Spatial and Social Inequalities in the Face of Death: Pilot Research on Cholera Epidemics in Poznań of the Second Half of the 19th Century

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Spatial and Social Inequalities in the Face of Death. Pilot Research on Cholera Epidemics in Poznań of the Second Half of the 19th Century

*Grażyna Liczbińska**

Abstract: *»Räumliche und soziale Ungleichheiten im Angesicht des Todes. Eine Pilotstudie über Choleraepidemien in Poznań in der zweiten Hälfte des neunzehnten Jahrhunderts.«* In the second half of the 19th century, various quarters of Poznań differed in terms of infrastructure, including access to clean water. This paper aims to analyse whether these spatial and social inequalities related to the quarter of residence in the city, and thereby whether access to sanitary infrastructure and clean water intake, and in general, differences in living conditions, influenced the probability of death from cholera. Data from four cholera epidemics – 1852, 1855, 1866, and 1873 – were used for this purpose. In total, 16,285 individual data entries from death registers of Catholic and Protestant parishes were used regarding such information as the date of death, sex, age at death, cause of death, profession, religion, and exact address of residence. There was a significant relationship between socioeconomic factors (quarter of residence, denomination, professions) and biological factors (sex and age at death), and the distributions of deaths due to cholera and other causes. Generalized Linear Models (GLMs) revealed that living in the Old Market Square did not decrease the chance of death from cholera, and on the other hand, living on the right bank of the Warta River did not increase the chance of death from cholera. In other words, better quarter of residence did not guarantee lower morbidity and did not protect from cholera and vice versa. This work also proves a significant interaction between the quarter of residence and such variables as denomination and occupation on probability of death from specific cause. Virtually until the end of the 19th century, the sanitary conditions in Poznań were so poor that they were conducive to epidemics of infectious diseases.

Keywords: Epidemics, quarter of residence, profession, denomination, city infrastructure, urban ecology, water intakes, Poland, Poznań.

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Historical Social Research Supplement 33 (2021), 37-53 | published by GESIS
DOI: 10.12759/hsr.suppl.33.2021.37-53

1. Introduction

Cholera is a disease caused by gram-negative *Vibrio cholerae*. So far, over 200 serogroups of *V. cholerae* strains have been identified (Chatterjee and Chaudhuri 2003). Among the strains of *V. cholerae*, two biochemical varieties have been distinguished: *V. cholerae* O1 classical type – the etiological factor of six pandemics – and *V. cholerae* type El Tor – the factor of the seventh most recent cholera pandemic (Harris et al. 2012; Hu et al. 2016). For epidemiological purposes, the O1 strains include three antigenic varieties: Ogawa (the most common), Inaba (less common), and Hikojima (the least common). Initially, only the O1 antigenic type was considered a pathogenic variant of cholera. Meanwhile, research in Kolkata found that there are 139 different groups of the somatic O antigen, including type O 139, which also can produce cholera toxin and was the cause of the cholera epidemic in India (Naruszewicz-Lesiuk and Stypułkowska-Misiurewicz 2017). *V. cholerae* transmission may occur through a faecal-oral route ("person to faeces to person") or from the environment (environmentally acquired infection; Ganesan, Gupta, and Legros 2020). Symptoms include watery diarrhoea, which leads to dehydration and low electrolyte level (Kappner 2019). About 10-20% of cholera infections are symptomatic and present as mild diarrhoea symptoms, while about 20% of cases are severe, so without rapid and adequate hydration and electrolyte replacement and antibiotic therapy, they can lead to death (Kappner 2019).

