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Houses and individuals in Udine during the cholera outreach of 1836
A geo-referenced analysis with micro-level data

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1. Introduction

The aim of this paper is to define some of the ways the cholera epidemics spread throughout a town setting. This study refers to Udine, a small town in the north-eastern part of Italy, about one hundred kilometers from Venice, in 1836. A spatial type of analysis will be carried out to reach the aim mentioned.

The subject has been dealt several times before and the most remarkable work was by John Snow, an English physician whose study about the cholera epidemics in London in 1854 is being considered the first example of medical cartography[1]. The present analysis will look at the spreading of the disease with particular reference to the spatial variables.

The first part of the work shows some of the demographic and socio-economic characteristics of Udine on the eve of the cholera epidemics and the description of the main infrastructural facilities for watering and draining of sewage.

The second part describes some of the characteristics of the cholera epidemics from a demographic, chronological and spatial point of view.

In the third and last part we hypothesize some the ways the cholera epidemics spread according to spatial dislocation of the houses in respect to the water supply.

2. Data and methods

To the purpose of this paper we collected the names of all the deceased within the walls of Udine in 1836. The source is the books from the civic Registry kept by each parish. The information gathered concerns the date of the event, the cause of death, the profession, the age and the registered domicile of the deceased. We looked at the relationship between these data and the results of a census carried out in 1834 which also reported information about age, domicile and profession of each individual and an 1809 survey concerning the characteristics of the town buildings properties. From a cartographic point of view the study considered the

[1] J. Snow, *On the mode of communication of Cholera*. Los Angeles: University of California, School of Public Health, 2002 (1849, 1855).

location of all the residential settings in Udine that were identified through their street number, the artificial waterways network – mostly still existing – and the layout of all drinkable water sources. For each house, we have then calculated the distances to the closest drinkable water source, artificial waterway and cistern.

3. Udine on the eve of the cholera epidemics

In the first half of the 19th century Udine was a small to medium-sized town (18,373 inhabitants in 1834) but included a wide area within its outermost city walls[2]. The town was divided into two main parts. The core, namely the "Cittadella", was enclosed within what used to be the third circle of walls and included the castle together with a high concentration of buildings that formed the old town. The "Borghi", on the other hand, were situated between the internal wall and the external wall that surrounded the town from the fifteenth to the nineteenth centuries. Vast zones within this area were given over to the cultivation of vegetables and mulberries.

Tab. 1. *Population in Udine, 1833-34. Area, buildings, inhabitants, density, families and profession (category) of head of the family*

	Duomo	S. Giacomo	S. Cristoforo	SS. Redentore	S. Quirino	B.V. Grazie	S. Nicolò	S. Giorgio	B.V. Carmine	Udine
Surface (ha)	28.40	5.56	7.74	24.78	13.19	40.60	9.82	18.53	35.31	183.93
Houses	349	160	120	339	152	214	218	272	273	2.097
Population: inhabitants n.	3,460	1,322	779	2,584	1,244	1,814	1,394	3,040	2,261	17,898
households n.	608	194	179	591	250	384	274	610	440	3,530
Density inhabitants/ha	121.83	237.77	100.65	104.28	94.31	44.68	141.96	164.06	64.03	97.31
Crowding inhabitants/rooms	0.84	1.00	0.86	1.47	1.19	1.27	1.16	1.25	1.27	1.13
Cholera mortality ‰	18	16	22	41	43	37	38	36	41	33
Occupation category (%)										
Agriculture	16.9	3.0	2.9	17.6	3.9	11.1	1.6	27.2	25.6	15.6
Manufacture	30.4	9.5	25.1	44.4	40.4	47.2	31.6	28.7	31.9	34.0
Trade	12.7	31.5	22.2	10.6	12.2	13.0	21.5	11.3	7.7	13.7
Transports	0	1.2	1.8	5.9	2.6	2.1	6.5	2.8	1.6	2.7
Services	9.2	14.9	21.1	9.5	16.5	10.1	18.2	14.8	9.8	12.4
Nobles, rentiers, professions	29.9	28.6	17.5	8.3	20.9	7.2	17.8	8.6	15.6	16.2
Others	0.8	11.3	9.4	3.6	3.5	9.3	2.8	6.6	7.9	5.4
Total	100	100	100	100	100	100	100	100	100	100
Unknown	0.8	1.2	3.5	5.2	7.8	1.1	10.1	13.5	1.4	5.0

Source: Archivio di Stato di Udine, *Census 1833-34*.

