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EARTHQUAKES AND PLAGUE DURING BYZANTINE TIMES: CAN LESSONS FROM THE PAST IMPROVE EPIDEMIC PREPAREDNESS?

POTRESI I KUGA U VRIJEME BIZANTSKOGA CARSTVA: MOGU LI POVIJESNE LEKCIJE POBOLJŠATI PRIPREMLJENOST ZA EPIDEMIJE?

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Summary

Natural disasters have always been followed by a fear of infectious diseases. This raised historical debate about one of the most feared scenarios: the outbreak of bubonic plague caused by Yersinia pestis. One such event was recorded in the Indian state Maharashtra in 1994 after an earthquake. In multidisciplinary historical approach to the evolution of plague, many experts ignore the possibility of natural foci and their activation. This article presents historical records from the Byzantine Empire about outbreaks of the Plague of Justinian occurring months or even up to a year after high-magnitude earthquakes. Historical records of plague outbreaks can be used to document existence of natural foci all over the world. Knowledge of these historical records and the contemporary examples of plague support the assumption that, in terms of organising humanitarian aid, poor monitoring of natural foci could lead to unpredictable epidemiological consequences after high-magnitude earthquakes.

Key words: *Byzantium, earthquakes, epidemic risk, plague*

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Introduction

Natural disasters have often been followed by fear of outbreak of infectious diseases, giving rise to a debate on the risk of epidemics. Some experts believe that, although natural disasters may not usually result in disease outbreaks, they may under certain circumstances increase disease transmission (Bartlett 2008, 351-357; Floret et al. 2006, 543-548). The knowledge of the nature, the dynamics, and the evolution of infectious diseases is critical for after-disaster health planning (Alexander 2007, 231-247; Manuell and Cukor 2010, 417-442). Plague is one such disease, which spreads after geophysical disasters in enzootic areas. This spread has been much debated, as there is no clear knowledge of activation mechanisms in the local natural foci. Such phenomena may be explained by sudden invasion of infected animals or sudden reactivation of natural foci that have been inactive for decades (WHO 1996, 165-168). When, in such cases, the balance between the population of the flea *Xenopsylla cheopis* and the rodents is dirubted, the rat-flea index (number of the rat flea collected from the rat examined / total number of rat examined) changes accordingly. It has been reported from World Health Organization that a rat-flea index greater than 1 represents an increased human plague risk (Gage 1999, 155-156).

In multidisciplinary research of the historical evolution of plague, many experts ignore these natural foci and their re-activation (Appleby 1980, 161-173). This article presents some historical records from the Byzantine Empire on the outbreaks of the Plague of Justinian. This Byzantine corpus includes historical sources, chronographies, and the ecclesiastic texts and covers the period from 541 AD to 780/81 AD, when the last epidemic was recorded. Information about the earthquakes is clear and direct. Byzantines used the term plague as an umbrella term and the identification of the disease is sometimes indirect, based on previous records describing its clinical symptoms. Of course, an *ex post facto* diagnosis is always debatable and the danger of misdiagnosis by contemporary writers remains a concern. Furthermore, as regards the evolution of the concept of disease, for Byzantine historians, the Greek words *thanatiko* (θανατικό), which means the deadly, and *loimos* (λοιμός), which means plague, alternated in their chronicles as synonyms. The results of the earthquake or the epidemic are quantitative, without accurate demographic data or further information on morbidity and mortality.

Earthquakes and plague in Byzantium

According to the Byzantine historian Procopius, plague first broke out in the empire in the Mediterranean port of Pelusium in Egypt (541 AD) (Procopii Caesariensis/Haury and Wirth 1905, 249-259). It spread over the empire, and the estimated mortality was 30% of the population (Rosen 2008, 253-314). In 542 AD, the disease appeared for the first time in Constantinople and gradually spread westwards, reaching Britain and Ireland (Procopii Caesariensis/Haury and Wirth 1905, 249-259; Russell 1976, 65-78). The last plague outbreak during the first pandemic in the Byzantine world took place in 748-750/51 in Syria and Mesopotamia, under Arab dominion (Chronicle of Zuqnīn/Harak 1999, 184-189). In fact, the Arab conquest of the eastern provinces of the Byzantine Empire (629-642) offers valuable information, as many Arab accounts of plague outbreaks verify the Greek and Syrian sources (Morony 2007, 59-86; Conrad 1981, 51-93).

During the Plague of Justinian, named after the Byzantine Emperor (482-565 AD), the Byzantine Empire suffered many natural disasters (Telelis 2004, 210-358,834,870-875). Most of them disturbed the demographic basis, trade, agriculture and even the Byzantine supremacy in some provinces. Earthquakes between the 6th and 8th century often struck the well-known seismic zone of the Eastern Mediterranean. Some plague outbreaks occurred months or almost a year after major earthquakes (Table).

