Blood Trials: Transfusions, Injections, and Experiments in Africa, 1890–1920

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ABSTRACT

From about 1880 to 1920, a culture of medical experimentation promoted blood transfusion as a therapy for severe anemia in Europe, which was applied in German East Africa in 1892 for a case of blackwater fever, a complication of malaria afflicting mainly Europeans. This first case of blood transfusion in Africa, in which an African's blood was transfused into a German official, complicates the dominant narrative that blood transfusions in Africa came only after World War I. Medical researchers moreover experimented with blood serum therapies on human and animal subjects in Europe and Africa, injecting blood of different species, "races" and ethnicities into others to demonstrate parasite transmissibility and to discover vaccines for diseases such as malaria, sleeping sickness, and yellow fever. While research in German colonies is highlighted here, this was a transnational medical culture that crossed borders and oceans. This research is of interest as a possible early pathway for the epidemic spread of HIV and other zoonoses in Africa and the world, which biomedical researchers have identified as emerging in West-Central Africa sometime around the turn of the twentieth century.

KEYWORDS: blood transfusion, blood serum, Africa, HIV, blackwater fever, malaria, sleeping sickness, German colonialism, animal research

Recent histories assert that the likely time and place for the emergence of epidemic strains of HIV from Simian immunodeficiency viruses (SIV) was in interwar Central Africa.¹ According to virological research, several strains of HIV originated in West-Central Africa sometime in the early twentieth century, most likely in the equatorial rainforests.² The most virulent is HIV type 1 group M (HIV-1M) that began with an

- 1 Jacques Pepin, *The Origins of AIDS* (Cambridge: Cambridge University Press, 2011), 7; William H. Schneider, *The History of Blood Transfusion in Sub-Saharan Africa* (Athens: Ohio University Press, 2013), 10; Tamara Giles-Vernick et al., "Social History, Biology, and the Emergence of HIV in Colonial Africa," *J. Afr. Hist.*, 2013, 54, 11–30.
- 2 Jun Takehisa et al., "Origin and Biology of Simian Immunodeficiency Virus in Wild-Living Western Gorillas," *J. Virol.*, 2009, 83, 1635–48; João Dinis de Sousa et al., "High GUD Incidence in the Early 20th

SIV that likely jumped from chimpanzees to humans in Southeast Cameroon between 1908 and 1933. Similarly, HIV-1O, a separate strain, emerged sometime between 1896 and 1942 in West-Central Africa.³ Because chimpanzees, monkeys, and possibly gorillas have transmitted SIVs to humans on multiple occasions without leading to epidemics, medical historians and biomedical researchers have sought factors that facilitated the epidemic spread of different strains of HIV in roughly the same time period—the late nineteenth or early twentieth century. Some have rightly drawn attention to mass inoculation campaigns in the European colonies of Africa, directed at sleeping sickness, bubonic plague, smallpox, and other diseases, when European doctors used sometimes unsterile needles to vaccinate tens of thousands of Africans. These campaigns may have facilitated “the adaptation of animal pathogens to human hosts” and allowed HIV to be transmitted to many people in a short time.⁴ Such injection campaigns, given their scale, may have passed nonlethal SIVs from a handful of infected patients, while accelerating their virulence, since SIVs are otherwise “weakly pathogenic for humans and incapable of sustaining an epidemic.”⁵

A related line of research has focused on the early history of blood transfusions in Africa, which may have allowed SIVs to adapt to humans by providing a highly efficient means of transmitting the virus from one person to another compared with sexual contact or unsterile needles.⁶ Transfusing blood, particularly when done serially, may have aided the evolution of SIVs or HIVs into virulent strains, enabling them to overcome epidemiological bottlenecks. The major historians of blood transfusion in Africa argue that the heyday of this procedure in sub-Saharan Africa followed World War I, which appears to be the period when some strains of HIV became epidemic. William H. Schneider posits a 1918 instance of blood transfusion to treat blackwater fever in German East Africa by a Belgian doctor during World War I as the first identifiable African case, leading to more widespread subsequent blood transfusions in Africa by the 1920s.⁷

Century Created a Particularly Permissive Time Window for the Origin and Initial Spread of Epidemic HIV Strains,” *PloS One*, 2010, 5, 1–16.

3 Takehisa et al., “Origin,” 1642.

4 Ernest Drucker, Phillip G. Alcabes, and Preston A. Marx, “The Injection Century: Massive Unsterile Injections and the Emergence of Human Pathogens,” *Lancet*, 2001, 358, 1989–92, 1990; Pepin, *Origins*, Chapter 7–8; Amit Chitnis, Diana Rawls, and Jim Moore, “Origin of HIV Type 1 in Colonial French Equatorial Africa,” *AIDS Res. Hum. Retroviruses* 2000, 16, 5–8; Jim Moore, “The Puzzling Origins of AIDS,” *Am. Scientist*, 2004, 92, 540–47.

5 William H. Schneider and Ernest Drucker, “Blood Transfusions in the Early History of AIDS in Sub-Saharan Africa,” *Am. J. Public Health*, 2006, 96, 984–94; Preston A. Marx, Ernest M. Drucker, and William H. Schneider, “The Serial Passage Theory of HIV Emergence,” *Clin. Infect. Dis.*, 2011, 52, 421.

6 Chitnis, “Origin of HIV,” 7; Drucker, “Injection Century,” 1990; Giles-Vernick, “Social History,” 25; Schneider, *History*, 3; John Iliffe, *The African AIDS Epidemic: A History* (Athens: Ohio University Press, 2006), 8.

7 Schneider, *History*, 22, 27; D. Spedener, “Le Traitement des Pneumonies par Transfusion de Sang des Convalescents,” *Bull. Med. Katanga*, 1924, 1, 234–38; W. K. Blackie, “Blood Transfusion in the Treatment of Blackwater Fever,” *Lancet*, 1937, 230, 1124–26.

In detailing the history of blood transfusion in Africa, Schneider makes several assertions that should be called into question, and that may have the effect of deterring research into possible earlier origins of one or more HIV strains or other blood-borne diseases in Africa. He suggests, for example, that the first “effective” blood transfusions in Europe or North America came only after 1900, although numerous cases of successful blood transfusions were reported decades earlier.⁸ Schneider and one of his co-authors, Ernest Drucker, assume that most pre-World War I transfusions were aimed at replacing blood, presumably in surgery or on the battlefield, thus neglecting a major role of pre-1900 blood transfusions as a therapy for anemia that accompanied a variety of diseases.⁹ Positing the presence of hospitals as a key factor in the introduction of transfusions, Schneider implies that only by World War I were hospitals available in Africa on a wide enough scale to perform transfusions.¹⁰ This is related to his claim that only after 1902 with breakthroughs in anastomosis—connecting the artery or vein of a donor to the vein of a recipient—blood transfusions were feasible, although he shows that simpler nonsurgical procedures were used in the first African transfusions. In his laudable attempt to assess the history of blood transfusion for the entire continent, Schneider selects case studies and uses British, French, and Belgian colonial sources, thus neglecting the pivotal role of German medical research and German colonialism in transfusion therapy. Nor do Pepin, in his history of HIV, or Giles-Vernick and her colleagues seriously engage the German era of Central African history. Finally, Schneider’s severing of North and South Africa from his analysis because of “different political, social, and demographic circumstances” misunderstands that colonial doctors and medicine were mobile and geographically intertwined across and outside of the continent.¹¹

This article suggests that the time frame for blood transfusions to be available as a therapy to European colonial doctors was earlier than Schneider asserts by several decades. In 1892, a German military doctor at the government hospital in Bagamoyo, German East Africa transfused blood from an African to a European man using a well-established syringe method. Despite this case being widely reported at the time, it has not been acknowledged in medical histories, perhaps because medical and other historians often neglect the role of Germans in the African colonies and German sources.¹² Yet, German colonialism (1884–1918) coincided with medical breakthroughs and experimentation in Europe and transnationally. During this period, Germany conquered four territories in Africa (Southwest Africa, Togo, Kamerun, and German East Africa, which included Ruanda and Urundi), and conducted widespread trade, medical, and missionary activities in many other parts of the continent and the world. Togo in West Africa and Kamerun in West-Central Africa were likely

8 Schneider, *History*, 11.

9 Schneider and Drucker, “Blood Transfusions,” 984.

10 Schneider, *History*, 11, 18.

11 Schneider, *History*, 4.

12 Exceptions include Deborah J. Neill, *Networks in Tropical Medicine: Internationalism, Colonialism, and the Rise of a Medical Specialty, 1890–1930* (Stanford: Stanford University Press, 2012); Wolfgang U. Eckart, *Medizin und Kolonialimperialismus Deutschland 1884–1945* (Paderborn: Schöningh, 1997).

epicenters for the emergence of HIV strains, although Ruanda and Urundi cannot be ruled out. These colonies all passed to other European powers following World War I, which often picked up where Germans left off with respect to medical research. Before 1914, German medical researchers were at the forefront of experimentation and research on transfusion therapy and other injection trials, such as the search for blood serums and vaccines for malaria, sleeping sickness, and other diseases.

German medical experimentation was not isolated.¹³ Most scientists of the period engaged widely in transnational networks of knowledge exchange at conferences and in journals, and experiments reported in one country were often duplicated in another.¹⁴ Italians took the lead in malaria research owing to the heavy toll this disease took in their country, and most colonial malaria researchers observed and sometimes participated in Italian experiments before moving on to Africa, Southeast Asia, or Latin America. Early colonial rule coincided with a culture of medical experimentation and risk that followed European precedents using human and animal subjects. Besides medical missionaries, who tended primarily to potential African converts, the first colonial doctors were largely associated with militaries in order to safeguard the health of European soldiers, officials, settlers, and African soldiers who made up the bulk of colonial armies.¹⁵ Yet, many medical men saw the tropics as a research arena that could not be replicated in European laboratories, and therefore spent time in the colonies investigating newly discovered diseases before returning home to distinguished careers. Most colonial governments recognized early that African populations were declining, undermining colonial economic development, and so mustered medical resources to attack diseases that were held to be responsible, such as smallpox, plague, sleeping sickness, and venereal diseases. Colonial doctors and researchers were mobile, working in multiple colonies across the continent, acquiring expertise that could be used for unexpected contingencies. It thus makes little sense to isolate practices in sub-Saharan or tropical Africa from other parts of the continent or colonial world.

As a zoonosis, the HIV connection to animal experimentation is of interest. It is generally assumed that SIVs entered human populations through “bushmeat handling”—presumably by African hunters who traded meat to local communities.¹⁶ Some have sought reasons for increased African reliance on game such as monkeys and chimpanzees. Yet the colonies, as sites of research laboratories, were places where animal experimentation was widespread before World War I. Mirroring successful vaccine research in Europe for diseases such as smallpox, rabies, diphtheria, and anthrax, European researchers in Africa tested human and animal blood for pathogens and possible immune agents, and injected blood of infected or recovered humans into test animals, and sometimes that of animals into people. The image of a bold colonial

13 Schneider, *History*, 4.

14 Neill, *Networks*.

15 Megan Vaughan, *Curing Their Ills: Colonial Power and African Illness* (Stanford: Stanford University Press, 1991), Chapter 2.