The 1833-34 census contained information regarding profession of the heads of households. This information shows us that manufacturing (involving over one third of the heads of household) and trade (13.6%) prevailed in Udine (Tab.1). The town was at the centre

[2] As regards the urban development of Udine, cf. F. Tentori, *Udine*, Bari, 1988.

of a vast area to which the inhabitants of the whole province converged in order to buy supplies and sell goods at the weekly markets and the numerous fairs. Trade and manufacturing had integrated with the strong rural sector which predominated in the "Borghi". The families involved in agriculture (15.6%) produced vegetables and reared small farm animals which they often sold directly in the city markets. A large proportion of the population (16.3%) was made up of the noble classes, a wide variety of professionals and a large number of people working in public administration, all supported by the presence of maids and servants. This substantial group, mostly living in the "Cittadella", formed the nucleus of political, administrative and proprietary power for the whole of the province.

The spreading of cholera was much facilitated by the existing infrastructures for drinkable water provisions and draining of industrial and public sewage. In 1836, in Udine as in many other Italian towns, the water supply for alimentary purposes relied upon a network of fountains, wells, cisterns, basins, canals and ditches as a substitute to the lack of waterworks (Fig. 1).

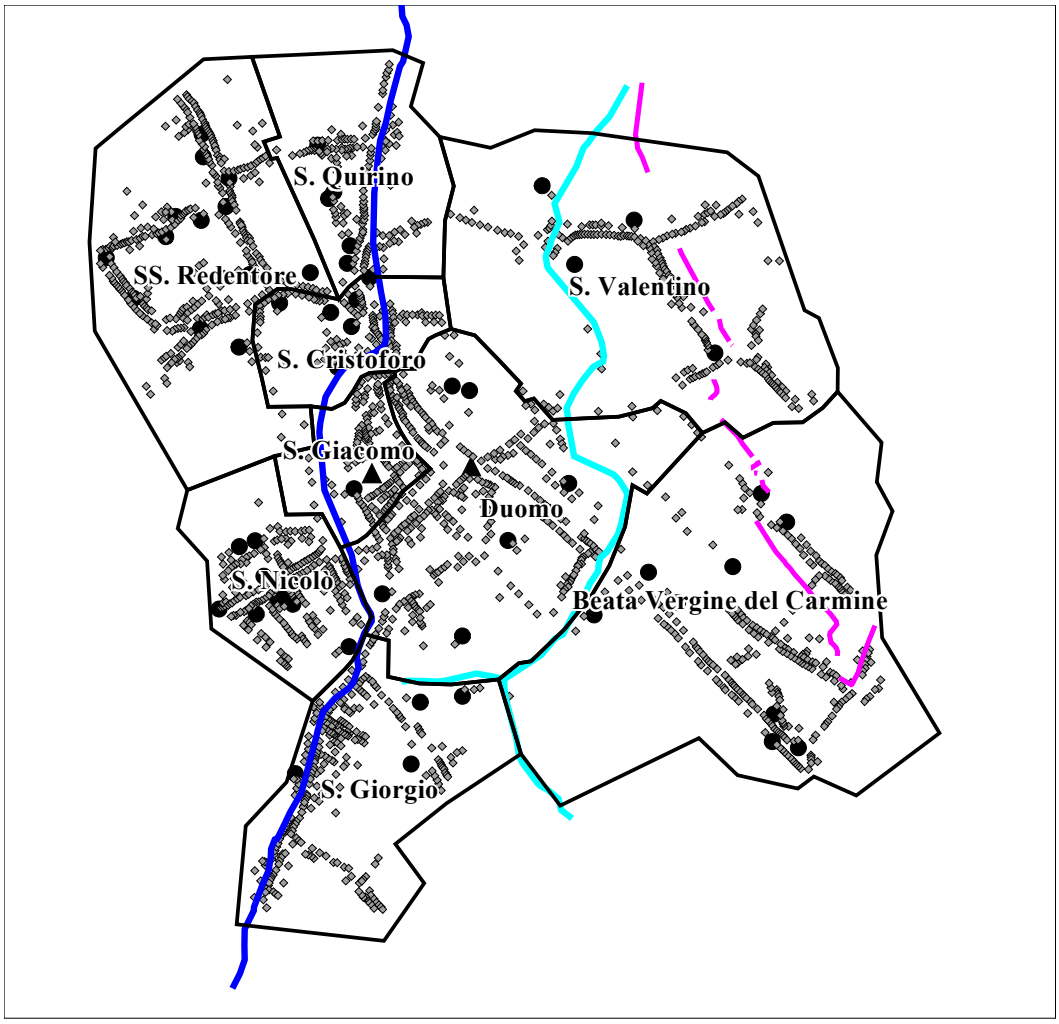
Two canals were the main source of water supply in Udine, a third, smallest, was a derivation of the previous one[3]. The canals, a part from feeding the wheels of the mills, served as drainage for the sewage coming from the dying factories, the tanneries and the laundry washing. The problems caused by the many functions of the canals and the growing pressure they sustained due to the town's heavier demographic presence meant that as the industrial use increased these waterways gradually lost their role for public use. However, at the same time the use of water for alimentary purposes was growing. It was then necessary to develop alternative supply systems or reduce the existing ones. The use of cisterns was the perfect solution to both.

