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Review

Human plague occurrences in Africa: an overview from 1877 to 2008

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ABSTRACT

Plague remains a public health concern worldwide, but particularly in Africa. Despite the long-standing history of human plague, it is difficult to get a historical and recent overview of the general situation. We searched and screened available information sources on human plague occurrences in African countries and compiled information on when, where and how many cases occurred in a centralised database. We found records that plague was probably already present before the third pandemic and that hundreds of thousands of human infections have been reported in 26 countries since 1877. In the first 30 years of the 20th century, the number of human cases steadily increased to reach a maximum in 1929. From then on the number decreased and fell below 250 after 1945. Since the 1980s, again increasingly more human infections have been reported with the vast majority of cases notified in East Africa and Madagascar. We show that public health concerns regarding the current plague situation are justified and that the disease should not be neglected, despite the sometimes questionability of the numbers of cases. We conclude that improving plague surveillance strategies is absolutely necessary to obtain a clear picture of the plague situation in endemic regions.

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1. Introduction

Plague is a rapidly progressing, serious illness in humans that is likely to be fatal if not treated.^{1,2} It remains a public health concern in many parts of the world, but particularly in Africa. Natural foci of plague exist in several countries across Africa,³ but most human cases are currently being reported from the Democratic Republic of Congo (DRC), Uganda, Tanzania and Madagascar. Today, human infec-

tions mainly occur in remote areas where the disease is endemic and where persons live in unsanitary, rat-infested environments.¹

Plague is a zoonotic disease caused by the bacterium *Yersinia pestis*, which circulates mainly in rodent hosts with occasional involvement of lagomorphs and is transmitted between them and to other mammals via wild adult fleas, cannibalism or (possibly, although this is still discussed) contaminated soil.^{3,4} Humans are extremely susceptible to *Y. pestis* infection; most common plague infections are bubonic and occur through the bite of an infected flea, but alternative infection routes are through skinning or consuming an infected animal.³ Plague is only occasionally transmitted between humans, most likely through close contact between a healthy person and an infected person

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via respiratory droplets.^{3,5,6} The result is the highly lethal pneumonic plague and this transmission may occasionally lead to an epidemic.

Historically plague has become widespread, affecting a large number of countries on most continents during three large pandemics. The third pandemic started in a remote area in the Chinese province of Yunnan. The disease spread rapidly along the tin and opium routes towards the south-east, reaching Canton and Hong Kong in 1894.⁷ Through rats and fleas on board trader ships, it spread to all corners of the world. The third pandemic killed approximately 13 million people in India alone but also claimed many victims in other countries, including Africa.³ As a result of repetitive introductions of plague via the sea into several African ports, urban epidemics occurred with large numbers of cases. At the same time, human plague cases were notified in already existing inland foci by early missionaries.⁸ Plague continued to exist in Africa, and human cases have been reported until today. However, it is difficult to get a clear view of the historical and recent situation of plague in Africa because information is scattered throughout all types of sources.

In this study, we aimed to give an overview of human plague occurrences in Africa from the end of the 19th century to date. To this end, we searched and screened all available literature sources and compiled information on when, where and how many human cases occurred in Africa into one centralised database, which could be a useful basis for studies regarding the epidemiology and ecology of plague.

2. Methods

A human plague database for Africa for the period 1877–2008 was created. Several avenues were followed and various information sources were consulted. We started with the table from the WHO *Plague Manual* (Table 1, p. 18–20).³ This table merely gives information about the yearly number of cases per country and is limited to the period 1954–1997. Next, the WHO Weekly Epidemiological Records (<http://www.who.int/wer/en/>) for 1951–2007 and ProMED-mail reports (<http://www.promedmail.org/>) for 1994–2007 were checked. Since ProMED-mail reports news from all sources (including newspapers, press releases, etc.), this information was interpreted with caution and verified wherever possible.

