

Empiric physiology in epidemiologic doctrines of the 18th century, Hungarian General Norm of Health in 1770

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According to standard textbooks, the last episode of European New Age plague pandemic died out by 1720 in Marseilles. Despite this allegation, the pandemic continued in well-documented new outbreaks, which attacked and devastated Central and Eastern Europe throughout the first half of the 18th century. At the beginning, military campaigns spread the infection out of the Ottoman Empire. Later on commercial goods took over this role via land or sea from Asia or out of the eastern Mediterranean region. Finally, the plague in Europe – except Russia and the Ottoman Empire – “died out” virtually by the end of the 18th century. Explaining this, there many scientific reasons were suggested: 1. Oriental rat fleas as main vectors of infection could not tolerate any more the European weather conditions (although there were no virtual climate changes in the last 300 years). 2. Black rats that lived in close proximity to man, were being outplayed by brown rats living rather outside of human habitats; 3. There emerged less virulent *Yersinia* strains that caused natural human immunisation. In spite of these suggestions, which may have contributed to the success, joint civil and military health authorities blocked the plague indeed, as a result of disciplined and relentless law enforcement. In Hungary, respectively in the Hapsburg Empire, well-advised health legislation backed up the effectiveness of local authorities. Following the last great devastation in 1738–1740, the General Norm of Health Service – a voluminous decree – summed up by 1770 all the time honoured empiric rules of foregoing centuries. It can be excellently demonstrated, how exactly the empiric rules discovered a century later met scientific facts of physiology and microbiology.

Keywords: plague in the late 18th century, professionally advised health legislation, relentless and successful health authorities, excellent empiric law enforcement, scientific facts of physiology and microbiology

Successive waves of plague epidemics came all the time out of central Asia or the eastern Mediterranean region via military campaigns or transport of commercial goods

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by sea or land as well. Looking back to the 18th century, it is hard to say that the so-called Black Death pandemic died out in Europe by 1720. Indeed, this year was the last outbreak in Marseille spreading to the surrounding area. Undoubtedly, it was the last manifestation of Black Death in Western Europe and the western Mediterranean region (1). However, Central and Eastern Europe suffered further on from returning plague epidemics. Without any doubt, these epidemics were subsequent links in the chain of outbreaks devastating Europe from 1346 up to the end of the 18th century.

There are many factors mentioned in the medical literature, which may have contributed to dying out of the plague. In scientific terms, these factors are of biomedical nature. No deliberate contemporary societal actions were ever appreciated to be successful against this infection. Nevertheless, it can be proven that well-advised state legislation, appropriately organised health authorities, and empirically justified law enforcement mastered eventually the situation in Central and Eastern Europe, respectively in the Hapsburg Empire. Undeniably, law enforcement operated under the threat of death penalty both for civil servants and the public. If anybody committed anything that was qualified as a negligence or deliberate action which spread epidemics, he or she was sentenced to death and imminently executed (2).

Biomedical reasons and considerations

An unmistakeable sign of plague in humans is a bubo (painful local lymphadenopathy, usually in the groin). Infection in this so-called bubonic form is transmitted by fleabites from rodents' fleas (first of all those of rats) to the man's lymphatic system. All great epidemics in Europe spread the flea species *Xenopsylla cheopis*, brought forth on infected shippers in the Mediterranean Sea transport, whose fleas bit also sailors and passengers as well. Alternative form of disease is a septicaemic plague that may develop from untreated bubonic form, or even may be the immediate stage after a fleabite, when infection by-passed the lymphatic system. Development of plague pneumonia is second to bubonic form, if patients outlived the hyper-acute septicaemia. This pneumonia is responsible for human-to-human spread by droplet infection which ends up in primary pneumonic plague, the most severe and mass manifestation of the Black Death as well.