There were 57 cisterns on the eve of the cholera epidemics (and two basins)[4]. Out of these, 18 were public. Two cisterns, located at the top of the hill that dominate the town, gathered the rainwater only. All the others were filled with water coming through subterranean ditches linked to the canals.

Fig. 1. *Water supply in Udine (1836)*

[3] The subject of canals has already been dealt with in many other published works. See: A. De Cillia - E. Mirmina, *Udine e il Torre. Un rapporto vitale*, in G. C. Menis, *Udin. Mil agn tal cûr dal Friûl*, Udine 1983, vol. I, pp. 51-73; F. Tentori, *Udine: mille anni di sviluppo urbano*, Udine 1982, pp. 161-177; I. Zenarola Pastore - L. Stefanelli - S. Colle, *Storia d'acque. Le rogge di Udine, patrimonio nascosto*, Udine 1995.

[4] Basin was a form of less elaborated cistern.



As well as the cisterns there was a well, the only one left of the five built during the centuries. The well got its water right from the source, but its function as a water supply in the overall picture of the town's water resources was almost non existent.[5]

In 1836 in Udine there were also two fountains which were the main drinkable water sources in town. The water supplying the fountains came from a torrent not far north of the town, were the water was cleaner.

To summarize it can be said that on the eve of the cholera epidemics the water for alimentary use in Udine came almost entirely from the cisterns or from the canals, which is the same, and partly from the two fountains.

The town needed a supply of drinkable water, but also a drainage system for the sewage be it from rain, humans or animals. But at that time Udine did not have a sewage draining system. The rainwater flowed into the canals, following the natural slopes of the fields or the roads.

[5]The well was definitely closed at the end of the eighteen hundred. See: L. Stefanelli, *L'acqua delle rogge nel XIX secolo. Forme di utilizzo e problemi di gestione*, in Zenarola Pastore - Stefanelli - Colle, *Storia d'acque* cit., p. 36.

The gathering and disposal of sewage was not at all planned. It was a task submitted to the single individuals. Human waste was gathered in holes dug into the earth and these could be found all over the town. People were allowed to use the human waste as fertilizer to spread over orchards and fields, even within the town walls.

Given such a situation the opportunities for potentially infected substances to enter the circle where water was also used for alimentary purposes were very numerous. The main danger was represented by the flow of rainwater which collected all the dirt it found on its way thus filling the canals, the same ones which made up the main source of water supply for everybody's use. On the eve of the cholera epidemics, the conditions for a fast and thorough spreading of the disease were ideal.

4. The cholera epidemics in Udine in 1836

An unpublished work by Francesco Pelizzo, a local physician, describes the development of cholera in Friuli from its outbreak in May 1836[6]. The threat of cholera, which had been expected to reach the area the previous year, had almost passed when Hapsburg troops returning to Austria introduced the disease to Veneto and Friuli. The contagion spread rapidly partly due to the fact that the soldiers found accommodation in private houses and were therefore in close contact with the local population.

After its appearance on May 21, 1836, the epidemic reached its peak in the second half of June, continued throughout the month of July, gradually declined in August and died out in September[7].

The 1836 cholera epidemic took Udine rather by surprise, yet it was not totally unprepared. The measures of sanitary prevention which had been introduced the previous year to no avail, were reintroduced, however, when the first cases of cholera struck Veneto and Friuli between May 15 and 20, 1836.

The epidemic quickly spread throughout the area and was brought to Udine by the Austrian troops. Pelizzo described how the first soldier suffering from cholera was admitted to Udine hospital on May 29 and that simultaneously there was the first civilian case, a