In addition, computerised searching of two international literature databases was carried out, namely PubMed (<http://www.ncbi.nlm.nih.gov/PubMed/>) and Web of Science (<http://apps.isiknowledge.com/>). A systematic search strategy was employed using the following search terms: 'Africa' or the name of one African country (e.g. 'Angola') AND 'plague' (in different languages, e.g. 'pest' or 'peste') OR '*Yersinia pestis*'. The search was refined to manuscripts that reported the occurrence of animal or human plague in African countries. Manuscripts in English, French, Dutch, Afrikaans, German and Portuguese were included. Original full texts were obtained for most studies. Additionally, the WHO library and archives in Geneva, including non-published reports, were studied and incorporated in the database. This was supplemented with information from Web-accessible documents and other grey literature (mission reports, old distribution maps, etc.) from libraries and archives in Belgium.

Plague experts from different African countries were contacted for information on human and animal plague occurrences in their country (Table 1), which provided a large part of the data. In addition, Ministries of Health from countries that notified plague were contacted requesting additional information. Whilst most of them never responded, seven countries replied that they were willing to provide whatever data were needed, but none of them provided new primary information.

The human plague database for Africa comprises information on 26 countries that have experienced at least one human plague case since 1877 (Appendix A, updated until 26 February 2009). Per country, the number of reported human infections and deaths is given per year. Furthermore, more specific information regarding where and when human plague occurred, from which source the information was extracted, and additional remarks are provided.

3. Results: history of human plague occurrences in Africa

From 1877 onwards a total of >200 000 human plague cases have been reported in 26 African countries. Throughout this period, the number of human cases reported varied largely, with a mean number of cases per year of 123 (1899–2007) (Fig. 1). The maximum number was reported in 1929, with 12 701 cases notified, whilst the minimum

Table 1
Summary of plague experts contacted

Name	Institute	Country about which information was provided
Dr S. Chougrani	University of Medicine, Oran, Algeria	Algeria
Dr J-C Shako Lomami	Ministry of Health, Kinshasa, DRC	DRC
Dr L. Rahalison	Institut Pasteur de Madagascar, Madagascar	Madagascar
Dr R. Nala	National Institute of Health, Ministry of Health, Mozambique	Mozambique
Dr K. Shangula	Ministry of Health and Social Services, Windhoek, Namibia	Namibia
Dr L. Arntzen	National Institute for Communicable Diseases, Johannesburg, South Africa	South Africa
Dr R. Makundi	Pest Management Centre, Sokoine University of Agriculture, Morogoro, Tanzania	Tanzania
Dr B. Kilonzo	Pest Management Centre, Sokoine University of Agriculture, Morogoro, Tanzania	Tanzania
Dr K. McClean	College of Medicine, University of Saskatchewan, Canada	Zambia

DRC: Democratic Republic of Congo.

