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The Austrian success of controlling plague in the 18th century: maritime quarantine methods applied to continental circumstances.

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Abstract:
After the last Western European outbreak (Marseilles 1720-1722), plague epidemics repeated swept through central and eastern Europe during the 18th century. At the beginning of the 1700s, the Habsburg Monarchy conquered the plague-stricken central European parts of the Ottoman Empire down to the northern Balkans. Endeavoring consolidation, health advisers of the Sanitary Court Commission in Vienna transformed maritime quarantine measures systematically to continental circumstances beginning in the late 1730s. A series of seaport-type quarantine stations were erected along the border crossings of the main oriental trade routes combined with traditional *cordon sanitaires* by the 1750s. Military policing forces were responsible for isolating and purifying all suspected transmitters of diseases (persons, vehicles, goods and animals). The numerous royal decrees were summarized in a Code named General Norm of Health Service 1770. A crucial test of the new system was the Russo-Turkish war 1768-1772. Until that time, the Habsburg monarchy had no epidemiological infrastructure on its northeastern border, yet it was established in several months as a highly successful anti-plague measure. The present study explains the success of the quarantine system implemented by the Habsburg Monarchy within the context of the 1770 General Norm of Health Service legislation.

Keywords: 18th century continental plague control, maritime quarantine rules applied, Habsburg public health legislation, high standards of organisation
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Introduction

Central parts of Europe surrounded by Russia and the Ottoman Empire suffered from repeated waves of plague epidemics from 1346 to the last decades of the 1700s. Having ruled also huge parts of Asia, Russians and Turks were connecting Europe with endemic foci of plague in Central Asia and the Eastern Mediterranean. Therefore, military conflicts of European nations with Russians and Turks on the great plane between the Black Sea and the Baltic region spread plague directly from these endemic centers. For example, when contaminated Russians defeated the Swedish army at Poltava in 1709, it had a serious impact on Eastern and

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Northern Europe. The Balticum (the region east of the Baltic Sea) was devastated by a plague epidemic in 1709-1710 (Khan, 2004).

In the rest of the continent, plague arose as usual in port cities, major trading centers and was facilitated by intern European military campaigns in the 17th and 18th century (Ell, 1984). The typical land route began in seaports and spread in three directions: through Low Countries to the Rhineland, along river Elbe to Bohemia, and through the coastal region of the Baltic Sea to Eastern Europe (Zietz, Dunkelberg, 2004). In the 17th century, the most important factor in plague dynamism was the Thirty Years' War (1618-1648), military campaigns which led to the rapid spread of the plague through towns and villages.(Cipolla, 1973). By the end of the 17th century, a new central European land corridor was struck by the plague, which travelled from the Near East through Asia Minor via the Balkans. The Turks went into their last great offensive against Central Europe, but after the decisive defeat at Vienna (1683), lost a series of battles and were forced to retreat to the northern edge of the Balkans. In 1699, as a result of the Peace Treaty of Karlowitz, the Habsburg monarchy became the new continental big power, controlling major routes of land trade from Western, Northern and Central Europe via Balkans to the oriental regions. The Monarchy, while facing the declining power of Venice, entered the maritime transportation business between Europe and the Eastern Mediterranean via its newly opened free ports in the northern Adriatic region. Since promotion of trade was a central idea of emerging mercantilism, the Habsburgs' entrepreneurial spirit exposed the monarchy to a series of plague epidemics with serious consequences in the first half of the new century.

Maintaining mutual commerce and effective disease control became a significant priority and challenge of the central administration. In the late 1730s, the Sanitary Court Commission in Vienna proposed a new method to prevent and curb plague epidemics. Health advisers coupled continental *cordon sanitaires* with exact replicas of maritime quarantine stations along border crossings of the main routes of oriental trade. *Cordon sanitaires* functioned like epidemiological "iron curtains" between the stations by eliminating (or limiting significantly) traffic along the state border. In newly erected facilities, staff of the Army Health Service trained on maritime regulations quarantined and purified all suspected transmitters of diseases (persons, vehicles, goods, animals and personal belongings). Through these methods that proved to be successful in Mediterranean seaports and by strict military policing methods, the Habsburg Monarchy became definitively free of plague by the 1750s.

Numerous royal decrees codifying the maritime-to-land quarantine conversion were summarized in a Code named the General Norm of Health Service 1770. The Russo-Turkish war of 1768-1772 presented the first test of the continental quarantine system as outlined in the General Norm of Health Service. However, when the news arrived about the first military actions and minor plague epidemics, the continental quarantines were implemented as early as 1768 in strict accordance with the General Norm of Health Service (HHStA, 1764-1775). Previously, the northeastern border of the Monarchy had no method to prevent or control the spread of plague. Likewise, Poland, a self-governing neighbor of the Habsburg Monarchy not subject to the strict quarantine measures, lost more than 250 000 lives as a result of the plague (Lesky, E. 1959). The Habsburg monarchy experienced only two minor plague outbreaks which were localized within 24 hours in a single county resulting in 40 and 46 death cases respectively (HNA, 1770).