16 Pepin, *Origins*, 43–46; Chitnis et al., “Origin of HIV,” 5. For a critique, see Giles-Vernick et al., “Social History,” 18–20.

doctor willing to inject himself to test a new drug or serum, and therefore willing to test Africans similarly, emerges periodically in the medical literature. Intentional blood injections, especially intravenously, were much more likely to spread pathogens or viruses at epidemic levels than random blood introductions through bushmeat, and thus merit consideration in histories of blood-borne diseases. Some doctors went so far as to advocate therapeutic transfusions of animal blood, even after the practice of animal-to-people blood transfusions declined (but did not disappear) in Europe after 1875. The early history of blood transfusions, injections, and experimentation offers a possible early pathway for HIV and other diseases of humans and animals in Africa.

TECHNIQUES OF BLOOD TRANSFUSION

Schneider argues that only with improvements in anastomosis from 1902—surgically attaching a donor’s artery to a recipient’s vein—did blood transfusion emerge as a widespread procedure.¹⁷ Yet, blood transfusion techniques were well in place by 1890 that could be used in colonial lazarets. In 1875, Leonard Landois surveyed 478 published cases of blood transfusion since 1667 that used a variety of techniques, 337 of which took place since 1864¹⁸ (table 1). From the time of the Franco-Prussian War (1870–71), a variety of devices—transfusors—had been developed to facilitate transfusion in hospitals and on battlefields, and to ameliorate some transfusion problems. Such problems included accidental injection of air into a patient; coagulation of blood once removed from the body for too long, risking injection of clots; and determining how much blood was removed and transfused. Hypodermic syringes, available since about 1850, could be used, and some made of glass made it possible to calibrate blood quantities.¹⁹ By 1865, Roussel had developed a device to transfuse from arm to arm that was marketed to militaries, and by the mid-1870s, portable transfusors designed by Schliep and Collins were available for battlefield use.²⁰ Transfusors designed by Dieulafoy and Potain were available since the 1880s.²¹ Improvements in indirect transfusion techniques using syringes and transfusors continued steadily through World War I, even as direct transfusion through anastomosis was steadily adopted in hospitals after 1902.

Medical texts from the late 1880s, some directed at battlefield surgery, instructed on methods of blood transfusion and circumstances when it was efficacious.²² Mosetig-Moorhof recommended transfusion in his 1887 surgical handbook in cases of blood loss, anemia, destruction of blood cells, or blood poisoning, while warning that

17 William H. Schneider, “Blood Transfusion in Peace and War, 1900–1918,” *Soc. Hist. Med.*, 1997, 10, 105–26, 109.

18 Olav Hanssen, *Transfusion und Anämie* (Kristiania: Jacob Dybwad, 1914), 10.

19 Friedrich Esmarch, *Handbuch der kriegschirurgischen Technik* (Hannover: Carl Rümpler, 1877), 165–172; Drucker et al., “Injection Century.”

20 Mühlvenzl, “Vom Wiener Welt-Ausstellungs-Platze,” *Dtsch. Mil. Aerztl. Z.*, 1873, 2, 343, 577; Bruberger, “Ueber Transfusion und ihren Werth im Felde,” *Dtsch. Mil. Aerztl. Z.*, 1874, 3, 525–34, 533.

21 Albert Ritter von Mosetig-Moorhof, *Handbuch der Chirurgischen Technik* (Leipzig: Toeplitz und Deuticke, 1887), 244; John Ashhurst, *International Encyclopedia of Surgery* (New York: William Wood, 1888), 527.

22 Friedrich Esmarch, *Handbuch der kriegschirurgischen Technik*, 3rd ed., 2 vols. (Kiel: Lipsius und Tischer, 1885), II, 250.

Table 1 Blood Experiments 1875–1922

		Location	Physician
Human-to-human blood transfusions using transfusors or syringes outside Africa			
1667–1874	347 cases cataloged by Landois	Europe	Various
1864–74	300 of above cases	Europe	Various
1879	Transfusion following surgery	Glasgow	Macewen
1875–80	19 transfusions for anemia	Bern	Quincke
1881	2 transfusions for typhoid	London	Mahomed
1883	1 transfusion for anemia	Manchester	Ransome, Mules, and Walter
1885	55 transfusions for cholera	Toulon	Roullier
1885–88	5 cases with 9 transfusions for anemia	Edinburgh	Brakenridge
1870s–87	40 transfusions for anemia	Rome	Porstemski
1892	1 transfusion for anemia	Edinburgh	Affleck
1892	24 transfusions for anemia	Munich	Ziemssen
1893	1 transfusion for anemia	Bath, UK	Evans
1895	1 transfusion for anemia	Berlin	Ewald
1899	Transfusion for anemia from malaria	Italy	Bastianelli and Bignami
1906–9	c. 20 transfusions for anemia	Strasbourg	Morawitz
1908–11	c. 31 transfusions for pellagra	Mobile, Alabama	Cole
1909	1 case with 3 transfusions for anemia	Germany	Cahn
1910	12 transfusions for pellagra	Chicago	Pollock and Curtis
1910–11	17 transfusions for anemia w/ blood analysis	Berlin	Schultz
1910–11	16 transfusions for pellagra	Austin, Texas	Bennett and Scott
1910s	61+ transfusions for anemia	Oslo	Hanssen
1908–14	30+ transfusion for anemia	Berlin	A. Plehn

Table continues

Table 1 Continued

		Location	Physician
Human-to-human injections of infectious malarial blood outside Africa			
1882	2 cases	Germany	Gerhart
1880s	5 cases	Italy	Gualdi and Antolisei
1884–86	10 cases	Italy	Mariotti and Ciarochi
1889	2 cases	Italy	Antolisei and Angelini
1890	4 cases	Italy	Bastianelli and Bignami
1890–92	2 cases	Italy	Bacelli
1891–92	1 case	Vienna	Mannaberg
1892	2 cases	Italy	Calandruccio
1895	5 cases	Sicily	Di Mattei
1893–98	2 cases	Italy	Bignami
1897	1 case	Baltimore	Thayer
1898	15 cases	Baltimore	Elting
1905	7 cases	Oklahoma	Ford
Human-to-human blood injections of other diseases			
1887	1 injection of infectious yellow fever blood	Vera Cruz, Mexico	Ruis
1900–1	17 injections of infectious yellow fever blood	Havana	Reed and Lazear
1901	8 injections of yellow fever blood and blood serum	Rio de Janeiro	Marchoux, Salimbeni
1901	8 injections of yellow fever blood	Havana	Guiteras
1901	2 injections of infectious yellow fever blood serum	Havana	Carroll

Table continues

Table 1 Continued

		Location	Physician
1903	2 injections of infectious yellow fever blood serum	Vera Cruz, Mexico	Parker, Beyer, and Pothier
1906	2 injections of infectious typhus blood	Vietnam	Yersin and Vassal
1906	12+ injections of infectious dengue fever blood	Manila	Ashburn and Craig
Timeline of early human-to-human blood transfusions and injections in Africa			
1892	Transfusion for blackwater fever	German East Africa	Steudel
1900	Transfusion for battlefield injury	South Africa	Matthiolius
1899–1900	7 injections of Africans with malarial human blood	Victoria, Kamerun	Ziemann
1900–1	4 Africans injected with malarial European blood	Buea, Kamerun	A. Plehn
1918	Transfusion for blackwater fever	German East Africa	Lejeune
1918	Transfusion for pernicious malaria	Algeria	Unnamed
1920	2 transfusions for blackwater fever	Senegal	Esquier and Godillon
Animal-to-human blood transfusions and injections			
1667–1874	131 animal blood transfusions cataloged by Landois	Europe	Various
1874	15 transfusions of lamb's blood	Europe	Hasse
1881	President Garfield transfused with "animal blood"	United States	Unnamed
1893–94	4 malarial bird blood injections	Kamerun	F. Plehn
1894–95	27 instances of dog blood transfusions	Italy	de Dominici
1895	4 instances of malarial bird blood injected into people	Sicily	Di Mattei

Table continues

Table 1 Continued

		Location	Physician
1897	6 injections of cattle and buffalo blood serum for malaria	Italy	Celli and Santori
1899	50 horse serum injections for malaria	Southwest Africa	Kuhn
1902	60 cattle and buffalo serum injections for malaria	Italy	Celli
1903	40 horse serum injections for malaria	Bosnia	Kuhn
1903	3 injections of cow's blood for sleeping sickness	Congo	Ascenso
1904	9 rabbit blood serum injections for malaria	Oklahoma	Ford
1906	6 cases of monkey blood serum injections for malaria	Philippines	Ford
1906	28 cases of goat serum injections for malaria	Philippines	Ford
1910	2 self-injections of ape blood for malaria	Hamburg	Gonder
1911	Rat blood injected for sleeping sickness	Liverpool	Ross
1917–18	130 injections of horse/mule blood for sleeping sickness	German East Africa	Taute and Huber
1922	Injections of malarial chimpanzee blood into 2 Europeans	Sierra Leone	Blacklock and Alder

transfusion should only be used “as a last resort” when the patient’s life was at risk.²³ Blood could be transfused directly from the vein (or artery) of a donor into the vein of a recipient, or indirectly by collecting it into a warmed vessel, and defibrinating and filtering it to prevent coagulation before injection into a recipient’s vein. The use of defibrinated blood solved the problem of fast blood coagulation before effective

23 Mosetig-Moorhof, *Handbuch*, 233.

additives were discovered. But, transfusion of defibrinated blood sometimes released fibrin elements in the recipient's blood, destroying blood corpuscles and causing coagulation.²⁴ This danger was lessened by transfusing defibrinated blood gradually, but many doctors believed that defibrinated blood lost some of the therapeutic "life-giving" value of blood. It was found in the 1880s that whole blood could be transfused without coagulation by diluting it with phosphate of soda.²⁵ In 1892, Ziemssen publicized a simple method of whole blood transfusion, drawing blood directly from the vein of a donor with a sterile syringe through a rubber tube attached to the vein of a donor, using a similar apparatus to push the blood immediately into the vein of a recipient.²⁶ He used several syringes in succession, each able to calibrate blood quantity, and repeated the process until about 300 cc was injected. Critiques argued that the method risked introducing blood clots into the recipient's bloodstream, therefore "strictly forbids its employment in man," but Ziemssen believed that this risk could be avoided with proper care.²⁷ Improvements in the syringe method were made in subsequent years, so that whole blood transfusions could be employed in the field. As Ficarra summarizes, "The last three decades of the nineteenth century witnessed an ardent fervor for blood transfusion, which knew no restraint. Instead of limiting the practice to rational usage, it was applied to all types of diseases. When therapeutic doubt existed, transfusion was indicated."²⁸ From the 1890s, adding sodium citrate to prevent coagulation facilitated blood transfusions and aided blood experimentation, although it was not widely used outside laboratories until World War I.²⁹

By 1890, most of the paraphernalia needed for transfusions were part of colonial medical toolkits. In 1891, for example, Paul Kohlstock, a German military staff doctor stationed in East Africa, advised doctors going to "tropical malarial regions" to supply metal and glass syringes and cannulas as basic accouterments.³⁰ He recommended them for injections of quinine and saline in cases of "pernicious fever" associated with malaria. Although occasionally colonial doctors reported lack of transfusion equipment, in general, even if doctors were not inclined to use blood transfusion therapy, they had the equipment to do so.