In the past, cholera spread from the Delta of Ganges six times and caused six pandemics: 1817–1823, 1826–1838, 1846–1863, 1865–1875,1883–1896, and 1899–1923. However, endemic cases of epidemics were recorded in India as early as the 18th century (Cvjetanovic and Barua 1972). In 1817, a cholera epidemic broke out in the Ganges Delta, quickly swept over the Indian Peninsula, and spread towards the Near and Far East. The year 1817 was considered the time of "birth" of the first cholera pandemic. The first wave of the pandemic reached Europe in the 1820s (within Russia in 1823; Czapliński 2012). In 1826, another cholera epidemic broke out in Bengal, which led to the second wave of the pandemic (1826–1838). In 1831, the pandemic covered almost the whole territory of Russia and soon reached the Kingdom of Poland (the Polish lands under the Russian partition) and Germany. In the same and the following year, the epidemic continued to spread to Galicia (the Polish territories under the Austrian rule), Hungary, and Bulgaria. It moved from Hamburg to England in 1832, and from England to France and Ireland. Then it spread to the rest of Europe, to Africa, and to both Americas (Czapliński 2012). Since 1839, there was no cholera in Europe, while in 1846 it began to push again towards Europe (the third wave, 1846–1863). In the fall of 1847, it was already in Moscow, and at the end of the year in the Kingdom of Poland, from where it got to Prussia in 1848. In the following years it covered Europe

(northern Europe in 1853), North America, and Mexico, and at the end of the pandemic, in 1863, it reached Brazil (Czapliński 2012). The next wave of the pandemic appeared in Europe and Asia in the 1860s and lasted until the 1870s (1865–1875). Until 1884, Europe was cholera-free. In 1883, the cholera epidemic broke out in India again and quickly spread to Persia, Arabia, and Egypt. Then it continued on its way to Europe with great force. It was the fifth wave of the cholera pandemic (1883–1896). Cholera was brought from Italy to both Americas (Czapliński 2012). The last wave of the cholera epidemic in the 19th century, in 1899–1923, began in India in 1892. It reached Russia in 1892 and from there it moved west. The year 1896 was considered the end date of the 19th century cholera pandemics. According to estimates, all cholera pandemics in the 19th century resulted in 30 to 40 million deaths (Czapliński 2012).

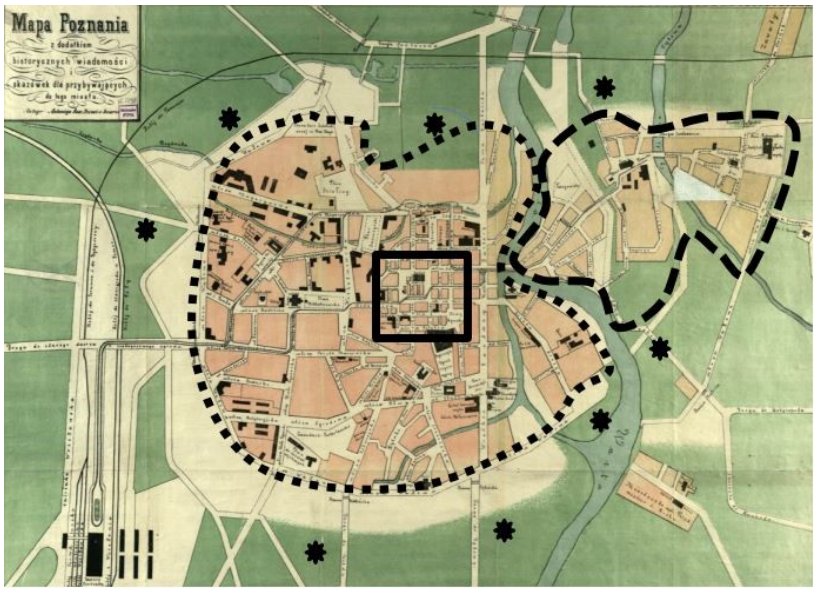
Cholera epidemics did not omit Poland. In Poznań, in the first half of the 19th century, they broke out three times: in 1831, 1837, and 1848 (Kaniecki 2004). Researchers have paid a lot of attention to the first two epidemics, especially to the one of 1831 (Gerstenberger and Stasch 1935; Kaniecki 2004; Stasch 1933; Trzeciakowska and Trzeciakowski 1987). Meanwhile, cholera epidemics returned to Poznań in the following years, with subsequent waves: 1852, 1855, 1866, and 1873. Due to the epidemic waves, in the third and fourth decades of the 19th century, the city already had a lot of experience in dealing with cholera in the next outbreaks. Meanwhile, the fact that the city was closed within the walls of the fortress, high population density and practically low sanitary level lasting until the end of the century made each subsequent outbreak of cholera a great challenge for the city (Kaniecki 2004).