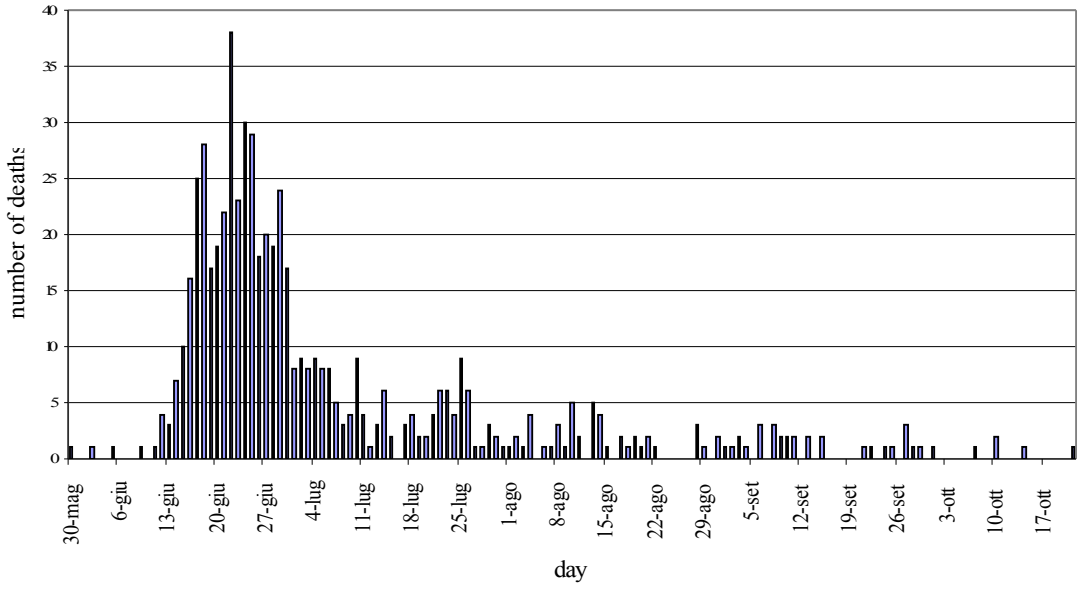
[6] This was an unpublished, three volumes manuscript bearing the title *Notizie Statistiche della Provincia del Friuli*, the author is the medical doctor Francesco Pelizzo. This work can be found at the Biblioteca Civica di Udine.

[7] F. Pelizzo, *Notizie Statistiche ...* cit., Parte Seconda, *Prospetto generale sull'andamento del Cholera Morbus dal primo sviluppo fino a tutto il mese di ottobre 1836 nella Provincia di Udine*.

shoemaker who had been in close contact with the army. The disease progressed slowly until June 11. From June 11 onwards there was an alarming acceleration of the epidemic which seemed to explode all at once.

Pelizzo's description of the epidemic's progression is confirmed by the number of deaths recorded per day (Fig. 2).

Fig. 2. *Daily number of cholera deaths (Udine 1836)*



The deaths rises sharply from the second week, reaches a peak the following week and gradually falls until it disappears altogether towards the end of September. Within the municipal boundary (which includes the town and some areas outside the perimeter wall), in the epidemic's 142 days duration (from May 21 to October 30) 1,639 people were contaminated (76 per 1000 inhabitants) causing 771 deaths (almost 1 in 2). The death rate, which reached a figure of 33‰ for the municipality overall, was higher inside the town (35.5‰) than in the area outside the city walls (27.9‰).

Pelizzo had noticed that cholera selected its victims preferably among the poor – something that will be verified in a previous study – but the spatial distribution was not clarified.

Figure 3 shows the distribution of cholera deaths in 1836 within the town centre and it clearly highlights a strong presence of the victims in the outer areas and along the canals.