24 L. S. Pilcher, "On Transfusion and Reinfusion of Blood," *Ann. Surg.*, 1886, 3, 226–30.

25 John Duncan, "On Re-Infusion of Blood in Primary and Other Amputations," *BMJ*, 1886, (1309), 192–93; N. S. R. Maluf, "History of Blood Transfusion," *J. Hist. Med. Allied Sci.*, 1954, 9, 59–107, 86–87; Hanssen, *Transfusion*, 25; T. Jürgensen, "Antiphlogistic Methods of Treatment," in *Handbook of General Therapeutics*, 7 vols., ed. H. von Ziemssen (New York: William Wood, 1885), II, 277, 289.

26 H. von Ziemssen, "Ein weiterer Beitrag zur Transfusionsfrage," *Dtsch. Arch. Klin. Med.*, 1892, 50, 491–508; Norbert Ortner, *Treatment of Internal Diseases*, 4th ed. (Philadelphia: J.B. Lippincott, 1908), 172.

27 A. Lazarus, "Clinical Features of Anemia," in *Diseases of the Blood*, ed. Alfred Stengel (Philadelphia: W.B. Saunders, 1905), 151–336, 176.

28 Bernard J. Ficarra, "The Evolution of Blood Transfusion," *Ann. Med. Hist.*, 1942, 4, 302–23, 309.

29 Geoffrey Keynes, *Blood Transfusion* (London: Henry Frowde, 1922), 16; G. H. Whipple, "Blackwater Fever and Pernicious Malaria in Panama," *Malaria: Intl. Arch.*, 1909, 1, 215–46, 239.

30 Paul Kohlstock, *Ärztlicher Ratgeber für Ostafrika und Tropische Malariagegenden* (Berlin: Hermann Peters, 1891), 131, 300, 325–28.

BLOOD TRANSFUSION, BLACKWATER FEVER, AND PERNICIOUS ANEMIA

According to Schneider, the first clear instance of blood transfusion in sub-Saharan Africa was in 1918 during World War I in German East Africa. In that case, a Belgian doctor, Emile Lejeune, transfused blood “as an ultimate therapeutic trial” for a European officer suffering from blackwater fever, who failed to respond to quinine, adrenaline, or saline injections.³¹ After testing 5 cc of blood from another European to ensure no adverse reaction, Lejeune transfused 500 cc of citrated blood intravenously with Dieulafoy syringes, which, he reported, enabled the technique to be done anywhere. The patient recovered and returned to Europe, a success considering that many cases of blackwater fever were fatal. Schneider considers this case to be pivotal since it demonstrated that trained doctors could perform blood transfusion successfully in Africa, under difficult circumstances, using equipment and techniques that had been recently perfected in Europe and the United States.

Schneider may be correct that blood transfusions only became widely used in tropical Africa after World War I, when their growing use created a possible window of opportunity for the spread of blood-borne diseases such as HIV. Other African cases were reported by war’s end. A soldier sent from Salonica to Algiers in November 1918, suffering from “a pernicious form of malaria,” became comatose, whereupon his physicians used blood transfusion “as a last resource.”³² A French doctor with considerable experience enlisted a female nurse as a donor. She succumbed to a severe case of malaria, which was believed to have been accidentally transferred during the procedure—hence it was publicized in medical journals. Shortly thereafter in Senegal, French naval doctors transfused citrated blood in two cases of blackwater fever in sailors, using a Potain transfusion apparatus.³³ In both cases, the threat of death from acute anemia and blood degeneration justified the procedure. Both the Dieulafoy syringe that Lejeune used and the Potain apparatus in Dakar had been used in Europe since the 1870s, although the addition of sodium citrate was a recent innovation.

These examples of the use of blood transfusions in Africa continued a Western therapeutic trend that went back to the 1870s. Consider the first—and only well publicized—case of blood transfusion in Africa from 1892. Emil Steudel, a senior doctor in the Schutztruppe (army) for German East Africa, performed the procedure in Bagamoyo, the main port city, and the location of a government hospital.³⁴ There he encountered German soldiers and officials who suffered from blackwater fever, which Steudel called “pernicious malaria.” In July 1892, a patient entered the hospital with symptoms of blackwater fever after returning from a long expedition to Central

31 E. Lejeune, “Transfusion Sanguine après Hémoglobinurie Grave,” *Ann. Soc. Belge Méd. Trop.*, 1921, 1, 299–300; Schneider, *History*, 12.

32 Alfred S. Gubb, “Accidental Transference of the Malarial Parasite in the Course of Transfusion,” *BMJ*, 1919, (3055), 74–75.

33 A. Esquier and Godillon, “De la Transfusion du Sang Citraté dans la Fièvre Bilieuse Hémoglobinurique,” *Bull. Soc. Med.-chir. Fr. Ouest Afr.*, 1920, 2, 90–93; J. W. W. Stephens, *Blackwater Fever* (London: Hodder and Stoughton, 1937), 349.

34 Emil Steudel, *Die perniciöse Malaria in Deutsch-Ostafrika* (Leipzig: F.C.W. Vogel, 1894), 1–2.

Africa. He was later identified as Franz Stuhlmann, already an accomplished naturalist, who went on to become one of the most important administrators in German East Africa. Stuhlmann had a high fever of 104°, accompanied by bloody urine—the main outward symptom of blackwater fever—and was given large doses of quinine until Steudel feared adverse effects on his heart. After a week, Stuhlmann's condition worsened with severe anemia, a rapid decrease in hemoglobin content, numbness, and hypersensitivity to light. Steudel recommended transfusion with defibrinated human blood “as a last resort” in order to increase red blood cell and hemoglobin content.³⁵ Stuhlmann immediately assented, and his “black servant,” a strong young man, agreed to provide blood. Steudel took 400 cc from an arm vein, which he channeled into a sterilized porcelain container and stirred to remove clots. The blood serum, kept warm, was then filtered through a sterilized cloth. Stuhlmann's left arm vein was exposed and attached to a glass tube connected to a sterilized hose and glass funnel to introduce 300 cc of the blood using digital compression.³⁶ Despite great care, two small air bubbles were injected. Stuhlmann's heart stopped suddenly, but slowly started beating. He shivered fiercely after two hours, experienced a strong pulse, difficult breathing, heavy sweating, and he expected to die. For several days, he experienced high temperatures, irregular heartbeats, hallucinations, and restlessness. After a week, Stuhlmann was sent to nearby Zanzibar, and several months later, he returned to Europe and recovered completely. The African donor experienced a strong malaria attack the day after the transfusion, which was treated with quinine.

Although Stuhlmann's recovery was difficult, Steudel noted that immediately after the transfusion, his hemoglobin count rose dramatically, from 8 to 20 percent. Another of Steudel's “pernicious malaria” cases with similarly low hemoglobin content, not treated with blood transfusion, resulted in death. Overall, he reported fifteen cases of blackwater fever, most of whom recovered without blood transfusion. Steudel believed that the transfusion saved Stuhlmann's life, and the case entered the medical literature as a successful use of blood transfusion against “pernicious malaria.”³⁷

All five cases of blood transfusion mentioned so far in this article were for cases of blackwater fever, which was one of the most feared maladies of Europeans in the tropics. From the mid-nineteenth century in regions of endemic malaria, European doctors noticed what was thought to be a particularly deadly form of malaria that afflicted mainly nonindigenous people, which went by a variety of names, including “pernicious malaria,” “hemorrhagic malaria,” and “hemoglobinuric fever.” Its most obvious symptom was hemoglobinuria—blood in the urine—hence “blackwater fever.” Other symptoms included jaundice, nausea, fever, acute renal failure, and severe anemia, including red blood cell destruction. Because in most cases, afflicted patients had used quinine inconsistently to treat bouts of malaria, some researchers considered blackwater fever to be a quinine poisoning. Many doctors thought that

35 Ibid., 58.

36 Steudel's method resembles Esmarch, *Handbuch* (1877), 165–72.

37 Hans Ziemann, “Das Schwarzwasserfieber,” in *Handbuch der Tropenkrankheiten*, 3 vols., ed. C. Mense (Leipzig: J.A. Barth, 1906), III, 558–90, 583.

Africans were immune to blackwater fever, until African cases emerged by the turn of the century, usually in people not indigenous to a region—for example, African soldiers conscripted in the Sudan to help subdue regions further south, or highlands Africans enlisted to work on lowland plantations or railways where malaria was rife.³⁸ Blackwater fever had a high mortality rate, thus was called “pernicious” or “malignant” malaria, and was sometimes confused with severe *Plasmodium falciparum* malaria, which often had severe anemia as a symptom, and was largely a disease of the tropics.³⁹ A 1903 report showed that about 2 percent of Europeans among French troops in West Africa developed blackwater fever annually, and about one-third of those diagnosed died.⁴⁰ Estimates of mortality varied by region, from 4 percent to 70 percent.⁴¹ There was no established treatment.

One of blackwater fever’s symptoms—severe acute anemia—had been treated in Europe with blood transfusions since about 1868, when A. Gusserow in Switzerland transfused several pregnant women with limited success.⁴² Other doctors reported positive results using blood transfusion for “pernicious anemia” in the 1870s and 1880s, debating whether whole or defibrinated blood was most effective.⁴³ It was often specified that transfusion was a last resort when death was imminent and all other therapies had failed.⁴⁴ In the unsuccessful cases, death was not necessarily attributed to transfusion; sometimes, it was applied too late, other times not enough blood was used. In 1880, T. Jürgensen wrote that it was “clearly established fact” that transfusing blood of the same species infused viable red blood corpuscles lost through anemia.⁴⁵ David Brakenridge at the Edinburgh Royal Infirmary reported in 1892 that he successfully used blood transfusion to treat patients with pernicious anemia.⁴⁶ In 1893, W. G. Evans in England reported a successful recovery of a patient suffering from pernicious anemia, transfusing defibrinated blood diluted with phosphate of

38 Albert Plehn, “Die acuten Infektionskrankheiten bei den Negeren der äquatorialen Küsten Westafrikas,” *Virchows Arch.*, 1903, 174, 85; Albert Plehn, *Die Malaria der afrikanischen Negerbevölkerung besonders mit Bezug auf die Immunitätsfrage* (Jena: Gustav Fischer, 1902), 42–43; Doering, “Ein Beitrag zur Kenntniss des Schwarzwasserfiebers,” *Dtsch. Med. Wochenschr.*, 1895, 21, 761–63. On military recruitment, see Myron Echenberg, *Colonial Conscripts: The Tirailleurs Sénégalais in French West Africa, 1857–1960* (Portsmouth: Heinemann, 1991).