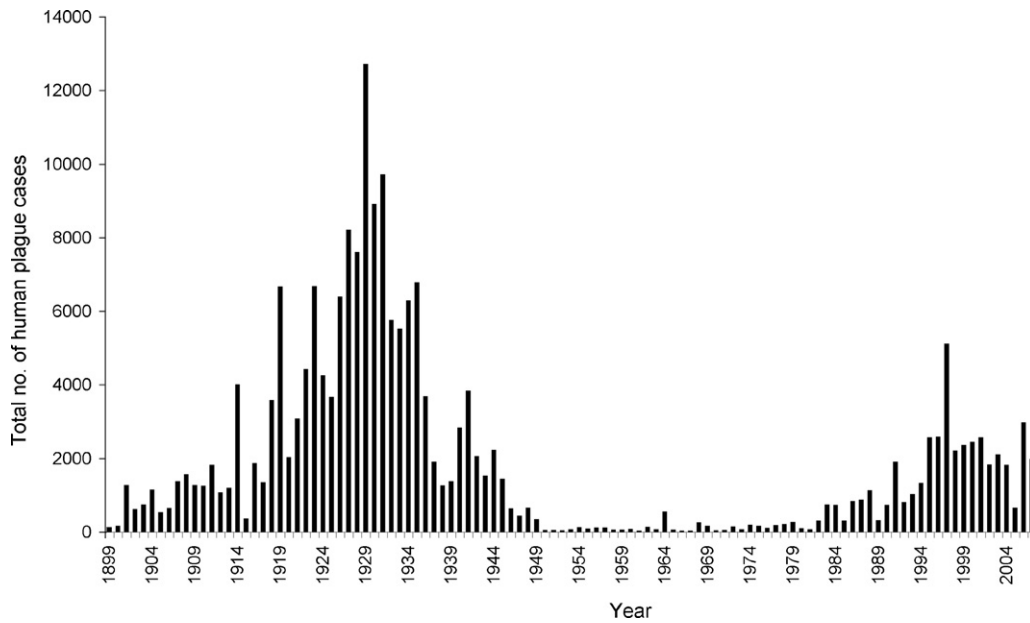


Fig. 1. Temporal evolution of the yearly number of human plague cases reported in African countries for the period 1899–2007. Data were extracted from the human plague database that was created (Appendix A). Note: human plague has been reported since 1877, but since no information is available on the exact numbers that occurred, the graph presents numbers of human plague cases only from 1899.

was recorded in 1966 with only 18 cases. Countries with a history of human plague include, in alphabetic order, Algeria*, Angola, Botswana, Burkina Faso, DRC*, Egypt, Ghana, Kenya, Lesotho, Libya, Madagascar*, Malawi*, Mauritania, Morocco, Mozambique*, Namibia*, Nigeria, Republic of Guinea, Senegal, South Africa, Tanzania*, Tunisia, Uganda*, Zambia* and Zimbabwe* (Fig. 2). Countries marked with an asterisk still experienced human plague in recent years (1995–2008). Cameroon reported human plague within its territory to the WHO in 1961 but retracted the report later. Fig. 2 presents, besides the infected countries, a number of locations where human plague infections occurred. For these localities, detailed geographical information was available, so that geographical coordinates could be assigned and presenting them on a map was possible.

Already in the 18th and 19th centuries epidemics alleged to be plague occurred in Kisumu, Kenya,⁸ but the earliest true records of plague were notified in Uganda by missionaries in 1877.⁹ From 1880 onwards there are records of plague outbreaks from a variety of localities around Lake Victoria, central Tanzania (1886), and at a few localities in southern and southeastern Kenya.^{8,10} These plague occurrences were encountered more than one decade before the third pandemic began in Hong Kong.⁸ The disease probably spread from the caravan routes from the north to the east coast. Most of the currently active and quiescent plague foci in Tanzania are found along these ancient trade routes.¹¹ During the period 1903–1908, most of the ports in Lake Victoria became involved in plague epidemics, which continued to spread inland where local epidemics occurred.¹²

At the end of the 19th century and the beginning of the 20th century, plague was imported into several places in Africa through ships coming from India and else-

where in Asia. Ports along the Atlantic and Indian Oceans and the Mediterranean Sea coasts were infected repetitively, e.g. Luanda (Angola), Algiers (Algeria), Alexandria (Egypt), Tripoli (Libya), Toamasina (Madagascar), Dakar (Senegal) and Cape Town (South Africa). From these newly infected areas the disease could spread inland and occasionally established itself to create new persistent plague foci (examples in ^{7,13,14}). Plague found its way to humans through contact between humans and the transported plague hosts or the newly infected local rodents.

