al., had also reported in 1989 that sooty mangabeys, the host monkey of HIV-2 ancestral viruses, were commonly kept as pets in West Africa. (Marx 1981) On the question of whether colonial rule in the twentieth century resulted in more hunting that might have increased chances of exposure to SIVs through the introduction of firearms, the researchers found instead a continuity of hunting practices in the early decades of the twentieth century. Guns were first introduced well before 1900 thanks to the slave and legitimate trades, but for obvious reasons European colonial rulers did not want Africans to have guns. There were significant changes, from head taxes to forced relocation of villages, but it took time –until the 1930s – for these to reach this part of Cameroon, well isolated from the capital of Yaoundé.

Researchers found evidence and testimony of long-established historical movement of people and goods down the Sangha River to the Congo, and notably upriver as well. Africans, Europeans and their pets, as well as commerce moved up and down this natural highway through the rain forest. But like hunting, there was more continuity than abrupt change in the early decades of the twentieth century when crossovers of SIV to HIV are estimated to have occurred. The overall conclusion of this research is that there is ample evidence to support the explanation that an African or European exposed to an SIV, or a chimp pet with SIV, moved from southeastern Cameroon to Kinshasa or elsewhere in the Congo River basin. It is also possible that there were ecological changes that caused a shift in the territory of these SIV-infected chimpanzees. Even if the molecular clock estimates of adaptation are accurate (1920 +/- 11 years), the time of the virus reaching Kinshasa is difficult to determine. In addition, more changes likely came to the region towards the end of the estimated period (~1930) rather than with the beginning of colonial rule (~1910).

If SIVs are ancient and the emergence of multiple HIVs in the twentieth century was not the result of a random mutation or cut hunter, what new circumstances can explain the adaptation of simian viruses to become human ones? One explanation that accounts both for

multiple emergence as well as epidemic spread of some HIVs is the serial passage theory of animal virologist Preston Marx. (2001, 2011) This explanation begins with the observation that HIVs are not a simple zoonotic infection caused by SIVs. (Marx 2004) Unlike rabies or Ebola which affect a person just as they do the infected animal, when a human is infected by a monkey or chimpanzee with SIV, as happens occasionally in Africa and primate labs in the U.S., the infection goes unnoticed, and the hypothesis is that an initial elevated viral load is suppressed in about 6-8 weeks. (Klatt 2012) This theory is supported by the lack of a life-long infection in persons infected with SIV or SIV-like viruses. If, however, through some means that person infects another person during this initial period, the SIV passage would result in a viral load higher and lasting longer, as the virus mutates and adapts for survival in the new human host. If this second person then infects a third, a more likely occurrence because of the increased and extended viral load, then the opportunity for further adaptation increases. Marx proposed that this serial passage was mediated by iatrogenic mechanisms, mainly unsterile injections, and Drucker showed the massive nature of ever cheaper injection devices being made available in the twentieth century. (Drucker 2001) Schneider expanded the concept by proposing transfusions would be the most efficient means of serial passage. (Schneider 2013) By the third passage, according to Marx, it is possible to have produced a bona fide "human" immunodeficiency virus that can be passed between people; in other words, it is an HIV.

Several features of this explanation fit what has been observed of the adaptation of multiple HIVs and epidemic spread of a few. First, serial passage is not new. Since being discovered by Pasteur, it has become a well-established biomedical technique used to develop vaccines such as the oral polio vaccine. Although common in the laboratory, serial passage in nature is neither common nor easy, hence it explains why there are not larger numbers of new HIVs. Second, serial passage is not so difficult as to make adaptation unique. In other words, the low and limited duration of viral loads at first and second passage explain the rare but not unique number of HIVs that have emerged. Finally, and most important, serial passage depends on an increase in transmission of viruses between humans, not simian-human infection. From this follows the most convincing feature of the theory, namely the reason why HIVs have both emerged and some became epidemic in the twentieth century: new developments making it easier for humans to pass viruses between themselves. This phenomenon is somewhat counter-intuitive because we are blind to the increased risk of infection that arose during the last century. Discoveries such as the germ theory, developments of new vaccines, and increased surveillance more than made up for increased risk of spreading infections because of urban growth, greater mobility of people, increased sexual relations with multiple partners, and new medical procedures such as injections and transfusions that could be contaminated especially by an unknown virus.