Sites and dates of earthquakes and plague outbreaks
Mjesta i godine potresa i pojave kuge

	Earthquake	Plague	Source
Constantinople	557	558	Agathias Ioannes Malalas Theophanes
Syria	567	568	Agapios
Syria (Antioch)	580	581	Agapios
Palestine & Syria (Antioch)	634	635	Michael the Syrian
Syria	712	713	Michael the Syrian

Between the 6th and 8th century, five plague outbreaks appear most interesting, i.e. those in Constantinople (558 AD), Syria (568 & 713 AD), Antioch (580 AD), and Palestine (634 AD). It is interesting that four of

the five records concern the provinces of Syria and Palestine around the Dead Sea, with a rich and well-documented history of large destructive earthquakes since 1355 BC (Sbeinati et al. 2010, 243-245). The Northern section of the Dead Sea fault (i.e. Lebanon, Syria) is among the main seismogenic zones. The identification of various seismic data on the elevated plateau of the region, in combination with the transformation of the area, both indicate periods with violent tectonic changes during historical times (Shulman et al. 2004, 225-237).

The first record of the 558 epidemic of Constantinople comes from a few months after the powerful earthquake of 14 December 557. The earthquake and the plague are well-documented in the chronicles of eminent Byzantine historians Agathias, Ioannes Malalas, and Theophanes (Agathias/Keydell 1967, 175-176; Malalas/Thurn 2000, 489; Theophanes/Mango et al. 1997,232, 235, 353).

On 2 April 557, a violent earthquake struck the capital with a continuous metaseismic action for 6 months. On 6 October 557, a new earthquake struck again and a sea-wave entered two miles into the area of the capital. However, the absolute disaster came from a 7.0-magnitude earthquake on 14 December 557. Some months after the incident, sources inform us about a new tragedy, the sudden onset of "the death of the buboes". According to Byzantine historians, countless citizens lost their lives; again, as in 542 during the first plague outbreak, unburied corpses filled the streets of the capital. Actually, this was the second plague outbreak, 15 years after the first epidemic in 542 (Procopii Caesariensis/Haury and Wirth 1905, 249-259). According to the chronological sorting of sources, it seems that the plague appeared in urban centres every 10-15 years and in Constantinople at intervals of 11-17 years, with an average interval of 14.2 years (Stathakopoulos 2004, 23-34). The second record does not provide enough information to allow us to identify the exact town, as it speaks generally of the province of Syria. According to Agapios, a major plague epidemic that devastated the province in 568 AD was linked to the disastrous earthquake in Syria in 567 AD (Agapios/ Vasiliev 1912, 438-439,469).

The previous plague outbreak was 8 years earlier in 560 AD (Theophanes/Mango et al. 1997, 235). Agapios also informs us about the third plague outbreak of 580/81 AD, after the earthquake in the Syrian city of Antioch (Agapios/ Vasiliev, 1912, 438-439, 469). In Antioch, plague re-emerged after 38 years (Syméon Stylite/van den Ven 1962,

59-60). The fourth record corresponds to the plague of 634/35. Michael the Syrian mentions a strong earthquake, with metaseismic action for 30 days in Palestine, that destroyed many monuments in Jerusalem (Michael le Syrien/Chabot 1899, 412,419,482). According to Michael and Agapios, after the disaster a severe plague epidemic broke out in Palestine and spread quickly to Syria with many victims (Agapios/ Vasiliev 1912, 469; Michael le Syrien/Chabot 1899, 412,419,482). The previous outbreak appeared 8 years earlier, in 626 AD (Michael le Syrien/Chabot, 1899, 419). The fifth case dates back to 713 AD. The Syrian Chronicle of Disasters and Michael the Syrian record a severe plague from December 712 until February 713 (Michael le Syrien/Chabot 1899,482, Chronica/ Brooks 1907, 176). The sources mention a devastating earthquake, some months before the epidemic (Chronica/Brooks 1907, 176; von Kremer 1880; 69-143). In this case, the previous recorded outbreak in the province was 7 years earlier, in 706 (von Kremer 1880,69-143). According to the records, the Plague of Justinian included 42 outbreaks in Syria and Palestine under the Byzantines or the Arabs (Stathakopoulos 2004, 23-34). The geographical spread of the epidemics revealed a steady presence of the disease in the Middle East, and plague seems to have been the "export product" of Syria to Mesopotamia and Palestine. Indeed, the disease seems to have been recycled among these three Byzantine provinces. The combination of historical records and geographical data allows identification of a possible natural focus around Lake Tiberias and the Golan Heights. In his poetic collection, Arab poet Hassān ibn Thābit mentions cities and villages affected by the plague and states that Syria, the "*ard al-Rūm*" i.e. the land of the Romans, suffered frequent plague epidemics for many years before becoming Arab land (Conrand 1994, 51-93). Apart from the cases of plague during Byzantine and Arab military campaigns or due to trade routes as an imported epidemic, it seems that in some cases earthquakes triggered the disease outbreak.