There are many theories (changes in climate, in rat populations, developing personal hygiene, immunity, etc.) explaining the dissolution of plague epidemics first in Britain after 1665 (Bayliss, 1980) and later in Western Europe by 1722. However, it can be proven that

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quarantine methods refined by empiricism of many centuries interrupted the weakest points the bubonic plague cycle. Of course, there is no counter-proof of this statement in plague-free Western Europe, since being plague free is not physical evidence in itself of this success. Nevertheless, if in a plague stricken environment of Europe there was a single state without epidemics, it is reasonable to conclude that only the special health policing methods preserved the Habsburgs' economy and population in the second half of the 18th century.

Quarantines and isolation

Spectacular success of the Austrian monarchy demonstrated that contemporary quarantine measures, when relentlessly executed, provided full protection against the threatening plague epidemics. It means that without any evidence-based medical knowledge, only societal actions, such as consistent law enforcement and jurisdiction based on successful empiricism were able to protect health and wealth of the countries. Quarantine as a preventive measure has a long and well-known history (Gensini, Yacoub, Counti, 2004). However, quarantine as a primary prevention must be separated from all secondary preventive measures of isolation. Looking back to the past millenia, writings of the Old Testament and decrees of Roman emperors focused on isolation of sick people than systematic detention of apparently healthy persons suspected of being infected. In the medieval Europe, the 14th century Black Death necessitated first systematic detaining and observing persons and goods, traffic and commerce between plague-free and infected seaside regions. One could argue that this detention and observation process was by happenstance, the earliest systematic human research of experimental epidemiology. Quarantine "experimentation" proved to be more useful than previous hypothetical ideas about the incubation period of acute diseases postulated since the Old Ages. Nevertheless, the successful quarantine model of the Western Mediterranean was tailored only to the dynamism of plague and functioned perfectly until the spectacular breakdown in cholera epidemics of the early 19th century.

Because it was observed throughout the Middle Ages that the plague typically broke out in seaports engaged in oriental business, the most exposed Adriatic region under Venetian rule initially implemented detention measures in the 14th century. Despite the unknown primary source of infection, secondary agents were accurately identified as ships, crewmembers, travelers and goods in sea transportation. The simplest way of detention cargoes and individuals was to require ships to lay at anchor and wait outside of the seaport. This passive type of 40 (*quaranta* in Italian) days waiting was introduced in Venice in 1348. The first active measures (1377) were best documented in Ragusa (today Dubrovnik/Croatia). During detention also purification of cargo by sun and fresh air was ordered and supervised by the seaport authority. At the beginning, increasing of detention from 30 to 40 days indicated uncertainty of the local legislation. It is understandable, because the plague free qualification given by the port authority was based only on "wait and see" principle of the ancient medicine. Finally, it was believed that 40 days provided more security. If within 40 days no bubonic cases were identified among quarantined people, it was assumed that no one was infected and that commercial goods had lost their ability to spread infection. Before the age of the evidence-based microbiology it was a remarkable achievement provided that observation and purification were carried out correctly without any negligence or human error.

In order to develop an objective decision making in ports of destination, written documents were intorduced about the epidemiological qualification of travellers, goods and crewmembers as soon as in the 16th century. Because authorities and skippers registered as usual departures and destinations in the maritime transport, this practice was used to introduce

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and refine the system of bills of health in the subsequnt centuries. Skippers were given written certificates about the epidemiological situation of all seaports visited during the journey. Later on, these bills made it possible to impose different periods of quarantine adjusted to the actual epidemic situation. The system functioned perfectly by the 18th century according to the relevant Austrian regulations (Linzbauer, 1852-61, pp 683-761). Seaports at departure and those visited during the journey released three types of bills with definitions free, suspected, and dirty. Dirty did not mean actual infection, rather a high probability of being infected. Ships with obvious signs of plague were banned from all seaports. Since epidemiological qualification was a bilateral (and often controversial) issue, ports of destination used four categories: free, clean, suspected, and dirty. Distinction between free and clean made it possible to question the credibility of seaport authorities abroad. However, credibility counted as an absolute principle of navies except during wartime: "warships while keeping the head's of port authority advices, are not obliged to present a certificate, and will have a free access by a declaration confirmed with a word of honor of the captain." (Linzbauer, 1852-61, II. p. 684). In commercial sea transport, a free bill was accepted only in the case of absolute security verified by public (visa of the consul) and secret service information of the country of departure. Additionally, ships during sea-voyage were functioning as quasi pre-quarantine stations, provided they did not have any contact en route with potential sources of infection. Therefore, skippers were required to make a statement in the port of destination about all contacts that happened on high sea (other ships, pirates, shipwrecked people).

In the Habsburg monarchy the system of maritime bills of health was converted word-by-word to the land trade in the 1740s, but printed certificates were introduced first as a result of a bilateral agreement with Istanbul since 1768.