Fig. 3. *Number of cholera deaths in Udine (1836)*

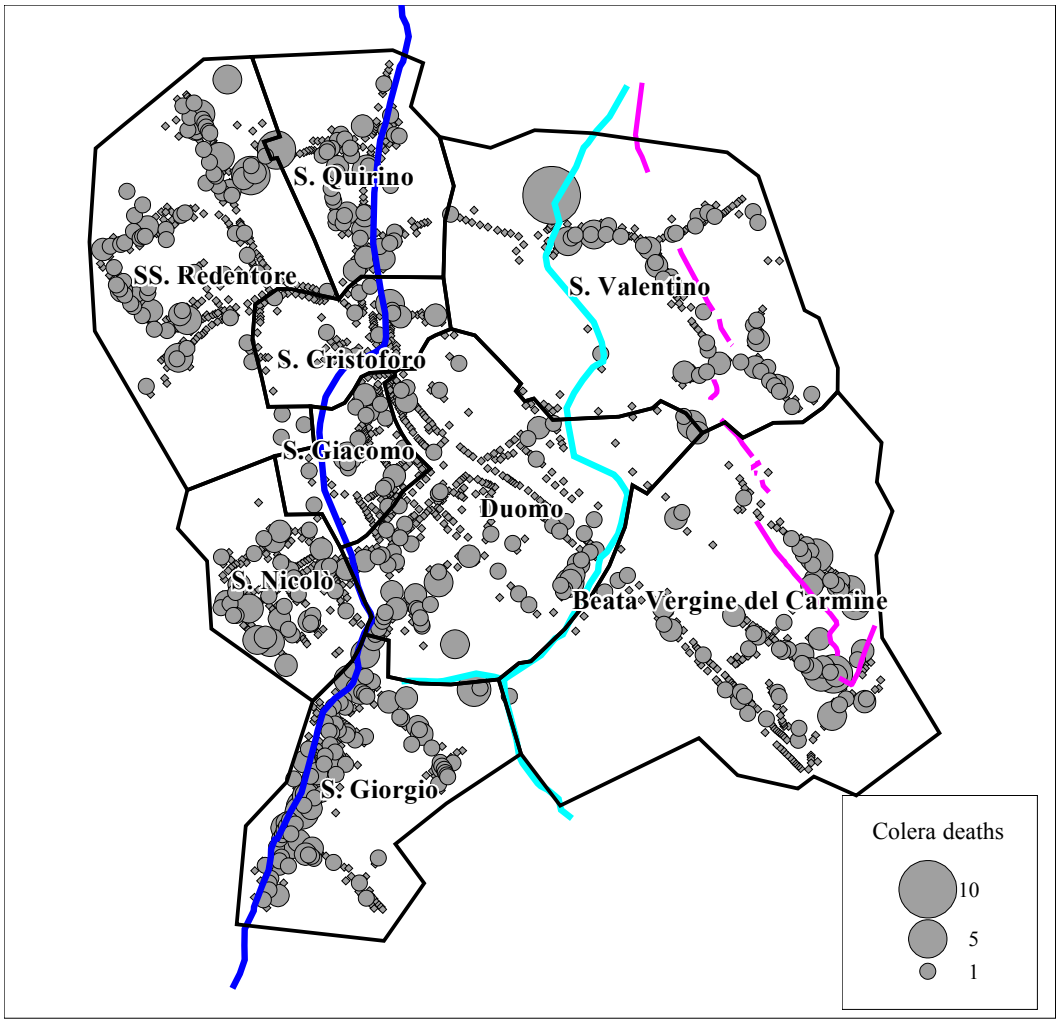
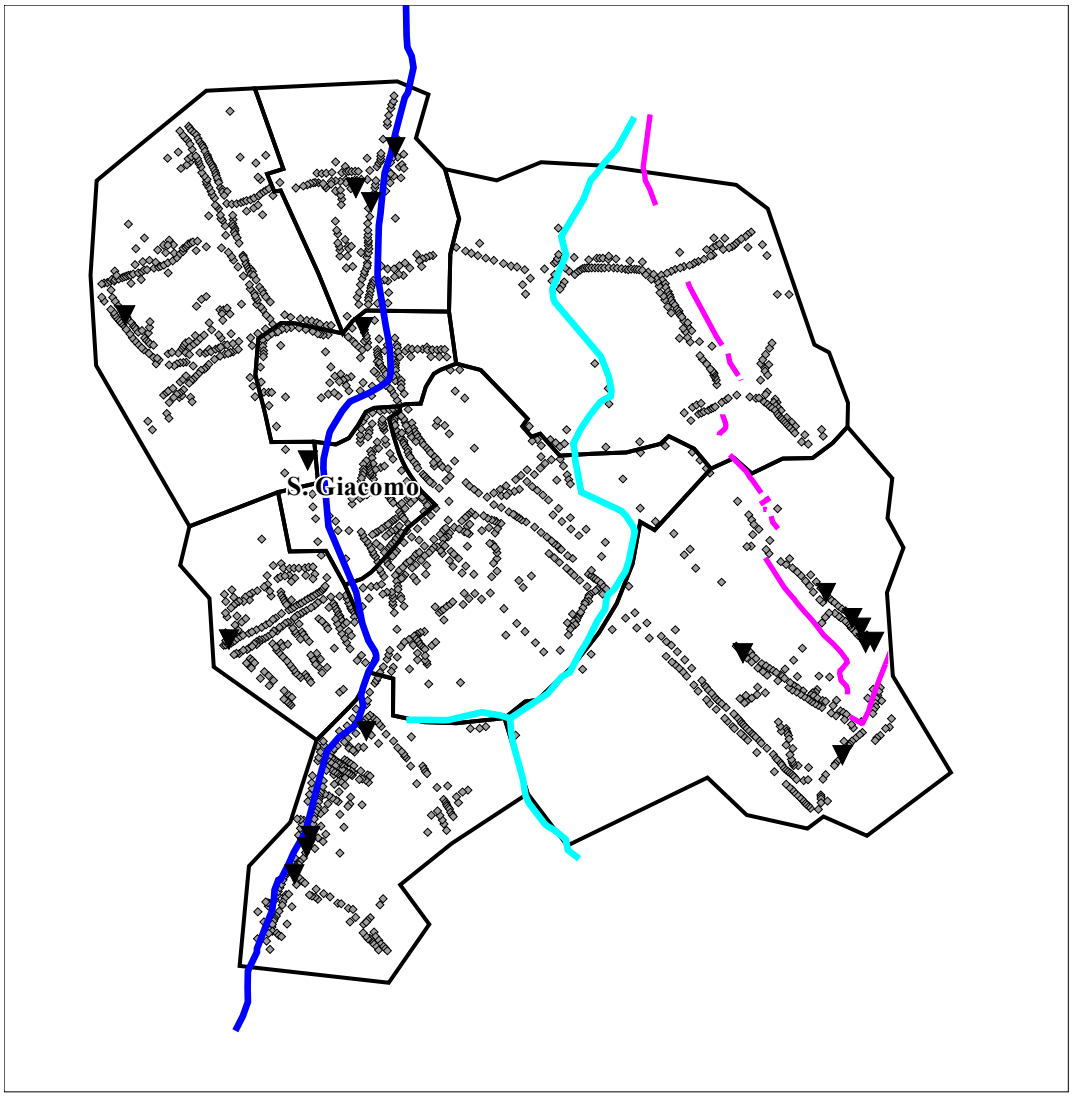