In the first 30 years of the 20th century the number of human infections steadily increased until 1929 (12 701 cases). Most infections were reported from major ports such as Algiers, Skikda and Oran (Algeria), Alexandria and Port Said (Egypt), Dakar (Senegal), and Port Elizabeth and Cape Town (South Africa); these were typical port plague cases resulting from repeated introductions and subsequent urban outbreaks.⁷ At the same time as the occurrence of recurrent port plague outbreaks, increasingly more cases were reported from Uganda from the 1920s onwards. Also, in 1921 Madagascar experienced its first large human plague epidemic and between 1921 and 1945 a high proportion of the total number of African human cases occurred on the island's plateau. Other countries that reported high numbers of cases in the 1920s and 1930s were Egypt and Senegal, and in 1940–1945 Morocco experienced the most important episodes in its plague history. After 1945, plague appeared to die out in North Africa for as yet unknown reasons.^{15,16} However, human plague outbreaks in 1972, 1976 and 1977 in Libya and in 2003 and 2008 in Algeria show that plague is still circulating in nature in specific regions in North Africa.^{16–18}

From 1929 onwards, the total number of human plague cases decreased gradually, and after World War II a period



Fig. 2. Human plague occurrences in Africa: map of Africa with countries that experienced human plague since 1877 (shaded). Several localities where human plague occurred and from which detailed geographical information was available are shown. More localities might have experienced plague but no geographical information was available.

of years with low plague incidence begun with never more than 250 cases, except in 1964 when 581 cases were recorded. This fierce relapse of plague can be partly attributed to the rise and application of newly developed antibiotics and a better understanding of plague's epidemiology, particularly with regard to the early detection and treatment of suspected plague patients to the extent that plague appeared to disappear in many locations in Africa.¹⁹ Meanwhile, in general there was a gradual improvement in people's living conditions and hygiene, and rodent surveillance and control practices were strictly applied in the main commercial ports. At that time, human plague was mainly reported from remote areas where people often did not have access to health facilities. Only occasionally, plague broke out in an urban environment. Until 1981, the incidence of plague in Africa remained fairly low. However, despite the low number of human cases reported, increasingly more African countries reported plague incidence within their borders, whilst in the Americas and Asia the number of reporting countries remained constant.² The reasons for this are still unclear but are most likely linked to

an improvement in the plague surveillance and reporting systems in African countries.

From 1982 onwards, the situation of plague occurrences in Africa changed dramatically and the number of human cases started to increase greatly, with >1500 cases reported in most years. The highest number of infections was reached in 1997 when >5100 human infections were notified to the WHO. The vast majority of cases were reported from East Africa; countries such as Tanzania, DRC, Uganda and Madagascar have experienced outbreaks of the disease almost yearly.

In the 1990s the numbers of human plague infections reported kept increasing and >90% of all human plague cases now notified to the WHO originate from African countries.^{2,20} The reasons for such a trend may be associated both with an actual increase in plague activity in its natural foci and a further improvement in notification to the WHO.²⁰ However, in the course of the last decade plague incidence decreased strongly in Madagascar, and consequently in Africa, since human cases in Madagascar amounted to 50% of the African total at that time.

Nevertheless, >15 000 cases have been reported from Madagascar, DRC and Tanzania alone since 1995.

4. Discussion: general trends of human plague occurrences in Africa

Plague foci in East Africa are very ancient and are presumed to have been present before the 1800s.²¹ Although a minority of authors believe that the eastern part of Central Africa is one of the natural homes of plague,^{8,22} most authors think that *Y. pestis* evolved from the Central Asian plateau and that the biovar Antiqua was first introduced to Central Africa at some point before the sixth century.²³ Some authors theorise that numerous rodent and flea species complexes that live in the Great Palaearctic Desert Belt, i.e. the desert area that extends from the Atlantic Coast of northwest Africa in the west to northeastern China, may have transferred *Y. pestis* from Central Asia to North, and subsequently to Central, Africa.^{22,24} Others think the disease may have been introduced from Egypt, Arabia and India by various mediaeval traders including slave and ivory caravans as well as pilgrims to and from Mecca.²⁵ Several centuries later, *Y. pestis* Orientalis was most likely introduced again during the third plague pandemic, originating from Central Asia, and its distribution appears restricted to East African ports today.²³