Scientific theories about declining of plague in Europe focus only on biomedical reasons, i.e. natural reservoirs and ways of transmission. Among them, it is a rather vague idea that the oriental rat flea could not tolerate any more the European weather conditions (3). However, there were no significant climate changes in the last 300 years in this part of the world. It seems to be more likely that black rats (*Rattus rattus*) having lived in close proximity to man, were being replaced by brown rats (*Rattus norvegicus*) which are living rather outside of human habitats (4). Additionally, it is a mere speculation that less virulent *Yersinia* strains have emerged since the third decades of the 18th century which caused natural immunisation (3). Unfortunately, there are no societal factors mentioned in the literature that may have had impact on epidemic

patterns. It is a rather curious idea that flea density on humans decreased as the use of soap became more widespread (3). Undoubtedly, achievements in personal hygiene changed the societal circumstances, but it was not a deliberate action of society directed to curb or even prevent plague epidemics as well.

Successful societal actions

Rulers of the Hapsburg house issued many plague decrees in the 1600s and 1700s. However, the first rule concerning systematic law enforcement came out under Ferdinand III (1637–1657). Of course, it proved to be ineffective without a proper infrastructure and well-disciplined policing forces. Following similar subsequent decrees, there was a devastating plague epidemic in 1715 in all hereditary provinces. It broke out in the midst of military campaigns against the Ottoman Empire. Hungary was the main area of land operations since 1686, and in the meantime (1703–1711) broke out the long-lasting Rákóczi freedom fight, too, with returning waves of epidemics. After a relatively short period of socio-economic consolidation, another great plague epidemic (1738–1740) devastated the country. Nevertheless, a stringent and successful health policy kept it away from all hereditary provinces. The Hapsburg legislation and professional civil service transformed all time honoured experiences – gained in the northern Adriatic sea-ports – to continental circumstances. Based on this success, the line of defence was being moved further to the southern and eastern provinces of the Empire. Finally, a huge military health service was set up on the 800 km-long border on the Balkans, which protected also the Hungarian Kingdom. Thirty years later in 1770, queen Maria Theresa (1740–1780) issued a comprehensive decree titled General Norm of Health Service (5). It was enacted on the 2nd of January in all hereditary provinces, and nine months later in the Hungarian Kingdom, too, exactly on the 4th of October (6). In the last third of the 1700s, a new sanitary cordon functioned excellently from the Adriatic Sea to the eastern Carpathians. Special vulnerability of this seemingly perfect system – with quarantine houses on border crossings of main commercial roads – became very clear when the first campaigns started in the war between Russia and the Turkish Empire (1768–1774). Threatening local outbreaks were reported out of Poland, and the Hapsburg Empire set up a brand-new sanitary cordon adapting exactly the methods that were laid down in the General Norm of Health Service (7). Eventually, in 1772 developed a large plague epidemic in Poland, which claimed a death toll of more than 250,000 people. However, there were only isolated cases in the neighbouring north-eastern parts of the Hungarian Kingdom. Successful implementation of rules in the General Norm was an excellent proof of victory over the plague. It was based on excellent empiric knowledge of physiologic conformities before the era of scientific epidemiology.

Medical doctrines and principles of protection

Legislation of Hapsburg Empire produced the first comprehensive public health regulation for Adriatic Maritime Provinces (MR-1) in 1755 (8). A year before the General Norm, it was updated (MR-2) using the latest experiences gained in Venice and the western Mediterranean region (9). Wording of both decrees is available in German and Italian in Austrian Archives in Vienna. The General Norm of Health Service (GN) mentioned above, analysed all maritime experiences and converted them by a genuine innovation to continental circumstances.