When a ship was qualified as "clean", it opened the way for arbitrary quarantine periods with minimum span of 7 days, which might have been extended in favor of trade across different countries and sometimes launched a real commercial war in coastal regions. Goods (including animals and personal belongings) were separated from merchants and processed by "purification". At the beginning, it was a simple and universal exposure to the fresh air and sunshine, but by the 1700s authorities used already itemized lists of goods with different plague susceptibility. As demonstrated below, this so-called plague susceptibility depended on the more or less favorable circumstances of survival for infected fleas hiding in different articles and raw materials.

Because in case of British Isles the only one way of spreading plague was the sea transportation, England is the best epidemic example for controlling plague by maritime quarantine measures along Mediterranean seaports. However, efficacy depended on consistent seaport authorities and strong administration. Without these, the English monarchy endeavored in vain to establish permanent quarantines against the plague ravaging Europe at the beginning of the 1660s. Ships bound to London had to wait the usual 40 days, but the authority practiced no cleansing (purification) of cargo and it was impossible to prevent illicit landing of people after the daylight hours, let alone ship rats descending mooring lines around the clock. Under these circumstances, there was inevitable the Great Plague of London in 1665. After more than thirty years plague free period, the Parliament enacted the first quarantine legislation in Queen Anne's reign in 1710. This time, epidemic of the Baltic region was feared to be imported. The ancient threat returned first when news arrived of a plague epidemic in France in 1720. In the preparatory period of a new quarantine act, the government sought advice and requested Dr. Richard Mead (1673-1754) for recommendations based on

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scientific theories. Mead's *Short Discourse Concerning Pestilential Contagion, and the Methods to Be Used to Prevent.* It was the first scientific medical literature used systematically in the legislation (Zuckermann, 2004). However, the first systematic legislation targeting merchandise, passengers and crew was the Levant Trade Act passed in 1752. Vessels coming from a plague-stricken Eastern Mediterranean had to perform their quarantine with cargoes opened and aired properly in safe Mediterranean seaports such as Venice, Messina, Malta, Leghorn, Genoa or Marseille.
While seaport quarantine was a primary prevention (as mentioned above), isolation (also in literal sense of the word) was a circular separation of prevalent foci within the country for other inhabitants endangered by the same epidemics. However, isolation was imposed also within the 18th century quarantine stations, which operated a more developed two-tier inner system. Thus, men diagnosed with definitive symptoms of plague were isolated imminently from other quarantined people and when deceased they were buried in a separate cemetery of the station.

In classic types of isolation, sporadic inland cases as emerging foci of epidemics were encircled as early as possible by armed guards named as sanitary cordons. Isolation was performed in very confined locations (which might have been a single family house in rural circumstances). Nevertheless, isolation was different in urban and rural environments. In rural areas a military cordon was set up and the military administration performed all necessary measures. People were forced to stay at home and all community events were prohibited. Dogs, cats and other animals, especially those in poultry farming were killed for they were believed to be the main vectors of plague according to contemporary medical doctrine.
Municipalities were isolated by their own authorities. A typical central European guideline prepared in 1771 demonstrates the measures executed (Torkos, 1771). The author, who graduated as a medical doctor in Halle a Prussian university, discussed the topic in three sections. The first section was about measures outside the town practiced by commissioners of the magistracy. Long distance travelers and goods were permitted to enter the town only if they were provided with a bill of health issued by the quarantine station on the state border. Men with an authentic bill of health, but apparently ill at the control, were not admitted. Based on humanitarian considerations, seriously ill travelers were allowed to stay in a separate house built outside of the city walls.
The second section of the guidelines focused on managing local epidemics. Infected persons were isolated from healthy people and, if a patient died, all bedclothes were burnt and the corps was laid in coffins closed imminently and buried deep in the graveyard. As an individual preventive measure, everybody had to keep a clean house against putrid exhalations and to burn aromatic substances. It was a remarkable recommendation that individuals should change frequently their underwear. Ill patients were treated to "draw the miasma into the lymphatic glands" and to promote local suppuration. The last section dealt with social welfare for indigent people specifically providing care for those unable to afford medicine. They were to be treated free of charge and all the costs were covered by the magistracy.

Timetable of the Austrian continental application

Although the Austrian monarchy was present from the end of the 1300s in the northern Adriatic region, the rulers were never interested in becoming a sea power and take part in the

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Mediterranean trade business. Trieste (the main navy base and commercial port of the monarchy until 1919) was declared first as a free port in 1717. However, the public health administration ignored quarantine measures until 1725 despite the outbreak in Marseilles in 1720. After 1725, Vienna seized control over all quarantine innovations of Venice and other Mediterranean towns in favor of mutual continental commerce. During this time, Charles VI (1711-1740) mandated the Sanitary Court Commission to erect seaport-type quarantine stations on the state border from the Adriatic Sea across the Balkans to the Eastern Carpathians.

Although mainland quarantines were theoretically feasible, their effectiveness depended upon geographic conditions and strict law enforcement. For example, controlling travelers and merchants with their goods was relatively simple in the plains with Border Rivers, which separated the two big powers. Everything that passed through these main trade routes was declared *ex officio* suspect of infection because travelers and merchants lacked any kind of formal documentation. Nevertheless, the same methods turned out to be illusory in the high mountains of Transylvania. Traditional smuggling was booming along hidden paths, which by-passed the "time consuming" quarantine stations. Due to lack of absolute discipline and uniform enforcement, a countrywide epidemic spread between 1738 and 1744 in the Habsburg ruled Transylvania and Hungarian Kingdom. In response, legislation introduced martial law in 1738. Members of the public health service, noblemen and common people were threatened by death penalty if they violated public health regulations. Additionally, everybody faced the same punishment if they were only concealing infected patients and the deceased.