From a historical and epidemiological point of view, three different plague occurrence regions can be distinguished in Africa: (i) Central and East Africa; (ii) North Africa; and (iii) along the coastal areas of the Indian and Atlantic Oceans. The region comprising the presumably oldest foci is situated on the northern shore of Lake Victoria in Central Africa.²⁶ They are presumed to be the origin of human plague occurrences in continental Africa before the third pandemic. The second region that can be distinguished consists of the North African areas bordering on the Mediterranean Sea. Between the 14th and 18th centuries—the second pandemic and its after-effects—a number of countries in North Africa, especially Egypt, Tunisia and Morocco, were victim to heavy plague epidemics just as Europe was.²⁶ From the 18th century onwards, plague spontaneously disappeared and at the beginning of the 20th century plague was again imported from overseas. The Mediterranean foci did not change their epidemiological appearances; ports were infected, epidemics occurred among port rats and occasionally humans, and plague spread to the rodent fauna of the savannahs and semi-deserts of the coastal hinterland. Plague led to the enzootic infestation of large areas that became quiescent or died out after World War II.¹⁵ The coast and islands of Africa, other than those situated in the Mediterranean region, constitute the third plague occurrence regions. Oceanic areas that face the Atlantic and Indian Oceans had been free of plague in historical times. These localities were infected for the first time during the third pandemic through overseas traffic with Asia.⁸ By these new importations, the epidemiological picture of plague in Africa changed fundamentally. Several ports were repeatedly infected and occasionally plague established itself in natural reservoirs and persisted for long time periods. Today, a large number of those natural foci still persist in ecolog-

ically diverse biotopes,²⁷ and human outbreaks re-emerge from time to time, even after long periods of quiescence.²⁸

It is likely that human plague has also occurred in regions other than those presented in Fig. 2, but we believe that most locations with human plague outbreaks with a local origin are indeed indicated. In contrast, the presence of human plague in an area does not necessarily mean that plague is endemic in that region, e.g. a number of ports where plague was introduced via the sea are shown.

It must be emphasised that the numbers given in the human plague database are rather questionable and might not adequately reflect the actual number of human plague infections. Global statistics on plague are incomplete due to communication failures, lack of adequate surveillance and reporting systems, and/or lack of adequate laboratory facilities and well trained health personnel for diagnostic confirmation of the disease. Several uncertainties and errors could lead to an under-reporting of plague cases. Moreover, countries are sometimes reluctant to notify cases within their territories, fearing consequences for international trade and tourism. In other countries, more cases might be notified than actually have occurred because of the limited specificity of the diagnostics used, which is often only clinical. When in 2007 Zambia reported 700 suspected cases with only 2 deaths, this raised questions about the reliability of the case definition. Indeed, it would be surprising that case management has so much improved or that the virulence of *Y. pestis* has suddenly decreased. To estimate the reliability of the reported incidence, we suggest looking at the case-fatality ratio (CFR), hereby using the CFR of Madagascar (i.e. approximately 12% of deaths among suspected cases, the vast majority being bubonic) as a reference for Africa since Madagascar is an African country with a well organised plague surveillance system.²⁹ In addition to the problem of the reliability of the reported incidence, available information sources sometimes differ in the number of (suspected) human cases that they report. Collected records are often dependent on the circumstances (i.e. peaceful or war region, direct or indirect communication) in which they were obtained. However, despite the questionability of the human records, a general idea of the incidence of human plague and its epidemics in African countries can be obtained from the numbers given in the human plague database.