Decrees of that time were not designed in exact legal wording of modern legislation. Lawmakers – in the name of the sovereign – argued with historic, scientific, common sense reasons, explanations, and justifications not only in the solemn preamble but also throughout the whole context. As a consequence of this technique, basic biomedical principles of spreading infection are laid down, e.g. in the midst of the decree, in section 18, chapter 2, part 2 of the General Norm: “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...” As the quoted section shows, the legislation was very cautious. There is no statement about a possible nature of contagion; it seems to be rather a kind of radiation, than an airborne particle. Understandably, lawmakers had no intention to favour a specific medical point of view among those which emerged in the contemporary scientific discussions. Instead of this, experiences of wise European nations were stressed, referring to the catalogues of commercial goods in maritime transport.

Beyond wares, there were persons, animals, and specific items (money, letters, and personal belongings) too related to the infection. Of course, persons were susceptible and they were able to spread the plague (according to the contemporary doctrine) by a close contact defined as commixing. Its definition and treatment in the decree: “commixing or even suspicion of that must be treated in each subsequent event by a regulatory sanitary procedure, e.g. if somebody got in physical touch with persons, animals, and wares out of prohibited provinces” (section 5, chapter 1, part 2 of GN).

The problem of animals at all, was very different under maritime and continental circumstances. There are in the decree no clear categories. Nevertheless, four different groups may be identified: draught animals, other livestock, pets, and stray animals. The first group occurs only under continental circumstances. Different draught animals, when stabled separately in quarantine stations needed no further special treatment. Other livestock out of non-infected neighbouring provinces, had to be flushed while driven against the water stream at shallows of rivers on the border. However, this purification was only allowed, if animals were of short fleece or short-haired.

Pets (exotic ones too) of passengers were only mentioned in the maritime regulation: “wild animals and all other ones must be chained up and – for sake of greater security –

have to be kennelled or closed in separated cages” (MR-1 chapter 4). Keeping of pets by staff members was strictly regulated: “directors and other officials are not allowed to keep birds, cats, and dogs unless closed or chained up; otherwise they would enter also the closed area of the station” (GN section 41, chapter 2, part 2). According to the contemporary epidemiologic doctrines, stray dogs and cats were being condemned as the most dangerous vectors of plague infection. Therefore, if a sentry at the gate of the quarantine station became aware of straying dog or cats, he was ordered “to drive them away, and failing this to shoot them” (MR-1 chapter 14 section 11). Free birds were also condemned to spread plague, but it was technically impossible to keep them away, subsequently there was no mention about any specific protection. Finally, there is not a single word mentioned about mice and rats in the decrees. Although, rats as extremely harmful animals were killed with all means beyond the memory of man, but on ships and in quarantine stations nobody ever ordered to kill rats for epidemic reasons.

Personal belongings or other specific items – pre-eminently documents, letters, money, and packing material – were suspected to be very dangerous. Susceptible valuables were treated in confidential procedures. During quarantine they were kept by the owners. Each person spent the predetermined days in a separated house, and the personal guard of each passenger carried out the purification. Under-garments were washed immediately, over-clothes, among them those made out of fur were permanently hung out on fresh air (sec. 11, chapter 2, part 2 of GN).

Papers must have regularly smoked with burning sulphur, but in case of threatening epidemic, documents and letters were steamed by boiling vinegar solution. However, letters may have also contained extremely susceptible samples of commercial goods; therefore such samples were removed and purified as wares of the same sort. There is no mention about paper-money in the regulations. Nevertheless, paper-money has been issued since 1762 in the Hapsburg Empire, as banknotes of Citibank Vienna (*Wiener-Stadt-Banco-Zettel*) in 5-10-25-50-100 denominations. Coppers and silver coins (rarely gold) were not processed the same way as all other metal items. Instead of being washed in simple salt-water, money was washed in boiling salt-water. When there was a real threat of infection, money was being purified even in boiling vinegar solution. Arms of all kind were taken away for security reasons when passengers entered the quarantine station. Some parts of weapons were qualified as susceptible, e.g. scabbard and cases of fire-arms which were purified as other commercial goods made out of the same materials.