The situation in Africa after colonial rule was obviously different, including new developments that unintentionally increased risks of passing viruses, but unlike Europe, the protections and limitations to minimize the risks were much less in effect. Thus, even though some argue that the health of Africans improved during the course of the twentieth century

(as reflected in population growth and life expectancy), there were also new developments permitting easier passage of viruses between humans, especially an undetected virus like HIV. Those cited to explain the HIV-1M pandemic include the increased movement of people, notably to growing urban centers, the rise of prostitution in the cities, and the mass campaigns against disease using injections and inoculations. Unfortunately, colonial rule brought only partially effective efforts to monitor, treat and prevent disease. Plus, some of these very efforts (e.g., inoculation with instruments insufficiently sterilized or contaminated blood transfusion) added to the passage of viruses.

Determining the role of each of the increased risks for all emerging HIVs is difficult because of their numbers and their isolated nature. Moreover, as the study of human-simian relations in southeastern Cameroon and West Africa has shown, there was likely frequent exposure of humans to SIVs. On the other hand, the four epidemic HIVs, produced by the same increased risk of infection, have left much more evidence to study. Hence, if the serial passage theory is correct, an examination of circumstances producing increased exposure of humans to each other's pathogens should explain both adaptation and the spread of the four epidemic HIVs.

The most frequently mentioned, and obvious new development was the movement of people and concentration in urban centers. This is fundamental to the Kinshasa as epicenter explanation, but the question is whether it also applies to the other three epidemic HIVs (HIV-1 group O and HIV-2 A and B). First, the demographic history of colonial Kinshasa was not one of simple and rapid growth. There was greater increase in population movement during the 1930s Great Depression (out of the city), and back into the city after the Second World War. (Gondola 1997) Second, although Abidjan likely played a similar role for HIV-2, there is no firm evidence that the two large urban areas of Cameroon (Douala and Yaoundé) played this epicenter role in the spread of HIV-1 group O which apparently was dispersed in various parts of the country. (Leoz 2015). Likewise, in the case of HIV-2A in Guinea-Bissau, there was no comparable urban center in the colony. To date, there is not enough research on HIV-2B to draw conclusions. It is also worth noting that HIV-1 group O and HIV-2 A and B have been reported to replicate slower than HIV-1 group M, and these virological differences may also have played a major role in transmissibility and epidemiological spread of the viruses. (Damond 2002, Mourez 2013)

The role of prostitution is even more complicated. It is likely that multi-partner prostitution played a significant role in Kinshasa, as has been frequently suggested in explanations (de Sousa 2010, Pepin 2011), but much more so after the Second World War. Before that time, there were limited numbers of women in the city, and the practice is better characterized as a kind of concubinage with stable and long-term relationships (Lauro 2018). It is likely that prostitution in Abidjan after 1945 played a role in the spread of HIV-2A, but this has been very little studied. (Amat-Roze 1999) Since the HIV-1 group O epidemic in Cameroon was at least in part rural, it is difficult to conclude that urban prostitution played a decisive role. Finally, researchers who have studied the case of Guinea-Bissau and

neighboring Gambia have found that prostitution was rural and regional, rather than the typically portrayed practice of a big city like Kinshasa. (Wilkins 1991, Pepin 1991, Buckner 1999)

The introduction of modern medical procedures, especially insufficiently sterilized needles used in disease campaigns, seems to be the new development that most likely played a role in all epidemic HIVs. Beginning with smallpox even before the first World War, then expanding to include yellow fever, sleeping sickness and venereal disease, mass disease prevention campaigns were introduced in all European colonies, including those in central Africa (Belgian Congo and Cameroon), and West Africa (the Ivory Coast and Guinea-Bissau) where the adaptation and epidemic HIVs emerged. The timing and specific practice varied by disease and local practice. For example, campaigns against smallpox and yellow fever were more widespread in West African locations (Schneider 2009), while sleeping sickness was the subject of campaigns in Cameroon and the Belgian Congo. (Ronin 2014, Janssens and Burke 1992, Lyons 2002) Kinshasa also opened a venereal disease clinic in 1929 that continued for the next two decades. (Pépin 2011), but campaigns against the other diseases were meant to reach the vast majority of the population in the countryside and villages, via periodic visits by teams of doctors and assistants. This model began in the Belgian Congo before 1914 (Ronin 2014), but it was dramatically increased and publicized by the work of Eugène Jamot. (Lachenal 2013) His mobile medical teams were especially active in south central Cameroon, where they examined over 600,000 people in 1928, with over 110,000 found to be infected with sleeping sickness. (Headrick 2014)

Blood transfusion came only slightly later to sub-Saharan Africa, but was slower to become widely practiced, because it was only done in hospitals (Schneider 2013). But the acceleration of investment in colonies after 1945, including hospital construction, plus advances in simplified blood transfusion during the war, and the lack of dependence on an external source of the “medicine” (blood was collected locally), greatly expanded the use of transfusion. In addition, the almost certainty of becoming infected by a contaminated transfusion, greatly magnified the role of the practice, at least in the epidemic spread of HIV beginning in the 1950s. Only in Guinea-Bissau did war play a significant role in the epidemic spread of HIV. The liberation war of 1963-74 greatly affected population movement, but there was increased use of disease campaigns only in the colonial ruled regions of the country. (Varanda 2018).