Researchers, based on diaries, newspaper articles, and published memoirs of people involved in the fight against cholera epidemics and on the numbers of deaths, state that the morbidity and mortality cases from cholera were unequally distributed in Poznań, i.e., differed between quarters in the city (Gerstenberger and Stasch 1935). This was related to the diversity of the quarters of Poznań in terms of urban infrastructure, including access to clean water and the socioeconomic status of city residents, etc. (Kaniecki 2004; Kędelski 1994; Liczbińska 2009a, 2009b, 2011, 2015; Trzeciakowska and Trzeciakowski 1987). However, the problem of spatial and social stratification of mortality from cholera in Poznań has not been elaborated in more detail. The proposed work tries to meet these shortcomings. The aim of the study was to investigate, using statistical tools, whether spatial and social inequalities in Poznań, translating into differences in access to sanitary infrastructure, clean water intake, and generally, ecological conditions and standards of living, resulted in a varied probability of dying from cholera.

2. Data

According to the resolutions of the Congress of Vienna (February 1815), the city of Poznań became the capital of the Grand Duchy of Poznań, which was a part of the Prussian state in territorial and administrative terms (Kędelski 1994). Since 1848, after the creation of the Province of Poznań (German: *Provinz Posen*) from the Grand Duchy, Poznań became the capital of this Province (Kozłowski 2004). In the first decades of the 19th century, Prussian authorities decided to turn Poznań into a fortress surrounded by walls (figure 1).

Figure 1 Map of 19th-Century Poznań



Source: Plany Miasta Poznania 1870-1944: https://cyryl.poznan.pl/kolekcja/633/plany-poznania-1870-1944-ptpn (Accessed September 6, 2021).

The Old Market Square
The City Centre
The right bank of the Warta River
Area outside the fortification

This decision inhibited the city's demographic growth within the walls for the next decades (Trzeciakowska and Trzeciakowski 1987). In 1867, the city had 53,400 inhabitants; in 1875, 61,000; in 1880, the population of Poznań increased to 65,700; and only at the beginning of the 19th century (1900), after the demolition of fortifications and the inclusion of quarters located outside

the walls to the city, to 117,000 (*Statystyczna Karta Historii Poznania* 2008, 53). In 1895, the population density in Poznań was over 7,700 people per km^2, and after the incorporation of such quarters as Wilda, St. Lazarus with Górczyn, and Jeżyce, it fell to 3,500 people per km^2 (*Statystyczna Karta Historii Poznania* 2008, 53).

Table 1 Descriptive Information Concerning Cholera Epidemics in the City of Poznań, the Second Half of the 19th Century

Year of epidemic	No. of deaths due to cholera	The onset of the epidemic	The end of the epidemic	The highest monthly temperature in summer (°C)[3]				No. of days with heat waves[4]
				VI	VII	VIII	IX	
1852[1]	1556	22 Jul	30 Sep	29.5	30.0	28.5	24.0	**34:** 5 (May) 7 (Jun) 14 (Jul) 8 (Aug)
1855[2]	2211	21 Jul	6 Dec	31.6	29.3	30.8	22.3	**18:** 8 (Jun) 4 (Jul) 6 (Aug)
1866[1]	1344	18 Jun	22 Oct	32.5	28.9	28.5	28.5	**34:** 17 (Jun) 5 (Jul) 5 (Aug) 7 (Sep)
1873[1]	60	23 Jul	6 Dec	26.8	30.5	32.6	23.8	–

[1] The onset and the end of the epidemic and the numbers of deaths after: Cyfrowe Lapidarium Poznania 2021.

[2] The onset and the end of the epidemic and the numbers of deaths after (Dzierżawski et al. 1892, 7).

[3] Temperatures derived from (Smosarski 1925, 118-9).

[4] Information on the numbers of days with heat waves derived from (Smosarski 1925, 127).