All kind of packing material was declared generally as susceptible. Nevertheless, there emerged serious problems of interpretation, if goods in the package emanated – according to the contemporary doctrine – a special power against the plague: “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, other people are thinking the same of victuals, metals, wires of iron, and salted fish, however We insist on general precautions, consequently these goods have only to be issued, if all susceptible parts of packing were being removed, retained, and separated” (sect. 26, chapter 2, part 2 of GN).

Catering was another crucial problem in all quarantine stations. Passengers – who had to pay for meals – were allowed to buy victuals too, which were sold by people coming from outside of the quarantine. Exact description of transactions is only laid down in the maritime regulation: “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” (MR-1 sec. 36, chapter 13).

The generally strong dogmatism was only reduced in favour of the local commerce in the border area. Geographically, the border between Croatia and the Turkish Empire was regulated in the General Norm. Local trade was allowed exclusively in times free of imminent danger of epidemic diseases. Supervised by military units – not by the otherwise competent quarantine stations – there were set up special open-air exchange places. Such a place was confined with circa 2 metre high fences carpentered out of wood with entrances on each side of the border. Crossing the border or entering at the same time for buyers and sellers was strictly forbidden. Trading was restricted to victuals specified as non-susceptible, further on to crude iron, other metals, and millstones. Sellers placed the ware on low tables and left afterward. Then came the buyers, took it away and left the money for it. Trading with animals happened outside of these places, but there must have been a river in a determined area. While selling draught animals, commixing of people was strictly prohibited too, and all parts of harness, especially horse-furniture had to be removed and withheld.

Time limits, sea and land specialities

Time span of isolation for persons, vehicles, transported goods, livestock and other items was a key issue of effective prevention. While converting the different maritime periods to continental circumstances, specific techniques must have been converted to the land transportation. Registration of departures, destinations, and daily events was a century old routine in sea transport administered both by skippers and port authorities. In sea ports there were four types of certificates issued for departing ships by authorities: free, clean, suspected, and infected. For the sake of completeness, domestic Navy was also regulated in domestic havens: “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 honour of the captain” (MR-1 chapter 2). Since epidemiologic qualification was a bilateral issue, there were also categories determined by the states of ports of destination. On this side there were three categories: free, suspected, and excluded, qualifying the port of departure and its background region. This bilateral system allowed, e.g. to declare a ship despite her clean certificate as suspected in the port of destination. However, it launched sometimes a long commercial war between states in the Mediterranean region.

Under continental circumstances – beyond technical details of feasibility – the main problem was a permanent commixing. On land routes there were men, animals, and wares all the times commixed with the environment, i.e. exposed to whichever infection. However, ships during sea-voyage functioned as an ideal pre-quarantine

station, provided they did not have any contact en route, which may have transmitted an epidemic disease. Consequently, skippers made a statement in the destination port about all contact that happened on high sea (other ships, pirates, shipwrecked people). The General Norm solved this problem by constituting a border zone, which was ex officio suspected in the neighbouring Turkish provinces.

Despite of sea quarantine counting, legislation applied a seven-day algorithm while calculating the periods. The shortest span was that of 7 days, and further periods were of 21, 28, and 42 days. Persons and goods arriving out of the Turkish Empire, fell ex officio under 21-day isolation. It was increased to 28 days, if the slightest suspicion arose, and 42 days were ordered, if plague was verified yonder in Turkish provinces. In the latest case, stations may have closed for an indefinite period, and the army shut down the border just hermetically. Sanitary cordons were set up with sentinels posted within sight and ordered to shoot down men and animals when attempting to cross the border.