Conclusion

The work of numerous virologists and evolutionary biologists has identified over a dozen HIVs that emerged in the twentieth century in two widely separated parts of Africa. Identifying how and why this occurred requires further research, but it is of crucial

importance to understand the historical, cultural and social setting at the time. Broad references to European colonial rule are not very useful in learning from this epidemic; more detailed analysis of specific customs, health practices, and living patterns offer a better understanding of common developments, such as mass injection campaigns, as well as the particular circumstances of labor migration or war that facilitated emergence and the epidemic spread of the viruses. Rather than seeing AIDS as a random natural occurrence, this perspective reveals the crucial role of human activity in epidemic disaster.

References:

Amat-Roze, Jean-Marie. 1999. Sexually Transmitted Diseases and HIV/AIDS in Côte d'Ivoire. In *Histories of Sexually Transmitted Diseases and HIV/AIDS in Sub-Saharan Africa*, eds. Philip Setel, Milton James Lewis, Maryinez Lyons. Westport, CT: Greenwood Press, 43-64

Brandt AM. and Gardner M. 2000 The Golden Age of Medicine? in *Medicine in the Twentieth Century*, Cooter R and Pickstone, J. eds. 21-37. Netherlands: Harwood Academic Publishing

Buckner M. 1999, Village women as town prostitutes: cultural factors relevant to prostitution and HIV epidemiology in Guinea Bissau. In *Vivre et penser le sida en Afrique / Experiencing and understanding AIDS in Africa*. Becker C, Dozon J-P, C. Obbo, et al. eds. 389- 404. Dakar/Paris: Codesria, IRD, Karthala.

Burnham J C 1982. American medicine's golden age: What happened to it? *Science* 215: 1474-79

Clavel F, Guétard D, Brun-Vézinet F et al. 1986. Isolation of a New Human Retrovirus from West African Patients with AIDS. *Science*, New Series, 233, No. 4761.: 343-346

Curran, J. W. and Jaffe, H. W. 2011 *AIDS: the early years and CDC's response*. *Morbidity and Mortality Weekly Report*, Supplements; 60(04);64-69

Damond F, Gueudin M, Pueyo S, Farfara I, Robertson DL, Descamps D, Chène G, Matheron S, Campa P, Brun-Vézinet F, Simon F. 2002. Plasma RNA viral load in human immunodeficiency virus type 2 subtype A and subtype B infections. *J Clin Microbiol.* 40(10):3654-9

de Sousa JD, Müller V, Lemey P, et al. 2010. High GUD incidence in the early 20 century created a particularly permissive time window for the origin and initial spread of epidemic HIV strains. *PLoS One.* 5(4):e9936

Drucker E, Alcabes PG, Marx PA. 2001. The injection century: massive unsterile injections and the emergence of human pathogens. *Lancet*; 358(9297):1989-92

- Faria NR, Rambaut A, Suchard MA, et al. 2014 HIV epidemiology. The early spread and epidemic ignition of HIV-1 in human populations. *Science*. 346(6205):56-61
- Faria NR, Hodges-Mameletzis I, Silva JC, et al. 2012. Phylogeographical footprint of colonial history in the global dispersal of human immunodeficiency virus type 2 group A. *J Gen Virol*. 2012. 93(Pt 4):889-99
- Gondola C D. 1997. *Villes miroirs: Migrations et identités à Kinshasa et Brazzaville, 1930–1970*. Paris: L’Harmattan
- Hahn BH, Shaw GM, De Cock KM, et al. 2000. AIDS as a Zoonosis: Scientific and Public Health Implications. *Science* 287:607-14
- Headrick D R. 2014. Sleeping Sickness Epidemics and Colonial Responses in East and Central Africa, 1900–1940. *PLoS Negl Trop Dis* 8(4): e2772.
<https://doi.org/10.1371/journal.pntd.0002772>
- Hirsch VM, Olmsted RA, Murphey-Corb M, et al. 1989. An African primate lentivirus (SIVsm) closely related to HIV-2. *Nature*. 339(6223):389-92
- Hooper E. 1999 *The River: A journey to the source of HIV and AIDS*. Boston: Little, Brown and Co.
- Huet T, Cheynier R, Meyerhans A, et al. 1990. Genetic organization of a chimpanzee lentivirus related to HIV-1. *Nature*. 345(6273):356-9
- Janssens, P. G. and Burke, J. (1992). Les trypanosomiases africaines, In Kivits M, Vuylsteke J. (Eds.) (1992). *Health in Central Africa since 1885; past, present and future*. Brussels: King Baudouin Foundation, 2: 1399-1595
- Kawamura M, Yamazaki S, Ishikawa K, et al. 1989. HIV-2 in west Africa in 1966. *Lancet*.1(8634):385
- Keele BF, Van Heuverswyn F, Li Y, et al. 2006. Chimpanzee reservoirs of pandemic and nonpandemic HIV-1. *Science*. 313(5786):523-6
- Klatt NR, Canary LA, Vanderford TH. 2012. Dynamics of simian immunodeficiency virus SIVmac239 infection in pigtail macaques. *Journal of Virology*. 86(2):1203-13
- Korber B, Muldoon M, Theiler J, et al. 2000. Timing the ancestor of the HIV-1 pandemic strains. *Science*. 288(5472):1789-96
- Kumar, S. 2005. Molecular Clocks: Four Decades of Evolution. *Nature Reviews Genetics*. 6: 654-62