In an effort to avoid another great epidemic, the Sanitary Court Commission proposed new legislation. The ideological backbone of the new era was the "interests of the State", the "protection of subjects" as maxims of Enlightened Absolutism, which developed first under queen Maria Therese (1740-1780) in the Habsburg House. Enlightened European rulers promoted public education and public health to enable subjects for new experiments in agriculture and industry, and to protect them as a source of economic and military power from devastating epidemics. In order to oversee and unify all regulations in health affairs, Maria Therese appointed a new Sanitary Court Commission in 1753. The chief medical adviser and also a member of the Commission was Gerard van Swieten (1700-1772) a pupil of Herman Boerhaave (1668-1738) who became a personal physician of Maria Therese in 1745. His most powerful position in academic sphere was the presidency of the medical faculty of Vienna University created for him personally in 1749. Supervising the dean of the faculty, van Swieten executed all absolutistic measures of the Court while modernizing the medical doctrines and public health legislation. After a relatively short period of preparation, the first comprehensive public health decree "General Rules and Instructions of Public Health Authorities to be implemented on the Austrian Coasts" was issued in 1755 (Linzbauer, 1852-61, II. pp 683-716). This decree was referred to as a "Regulation of Trieste" after the main port of the Adriatic provinces.

The next step was the revision of criminal law pertaining to public health. Numerous decrees followed the original "martial law" legislation in 1738 and were unified in a comprehensive decree issued in 1766 (Linzbauer, 1852-61, I. pp. 771-775). According to the title, perpetrators of quarantine regulations must be hanged by the neck till death. Legal procedures under martial law ended with the same "democratic" outcome for common people, officers and noblemen respectively. By this extreme strength of jurisdiction, the Monarchy overcame even habitual corruption of state and local military and civil bureaucracy.

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By the end of the 1760s, the Sanitary Court Commission began to evaluate systematically day-to-day experiences in maritime affairs and the effectiveness of methods applied to continental circumstances. This evaluation resulted is a series of amendments, the most important of which (Trieste Amendment) was issued in 1769 titled "Regulations of Public Health Policing and Economic Order for Lazaretto and Dirty Port of Trieste" (AVA, 1769). The Sanitary Court Commission assumed control over the latest regulations of Venice and the most important seaports of the Western Mediterranean region (e.g. Leghorn, Geneva and Marseilles). Finally, the General Norm of Health Service (GNHS) as a comprehensive code was issued in German (Linzbauer, 1852-61, I. 821-871) and in Latin (Linzbauer, 1852-61, II. 535-571) on the 2 January 1770.

Why the quarantine procedures succeeded?

The essential function of quarantine stations was to break the plague cycle by separating infected fleas from rats and subsequently killing them. The plague in maritime transport could enter the county in three ways: passengers and crew carried around infected fleas on their body, fleas were hiding in merchandise, infected rats escaped from ships and invaded the country. Empirical quarantine measures were a perfect fit based on the biomedical nature and spread of bubonic plague. Provided that all manipulations were carried out without any compromising, plague proved to be preventable by special observational and purification procedures.

Regarding contemporary understanding of how plague was spread, scientists were divided into contagionists and non-contagionists throughout the 18th century (Zuckerman, 2004). Scientific doctrines also emerged in the legislation as in the GNHS 1770. According to this law, the plague agent was a "contagion", which spread via contaminated persons, animals, commercial goods and specific items (e.g., coins, letters, and personal belongings). The GNHS explains the contagion's nature in a specific context while treating susceptibility of commercial goods: "Goods are to be reputed as susceptible, if they are able – after having received effluvia out of infected objects – to communicate emanation of the contagion, while other goods are said as non susceptible, for they are incapable of this communication. Empirics as the best teacher of mankind shed a bright light on objects being immune against a spreading contagion, and their catalogue was published soon by more European nations, which evaded the plague by wise regulations …" (Linzbauer, 1852-61, II. 555). The full list of free goods with 154 items was first published in the Regulation of Trieste 1755. Related to this original definition, contagion seemed to be an airborne particle driven by a specific force of radiation. Without question, different goods should have had different epidemic characteristics by their ability to take over and carry on contagion. Based on the definition above, it is clear that the Sanitary Court Commission avoided the details about discussed scientific theories. However, there is no mention about corrupted air and other non-contagionist ideas.