While preparing the General Norm, the Court Commission of Public Health – according to the minutes of meeting on the 11th of November, 1764 – discussed the 84-day period of isolation. Royal Councillor von Zwennhoff presented a very characteristic point of view while arguing against the decrease to 42 days. Comparing Venice and the continental border, he said: “Here, the main difference against Venice is the geographic situation. Venice is surrounded by sea, but our country lies in a continental environment, which is more promoting for the spread of contagion. Consequently, here is needed more purification and more rigorous implementation” (7). Finally, the definitive version of General Norm rejected the 84-day isolation, but it prepared an artificial loophole in the context as it follows. If there was a plague epidemic far away in the Turkish Empire, quarantine was immediately increased to 42 days. According to the medical doctrine, infected cases became manifest within the first 20 days in the station, but patients may be treated and finally dismissed latest on the 42nd day. However, susceptible goods must be further on manipulated during the following 2 weeks. Personnel and passengers having had contact with these goods remained in isolation up to the 56th day. In the most dangerous situation, when there was an outbreak just in the neighbouring Turkish provinces “the period may be more extended”.

Quarantine methods

Within a quarantine station, persons of the same intake were also separated, in order to prevent any communication with one another and the personnel, too. They were locked up in ca. 10 m² single-room houses. Medical inspection was carried out first at the reception and later on each subsequent day until discharging. A surgeon looked at the nude passengers “from a safe distance”, which is not exactly determined in the 1770 regulation. A year before, the maritime decree went into details according to male and female passengers, respectively persons 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 felt only on the usual parts of their bodies” (MR-2, sect. 39). Sometimes, it was unavoidable

to examine the patients by physical contact, but in this case the surgeon or a doctor was closed up into the same quarantine as the examined person. Of course, then inspection was not a sophisticated diagnostic activity. Only buboes were looked for in the groin or the armpit, i.e. on “the usual parts of body” as mentioned above. Recovered persons were washed with vinegar solution; deceased were buried in a 1.9-metre-deep grave covered with quicklime.

Methods of purification of commercial goods were more sophisticated. According to the principle of separation, it must have been decided which ones were susceptible to the contagion, for susceptible items required major vigilance. In the maritime regulation 1755 and the General Norm 1770 too, there is an itemized list of free goods that need some quick purification, but no intake in the quarantine station (e.g. all kind of grain, wooden and metal wares, wax and sponge, etc.). Other goods on the free list, if packed in any kind of susceptible material (e.g. ropes, cords, straps, wrapping paper, and sacks out of flax and hemp even horse-hair) were transported in quarantine storehouses, where they were unwrapped in presence of the director. Packing material was usually burnt, and goods were set free immediately. Sometimes the rigorous rules were compromised, when unpacking would have been very complicated (e.g. raisin in great linen sacks). In this special case the sack was cautiously cut and tarred on four edges. The most dangerous goods were bales of wool, cotton, flax, and silk, respectively all textiles made out of these materials. According to the doctrine of purification, fresh air was the best agent, provided it penetrated the whole bale, which was only partially opened for technical reasons. In order to achieve this effect, servants had to put their nude arms every day into the bales to make it loose and permeable. Servants indeed, spent the quarantine in storehouses, but sleeping on bales – apparently a desirable option – was strict forbidden. In the relevant section even apologised the General Norm saying that servants however carried out a very useful service for the whole society.

Empirics and flea physiology

It is very clear at the first glance, that regulations of the 18th century met exactly the plague cycle, man of which was only an accidental host in the nature. Plague was preventable, if measures were set on successfully at the very beginning. It means the initial form of spreading only by fleabites. Opposed to sea transport, infected oriental rats as hosts of *Xenopsylla cheopis* could hardly have joined the carts of merchants or travellers across the Balkans. However, infected fleas may have done this in endemic regions, and survived in “susceptible” transported goods, pre-eminently in bales of wool and cotton. When carts arrived at a quarantine house on the border, infected persons – already with buboes in the groin or armpit – were simply detected by medical inspection. Keeping safe distance (e.g. at inspections, catering, etc.) was only effective, for *Xenopsyllas* – let alone the infected ones – can jump as long as 180 mm (10), and they do not leave the host, unless it dies and its body temperature sinks below the normal values. However, buboes manifest usually after a 1- to 8-day incubation period, but lymphadenitis may develop as late as by the end of the second week. Other

symptoms (fever, chills, headache, nausea and vomiting, etc.) were not characteristic. This way, infected but actually non-detected persons may have had close contact with pets of personnel, if pets would not have kept as ordered in the regulations.