Figure 4 is about the cholera deaths during the first week from the first case of death and it highlights how the epidemics started from the furthest western canal and from a branch of the eastern secondary canal. From these first outbreaks cholera spread rapidly all over the town.

In a previous paper (Breschi, Fornasin 1999) we determinate some of the phases of the cholera epidemics in Udine in 1836 on the basis of some socio-economic categories. The picture drawn from the data on the cholera deaths referring to the socio-professional categories as shown by the 1834 census gives the opportunity to make comparisons among the parishes within the town.

There was also a wide differentiation according to locality, which was unrelated to the sex and age of the inhabitants living inside the various parishes. At the heart of the "Cittadella" (parishes of Duomo, S. Giacomo and S. Cristoforo) the number of cholera victims was much lower (16 per 1000 inhabitants) than that recorded in some of the "Borghi" (35-42 ‰).

Fig. 4. *Deaths in the first week of cholera epidemic (Udine 1836)*



The lower incidence of cholera amongst the inhabitants of "Cittadella", despite the higher population density, could be linked to the socio-economic condition of the people residing there. Over a quarter of the heads of family were involved in some kind of remunerative commercial activity or other and approximately another third belonged to the upper classes. The "Borghi" (parishes of Carmine, S. Giorgio, S. Nicolò, S. Quirino, SS. Redentore, Beata Vergine delle Grazie) mainly comprised artisans, workers involved in manufacturing, domestic staff (footmen, servants etc.) and farmers; all classes that contained a large percentage of poor[8].

The "Cittadella" had also a rudimentary water and sewage system. Not long before, the town centre had, in fact, undergone improvement. The squares and porticos had been paved and the channels collecting rainwater had been covered and separated from those carrying sewage. What is more, the only two fountains with drinking water were localized in this area.

[8] Archivio di Stato di Udine, *Archivio Comunale Austriaco* I, b. 169, f. 14, *Elenco dei poveri, 1830*.

The poorer socio-economic conditions of the parishes in the "Borghi" were reflected in an almost inexistent water and sewage system. The canals acted both as an important source of water for domestic use and a direct means of eliminating sewage. The role of these canals in the conveyance of cholera would appear to be significant in several specific cases.

In the parish of the Carmine cholera deaths were concentrated in confined areas that coincided with the sections of the canals closest to the external wall (in the Borgo dei Ronchi and Borgo di Mezzo). At this point, after having crossed a wide area of the town, the waters were close to the town limits and, therefore may have been infected to a greater degree. Borgo Aquileia, on the other hand, despite hosting one of the first cholera deaths, was one of the areas where the effects of the disease were most limited. Conditions here may not have favored its propagation. From a strictly demographic perspective (sex, age, composition of the family, etc.), the characteristics of the latter Borgo's population do not much differ from the two most affected Borghi, except for the fact that there were fewer families involved in agriculture. The farming population was most vulnerable perhaps due to the fact that they were in closer contact with the waters of the canals, which they used to irrigate their vegetable crops.

Borgo Aquileia was less agricultural and more closely linked to the "Citadella". The small farmhouses had given way to larger, taller buildings, many of which belonging to rich property owners. What is more, the water and sewage systems were less run down, the main canal and all the main drainage channels had been for the most part covered over.