39 For example, an 1891 description of a severe acute form of malaria was probably blackwater fever. Kohlstock, *Ärztlicher Ratgeber*, 123. Although blackwater fever was a complication of falciparum malaria, relatively few malaria sufferers developed the range of its symptoms. James L. A. Webb, *Humanity’s Burden: A Global History of Malaria* (Cambridge: Cambridge University Press, 2009), 4–6.

40 Charles R. P. George, “Blackwater Fever: The Rise and Fall of an Exotic Disease,” *J. Nephrol.*, 2009, 22, S120–28.

41 Aldo Castellani and Albert J. Chalmers, *Manual of Tropical Medicine* (London: Balliere, Tindall and Cox, 1910), 695.

42 Hanssen, *Transfusion*, 22; A. Gusserow, “Ueber hochgradigste Anämie Schwangerer,” *Arch. Gynäkol.*, 1871, 2, 218–35.

43 Hanssen, *Transfusion*, 23–26; Keith Wailoo, *Drawing Blood: Technology and Disease Identity in Twentieth-Century America* (Baltimore: Johns Hopkins University, 1997), Chapter 4.

44 “Therapeutics of Anaemia,” *Ther. Gaz.*, 1882, 6, 478.

45 Hanssen, *Transfusion*, 24.

46 David J. Brakenridge, “Transfusion of Human Blood in the Treatment of Pernicious Anaemia,” *Edin. Med. J.*, 1892, 38, 409–29.

soda.⁴⁷ In Germany, von Ziemssen was a strong advocate of whole blood transfusion using his syringe technique for cases of severe anemia resulting from blood loss, surgery, or infectious disease.⁴⁸ In Australia, in 1894, a doctor Jennings advocated blood transfusion in cases of acute and chronic anemia.⁴⁹

Because severe anemia accompanied multiple diseases, many doctors hearing of the possible therapeutic and “life-giving” qualities of blood transfusion were prepared to use it in their medical tool kits. After 1900 in the United States, for example, Herbert Cole used blood transfusion to treat severe anemia from pellagra, which was epidemic in many states, although its cause—nutritional deficiency—was not yet known.⁵⁰ Cole’s apparent success inspired similar treatment of anemia in “desperate cases of leprosy.”⁵¹ Cole advocated blood transfusion to treat anemia associated with yellow fever, and other researchers recommended it for “other wasting diseases.”⁵² Many believed that transfusion “revived the power of blood regeneration,” stimulated bone marrow, and had an antitoxic effect.⁵³

Despite skepticism from many quarters at a time when blood typing was unknown or little known, blood transfusions for severe anemia, especially when no other therapies seemed to work, were an established practice from the late 1870s up to World War I. The Norwegian Olav Hanssen, who published a history of the procedure in 1914, recorded twenty-nine cases of his own.⁵⁴ Werner Schultz in Berlin wrote in 1911, “The transfusion of defibrinated human blood, after a long struggle, has conquered modern therapy, and in certain cases of severe anemia offers us the superior means of saving lives, which cannot be substituted with any other known method of healing.”⁵⁵ Medical researchers in Chicago concluded that “Blood transfusion is the treatment of choice in severe anaemia. The transfused blood is capable of resuscitating from otherwise fatal haemorrhages and physiologically replaces the blood which has been lost.”⁵⁶ The technique was well enough known that in 1908, a missionary wrote, “To have conscience introduced where none existed is like transfusion of blood in the case of anemia. Life may follow instead of death.”⁵⁷ Mid-twentieth-century

47 W. G. Evans, “Case of Pernicious Anaemia Treated by Transfusion; Recovery,” *Lancet*, 1893, 141, 1133–34.

48 H. von Ziemssen, “Ein weiterer Beitrag zur Transfusionsfrage,” *Ther. Monats.*, 1893, 7, 369.

49 “Transfusion of Blood and Saline Fluids,” *Ther. Gaz.*, 1895, 19, 43–44.

50 Herbert P. Cole, “Pellagra: Treatment by Direct Transfusion of Blood,” *J. Trop. Med. Hyg.*, 1911, 14, 264; T. J. Bennett and Z. T. Scott, “The Surgical Treatment of Pellagra with Report of Sixteen Cases,” *Tex. St. J. Med.*, 1911, 7, 140–42.

51 F. M. Sandwith discussion in *J. Trop. Med. Hyg.*, 1911, 14, 265.

52 Herbert P. Cole discussion in *J. Trop. Med. Hyg.*, 1911, 14, 261; L. J. Pollock and Arthur H. Curtis, “Transfusion of Blood in Pellagra,” *J. Infect. Dis.*, 1912, 10, 191–95.

53 Karl M. Vogel and U. F. McCurdy, “Blood Transfusion and Regeneration in Pernicious Anaemia,” *Arch. Intern. Med.*, 1913, 12, 707–22, 719–20.

54 Hanssen, *Transfusion*; P. Morawitz, “Die Behandlung schwerer Anämien mit Bluttransfusionen,” *Muench. Med. Wochenschr.*, 1907, 54, 767–70; Werner Schultz, “Ueber Bluttransfusion beim Menschen unter Berücksichtigung biologischer Vorprüfungen,” *Berl. Klin. Wochenschr.*, 1910, 47, 1407.

55 Werner Schultz, “Ein weiterer Beitrag zur Transfusionsfrage,” *Berl. Klin. Wochenschr.*, 1911, 48, 934–36.

56 V. C. David and Arthur C. Curtis, “Experiments in the Treatment of Acute Anaemia by Blood Transfusion and by Intravenous Saline Infusion,” *Surg. Gynecol. Obstet.*, 1912, 15, 476–80, 480.

57 Henry Otis Dwight, “The Greatest Work in the World,” *Mission. Rev. World*, 1908, 31, 733–42, 738.

science went on to verify the therapeutic value of transfusing blood for acute or chronic anemia.⁵⁸

From the beginning of the European “Scramble for Africa” in the 1880s, doctors knew of transfusion therapy for severe anemia when no other methods seemed effective, hence Steudel’s use of the procedure in 1892. Karl Däubler, since 1878 a military doctor in the Dutch East Indies and later East Africa, advocated blood transfusion for severe malaria in his 1895 treatise on tropical health, especially when “the hemoglobin content is below 25% of the norm.”⁵⁹ Däubler claimed “already years ago” to have seen “striking successes” with this treatment for malaria. Some doctors knew of the procedure, but did not resort to it. W. A. Scott, working at the Blantyre Mission Station in British Central Africa in 1892, treated a coffee planter suffering from “malignant malarial fever,” who died despite receiving large doses of quinine and other drugs. Scott conjectured that “It might be worth while to try transfusion of blood from a healthy adult native, but I should not expect much good therefrom.”⁶⁰ Despite acknowledgment of the potential value of blood transfusion to treat severe anemia associated with malaria and blackwater fever by British, French, and American physicians until World War I, no concrete cases emerge in the published literature after Steudel’s. The preferred therapies included quinine injections and saline transfusions, even when many patients died.⁶¹

The major breakthrough in a new acceptance of blood transfusion therapy came with Karl Landsteiner’s discovery in 1900 that different individuals had different blood types, and that injecting incompatible blood could cause death.⁶² Researchers soon realized that this had been the major cause of transfusion failures. Blood compatibility testing revived transfusion therapy, as Schultz and Plehn in Berlin and Morawitz in Strasbourg demonstrated.⁶³ The growing acceptance of sodium citrate as an anticoagulant increased the willingness of physicians to use blood transfusion, in time for World War I.

As the war erupted, practitioners were therefore prepared to transfuse blood in cases of blackwater fever.⁶⁴ Arthur Alport, a South African trained in Edinburgh, was posted first in Southwest Africa then in Macedonia and Salonica. In 1918, he turned to blood transfusion when a soldier suffering from pernicious anemia and malaria deteriorated

58 Elmer DeGowin, Robert C. Hardin, and John B. Alsever, *Blood Transfusion* (Philadelphia: W.B. Saunders, 1949), 15–16.

59 Karl Däubler, *Die Grundzüge der Tropenhygiene* (Berlin: Otto Enslin, 1900), 261; Stephens, *Blackwater Fever*, 347–48.

60 W. A. Scott, “On Malignant Malarial Fever in British Central Africa,” *Edin. Med. J.*, 1892, 38, 451–56.

61 Great Britain Colonial Office, *Blackwater Fever in the Tropical African Dependencies. Reports for 1912* (London: H.M. Stationary Office, 1914); “Extract of a Lecture on Tropical Diseases Delivered at Glasgow by Sir William MacGregor,” *J. Roy. Afr. Soc.*, 1903, 2, 324–25. Albert Clarac, “Notes sur le Paludisme Observé à Dakar,” *Ann. Hyg. Méd. Colon.*, 1898, 1, 9–114, 111; H. Gros, “La Transfusion dans le Traitement des Manifestations Paludéennes,” *Arch. Méd. Nav.*, 1896, 65, 321–35, 401–25; Walter V. Brem, “Studies of Malaria in Panama: Pernicious Malarial Fever,” *S. Cal. Pract.*, 1911, 26, 595–96.

62 DeGowin, Hardin, and Alsever, *Blood Transfusion*, 2.

63 Morawitz, “Die Behandlung”; Schultz, “Ueber Bluttransfusion”; A. Plehn, “Ueber grosse Bluttransfusionen,” *Berl. Klin. Wochenschr.*, 1914, 51, 1862–63.

64 H. Rogge, “Bluttransfusion von Vene zur Vene,” *Muench. Med. Wochenschr.*, 1917, 64, 1602–3.

to blackwater fever.⁶⁵ He transfused eight ounces of blood from a company sergeant, after testing it for compatibility, although the soldier died a week later. On the German side, Coenen, working in Breslau, reported on a Sergeant K., who returned from service in Turkey and the Sinai Desert with symptoms of blackwater fever, and, facing death, was prescribed “vitale Bluttransfusion” using the anastomosis method.⁶⁶ By then Hans Ziemann, who had long experience as a doctor in West Africa, concluded that the wartime use of direct artery-to-vein blood transfusions for surgery proved its usage in cases of severe malaria and “blood destruction associated with blackwater fever.”⁶⁷

Despite these trends, it is true that many colonial doctors, even those with access to current medical journals and outfitted with good hospitals, laboratories, and knowledge of purported transfusion success in Europe and the United States did not use the therapy in Africa, even in cases of blackwater fever that ended in death.⁶⁸ Friedrich Plehn, who worked in Kamerun before transfer to German East Africa in the 1890s, lambasted Steudel for not first analyzing the blood of the African donor in the Stuhlmann transfusion, and implied that Steudel infected Stuhlmann with malaria. This may have warded off the use of transfusion by other doctors.⁶⁹ Blood typing was not discovered until 1900, so that cases of transfusion going awry warded off its general use. Some handbooks on tropical medicine that discussed blackwater fever did not prescribe blood transfusion.⁷⁰ Many defenders of blood transfusion for severe anemia after 1900 referred back to the high-tide of the procedure before it fell out of favor.⁷¹

In terms of an early HIV pathway, African blood may have been transfused into Europeans, as in the Stuhlmann case, but doctors were less likely to transfuse African blood into other Africans before World War I for therapeutic purposes, except potentially in the case of African soldiers; and even then no cases have come to light. Blackwater fever became more noticeable in Africans from the interwar period, after the first colonial generation had begun to use quinine.⁷² African migration from nonmalarial to malarial regions also increased incidences of the disease. In Nigeria in 1950, an African boy suffering from blackwater fever died in a case where his parents refused a blood transfusion. In more recent decades, Africans from the highlands of

65 Arthur Alport, *Malaria and Its Treatment* (New York: William Wood, 1919), 163–72.

66 H. Coenen, “Soll man bei Schwarzwasserfieber lebendes Blut überleiten?,” *Muench. Med. Wochenschr.*, 1919, 66, 286–87.