According to the modern microbiology and entomology, contagion has to be identified as the oriental rat flea *Xenopsylla cheopis*. This main vector flea can leap to a height of 65 mm and a length of 180 mm (WHO, 1983). It explains the safe distance of protection to be kept from contaminated objects, animals and patients, but the vector born way of spreading ruled only the bubonic cases. Regarding Europe's great plague epidemics with an immense death toll and weighting all biological and social factors, it seems to be inevitable that those epidemics

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must have been caused by droplet infection spread by secondary pneumonic patients. Nevertheless, there are serious concerns questioning either bubonic or pneumonic origin of these devastations (Twigg, 2003). Although, our present knowledge about human-to-human transmission is incomplete, pneumonic epidemics occur typically in cool climates with moderate humidity and close contact with infected persons (Worsham, et al. 2007). *Yersinia pestis* as a causative agent is not a truly airborne microorganism. Face-to face exposure to racking cough of severely ill patients may explain the extreme lethality of European epidemics. The well-known medieval mask of plague doctors in the shape of a bird's beak must have provided sufficient protection at least from the droplet infection.

To the success of quarantine contributed also the fact that fleas do not infect each other and their reproductive organs remain free of causative agent, consequently there is neither transmission from flea-to-flea nor intergenerational transmission. As a result, fleas alone separated from infected rats cannot maintain the plague cycle (Perry, Fetherstone, 1997). In seaports, ships qualified as clean or suspected were quarantined outside of pier, but dirty ships, if processed successfully; lay off the harbor outside of swimming range of rats (maximum 400-600 meters) (Internet, 2008). If seaport authorities compromised this distance, rats might have broken the seemingly perfect quarantine measures. As an ideal hiding place for fleas, the most dangerous goods were bales of wool, cotton, flax, and silk, respectively and all textiles made out of these materials. Another typical materials were raw furs in bales or used as dress decoration. For example, there is a registered case of a lady in minutes of the Sanitary Court Commission. She was quarantined for 37 days when she wore a "purified" dress decorated with fur. Soon thereafter, she was taken ill with plague and died in several days (HHStA, 1764). It was apparently a hyper-acute case experienced often in quarantine stations.

Commercial goods avoided by fleas (e.g., all kind of grain, wooden and metal wares) required only a quick purification, even if the whole ship was "suspected". For example, wheat was passed through a sieve only to separate it from "bad" materials (little piece of paper, string etc.). All rests of packing materials were thought to be susceptive, i.e. they may have hidden *Xenopsyllas.* After this quick "purification", goods were released for waiting agents of inland transport companies. Commercial concerns were always important in quarantine regulations, weighing the loss of trade against the number of possible victims. Thus, selective periods for different merchandize outside of the most dangerous goods were determined rather by commercial interests than medical theories. The case of dried tobacco leaves was a typical example. If bundled leaves were spread out and aired through 7 days, they were perfectly purified and released for inland transport.

In special cases, rigorous rules were compromised, when unpacking of goods would have been very complicated, e.g. raisin in great linen sacks. There were applied fantastic manipulations: sacks were cautiously cut and tarred only on four edges. Goods to be unpacked easily and wrapped up in suspicious materials (e.g. ropes, cords, straps, paper, and sacks made out of flax, hemp or horse-hair), were opened under supervision of director of the station. Wooden barrels and other washable containers were processed with pure cold water, but ropes, cords, straps, wrapping paper, and sacks out of flax, hemp and horsehair were burnt immediately.

Beyond susceptibility and non-susceptibility, legislation took into account the third category, i.e. goods emanating special anti-plague "power": "Some people guess that aromatic materials in itself have a power, which may purify the whole packing, consequently these goods can pass the station without any processing, another people are thinking the same of victuals,

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metals, wires of iron, and salted fish, however We insist on general precautions, consequently these goods have to be issued only, if all susceptible parts of packing were being removed, retained, and separated"(Linzbauer, 1852-61, II. p. 557).

Aromatic substances (e.g., exotic spices) were generally believed to deter the plague. Although one could argue that aromatic substances would deter the plague from materials used in their packaging, the GNHS still required that spices wrapped in suspicious material demanded the same treatment as other non-aromatic substances. Today, it may be judged as a symbolic measure, but it is a physiological fact that fleas avoid many aromatic substances. Additionally, it was a common experience in the past centuries that stable boys in day-to-day contact with solid-hoofed animals (typically horses) were more protected in plague epidemics, compared to the general population. As the saying went: "horse-blanket guards against the plague." (Makara, Mihályi, 1943). Although, it was never proven scientifically, the smell of horses absorbed in blankets might have deterred fleas.

While manipulating commercial goods and specific items (e.g. personal belongings), fresh air and sunshine were used as an active agent. To understand the effect of this measure, it is important to note that fleas separated from rats will die when temperatures drop to less than 10^0C or rise more than 40^0C combined with low relative humidity (less than 70-80%). According to the 40 days periode, it is proven that even at favourable temperatures (between 10^0C-40^0C) and even an uninfected but unfed *Xenopsilla* will die within 38 days (WHO, 1983). Infected fleas would have survived under favorable climatic circumstances when transported in goods by land (e.g., in fur by caravans) and by merchant fleets (e.g., in bales of wool or cotton). Sea vessels provided livable accommodations for rats, fleas and humans. Moreover, ships moved faster than contemporary land transportation (e.g., camels or carts). Unfortunately, medieval and early New Age armies moving slowly with their very poor hygienic culture provided an ideal environment for a large associated commensal rat and mouse populations. For example, campaigns of the Ottoman Empire started in Istanbul to Central Europe (a distance of about 900 miles), reached only within 6-8 weeks the northern Habsburg provinces (Cartledge, 2006).