The canals and the quality of the water were probably of lesser importance in the parishes of San Quirino and the S.S. Redentore. These were located to the north at a point in which the water entered the town. Despite this, the effects of cholera were very strong especially in San Quirino (42 deaths per 1000 inhabitants). Unlike the pattern observed in the parish of the Carmine, the epidemic did not confine itself to specific areas but spread throughout the district reaching notable intensity in certain zones. This was the case in Calle Cicogna (parish of San Quirino) where the rate of mortality surpassed 60‰. Writings from that era describe the area as being particularly rundown. The closely set buildings lined a narrow street and many of them were desperately in need of renovation. Water was supplied by means of an old underground canal. The inhabitants of this street carried out the same kind of jobs as the other inhabitants of the two parishes. They were mainly craftsmen (cobblers, carpenters etc.), textile workers (spinners, weavers etc.) or servants and maids.

Up to now, the association between localization of water supplies and deaths have been done arbitrarily, taking for granted that water sources were the main responsible of the spread

of cholera. Water played for sure a key role, but there were many other ways through which the bacillus of cholera could enter the human nutrition chain. In Udine, as already mentioned, cholera arrived in town with the Austrian army. After the first phases of spreading of cholera, it was quite easy to get infected by direct contact with the dejections of individuals stricken with cholera. However, the spatial distribution of water sources and points of water supply might have played as well a key role in the diffusion of the epidemic and in this paper we will try to prove it.

5. The spreading of cholera in a spatial perspective.

In this work we will focus on the territorial characteristics that determined the spread of cholera. Many are the information at our disposal.

For this purpose, the deaths for cholera in the city of Udine have been analyzed according to their localization within the town. Thus, it has been important to collect information not only on inhabitants but also the houses they lived in. It is the position and localization of each house that allows us to investigate some specific characteristics of the spread of cholera in an urban context.

We have data on the 2094 houses for whom we have been able to determine their geographic coordinates. We have then supplemented data on houses with information on the people that lived there, data that we have taken from the census of 1836. Although the total number of houses within the walls of Udine was certainly slightly higher, the 2094 we have considered represent the totality of buildings in which at least one person have died by cholera.[9]

Our hypothesis is that the distance of houses from points of water supply has been one major determinant of the risk of dying by cholera. Hence, the localization of fountains, waterways and cisterns become a decisive element in our analysis. The idea is that the inhabitants of a house supplied themselves with water at the closest water source, and that its degree of infection might deeply affect their chances of death.

The distances between the houses and, respectively, the two fountains, the 57 cisterns and the two waterways that passed through the city have been calculated in metres. The criterion was to link each civic number to the closest point of water supply for each of the three typologies above described. Wells were not considered since at that time they did not drain stratum water

[9] Even though many people died at the hospital, we have retrieved information on their residence address for 638 individuals.

and in any case they did not provide much water.[10] The result of these elaborations is shown in figure 5.

Fig. 5a. *Distances Houses-Fountains*

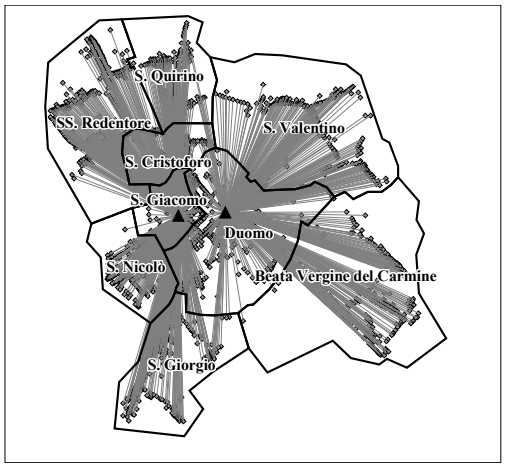


Fig. 5b. *Distances Houses-Cisterns*

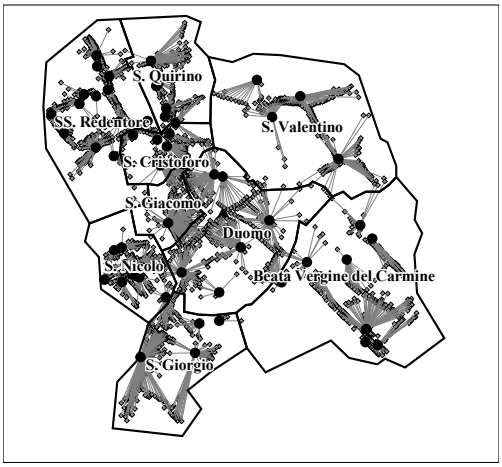
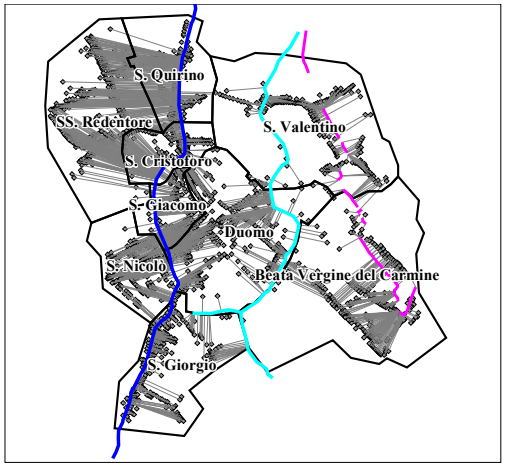