The work used individual data entries on deaths from parish books of Poznań parishes of Catholic denomination: St. Mary Magdalene, St. Margaret, St. Martin, St. Roch, and parishes of Protestant denomination: St. Peter and the Holy Cross. The books for 1850–1874 were used and thus the data for 4 cholera epidemics in 1852, 1855, 1866, and 1873 in all parishes were gathered. Information about the onset and the end of each cholera epidemic in Poznań and the numbers of victims in the city were presented in Table 1. The initial database included 24,831 individual pieces of information on the date of death, sex, age at death, cause of death, profession (in the case of children – the parent's profession, and in the case of unemployed women – the husband's profession), religion, and place of residence.

3. Methods

Individuals with the exact address of residence were selected from the database for further analysis. Thus, ultimately the database consisted of 16,285 individual data entries including information concerning names and surnames, sex, ages at death, causes of deaths, denomination, professions, and addresses of deceased. The exact address of residence included the name of the street, sometimes the name of the street and the house number, which allowed the person to be assigned to one of the 4 categories distinguished within the variable *"quarter of residence"* (see figure 1):

0) The Old Market Square – gathering people living around the market square and neighbouring streets, such as Kozia, Klasztorna, Woźna, Wielka, Ślusarska, Kramarska, Mokra, Dominikańska, etc. The ecological situation in this part was better than anywhere else in Poznań. People living in the vicinity of the market square were privileged in terms of access to clean water, and sewage in this part of the city was discharged through underground channels (Kaniecki 2004).
1) The city centre, as well as Piotrowo and Berdychowo belonged to the area, which was surrounded by the fortress. The city centre was inhabited by wealthier Poznań residents. Unfortunately, at the end of the 19th century, this part of the city was virtually "suffocating within the walls" due to the lack of free space and high population density (Kaniecki 2004).
2) Quarters located on the right bank of the Warta River: Śródka, Ostrówek, Zawady, Chwaliszwo, Ostrów Tumski. It is worth mentioning that Śródka, Ostrówek, Ostrów Tumski, and Chwaliszwo were also within the fortress, but the very low standard of living of the inhabitants and the lack of infrastructure in this area (Kaniecki 2004; Karolczak 1997a, 1997b) led to excluding them from category 1 and appointing to the category of "right-bank quarters."
3) The city area outside the fortress, attached to Poznań after 1900. This area included the following quarters: Górczyn, Jeżyce, Wilda, and Lazarus. The lands outside the fortress walls were characterized by a lower population density and better ecological conditions than in the city centre (Budziałowska and Górna 2014).

The historical index of street names in 19th-century Poznań was used (Nezborała 2010). Another variable distinguished in this work is *"religious denomination,"* within which 2 categories were distinguished: 0) Protestants; 1) Catholics.

The work also uses information about the profession of the deceased; in the case of children, information about the father's profession; and in the case of women without a given profession, information about the husband's

profession provided in the death record (e.g., wife of a shoemaker, widow of a locksmith, wife of a worker). In relation to historical and contemporary populations, profession is a commonly used indicator of socioeconomic status. This indicator was associated with differences in the standard and quality of life and influenced the stratification of demographic and biological characteristics (e.g., Liczbińska et al. 2017, 2018; Łopuszańska et al. 2016). In this paper, profession was considered a proxy for socioeconomic position of Poznań citizens. The variable "*profession"* included 4 categories: 0) Workers (skilled and unskilled workers, daily laborers, etc.); 1) Craftsmen (shoemakers, carpenters, tailors, etc.); 2) Workers in the service sector (service, carriers, guards, servants); 3) White-collar workers (doctors, lawyers, professors, pharmacists, teachers).

Another variable is *"age at death,"* within which 6 categories were distinguished: 0) ≤14 yrs.; 1) 15-24 yrs.; 2) 25-34 yrs.; 3) 35-49 yrs.; 4) 50-59 yrs.; 5) ≥60 yrs. *"Causes of deaths"* were divided into: 0) deaths from other causes; 1) deaths from cholera. The Chi-squared test was used to verify whether there were any differences between socioeconomic variables (religious denomination, quarter of residence in Poznań, profession) and biological variables (sex, age at death), and the frequencies of deaths due to *cholera* and *"other causes."*