67 Ibid., 286; Hans Ziemann, *Malaria und Schwarzwasserfieber* (Leipzig: J.A. Barth, 1924), 382, 554, 564–65.

68 Ludwig Külz, *Blätter und Briefe eines Arztes aus dem tropischen Deutschafrika* (Berlin: Wilhelm Süsserott, 1906), 53, 65, 86–87; Albert Plehn, “Über die Verhütung und Behandlung des Schwarzwasserfiebers,” *Arch. f. Schiffs- u. Trophg.*, 1903, 7, 541–52; Friedrich Plehn, *Die Kamerunküste* (Berlin: A. Hirschwald, 1898), 189–208; F. Plehn, “Ueber das Schwarzwasserfieber an der afrikanischen Westküste,” *Dtsch. Med. Wochenschr.*, 1895, 21, 397–400, 416–18, 434–37.

69 F. Plehn, “Erwiderung auf Stabsarzt Steudel’s Aufsatz ‘Zur Chininbehandlung des Schwarzwasserfiebers,’” *Muench. Med. Wochenschr.*, 1896, 43, 225–27.

70 Castellani and Chalmers, *Manual*, 695–96.

71 A. Weber, “Über die Behandlung schwerer Änämien mit Menschenbluttransfusionen,” *Dtsch. Arch. Klin. Med.*, 1909, 97, 165–89.

72 D. B. Jelliffe, “Blackwater Fever in African Children,” *BMJ*, 1951, (4715), 1117–19.

Kivu in the Congo, where malaria is not endemic, have had an upsurge in blackwater fever owing to the increased use of quinine.⁷³

MALARIA AND THE SEARCH FOR IMMUNE SERA

Medical research using blood serum therapy was a possible avenue for the early transmission of pathogens between Africans or between Africans and Europeans. It is likely that Steudel's recruitment of an African donor to treat blackwater fever in 1892 was not based only on availability. After all, it was common for doctors to enlist other patients as blood donors in Europe, and Steudel might have found a willing European donor in the Schutztruppe or from a nearby mission station. Just as Scott in Nyasaland wondered if he should have used a healthy African as a donor, both physicians were likely thinking in terms of recent discoveries in blood serum therapy, with the idea that Africans, who were widely believed to be immune to malaria and blackwater fever, might be able to convey immunity or some kind of antitoxin to a recipient through their blood.⁷⁴

Researchers at the turn of the century believed that people indigenous to a region carried a resistance, if not an immunity, to local diseases. Although by 1900, Africans were not considered to be absolutely immune to malaria, blackwater fever, or tropical diseases such as yellow fever, they nevertheless were far less susceptible than Europeans.⁷⁵ Moreover, individuals who had recovered from a disease were believed to be able to convey therapeutic properties through blood injections. In 1879, J. Gailhard, a French naval doctor, suggested that African blood should be transfused to Europeans during a yellow fever epidemic in Senegal (and Louisiana) because "yellow fever is one of those diseases in which the doctor has the right to try everything."⁷⁶ This idea of a transferrable African immunity was revived periodically during subsequent yellow fever epidemics in Senegal, although it is not clear that it was ever used.⁷⁷

From the 1890s, blood serum therapy contributed to this thinking. Emil von Behring and Shibasaburo Kitasato of the Institute of Infectious Diseases in Berlin discovered that "the blood and blood serum of an individual which has been artificially rendered immune against a certain infectious disease may be transferred into another individual with the effect to render the latter also immune, no matter how susceptible this animal is to the disease in question."⁷⁸ Others applied this line of research to the physiological properties of blood that might kill pathogens.⁷⁹ Serum therapy assumed

73 C. Delacollette, H. Taelman, and M. Wery, "An Etiologic Study of Hemoglobinuria and Blackwater Fever in the Kivu Mountains, Zaire," *Ann. Soc. Belge Méd. Trop.*, 1995, 75, 51–63.

74 Steudel believed that Africans had a relative immunity to "pernicious malaria." *Die perniciöse Malaria*, 345.

75 Whipple, "Blackwater Fever," 239–46; Joseph Herbert Ford, "The Antitoxin Treatment of Tertian Malarial Infections," *Med. Rec.*, 1904, 66, 1001–7; Joseph Herbert Ford, "The Antitoxin Treatment of Tertian Malarial Infections," *JAMA*, 1907, 48, 133–36.

76 J. Gailhard, "Traitement de la Fièvre Jaune," *J. d. Ther.*, 1879, 6, 342–43.

77 A. Kermorgant, "Épidémie de Fièvre Jaune du Sénégal en 1900," *Ann. Hyg. Méd. Colon.*, 1901, 4, 325–436, 409; "Au Sujet de la Transfusion," *Arch. Méd. Nav.*, 1896, 65, 76–77.

78 A. Dieudonné, *Schutzimpfung und Serumtherapie* (Leipzig: Johann Ambrosius Barth, 1895), 41; Georg E. Krieger, *Blood Serum Therapy and Antitoxins* (Chicago: E.H. Colegrove, 1895), quote on 11.

79 Michael Worboys, *Spreading Germs: Disease Theories and Medical Practice in Britain, 1865–1900* (Cambridge: Cambridge University Press, 2000), 219–21.

that some species, “races,” or individuals were more resistant or even immune than others to a particular disease, some because of acquired immunity after prior exposure. Cole in the United States, for example, transfused blood into patients suffering from pellagra from donors who had recovered, both for the therapeutic blood and for a possible immunizing agent. Blood serum therapy inspired malaria researchers in Italy to seek blood agents that could convey immunity from resistant to susceptible individuals, and other researchers looked for such agents for pneumonia, typhoid, cholera, and other diseases.

Malaria research was stimulated by the 1880 discovery by Alphonse Laveran in Algeria that the disease was caused by a parasite in the bloodstream.⁸⁰ This breakthrough led Italian researchers in the following years to investigate modes of malaria transmission (a decade before *Anopheles* mosquitoes were proven to be the vector of the disease in 1897) and the interplay between immune, resistant, and susceptible people and animals in the malaria-infested Campagna and Pontine marshes.⁸¹ Annually, tens of thousands of Italian agricultural laborers migrated from malaria-free highlands to infested lowlands during the summer months, exposing themselves to the disease.⁸² Fifteen thousand people annually died from malaria in Italy, and seven hundred and fifty thousand suffered fevers, costing “workdays and capital,” while some six hundred thousand hectares went untillied.⁸³ Medical efforts to understand how malaria was transmitted meant injecting blood from infectious into healthy individuals. Typically, small amounts of “blood in the natural state, soon after it had been drawn from the patient’s vein” were injected directly into the vein of the recipient in an attempt to reproduce the disease.⁸⁴ Although it was learned that malaria could be transferred subcutaneously, many considered intravenous injections to be more reliable.⁸⁵

By the 1890s, the Italian trials, influenced by blood serum therapy, aimed to transfer not just parasites but immunity, presumed to be acquired or inherited, from indigenous people to recent arrivals.⁸⁶ Angelo Celli’s experiments were the most widely publicized. In one, he inoculated a malaria-free test subject with the blood from five different “malaria-immune” individuals, hoping to induce antitoxins, then later injected him with infectious blood to determine if an immunity had been induced. Other Italians, Gualdi and Montesano, and the Austrian Mannaberg, performed similar trials, inoculating “considerable amounts” of blood serum—50–260 cc—from

80 Webb, *Humanity’s Burden*, 128; Randall M. Packard, *The Making of a Tropical Disease: A Short History of Malaria* (Baltimore: Johns Hopkins University, 2007), 115.

81 Eugenio di Mattei, “Beitrag zum Studium der experimentellen malarischen Infektion am Menschen und an Tieren,” *Arch. f. Hyg.*, 1899, 22, 191–300.

82 Packard, *Making of a Tropical Disease*, 78–83.

83 Ziemann, *Malaria und Schwarzwasserfieber*, 302.

84 Ettore Marchiafava and Amico Bignami, “Malaria,” in Ettore Marchiafava et al., *Malaria and Microorganisms* (New York: William Wood, 1900), 1–522, 126–27; Julius Mannaberg, *Die Malaria-Krankheiten* (Wien: Alfred Hölder, 1899), 48–51, 102–3; Julius Mannaberg, *The Malarial Parasites* (London: New Sydenham Society, 1894), 259; Alphonse Laveran, *Paludism* (London: New Sydenham Society, 1893), 76–77.

85 Reinhold Ruge, “Der Parasitenbefund bei den Malariafiebern,” *Arch. f. Schiffs- u. Trophyg.*, 1897, 1, 248–63, 359–67, 259, 365.

86 Fischer, “Die Malariaforschungen der Italiener,” *Dtsch. Tropmed. Z.*, 1902, 6, 30–35.

infectious people at various stages of fever into healthy individuals, including children, both intravenously and subcutaneously. These experiments failed to discover immunizing or protective agents in the infectious blood. In addition, as many as sixty people from malaria-free regions of Italy were inoculated with the blood serum of “malaria-immune” cattle and buffalo based on the theory that, as cowpox provided an antitoxin for smallpox, supposed “cattle malaria” might do the same for people.⁸⁷ Overall, these trials, which continued for decades, showed that a malaria immunity, resistance, or antitoxin of some sort could not be transferred. Some observers faulted these trials as not done in malaria-free environments. Critics complained that the Italians transferred malaria to healthy individuals with dubious consent.⁸⁸

The Italian trials assumed that indigenous people (or animals) resistant or immune to malaria might provide blood serum for nonindigenous and vulnerable individuals. The parallels with Africa were clear, and German researchers followed up with similar trials after 1890 in Kamerun.⁸⁹ They were begun by the government doctor, Friedrich Plehn, who had previously researched malaria in Berlin and knew of the early Italian trials before founding a research laboratory at Buea on the southern slope of Mt. Cameroon.⁹⁰ At a time when the mosquito vector of malaria had not yet been proven, Plehn researched malaria transmissibility in people and animals by injecting small amounts of malarial human blood into simians (*Affen*) and dogs. Detecting a parasite that resembled *Plasmodium* in birds, Plehn injected bird blood into “two strong Negroes” as well as various animals to determine if the parasites could be transferred. Finding malaria-like parasites in African gray parrots, Plehn injected two other Africans with their blood. Reviewing his own experiments, as well as others done in Europe, Plehn concluded that “the numerous attempts to transfer animal blood containing parasites to humans through inoculation have so far been unsuccessful.”⁹¹ During this time, Plehn also tested the mosquito theory of malaria infection by allowing mosquitoes with infectious blood to bite nine healthy Europeans and Africans, with five successful infections.⁹²

Transferred to German East Africa in 1894, Plehn was replaced by his brother, Albert, who had been a student of H. Quincke, one of the pioneers of therapeutic blood transfusion in Germany.⁹³ Over the next eight years at Buea, Albert Plehn treated over fifteen thousand Africans both in the native hospital and in the

87 Ibid.; Marchiafava et al., “Malaria,” 445. For French trials, see Worboys, *Spreading Germs*, 220, fn 134.

88 Barbara Elkeles, “The German Debate on Human Experimentation between 1880 and 1914,” in *Twentieth Century Ethics of Human Subjects Research*, ed. Volker Roelcke and Giovanni Maio (Stuttgart: Franz Steiner, 2004), 19–33, 23; J. Schwalbe, “Redactionelle Bemerkungen zu Herrn Bignami’s Erwiderung,” *Dtsch. Med. Wochenschr.*, 1899, 25, 184.