- Lachenal, G. 2013 "Médecine, Comparaisons et Échanges Inter-impériaux Dans Le Mandat Camerounais : Une Histoire Croisée Franco-Allemande De La Mission Jamot." *Bulletin canadien d'histoire de la médecine* 30, no. 2: 23-45
- Lauro A. 2018. *Sexe, race et politiques coloniales. Encadrer le mariage et la sexualité au Congo Belge 1908-1945*, Frankfurt am Main: PIE-Peter Lang
- Le Fanu, J. 1999. *The Rise and Fall of Modern Medicine*, New York: Carroll and Graf
- Le Guenno B. 1989. HIV1 and HIV2: two ancient viruses for a new disease? *Transactions of The Royal Society of Tropical Medicine and Hygiene*. 83 (6): 847
- Lemey P, Pybus OG, Wang B, et al. 2003. Tracing the origin and history of the HIV-2 epidemic. *Proceedings of the National Academy of Sciences of the United States of America* 100(11):6588-92
- Leoz M, Feyertag F, Kfutwah A, et al. 2015 The Two-Phase Emergence of Non Pandemic HIV-1 Group O in Cameroon. *PLoS Pathogens*. 11(8):e1005029
- Locatelli S and Peeters M. 2012. Cross-species transmission of simian retroviruses: how and why they could lead to the emergence of new diseases in the human population. *AIDS*. 26(6):659-73
- Lyons, Maryinez 2002. *The Colonial Disease: A Social History of Sleeping Sickness in Northern Zaire, 1900–1940*, Cambridge: Cambridge University Press
- Martin B. 2001. The Politics of a Scientific Meeting: The Origin-of-AIDS Debate at the Royal Society. *Politics and the Life Sciences*. 20 (2):119-130
- Marx PA, Li Y, Lerche NW, et al. 1991. Isolation of a simian immunodeficiency virus related to human immunodeficiency virus type 2 from a west African pet sooty mangabey. *J Virol.*; 65(8):4480-5.
- Marx PA, Alcabes PG, Drucker E. 2001. Serial human passage of simian immunodeficiency virus by unsterile injections and the emergence of epidemic human immunodeficiency virus in Africa. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 356(1410):911-20
- Marx PA, Apetrei C, Drucker E. 2004. AIDS as a zoonosis? Confusion over the origin of the virus and the origin of the epidemics. *Journal of Medical Primatology*. 33(5-6):220-6.
- Marx PA, Drucker EM, Schneider WH. 2011. The serial passage theory of HIV emergence. *Clinical Infectious Diseases*. 52(3):421
- Mourez T, Simon F, Plantier JC. 2013. Non-M variants of human immunodeficiency virus type 1. *Clin Microbiol Rev*. 26(3):448-61. doi: 10.1128/CMR.00012-13. Review.PMID:23824367