There is no doubt that the staff employed in quarantine stations had close contact with infected passengers, goods, animals and specific items (money, letters, and personal belongings) and were exposed to be infected repeatedly. Direct contact or even its suspicion named as commixing was declared imminent, when somebody "got in physical touch with persons, animals and goods out of prohibited provinces." (Linzbauer, 1852-61, II. 549). Nevertheless, even this direct contact was unavoidable while servants were performing purification as a special proceeding of goods in stores of the quarantine. Therefore they were enclosed in the same stores for the whole period of purification. The most important issue was manipulating "susceptible" bales of wool, cotton, flax and silk. However (avoiding multiple fleabites and delayed reaction of servants), lawmakers prohibited sleeping on these bales, which must have been a desirable option among staff members, who were isolated in storehouses. Nevertheless, the GNHS apologized for this prohibition and praised these men's service that they have performed very useful deeds for the whole society. Complete unfolding of bales would have been the best solution, but it was not realistic because of the confined space in storehouses. Hence, bales were opened on the top, laid in horizontal position and to achieve sufficient air penetration, servants put their nude arms into the bales to make the material loose and permeable. Stressing nude arm in legislation was an excellent example of successful empiricism for hiding fleas jumped on the skin of public health servants. While killing them, servants have completed the "fresh air effect" of purification. It must be

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emphasized that in Central European military bases, the so-called "barrack method" was practiced to extinguish fleas as late as the beginning of the 20th century. A barefooted soldier walked along the floor and at the end he killed the fleas jumping on his leg (Makara, Mihályi, 1943).

Other personnel had to keep safe distance from every possible source of infection (e.g., at medical inspections, church service, catering, security control). Unfortunately, there is no exact measure of "safe distance" in the GNHS or any other legislation regarding the most dangerous activity, i.e. medical examination. The rules must have been kept by oral tradition when quarantine surgeons inspected nude passengers at reception and later on each subsequent day until discharging. However, safe distance inspection was not a sophisticated diagnostic activity. Only buboes (enlarged lymphatic glands) were looked for in the groin or the armpit of nude persons. Questions emerging today about this inspection may be answered by the section 39 of the Trieste Amendment 1769. It is the only one site that went into details by classifying males and females, men of lower and higher social status: "people on the ship should appear before the public health doctor on the breakwater to be inspected under usual circumstances, ladies and the captain excepted, who are allowed to be touched only on the usual parts of their bodies" (AVA, 1769). "To be touched" is a clear definition of physical contact with dressed persons, but experts and members of the Sanitary Court Commission overlooked it without any further explanation. Sometimes, it was unavoidable to examine apparently ill patients by physical contact too, but in this case the surgeon or a doctor had to be quarantined the same way as the actually enclosed population.

As in every infectious disease, natural immunity has to be taken into account among those who survived plague infections. Long-term members should have acquired natural immunity to survive repeated contacts during this day-to-day activity. Without this, rapid decrease of natural immunity over time may explain the return of epidemic waves in 2- to 5-year cycles (Drancourt, Raoul, 2002). Recently, the relative high frequency in Europe of the HIV-1 protecting allel CCR5-Δ32 was considered among others as an indirect evidence of parallel past protection against *Yersinia pestis* infection (Nagy, 2006). Nevertheless, the latest results among the Central European population indicate that the origin of this high frequency has to be traced back before the Black Death of the Middle Ages (Zawicki, Witas, 2008). According to the staff of quarantine stations, it is remarkable that even young adult men were at greatest risk becoming victims of plague infection among the general population (Ell, 1984). Unfortunately, there are no data in Habsburg archives about staff members' mortality in quarantine stations. Servants manipulating the most dangerous goods may have been immunized by mild plague infections, or must have died shortly after being employed in the public health service. However, it is documented that surgeons were most frequently in dangerous contact with suspected persons. In 1765, the Sanitary Court Commission in Vienna proposed via Chancellery to the queen (Note to the Court Chancellery with Minutes of the session of Court Sanitary Commission on 1 September 1765) to employ a second surgeon in pre-quarantine stations, because "it is contrary to the public health prescriptions, that the surgeon, who examines persons just arrived *per visum et tactum* has also to make the same way examination of people discharged on the same day… therefore it is reasonable to request another surgeon to be employed, additionally, two surgeons may deputize each other if needed or deputize also the supervisor of purification." (HHStA, 1765).