89 A. Plehn, “Über Malariaimmunität,” *Arch. f. Schiffs-u. Trophg.*, 1906, 10, 37–51, 39.

90 Friedrich Plehn, *Ätiologische und klinische Malaria-Studien* (Berlin: August Hirschwald, 1890), 5–6; Plehn, *Kamerunküste*, 2, 170–71.

91 Plehn, *Kamerunküste*, 171.

92 Ibid., 172–73; Carl Schwalbe, *Beiträge zur Malaria-Frage* (Berlin: Otto Salle, 1901), 16–17.

93 Albert Plehn, *Weiteres über Malaria Immunität und Latenzperiode* (Jena: Gustav Fischer, 1901), 13.

laboratory.⁹⁴ Most were Kamerunians from malarial and nonmalarial regions, from coastlands and inland highlands and rain forests, and from the savanna north. His patients and trial subjects included African soldiers in the Schutztruppe from Sudan; porters and laborers from Liberia, Togo, Nigeria, Senegal, Angola, and the Gold Coast; and prisoners of war from Southwest Africa. Hospital assistants and convicts offered good research subjects owing to a long-term traceable presence in Buea, as did the children of African assistants and others from a nearby Catholic mission. A variety of European missionaries, soldiers, traders, settlers, and officials from various nations passed through, some with histories of malaria and quinine use, others new arrivals with no experience of malaria. Plehn and other colonial doctors interested in blood serum conducted blood trials on Europeans and Africans, following up on his brother's research begun in 1893.

Influenced by the Italian experiments, Plehn tested the immunity question in "malaria-free" Buea on African subjects, including three Duala men (from Kamerun) and a Liberian, present in Kamerun for several years.⁹⁵ In April 1900, each was injected subcutaneously with 0.8 cc of blood from a European suffering from severe malarial fever who had been in Kamerun for three weeks. The Africans were said to have assented to the experiment after being told that they might become feverish. All developed malaria symptoms within a few weeks, and blood examinations showed parasites and a drop in hemoglobin levels. Yet Plehn concluded that each recovered naturally with no need for quinine. Plehn did not subject newly arrived Europeans to similar tests, because such cases had been demonstrated in Europe, and he doubted Europeans would withstand the severity of Kamerun malaria. At a time when many researchers postulated that Africans were immune to malaria, Plehn's experiments conclusively demonstrated the susceptibility of adult Africans to acute malaria infection through blood inoculations.⁹⁶

Plehn's successor after 1903 was Hans Ziemann, who had researched malaria as a naval doctor stationed in Kamerun in the mid-1890s. Back in Germany, Ziemann conducted long-term research on malarial soldiers in the ports of Wilhelmshaven, Lehe, and Helgoland.⁹⁷ He returned to Kamerun and Togo for malaria trials before spending half-a-year in Italy testing malaria blood inoculations alongside Italian researchers. By 1899, again in Kamerun, Ziemann assisted Plehn with malaria trials on the coast at Duala. These included mixing blood in vitro of a Duala who had previously been inoculated with "pernicious malaria" blood and showed no reaction—therefore was considered immune—with blood from a European feverish with malaria.⁹⁸ In 1900, Ziemann injected infectious blood into seven "willing adult Negroes" of Kamerun

94 A. Plehn, "Die acuten Infektionskrankheiten," 2.

95 A. Plehn, *Weiteres über Malaria*, 5–12.

96 Plehn, "Über Malariaimmunität," 37–51, 39.

97 Hans Ziemann, *Ueber Malaria- und andere Blutparasiten* (Jena: Gustav Fischer, 1898); Hans Ziemann, "Ueber Blutparasiten bei heimischer und tropischer Malaria," *Centralbl. f. Bakt., Parasitenk. u. Infektionskr.*, 1896, 20, 653–72.

98 Hans Ziemann, "Malaria," in *Handbuch der Tropenkrankheiten*, 1st ed., 3 vols., ed. C. Mense (Leipzig: J.A. Barth, 1906), III, 448–49.

who had previously suffered from the disease, not specifying whether the blood came from Europeans or Africans.⁹⁹

The Italian and German trials were not unique. In the Philippines, American researchers of dengue fever inoculated healthy people intravenously with virulent blood from infected persons in search of a serum cure, and Ford pursued similar trials for a malaria vaccine.¹⁰⁰ Americans in Cuba and French in Brazil injected healthy people with infectious yellow fever blood, and French researchers in Vietnam did likewise with typhus-infected blood.¹⁰¹ In 1898, Arthur Elting at Johns Hopkins in Baltimore reviewed some thirty-nine instances of malaria blood injections from infected to healthy individuals conducted by Italian and German researchers.¹⁰² Pursuing his own experiments, Elting injected fifteen individuals, most intravenously, with malarial blood at different stages of parasite development.

The era of blood serum research, and research into the modes of malaria transmission, coincided with public debates in Germany over medical experimentation on humans and animals.¹⁰³ Several scandals over medical research and patient consent emerged in the 1890s, some dealing with malaria research in Italy, so the decade ended with researchers sensitized to the need to demonstrate patient consent. In response to this debate, in 1900, the Prussian Ministry of Cultural Affairs required subjects of experiments to be instructed on possible mal-effects of procedures, and to give their consent.¹⁰⁴ Yet in many cases, patients or experimental subjects were people lacking social power—children, prostitutes, agricultural laborers, prisoners, soldiers, and colonial subjects. Thus, consent may have been dubious. Most researchers were convinced that their actions were for the good of humanity, and this often led them to lower their guard against abuses.

BLOOD EXPERIMENTS AND ANIMAL SUBJECTS

The medical community's enthusiasm for transfusing animal blood into people as a therapy for pernicious anemia and for war surgery characterized the decades before 1880.¹⁰⁵ German military surgeons during the Franco-Prussian War advocated sheep blood transfusions since, unlike human donors, they were readily available

99 Ibid., 269–557, 381; Hans Ziemann, “Zweiter Bericht über Malaria und Moskitos an der afrikanischen Westküste,” *Dtsch. Med. Wochenschr.*, 1900, 26, 753–56; Plehn, “Über Malariaimmunität,” *Arch. f. Schiffs- u. Trophyg.*, 1906, 10, 43.

100 R. Doerr and V. K. Russ, “Die gutartigen kurzfristigen Fieber der warmen Länder,” in *Handbuch der Tropenkrankheiten*, 2nd ed., 6 vols., ed. C. Mense (Leipzig: J.A. Barth, 1914), III, 388–425, 397–400; P. M. Ashburn and Charles F. Craig, “Experimental Investigations Regarding the Etiology of Dengue Fever,” *Philip. J. Sci., B. Med. Sci.*, 1907, 2, 93–147; Ford, “Antitoxin Treatment,” *JAMA*.

101 James Carroll, “Gelbfieber,” in *Handbuch der Tropenkrankheiten*, 1st ed., 3 vols., ed. C. Mense (Leipzig: J.A. Barth, 1905), II, 108–39; A. Yersin and J. J. Vassal, “Une Malade Rappelant le Typhus Exanthématique Observé en Indo-Chine,” *Bull. Soc. Pathol. Exot.*, 1908, 1, 156–64.

102 Arthur W. Elting, “Ueber Malaria nach experimentellen Impfungen,” *Z. Klin. Med.*, 1898, 36, 491–526.

103 Elkeles, “German Debate,” 19–33.

104 Ibid., 28.

105 Hanssen, *Transfusion*, 8–9.

when needed.¹⁰⁶ Although the discovery that the blood of different species destroyed the red blood cells of another, acting as a poison, brought the practice of interspecies transfusion into disapproval, it did not go away.¹⁰⁷ According to Hanssen, after President Garfield was shot by an assassin in July 1881, lingering for two-and-a-half months before he died, animal blood transfusion was used in treatment.¹⁰⁸ The Italian de Dominicis in Naples in the mid-1890s transfused the blood of dogs directly into the veins of twenty-seven severely anemic people, some receiving multiple transfusions of as much as 130 cc.¹⁰⁹ In 1895, the English doctor J. Murray wrote in a guide book on tropical health that goat blood and serum were “useful as preventive and therapeutic agents in malarial poisoning.”¹¹⁰ Arguing that goats were immune to malaria, as shown by Celli and Marchiafava, and therefore might possess antitoxins, Murray recommended using syringes or transfusing the goat’s blood directly from its carotid artery into an arm vein of the malaria sufferer.

The 1890s was an ideal decade for testing animal blood serum therapy owing to the widely reported Italian malaria trials and Behring’s use of animals to produce immunity serum for diphtheria and tetanus.¹¹¹ Hans Ziemann, working in Togo and Kamerun, argued that malaria parasites used bats and monkeys as reservoirs, and he used their serum in immunization trials.¹¹² Ziemann also claimed to have detected malaria and trypanosome parasites in chimpanzees from French Congo. He and other researchers attempted to transfer human malaria parasites to bats and the parasites of these animals to humans.¹¹³

Theories of blood transfusion and serum therapy alike were bolstered by zoological studies of the relationship between different species, influenced by Darwinian science. Blood analysis was a new way to determine closeness of “races” and species.¹¹⁴ Hans Friedenthal in Berlin wrote that the equivalency of human blood types to each other had been demonstrated by the “many successfully implemented blood transfusions

106 Hiller review of Oscar Hasse, *Die Lammbhut-Transfusion beim Menschen*, in *Dtsch. Mil. Aerzt. Z.*, 1874, 3, 350–53.

107 J. Schneider, *Entwicklung, Bau und Leben des menschlichen Körpers* (Leipzig: Theodore Thomas, 1905), 168.

108 Hanssen, *Transfusion*, 9.

109 De Dominicis, “Transfusione diretta e immediata del sangue dal cane all’uomo,” *Centralbl. Inn. Med.*, 1894, 15, 373.

110 J. Murray, *How to Live in Tropical Africa* (Liverpool: George Philip & Son, 1895), 156–59.

111 Emil von Behring, *Die praktischen Ziele der Blutserumtherapie* (Leipzig: Georg Thieme, 1892), 7–9.

112 Ziemann, “Zweiter Bericht,” 753–56, 769–72, 772; Hans Ziemann, “Über das Vorkommen von *Filaria perstans* und von Trypanosomen beim Chimpanse,” *Arch. f. Schiffs- u. Trop. Hyg.*, 1902, 6, 362.