- Nahmias AJ, Weiss J, Yao X, et al. 1986. Evidence for human infection with an HTLV III/LAV-like virus in Central Africa, 1959. *Lancet*.1(8492):1279-80
- Peeters M, Honoré C, Huet T, et al. 1989. Isolation and partial characterization of an HIV-related virus occurring naturally in chimpanzees in Gabon. *AIDS*. 1989 Oct;3(10):625-30
- Pepin J, Dunn D, Gaye I, et al. 1991. HIV-2 infection among prostitutes working in The Gambia: association with serological evidence of genital ulcer diseases and with generalized lymphadenopathy. *AIDS*. 1991 Jan;5(1):69-75
- Pepin J. 2011. *The Origins of AIDS*, New York: Cambridge University Press
- Plantier JC, Leoz M, Dickerson JE, De Oliveira F, Cordonnier F, Lemée V, Damond F, Robertson DL, Simon F. 2009. A new human immunodeficiency virus derived from gorillas. *Nat Med*. 15(8):871-2. doi: 10.1038/nm.2016. Epub 2009 Aug 2. PMID: 19648927
- Quammen D. 2015. *The Chimp and the River: How AIDS emerged from an African forest*, New York: W.W. Norton
- Ronin, V.K. (2014). A Doctor from Russia in Belgian Congo: Yakov Schwetz. *History of Medicine*. 1 (1): 84–93
- Rupp S, Ambata P, Narat V, Giles-Vernick T. 2016. Beyond the Cut Hunter: A Historical Epidemiology of HIV Beginnings in Central Africa. *Ecohealth*. 13(4):661-671
- Schneider WH. 2009. “Smallpox in Africa during colonial Rule,” *Medical History*, 53: 193-228
- Schneider WH. 2013. *The History of Blood Transfusion in Sub-Saharan Africa*, Athens, OH: Ohio University Press
- Simon F, Maucière P, Roques P, Loussert-Ajaka I, Müller-Trutwin MC, Saragosti S, Georges-Courbot MC, Barré-Sinoussi F, Brun-Vézinet F. 1998. Identification of a new human immunodeficiency virus type 1 distinct from group M and group O. *Nat Med*. 4(9):1032-7.PMID: 9734396
- Snowden, Frank M. 2008. Emerging and reemerging diseases: a historical perspective. *Immunological Reviews*. 225: 9–26
- Timberg C and Halperin D, 2012. *How the West Sparked the AIDS Epidemic and How the World Can Finally Overcome It*. New York: Penguin
- UNAIDS 2017. *Ending AIDS: Progress Towards the 90-90-90 Targets*. Geneva: UNAIDS, http://www.unaids.org/sites/default/files/media_asset/Global_AIDS_update_2017_en.pdf
- UNAIDS 2022. *Global HIV & AIDS Statistics – Fact Sheet*. Geneva: UNAIDS, <https://www.unaids.org/en/resources/fact-sheet>

Weiss RA. 2001. Polio Vaccines Exonerated. *Nature*. 410(6832):1035-6

Wertheim JO and Worobey M. 2009. Dating the age of the SIV lineages that gave rise to HIV-1 and HIV-2. *PLoS Computational Biology*. 5(5):e1000377

Wilkins A, Hayes R, Alonso P. 1991. Risk factors for HIV-2 infection in The Gambia. *AIDS*. 5(9):1127-32

Worobey M, Telfer P, Souquière S, et al. 2010. Island biogeography reveals the deep history of SIV. *Science*. 329(5998):1487

Worobey M, Santiago ML, Keele BF, et al. 2004. Origin of AIDS: contaminated polio vaccine theory refuted. *Nature*. 428(6985):820

Further Reading:

Giles-Vernick T, Gondola D, Lachenal G, and Schneider WH. 2013. “Social history, biology and the emergence of HIV in colonial Africa,” *Journal of African History*, 54, 1, 1-20

Illife, J. 2006. *The African AIDS Epidemic*, Athens, OH: Ohio University Press

Lachenal G. 2010. The Doctor Who Would Be King. *Lancet*. 376(9748):1216-7

Piot P. 2012 *No Time to Lose*, New York: W.W. Norton

Schneider WH, ed.. 2021. *The Histories of HIVs: The Emergence of the Multiple Viruses that Caused the AIDS Epidemics*, Athens, OH: Ohio University Press.

Schneider WH, Drucker E. 2006. Blood transfusions in the early years of AIDS in sub-Saharan Africa. *Am J Public Health*. 96(6):984-94

Sharp PM and Hahn BH. 2011. Origins of HIV and the AIDS pandemic. *Cold Spring Harb Perspect Med* 1(1): a006841

Varanda J and Direito B. 2018. Biomedical Healthcare in Guinea-Bissau 1900-1975. In *Learning from Empire: Medicine, Knowledge and Transfers under Portuguese Rule*, ed. Poonam Bala, Cambridge Scholars Publishing, UK, 230-53

Visseaux B, Damond F, Matheron S, Descamps D, Charpentier C. 2016. HIV-2 molecular epidemiology. *Infect Genet Evol*. 46:233-240