Processing persons, personal belongings and animals

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Except the free qualification of merchandize, there were only two traditional spans with 7 or 40 days in seaports for clean and suspected cases by the 1700s. Having a clean bill, passengers and crew could leave the ship and were immediately transferred to the seaport quarantine station. People deemed of higher standard by personal hygiene became free of fleas by a simple measure: "if passengers, the skipper or the owner and the ship's clerk strip to the skin and take on new uninfected cloths, they will benefit 5 days out of the *quarantana*, consequently they may be released 5 days earlier. There is no benefit for common sailors by any reasons. Notwithstanding, 5 days benefit is due also for officers of the Royal Navy and Commercial Fleet as well." (Linzbauer, 1851-62, II. p. 691). In case of the 7 days quarantine, only 2 days of observation were required. Because ships functioned as virtual pre-quarantine stations, provided that there were no suspicious signs detected on board, there was little risk in releasing people after two days observation. Of course, people had to spend 40 days under observation, if they were qualified as suspected.

Catering was a crucial hotel service problem in all quarantine stations. Travelers and businessmen, who had to pay extra for meals, were allowed to buy provisions from outside of the quarantine. The mood of this transaction is detailed in the Regulation of Trieste 1755: "transfer must be carried out with a basket fixed at the end of a long rod, but money paid for food can only be taken away, if it was washed in vinegar or salt-water." (Linzbauer, 1851-62, II. p. 707). Fifteen years later, the GNHS increased security at purification of coppers and silver (or gold) coins by washing them in boiling salt-water. Furthermore, if there was a real danger of an epidemic, money was purified in a boiling vinegar solution. The Bank of Vienna issued paper money as of 1762 in five denominations (5-10-25-50-100), but it was used only sporadically in international trade.

Personal belongings as documents, letters, clothes or other specific items were considered to be very dangerous. Undergarments were washed immediately, while over-clothes were permanently hung out in fresh air. Valuables were allowed to be kept by owners and treated as confidential. For travelers and merchants isolated in a separated facility, a personal guard performed the purification. Papers were smoked by burning sulphur, but in case of imminent threat documents and letters were opened and steamed by boiling vinegar solution. Commercial letters containing samples qualified as extremely susceptible were treated separately. Samples were removed and purified as goods of the same sort. The best example of sophisticated empirics was the proceeding of weapons. While entering the station, arms were taken away for security reasons. Being made out of metal and wood, they were classified generally as non-susceptible. Nevertheless, some parts of weapons (e.g., scabbards) and cases of firearms were made out of susceptible materials. Therefore they were separated and purified as leather wares and textiles of the same type.

Regarding animals, the GNHS had no previous classification that could be adopted from maritime legislation. Keeping of pets on board by crewmembers was usual and sometimes exotic animals were transported for spectacular events. These animals had to be secured in seaport quarantine stations as ordered in chapter 4 of Regulation of Trieste: "wild animals and all other species must be chained up and—for sake of greater security—have to be kenneled or closed in separated cages" ((Linzbauer, 1851-62, II. 690).

Animals in continental trade and transportation provided serious problems. Carts arrived with draught animals (oxen or horses) at the quarantine stations. Draught animals were stabled and separated immediately in quarantine stations. Additionally, livestock to be slaughtered was being imported. Livestock out of non-infected neighboring provinces were flushed in cold water as one of the best protective agents. Animals were driven against the stream at shallows

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of Border Rivers, but this method was followed only for short fleece or shorthaired ones. Fleas may have survived on long fleece animals hence this simplified procedure was forbidden e.g. among sheep the most frequently imported species.
Stray animals were also crossing the border. They were suspected to be the main vectors of spreading infection. Therefore, if a sentry at the gate of the quarantine station became aware of stray dog or cats, he was ordered, "to drive them away, and failing this to shoot them." (Linzbauer, 1851-62, II. 707). There were pets of passengers, the director and other officials. While keeping pets, staff members faced hard disciplinary measures: "directors and other officials are not allowed to keep birds, cats, and dogs unless closed or chained up; otherwise these animals would enter the closed area of the station." ((Linzbauer, 1851-62, II. 562). Free birds were also condemned to spread plague, but it was technically impossible to keep them away, subsequently there is no regulation about them in any legislation. Finally, rats were never mentioned in any decrees.

Quarantine periods and measures discussed for continental conversion

According to the maritime regulations, 40 days was only a terminal stage of the quarantine. It was preceeded by different time consuming procedures. In suspected and dirty cases, the cargo hold remained closed first and only men's personal belongings in chests were brought up to the upper deck, opened, observed and exposed to the fresh air until the 3rd or 5th day. Afterward men with personal belongings were brought to the quarantine station. The next step was the so-called pre-purification, i.e. the hold was opened and the most dangerous goods were placed on the upper board, unwrapped and manipulated on the fresh air. It lasted at least 10 or more days, while rats remained on the lower decks or were killed by servants of pre-purification. If the cargo needed more place than the whole board surface, purification was repeated in 10-day intervals. Objectively, these manipulations served the radical deratting and killing fleas by low fresh air temperatures. Having finished the whole procedure, goods were transported to the stores of the port quarantine and it was the starting point of the 40 days quarantine.