Provided that nobody was ill at the arrival, infected fleas may have hidden in so-called susceptible goods yet. Without being infected, adult and unfed *Xenopsyllas* can survive for 38 days under favourable circumstances (11). Worldwide, they occur usually between latitudes 35° South and 35° North, but they may survive much further north, too. Temperatures (less than 10 °C and more than 40 °C) and low relative humidity (less than 70–80%) kill the adult fleas. These facts can explain in itself the effectiveness of “fresh air and ventilation”. Unfortunately, there are no exact data about the lifetime of infected ones. They may live “a few days or a week” (12) or even more when became infected. *Yersinia pestis* bacilli multiply in the flea’s foregut (proventriculus), and block it by producing a fibrinoid mass of these bacteria. Fleas with a blocked foregut cannot feed any more, but being thirsty they bite and bite again and regurgitate bacteria into the human or animal victim’s blood-stream. Fleas cannot transfer the plague immediately to one another and to the next generation, so the spread will be blocked, when the last flea separated from an infected host will have been destroyed. For infected fleas may survive a week and buboes may develop after 14 days too, it was quite understandable that the mildest quarantine lasted for 21 days on the Turkish border. Extremely prolonged period did not have any sense, for fresh acquired infections on the Turkish side manifested latest in 3 weeks, and even uninfected fleas perished without a blood meal in 38 days.

According to the physiologic temperatures, cold and hot water – especially hot vinegar steam – used for purification, does not need any further explanation. Cold water was a natural agent too, when animals were driven against the stream at shallows of border rivers. Fleas may have survived – pre-eminently hidden on long fleece animals (sheep) – this procedure, which explains the restriction described above. Moreover, it is well known that solid-hoofed animals (typically horses) are free of any fleas. Consequently, stable-boys were less endangered in plague epidemics, than other people. As the saying went: horse-blanket guards against the plague (13). However, it is not proven scientifically that horse smell scares away fleas, but aromatic materials do it anyway. Consequently, fleas avoided such substances among commercial goods as well.

According to a nude arm method of the 18th century, the effectiveness of “purification by fresh air” coincided with manual killing of fleas that jumped on the skin of public health servants. It is noteworthy that servants manipulating the wares may have survived mild plague infections, or died shortly after being employed. In the first case they became immunized against the epidemic. Besides in Central European military bases, at the beginning of the 20th century was well known the so-called “barrack method” to extinguish fleas hiding in the floor of buildings. A barefooted soldier went along the floor, fleas jumped on his leg, and were immediately killed at the end of the walking (13).

Conclusions and afterword

Following the scientific revolution in microbiology, the great success of 18th century health administration fell into oblivion, let alone it was suppressed by complacency of scientific enthusiasm at the end of the 19th century. Undoubtedly, authorities strove all the time to curb epidemics by very strong, sometimes draconian regulations. Nevertheless, strong wording and rough treatment did not ever suffice to localize and extinguish epidemics.

However, victory over the plague some 250–300 years ago should not be traced back only to biomedical reasons. Pledge of the 18th century success was relentless and professional bureaucracy, and on the other hand, effective empiric knowledge that was painstakingly being collected through many centuries about emerging and spread of plague epidemics.

Unfortunately, the public health service trained excellently on anti-plague methods was unable to cope with the next great epidemic of quite another nature – namely the cholera – some decades later in the 19th century. It is understandable but non pardonable, that this fiasco overshadowed the excellent results of the 18th century. It is time to do justice to the legislation, state and local administration, and public service who all made a huge sacrifice for the whole society.

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