113 Ziemann, *Malaria und Schwarzwasserfieber*, 44–45, 117.

114 Hans Friedenthal, “Ueber einen experimentellen Nachweis von Blutverwandtschaft,” *Arch. f. Physiol.*, 1900, 494–508; Herbert W. Rand, “Friedenthal’s Experimental Proof of Blood-Relationship,” *Am. Nat.*, 1901, 35, 1017–22. A few years later Carl Bruck, working in the Dutch East Indies, claimed to have determined biological distinctions between the blood of humans and apes, different ape species, and different “human races.” Carl Bruck, “Biologische Differenzierung von Affenarten und menschlichen Rassen durch spezifische Blutreaktion,” *Berl. Klin. Wochenschr.*, 1907, 44, 793–97. The discovery of blood groups led some researchers to see blood type as a basis for racial difference. Susan E. Lederer, “Bloodlines: Twentieth-Century America,” *J. R. Anthropol. Inst.*, N.S., 2013, 19, S118–29; L. Hirschfeld and H. Hirschfeld, “Sero-logical Differences between the Blood of Different Races,” *Lancet*, 1919, 194, 675–79.

between so distant races as the Negro and the white.”¹¹⁵ Moreover, “the anthropomorphic apes are so closely related to humans that the blood types can be regarded as identical.” Although Friedenthal conducted experiments of blood serum samples of apes and humans outside the body, he argued that the full relationship between ape and human blood must be determined by direct transfusions. He injected 25 cc of defibrinated human blood intravenously into an adult male chimpanzee from the Berlin zoo and saw no signs of incompatibility, suggesting that humans and great apes should be classified in the same zoological family. Friedenthal concluded that in cases where human blood was deficient or insufficient, it could be replaced with great ape blood; only animal availability prevented this. J. Schneider agreed that the compatibility of human and chimpanzee blood “proved scientifically” their close relationship.¹¹⁶

The parasitologist Eduard Reichenow followed up on the work of Ziemann and Friedenthal with ape–human blood trials in Africa.¹¹⁷ Reichenow had prior experience from 1909 to 1912 at the zoological research station of Rovigno on the Adriatic Coast before being posted to the Ajoshöhe sleeping sickness camp on the Nyong River in Kamerun. While there Reichenow investigated whether chimpanzees and gorillas could act as reservoirs for malaria. His research site south of the Sanaga River was well within the range of the *P.t.troglodytes* chimpanzee that is considered the source of HIV-1 group M.¹¹⁸ He captured (and sometimes killed) sixteen chimpanzees and gorillas at Ajoshöhe, concluding that malaria parasites could be found in the blood of the great apes, as Ziemann had claimed earlier. Reichenow wrote that only inoculation of malarial blood between apes and humans could demonstrate conclusively that both shared the same parasites, although he apparently did not carry out such trials himself. Reichenow also infected “apes” with human blood containing *Trypanosoma gambiense* sleeping sickness, many of which subsequently died. Modern HIV researchers theorize that a “cut hunter” first came into contact with SIV in equatorial Africa through butchering a chimpanzee.¹¹⁹ Apart from his laboratory trials, Reichenow reported that farmers hunted great apes regularly for food and crop protection, increasing the likelihood of exposure to their blood.¹²⁰

Simian blood research in Africa had parallels in Europe. At the Institute of Tropical Diseases in Hamburg in 1910, Gonder injected himself twice with malarial “Affenblut” after efforts to infect apes failed.¹²¹ At the Pasteur Institute in Paris in

115 Friedenthal, “Experimenteller Nachweis,” 505–8.

116 Schneider, *Entwicklung*, 168.

117 Eduard Reichenow, “Ueber das Vorkommen der Malariaparasiten des Menschen bei den afrikanischen Menschenaffen,” *Centralbl. f. Bakt., Parasitenk. u. Infektionskr.*, 1920–21, 85, 207–16.

118 Pepin, *Origins*, 24.

119 For a critique of this model, see Tamara Giles-Vernick and Stephanie Rupp, “People, Great Apes, Disease, and Global Health in the Northern Forests of Equatorial Africa,” in *Global Health in Africa: Historical Perspectives on Disease Control*, ed. Tamara Giles-Vernick and James L. A. Webb (Athens: Ohio University Press, 2013), 117–37.

120 Eduard Reichenow, “Biologische Beobachtungen an Gorilla und Schimpanse,” *Sitzungsbericht der Gesellschaft naturforschender Freunde zu Berlin*, 1920, 1, 1–40; Eduard Reichenow, “Untersuchungen über das Verhalten von *Trypanosoma gambiense* im menschlichen Körper,” *Z. Hyg. u. Infektionskr.*, 1921, 94, 266–385, 293–95.

121 R. Gonder and E. Rodenwaldt, “Experimentelle Untersuchungen über Affenmalaria,” *Centralbl. f. Bakt., Parasitenk. u. Infektionskr.*, 1910, 54, 236–40.

1917, Mesnil and Roubaud inoculated two chimpanzees with malarial human blood.¹²² In 1922, British researchers in Sierra Leone went so far as to inject infectious blood from a *P.t.troglodytes* chimpanzee that had recently died from falciparum malaria into two Europeans.¹²³

The most overt example in Africa of using animal blood as a serum for malaria sufferers was that of Philateles Kuhn, a staff doctor for the Schutztruppe in German Southwest Africa in the 1890s, later posted to Kamerun.¹²⁴ Investigating African horse sickness (*Pferdesterbe*), Kuhn concluded that it was the same disease as malaria, and therefore the serum of recovered horses might provide a vaccine for human malaria. In early 1899, during a malaria epidemic in Grootfontein, Kuhn inoculated “numerous natives” and around twenty whites—“old Afrikaners” as well as new German arrivals—subcutaneously with horse serum. He believed that the serum ameliorated malaria fevers and subsequent attacks, and provided a protective agent that expedited an acquired immunity. As a substitute for quinine, horse serum also lessened the threat of blackwater fever. Kuhn went on to visit malarial regions of Bosnia, where he applied his malaria “vaccine” to forty patients and to several patients at the Seaman’s Hospital in Hamburg. He and others publicized his serum as a successful vaccine for malaria.¹²⁵ Ford conducted similar trials using infectious rabbit, monkey, and goat blood injected into test subjects in Oklahoma and the Philippines, and for a time believed that he had developed a successful vaccine.¹²⁶

Besides malaria, the colonial obsession with human and animal sleeping sickness provided another arena of human–animal blood experiments. By 1900, colonial authorities concluded that sleeping sickness obstructed economic development by thwarting cattle economies and depleting African populations.¹²⁷ It was not yet known that human sleeping sickness was related to *nagana* bovine sleeping sickness. Within a few years, it was discovered that parasites—trypanosomes—in the bloodstream of wild and domestic animals and people, transmitted through tsetse fly vectors, caused the disease. Yet, there apparently were different species of trypanosomes infecting animals and people, some more deadly than others, and different tsetse fly species throughout the continent. For the next half century, colonial policy makers experimented with multiple methods of combating the disease, while medical researchers sought chemical and blood therapies to treat patients and potentially create immune populations. The early discovery that an arsenic compound called atoxyl could cure patients led to campaigns to identify individuals infected with sleeping

122 F. Mesnil and E. Roubaud, “Essais d’Innocation du Paludisme au Chimpanzé,” *Ann. Inst. Past.*, 1920, 34, 466–79; Ziemann, *Malaria und Schwarzwasserfieber*, 44.

123 B. Blacklock and S. Alder, “A Parasite Resembling *Plasmodium falciparum* in a Chimpanzee,” *Ann. Trop. Med. Parasitol.*, 1922, 16, 99–104.

124 Philateles Kuhn, “Über eine Impfung gegen Malaria,” *Arch. f. Schiffs- u. Trophg.*, 1901, 5, 283–90, 342–65, 351.

125 Philateles Kuhn, “Ueber den Verlauf der Malaria ohne Chinin mit besonderer Berücksichtigung meiner Impfung,” *Verhandlungen des deutschen Kolonialkongresses* (Berlin: Dietrich Reimer, 1903), 268–81; Ludwig Sander, “Eine Heil- und Schutzimpfung gegen Malaria,” *Dtsch. Med. Wochenschr.*, 1900, 26, 716.

126 Ford, “Antitoxin Treatment,” *JAMA*.

127 Neill, *Networks*, Chapter 4.

sickness, and round them up into lazarets that could be isolated from the general population for injection. Lazarets were in effect laboratories for treating and studying sleeping sickness and other diseases in Africa.¹²⁸ As with malaria, the question of whether people were the only reservoirs of sleeping sickness preoccupied researchers, and many investigated the blood of people and a variety of animals, reptiles, and birds to determine trypanosome transferability.¹²⁹

Historians of medicine interested in possible early pathways of HIV in Africa have called attention to the massive injection campaigns aimed at combating sleeping sickness in people, particularly from World War I.¹³⁰ Less focus has been given to blood trials related to sleeping sickness research that included efforts to determine etiologies between animal and human sleeping sickness, their possible transmissibility, and whether vaccines could be developed from immune animals or recovered people.¹³¹ Many of these trials took place in Africa, involving hundreds, if not thousands, of animal and human subjects, and created the possibility of accidental as well as intentional laboratory infection.¹³²

As with malaria, sleeping sickness researchers in Europe and Africa conducted blood trials in search of an “anti-diphtheritic serum” that might transmit an immunity from resistant people or animals.¹³³ Blood testing was also used to establish whether animal and human sleeping sickness were the same disease. An early attempt was in 1903 by a Dr. Ascenso in Congo near Lake Mweru, who brought in livestock for sleeping sickness experiments.¹³⁴ Seeking to determine if the blood of an infected cow was pernicious to humans, he inoculated himself and two African servants subcutaneously with its blood. Alphonse Laveran, the discoverer of the malaria parasite in 1880, studied trypanosomiasis after 1900 at the Pasteur Institute in Paris.¹³⁵ His team found that some animals, such as sheep and goats, were less susceptible to *nagana*, and cattle that survived nagana were “salted” against subsequent infections. Their blood could be used as a serum to cure nagana in nonimmune animals. He believed that some simians, especially baboons, had strongly therapeutic blood serum. Although human blood serum was especially potent in killing the trypanosomes of nagana, it was impractical as a vaccine given the quantity needed for whole herds. French researchers in Senegal followed up on Laveran’s experiments with trials on animals using human

128 Wolfgang U. Eckart, “The Colony as Laboratory: German Sleeping Sickness Campaigns in German East Africa and in Togo,” *Hist. Phil. Life Sci.*, 2002, 24, 69–89; Maryinez Lyons, *The Colonial Disease: A Social History of Sleeping Sickness in Northern Zaire, 1900–1940* (Cambridge: Cambridge University Press, 1992).