Today, it is trivial that among people, separated definitely from every possible sources of infection, 40 days exceeded even the longest span (2 to 8 days in bubonic plague) between inoculation and the first symptoms. It means that 40 days were never needed to confirm the disease among people with possible infection. Manifestations, which occurred after 8 days in quarantined populations, must have been due to cross-contamination with people admitted later to the same facility or as a result of contact with contaminated goods transported.
Experiences in continental circumstances clearly demonstrated that the simple 7 and 40 days model was insufficient against the spread of plague epidemics. Indeed, the failing pre-quarantine function of ships that were isolated during the journey and on the other hand lacking the possibility of anticipated purification on the ship's upper board required more sophisticated measures. However, the Habsburg administration endeavored to raise analogous facilities on the most dangerous sites of the border crossings. Modeling the upper deck of ships, pre-quarantine (so-called dirty) stations were planned at a safe distance from the main station. Unpopulated islands of Border Rivers were preferred for these facilities, but all measures were realized imminently as an action against the status quo in Istanbul. As a result of an exchange of diplomatic notes, all preparation for construction were stopped e.g. on an

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unpopulated island of Danube and the original circumstances restored in 1757 (Kriegsarchiv, 1738-1775).

Since travelers and merchants with their goods out of oriental regions were all the time suspicious, the Habsburg legislation used never the 7 days period in continental circumstances, but 7 days served as a general unit of multiplication to determine periods of 21, 28, and 42 days on the Turkish border. Merchants and travelers fell *ex officio* under 21-days detention. This basic period was increased to 28 days, even if the slightest sign of real threat occurred and 42 days were ordered at once, if virtual plague foci were verified somewhere in neighboring Turkish provinces. Nevertheless, the spirit of mercantilism faced the greatest challenge when there was a general epidemic on the other side of the border. There were only two options: (1) to close the border stations and order military cordons with soldiers shooting every men and animals without warning when they attempted to cross the border, (2) increase periods to 84 days in quarantine stations. Discussions culminated during the preparations of the new comprehensive legislation (GNHS) in the 1760s. Finally, public health decisions were compromised with gains and losses of the mutual commerce. The problem was discussed repeatedly in the sessions of the Sanitary Court Commission. In a special session on 11 November 1764 members of the Commission proposed to the queen the general implementation of 84 days period instead of total disruption of the commerce. A single physician councilor while arguing for 84 days, compared Venice and the continental borders of the Habsburg Monarchy: „There is no absolute security in public health affaires and to compare the situation here with that of Venice has not to be allowed for – let alone the fact that every country has the freedom to determine ways and means of its own security – the diversity of precautions needed is plausible because of the different geographical situations. Venice is surrounded by sea, but our country lies in a continental environment, which is more promoting for spreading the contagion. Consequently, here we need more accurate purification and more rigorous implementation." Finally, the chairman pointed out the most serious problem in the north western part of the Balkans: "provided that 84 days would be accepted, it had to be implemented generally on all border sections, nevertheless, invasion of plague has less to be feared in the Hungarian Kingdom, Croatia, Slavonia and Transylvania than in the coastal region from provinces of Venice, because as a result of the very poor public health situation in Venetian Dalmatia the contagion may creep in the Imperial-Royal Hereditary Provinces with the most devastating consequences" (HHStA, 1764).

The chairman's summary, while accusing Venice, emphasized clearly the different attitudes of the two powers. Venice was interested only in the maritime business and neglected health issues of continental provinces. Opposed to this behavior, the Habsburg monarchy was developing and strengthening both types of measures in disease control and prevention. In subsequent years, the Commission discussed repeatedly the span of epidemiological detention. Finally, the legislation rejected the 84 days quarantine, but it proposed to add extra two weeks to the 42 days period for purification of susceptible goods if there was a real threat of plague from the other side of the border.

In plague free years, the most serious problem of dogmatism was to manage local commercial contacts between people living close to both sides of the border in plain agricultural regions. Additionally, the army was also supplied with products of the local agriculture. Experience taught that epidemic patterns of long-distance trade might have been waived in this geographical situation, but to maintain epidemic vigilance among people was a crucial issue at the same time. Therefore, local trade was separately regulated outside of quarantine stations and supervised by military guard in special open-air exchange facilities. These stations were

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located on the borderline confined by 7 feet high wooden fences. Separated entrances were built on each side of the border. Buyers and sellers were supervised by an officer sitting in a box within the station. Sellers placed first the ware on low wooden tables and left. Then the buyers approached the table, took away the ware and left money. Trading was restricted to provisions specified as non-susceptible, along with crude iron, other metals, and millstones.

Conclusions

During the Black Death, European authorities endeavored to curb plague epidemics by very strong, sometimes draconian regulations. Sophisticated methods of disease control named as quarantine were developed first by Venice and Ragusa in the Adriatic region of the Mediterranean. As a result of maritime quarantine measures, the British Isles and Western Europe became plague free despite enormous devastations in Central and Eastern Europe throughout the 18th century. From the 1750s, the only exception was continental regions and provinces governed by the Habsburg monarchy. Because there were no significant differences in the natural environment, it is reasonable to conclude that the special health policing methods saved the economy and the population. It is well documented that public health authorities converted seaport quarantine regulations word-by-word to the continental circumstances. In light of the modern epidemiology, empirical methods targeted exactly the critical points of bubonic plague dinamism. These methods, if coupled with relentless and professional bureaucracy were able to provide full epidemiological protection.

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