Fig. 5c. *Distances Houses-Canals*



Our work hypothesis can be further broaden by assuming that water quality worsened as waterways and canals went through the urban area, getting overloaded by sewage. Since the waterways of Udine flow in north-south direction on account of the natural slope of the terrain, we can assume that water quality got worse with latitude decrease. Moreover, it is likely that water quality changed also according to the population size of the urban areas waterways and canals passed through.[11]

To take account of those elements, we have added two further pieces of information. First, the latitude of each house, with the hypothesis that the more north one lived, the cleaner was the water. Second, an indication about the closest waterway to each house. Finally, two

[10] It is to remind that taking water from a well was a difficult and long operation in any case. In fact, a basin should have let down for about 60 metres.
[11] The largest part of the population lived on the westernmost waterway.

different logistic regression models were estimated at the house level. In both models, the dependent variable is the occurrence or not of at least one death in a given house identified by a unique civic number. In the first model, we introduced number of inhabitants per house and distance to, respectively, fountains, cisterns and waterways as explanatory variables. In the second model, we have added latitude of the house and indication of the closest waterway, which should be both regarded as proxy of water quality. The results are shown in table 2.

Tab. 2. *Houses with Cholera deaths. Udine 1836*

		Model 1		Model 2	
	Freq	Odds ratio	P>z	Odds ratio	P>z
N. House inhabitants		1.065	0.000	1.064	0.000
Distance from fountain		1.002	0.000	1.002	0.000
Distance from cistern		0.998	0.088	0.998	0.063
Distance from canal		0.999	0.070	0.999	0.058
House latitude				1.000	0.223
Canal (ref. Ditch of Udine)	67.4				
Canal of Palma	13.4			1.072	0.694
Secondari Canal	19.2			0.655	0.012
Log likelihood		-924.3			-920.1
N. of observed houses		2094		2094	
Houses with at least 1 death		464		464	
LR test p-value				0.037	

A large part of the explanatory variables resulted statistically significant. Not surprisingly, the risk of having a death by cholera in a given house was strictly and positively associated with the number of inhabitants per house. The other three covariates must be discussed together. The distance to points of water supply is always statistically significant although the sign of the association is not always concordant. The relationship between death by cholera in a given house and distance to fountains is positive, which implies that the longer the distance from a clean water source, the higher the risk of death. Conversely, the association is negative for cisterns and waterways. It means that the risk of finding someone dead by cholera decreased as the distance between house and a source of potentially-infected water increased. These results support our work hypothesis of a relationship between deaths by cholera and distance to points of water supply.

In model 2, the introduction of the two variables relative to water quality improves significantly the explanatory power of the model. While there is no significant association between latitude and death by cholera, the variable concerning the closest waterway seems playing an important role in modifying the risk of death. Houses localized along the easternmost branch of the waterway show a lower risk of having one of their inhabitants dead by cholera. This is probably due to the better quality of the water in that area and also because

population density was there lower than in the southernmost part of the city. Moreover, it is likely that only few families used the waterway for water supply. On the contrary, in the southern area of Udine, which was more densely inhabited and where the canal formed a large and easy-accessible basin, there were much more deaths.

6. Conclusions

Cholera is a social illness closely connected with the social status of individuals and families. Poor people in bad health status and bad nutrition conditions are the first and easiest targets of cholera. Home is another element that describes the socioeconomic conditions of a person and a family. In the 19th century, in Udine the upper-class families lived usually in the most central areas of the town. Poorest families, conversely, did not live in specific quarters but they were spread everywhere in the urban area.

In mid-nineteenth century Udine it is therefore possible to find similarities between the geography of mortality and the presence of alternative sources of water supply. At the end, even institutions of public assistance had favoured those situations that already enjoyed consistent privileges and advantages. The cleanest water was lead where life conditions were better and more favourable, also from an economic point of view, and where the risk to be infected by cholera was already lower. However, there were also poor people living outside the richest areas of the city that could have the fortune to live next to a good and clean point of water supply or, at least, less contaminated and infected.