The worsening situation from 1982 onwards may have been the result of various factors. First, there is the fact that a large number of African countries harbour natural foci endemic for plague, either quiescent or active, which are often situated very close to human habitations. Second, in some countries there was an attenuation of the established surveillance systems, which had proved effective over the last 40 years, especially in remote areas.²⁰ These systems enabled quick measures to be taken to prevent further spread of the disease after plague in humans was detected. The fact that plague sometimes did not appear for a longer period strengthened the deterioration of these surveillance systems in a way that some countries decided to phase out their plague prevention and surveillance programmes. If a plague outbreak re-emerged while no prevention and control strategies were effective, the disease could spread rapidly and infect many humans. Eventually, other factors

that may have contributed to the increasing number of human plague cases could be landscape–ecological, climatic, sociocultural and socioeconomic.³⁰

In the last few years, a single region, Province Orientale in northeastern DRC, has accounted for approximately 50% of all the reported cases worldwide, but the confirmation rate does not pass 2% and the CFR is far below the reference of 12% among suspected cases. This suggests an over-reporting of human cases in DRC, which again illustrates the questionability of the global reported incidence. Moreover, nearly 90% of cases worldwide are reported from Africa, approximately 80% of the African cases from DRC and approximately 90% of the latter cases from Orientale province, which is regularly affected by political troubles. Indeed, even a slight modification of the surveillance system in a single African district would most likely modify the entire global plague statistics. Improved surveillance strategies will help in estimating risks for local populations, developing and applying most favourable control strategies, and intervening optimally during plague outbreaks.

We further wish to stress that the burden of plague cannot be measured through its incidence only, but indeed having an active plague focus in its territory means for a country a permanent risk of pneumonic plague outbreaks that are very challenging to control, especially in an urban context or in crisis situations with potential international concerns. Moreover, it is alarming that several plague foci, such as the Ituri focus in the Orientale province in DRC, appear to be currently undergoing an expansion.²⁰ Reasons for this are so far unknown. This might result in the closer proximity of urban settings to plague-endemic foci, as is already the case in Oran (Algeria) and Kisangani (DRC), and thus higher risks of human infections and possibly urban plague outbreaks.

One remarkable but typical characteristic of plague is that it sometimes disappears indefinitely and re-emerges suddenly, such as in Boteti, Botswana, in 1989 after >35 years,³¹ in the port of Mahajanga, Madagascar, in 1991 after >60 years,³² in Oran, Algeria, in 2003 after >50 years¹⁶ and most recently in Mbulu, Tanzania, in 2007 and 2008 after >30 years.³³ That human cases reappear after decades of quiescence is not always the result of the re-emergence of plague foci themselves³⁴ because the absence of reported human plague cases does not necessarily mean absence of plague in this area. Plague bacteria can be circulating in nature,³ but when human populations are absent the presence of *Y. pestis* will not be noticed. Alternatively, plague bacteria can be present where human populations are present, but plague transmission does not occur due to various reasons. Indeed, when appropriate vectors to transmit *Y. pestis* to humans are absent or when humans do not come into contact with infectious vectors or hosts owing to their daily living behaviour, human infections will not occur. Changes in climatic or ecological (deforestation, urbanisation, etc.) circumstances and sociocultural behaviour or deterioration of living conditions (civil wars, economic crises) can for instance induce changes in flea and rodent populations or the frequency of contacts between humans and infectious plague sources.³⁴ Finally, the lack of diagnostic and/or communication facil-

ities can prevent the recognition or reporting of plague cases.

In summary, we conclude that plague has been present in Africa at least since 1877, which is before the introduction of *Y. pestis* Orientalis during the third pandemic. The disease has been reported in 26 countries with >200 000 human cases in total. The increased incidence since the 1980s shows that public health concerns today are justified, even though questions can sometimes be posed about data reliability. With this manuscript, we further wish to stress the importance of improving surveillance strategies for a clear picture of the situation in plague-endemic areas. The plague database may serve as a basis for studies regarding the epidemiology and ecology of plague in Africa.

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Ethical approval: Not required.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.trstmh.2009.07.028.

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