Discussion

Natural plague foci persist in Asia, the Americas, and Africa (Gratz 1999, 63-96). Plague re-emergence in the same region after years or decades of epidemic silence is a critical question. The most impressive example in Byzantine historiography is the 672 plague epidemic in Egypt, after a disease-free period of 54 years (Theophanes/Mango et al. 1997, 353). A similar contemporary case is the 2003 outbreak in the Oran region of

Algeria, a country where no plague cases have been reported to the WHO for 50 years (Bertherat et al. 2007, 1459-1462).

The enzootic behaviour of rodent populations allows the disease to sustain itself for decades (Dennis 2000, 402-411). In a population of 60.000 rodents, a likely number for a middle-sized early medieval town, the bubonic plague could sustain itself for nearly 100 years (Keeling and Gilligan 2000, 2219-2230). The enzootic behaviour of rodents and enzootic areas show fluctuations. It is estimated that the frequency of an enzootic outbreak affects a population every 3 to 5 years, but longer intervals have been recorded (Pollitzer 1954, 266). The infection is maintained in wild rodent colonies, which serve as natural foci of the disease, thanks to transmision between rodents by their parasites. The plague microbe (*Yersinia pestis*) is only occasionally introduced into colonies of more susceptible species. Many species of rodents are susceptible to infection but are only occasionally infected. This occurs in nature through an overlap of individuals or populations of two different species. The longer *Yersinia pestis* is maintained in the susceptible rodent population (disease resistant and non-resistant), the longer the plague remains active (Gratz 1992, 63-96). The maintenance of the bacteria in the population depends on numerous factors: the hosts and their parasites, the local ecosystem, the climate, topography and available food and water reserves (Baker 1984, 103-111).

As regards contemporary plague outbreaks after large earthquakes, we should mention the case of the Indian state Maharashtra, which suffered an epidemic in 1994 for the first time in 30 years (WHO 1996, 165-168). The circumstances are unknown and the factors contributing to the re-emergence of the disease theoretically include environmental changes created by the 6.4-magnitude earthquake in September 1993. The natural disaster disturbed the equilibrium density of the domestic rodents *Rattus rattus* and their fleas *Xenopsylla* cheopis (WHO 1996, 165-168). After a powerful earthquake, the rodent population gradually increases over the following 8 to 10 months, upsetting the balance between rodents and fleas (McCormick 2003, 1-25).

If the case of Maharashtra was the absolute surprise for the authorities, the case of Qinghai in China proves the value of monitoring and surveillance in humanitarian planning. After the deadly 6.9-magnitude earthquake in Qinghai in April 2010, the Chinese authorities immediately ordered the rescue workers and survivors to avoid any contact with dead

animals, especially marmots. Marmots usually hibernate in their burrows together with their fleas until late April or early May, but can resurface early due to the earthquake. The authorities' fears were based on previous cases of lung plague in the Qinghai province and on the data of an epidemiological surveillance of the area for years (Wank 2005, 684-686).

Conclusions

The WHO warns about the increased risk of epidemics after great natural disasters such as earthquakes. Humanitarian organizations face a challenge in the developing countries due to a lack of sound epidemiological data on certain diseases. After a disaster, water-borne diseases are always the first concern, but other diseases, such as plague, can be neglected, unless proper epidemiological surveillance has been in place. The mechanism of plague's onset after natural disasters is a much debated medical issue, but the case of Maharashtra in India seems to caution that this issue is not a fiction. Moreover, according to certain historical records about the plague's first pandemic in the Byzantine Empire, i.e. the Plague of Justinian, there seems to have been an interaction between the high-magnitude earthquakes and plague's onset in areas with a steady presence of the disease for decades, such as enzootic foci. In the framework of the historic research and contemporary examples, it seems that the knowledge of recorded interactions between earthquakes and epidemics and continuous monitoring of natural foci are of great importance. In such cases, the increased risk of epidemic is mainly due to poor monitoring of natural foci. In addition, the lack of accurate epidemiological data on high-risk areas with known outbreaks - even if they happened decades ago - could have unpredictable epidemiological consequences after violent geophysical disasters.

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Sažetak

Nakon prirodnih katastrofa uvijek slijedi strah od zaraznih bolesti. Otuda i povijesni prijepor o jednom od najgorih mogućih scenarija – pojavi jersinije pestis odnosno bubonske kuge, kakva je 1994. nakon potresa izbila u indijskoj državi Maharashtra. U multidisciplinarnome, povijesnom istraživanju razvoja kuge, mnogi stručnjaci zanemaruju mogućnost prirodnih žarišta bolesti i njihova aktiviranja. Ovaj članak donosi povijesne bilješke iz doba Bizantskoga Carstva o izbijanju Justinijanove kuge mjesecima pa čak do godine dana nakon snažnih potresa. Povijesni dokumenti mogu poslužiti kao pokazatelji mogućih prirodnih žarišta kuge diljem svijeta. Uvid u te dokumente i suvremene primjere izbijanja kuge potvrđuju pretpostavku da, vezano uz organiziranje humanitarne pomoći, nedovoljan nadzor nad prirodnim žarištima može dovesti do nepredvidljivih epidemioloških posljedica nakon snažnih potresa.

Ključne riječi: *Bizant, potresi, epidemijski rizici, kuga*