129 C. Mense, “Die afrikanische menschliche Trypanosomenkrankheit (Schlafkrankheit),” in *Handbuch der Tropenkrankheiten*, 2nd ed., 6 vols., ed. C. Mense (Leipzig: J.A. Barth, 1916), IV.1, 138–300, 192–96.

130 Pepin, *Origins*, 103–67; Drucker, “Injection Century,” 1990–91.

131 For the interwar period, see Luise White, “Tsetse Visions: Narratives of Blood and Bugs in Colonial Northern Rhodesia, 1931–9,” *J. Afr. Hist.*, 1995, 36, 219–45.

132 Mense, “Die afrikanische,” 197.

133 “Report of the Inter-Departmental Committee on Sleeping Sickness,” Cd. 7349 in *British Parliamentary Papers, Reports from Commissioners, Inspectors and Others*, Vol. 38 (1914), 18.

134 F. K. Kleine and M. Taute, “Sleeping Sickness Investigations in German East Africa,” *Sleeping Sickness Bull.*, 1911, 3, 165–75, 174.

135 A. Laveran and F. Mesnil, *Trypanosomes and Trypanosomiasis* (London: Ballière, Tindall and Cox, 1907), 177–79.

blood.¹³⁶ Ronald Ross, discoverer of the mosquito vector of malaria in 1897, while working at the Royal Southern Hospital in Liverpool a decade later treated a European suffering from sleeping sickness contracted in Northern Rhodesia.¹³⁷ When applications of atoxyl and quinine failed to cure him, Ross sought a blood serum by inoculating virulent blood into a rat, which killed the rat. He then withdrew blood from the rat, mixed it with saline, heated it to attenuate its virulence, and injected it subcutaneously into the patient, who nevertheless died after five months.

In the Great Lakes region of East Africa, German and British researchers actively sought blood sera during an ambitious campaign to stanch human sleeping sickness, which had killed hundreds of thousands of people in recent years. They set up chains of sleeping sickness camps to quarantine sufferers and inject them with atoxyl and other drugs. Among the goals of the German research team working near Lake Victoria and Lake Tanganyika was to determine whether *T. brucei*—nagana—was identical to a virulent form of human sleeping sickness called *T. rhodesiense*, and whether the latter offered resistance to the more common West Africa form, *T. gambiense*. Prominent among these researchers were Friedrich Kleine and a German staff doctor, Martin Taute. In efforts to determine whether *T. brucei* was a human disease, Kleine analyzed the blood of one thousand and five hundred children.¹³⁸ At the Niansa sleeping sickness camp in 1911, Taute injected simians with blood from infected people, and allowed infected flies to feed on the apes.¹³⁹ He went on to investigate transmissibility of different strains of trypanosomes from animals to people in German East Africa, Portuguese East Africa, and Northeast Rhodesia in 1913.¹⁴⁰ Taute experimented with cattle, dogs, rats, monkeys, baboons, wild pigs, warthogs, buffalo, and antelope, inoculating animals across species with infected blood.¹⁴¹ Influenced by Ascenso's self-injection a few years earlier, Taute injected himself with *T. brucei* to prove that nagana was not infectious to people. Back at Niansa on Lake Tanganyika in 1914, Taute researched trypanosome transmissibility in "higher apes," including chimpanzees, before World War I interrupted.

The war, Taute wrote, offered the opportunity to investigate the transmissibility of *T. brucei* owing to unusual medical oversight over masses of people under circumstances that resembled a large-scale "natural epidemiological experiment."¹⁴² Fought after 1916 as a guerilla campaign, the war in East Africa demanded that German

136 A. Thiroux and L. d'Anfreville, "De l'Action du Sérum Humain sur Trypanosoma Pecaui Laveran," *C. R. Acad. Sci.*, 1908, 147, 462–64.

137 Ronald Ross and David Thomson, "A Case of Sleeping Sickness Studied by Precise Enumerative Methods," *Sleeping Sickness Bull.*, 1911, 3, 61–65, 64.

138 M. Taute and F. Huber, "Die Unterscheidung des Trypanosoma rhodesiense vom Trypanosoma brucei," *Arch. f. Schiffs- u. Trophyg.*, 1919, 23, 211–26, 212.

139 M. Taute, "Experimentelle Studien über die Beziehungen des *Glossina morsitans* zur Schlafkrankheit," *Z. Hyg. Infectiönsk.*, 1911, 69, 553–58, 554–55.

140 Taute and Huber, "Die Unterscheidung," 211–26.

141 M. Taute, "Untersuchungen über die Bedeutung des Grosswildes und der Haustiere für die Verbreitung der Schlafkrankheit," *Arb. Kaiserl. Gesundheitsamte* (1913), 45, 102–4; Taute, "Experimentelle Studien," 553–58.

142 Taute and Huber, "Die Unterscheidung," 219; John Ford, *The Role of the Trypanosomiases in African Ecology* (Oxford: Clarendon Press, 1971), 73.

forces relocate frequently. Thousands of soldiers, porters, camp followers, and prisoners were available as test subjects, particularly in the spring of 1917 when nagana began to kill horses and cattle. Taute once again used himself (and his associate Huber) as test subjects, as well as “some colored criminals” and “a great number of native porters,” who Taute claimed represented eleven different East African ethnic groups. From October 1917 into January 1918, he injected small quantities of infected horse and mule blood into the chests of some 129 prisoners and porters. Although in no cases did *T. brucei* infect the trial subjects, of interest is Taute and Huber’s willingness to inject infected animal blood into Africans who were not in a position to object.

CONCLUSION

Between 1880 and 1918, a culture of experimentation existed in Europe, North America, and the wider world that sought novel therapies for a variety of diseases in an age of nascent germ theory. The discovery of the healing properties of blood and blood serum, however imperfect, led to the widespread clinical use of animal and human blood transfusions to treat a variety of diseases that had severe anemia as a key symptom. Although breakthroughs were piecemeal, knowledge was limited and sometimes incorrect, and research often led to dead ends, medical researchers nevertheless applied their techniques in the laboratory, in hospitals, and on the battlefield. As this paper’s centering of German colonial doctors demonstrates, this period coincided with the European conquest of Africa, where techniques developed in the metropole could be used to benefit European officials, soldiers, settlers, and missionaries. Gradually, the colonial project recognized the need to increase African populations for economic development, and this meant applying sometimes flawed European science. Dissimilarities between African and European susceptibility and resistance to diseases such as malaria, blackwater fever, yellow fever, and sleeping sickness motivated the search for immunizing agents in African blood for the benefit of vulnerable Europeans and possibly other Africans. A sensibility against transfusing the blood of one “racial” group into another does not stand out in the medical literature before World War I; indeed, there was more concern about availability of blood when transfusions were needed.¹⁴³ A competitive medical culture motivated field doctors to experiment with trial subjects in the hope of breakthroughs that could make a name and benefit careers. Limitations on research in Europe, such as a paucity of test animals and unsuitable disease environments, made the colonies important extensions of metropolitan laboratories.

This culture of medical experimentation coincided with a time period when HIVs emerged in Africa through human contact with the blood of simians, a process where SIVs evolved into multiple strains of HIV, some more virulent than others. The zoonotic jump from SIV to HIV likely took different pathways in different parts of

143 In their overview of sixteen cases of blood transfusion to treat pellagra in Texas, for example, Bennett and Scott specified only in the single case of a black patient that the blood was “furnished by a Jew.” Bennett and Scott, “Surgical Treatment,” 141. Wailoo argues that the discovery of sickle cell anemia in 1910 and its association with people of African descent contributed to racial fears of blood mixing by the 1920s. Wailoo, *Drawing Blood*, Chapter 5.

West-Central Africa, and some probably became epidemiological dead ends; there was no single “smoking gun.”¹⁴⁴ Besides transfusions, experimental injections of human and animal blood, as well as mundane injections of saline, quinine, caffeine, and other therapies under sometimes unsterile conditions may have facilitated the spread of HIV. Human mixing of bodily fluids during an era of urbanization and mobility spread the virus to other regions and ultimately the world. As established by past researchers, the early colonial use of syringes on hundreds of thousands of villagers for diseases such as smallpox, syphilis, bubonic plague, and sleeping sickness may have provided fertile ground for infection through dirty needles or accidents. However, recent research asserts that the ability of SIVs to mutate into virulent human viruses is dramatically increased by serial passage in human bloodstreams by way of transfusions or injections. The current narrative identifies the first instance of blood transfusion in sub-Saharan Africa as 1918 in German East Africa, in effect launching blood transfusion therapy during the interwar period elsewhere on the continent. It asserts that only by then were conditions, including knowledge, instruments, techniques, and facilities, ready for the widespread application of transfusion therapy. This article shows that an earlier case of blood transfusion occurred in German East Africa in 1892, and that circumstances existed that made it feasible that transfusions were resorted to elsewhere in Africa during early colonial rule. Although this case is unlikely to have been the father of one of the strains of HIV in Africa, it demonstrates a willingness and ability of colonial doctors to use transfusions in extreme circumstances, particularly when European lives were at stake. Some colonial doctors even continued to advocate animal blood transfusion as a therapy, a practice that had been discouraged in Europe since about 1875, but which never disappeared. Suggestions that technics were inadequate before 1914 to perform blood transfusions under colonial conditions are belied by ample evidence. Transfusion apparatuses were widely available and used for saline transfusions even if doctors were not inclined to attempt blood transfusions. More research is needed, especially in colonial medical archives, to determine whether the Bagamoyo case was singular.

Beyond blood transfusions as such, from the 1890s, colonial doctors tested human and animal subjects for parasite transmissibility and in the search for blood serums that might convey artificial immunities to multiple diseases. The realization that different Africans had different degrees of resistance to many tropical diseases encouraged experimentation that may have seen infected blood injected from person to person or animal to human in the search for vaccines. The unintended medical consequences of such blood trials might have been multifaceted and widespread.¹⁴⁵ Colonial laboratories and sleeping sickness internment camps provided ideal testing grounds for such experiments, and some, such as Ajoshöhe in Kamerun and Niansa in German East Africa, were in close proximity to simian test animals, including chimpanzees and gorillas. Darwinian science at the time encouraged the belief that human and higher ape

144 Giles-Vernick et al., “Social History,” 26.

145 Pepin, *Origins*, 103; Anne Marie Moulin, “Defenseless Bodies and Violent Afflictions in a Global World: Blood, Iatrogenesis, and Hepatitis C Transmission in Egypt,” in Giles-Vernick and Webb, *Global Health*, 138–58.

blood was compatible, at a time when even human blood typing was not widely known. Research into multiple vaccines had long established the possibility of attenuating viruses by passage through different species, so that it was not shocking to inject animal blood serum into people, as Italian researchers had openly demonstrated with malaria. Occasionally, doctors injected themselves with infected blood, which also showed a willingness to perform similar trials on Africans who had little volition. Medical research therefore may have provided a different pathway for cross-species pathogen sharing than those posited by simple “cut hunter” models or anthropogenic shifts in the environment. Early colonial blood trials may have intersected with the jump of SIVs into HIVs, or may have involved other zoonoses, such as influenzas or hemorrhagic fevers.

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