It was verified whether the quarter of residence influenced death from a specific cause with denomination and occupation as covariates. MANCOVA was applied for this purpose. Generalized Linear Models (GLMs) with binomial error distribution and the logit link function were used to examine whether a quarter of residence in Poznań, and thus the achievements of civilization, infrastructure in the quarter, the status of its residents, etc., was (or not) significantly associated with probability of death due to cholera. The dependent variable took two values: if the death occurred from "cholera": 1 and 0 in the case of death from "other causes." "*Quarters of residence in Poznań"* were explanatory variables (4 quarters = 4 separate variables). A given quarter was a separate explanatory variable marked as 1 (the event of interest to us) while other quarters (places of residence) in the column for this variable were marked as 0. The odds ratios and their 95% confidence intervals (CI) were calculated to characterize the effect of the explanatory variable on the binary response. Odds ratios helped to assess the chance of deaths due to cholera depending on the distinguished categories of the place of residence in Poznań (the quarter of Poznań). To assess test efficiency, receiver operating characteristics (ROC) and areas under curves (AUC) were calculated. ROC curve is a graphical representation of the relationship between true positive percentages of results and false positive percentages of results. The area under ROC-AUC curve, ranging from 0 to 1, determines the test's ability to distinguish between normal and abnormal results. The greater AUC value (the more

concave the ROC function is), the greater the diagnostic power of the test, and thus the better the resolution of the test (Stanisz 2007).

All statistical analyses were carried out using STATISTICA version 13.3 (StatSoft, Inc. 2019). Significance was set at $p<0.05$ and $p<0.0001$.

4. Results

The relationship between the categories of the following variables: sex, quarter of residence, religious denomination, profession, age at death, and the frequencies of deaths due to cholera (and other causes) were presented in Table 2.

Table 2 The Relationship Between Sex, Quarter of Residence, Religious Denomination, Profession, and Age at Death by Cause of Death; Chi^2 test values

Variable	Category	Cholera deaths (%)	Other causes (%)	Ch^2
Sex	Male	46.59	51.18	11.75; df=1 $p<0.0001$
	Female	53.41	48.82	
Denomination	Catholics	72.40	64.22	42.28; df=1 $p<0.001$
	Protestants	27.60	35.78	
City district	Old Market Square	9.81	17.82	108.85; df=3 $p<0.0001$
	City centre	52.78	37.99	
	Right bank	30.28	34.23	
	Outside wall area	7.13	9.95	
Profession	Workers	42.84	36.76	16.50; df=3 $p<0.001$
	Craftsmen	34.04	33.64	
	Servants	18.01	23.10	
	White-collar workers	5.11	6.50	
Age at death	≤14 yrs.	41.24	60.60	290.62; df=5 $p<0.0001$
	15-24 yrs.	6.69	4.04	
	25-34 yrs.	14.33	6.55	
	35-49 yrs.	18.80	11.18	
	50-59 yrs.	9.40	6.41	
	≥60 yrs.	9.53	11.22	

Women more frequently died due to cholera than men (Ch^2= 11.75, df=1, $p<0.0001$). There were higher frequencies of deaths from cholera among Catholics than among Protestants (Ch^2= 42.28; df=1; $p<0.001$). The frequencies of deaths due to cholera were unequal in the quarters of residence in Poznań (Ch^2=108.85; df=3; $p<0.0001$): the greatest frequency of deaths from cholera was recorded in the city centre (almost 53% of all deaths from cholera) and

on the right bank of the Warta River (30% of all deaths from cholera). Deaths from cholera in the Old Market Square and outside the fortress walls amounted to less than 10% of all deaths from cholera in 4 analysed city quarters. There was also a relationship between occupation (socioeconomic status of the deceased) and distribution of deaths due to cholera (Ch^2=16.50; df=3; p<0.001): among all those who died from cholera, the most frequent professions belonged to workers and craftsmen (42.8% and 34.0% of all deaths from cholera, respectively). Taking into account the age at death among those who died due to cholera, the most frequent groups were children (individuals aged up to 14) and people aged 25-34 and 35-49 (41.4%, 14.3%, and 18.8%, respectively; Ch^2=290.62; df=5; p<0.0001).

The ROC curves with AUC placed at 0.75 indicate rather poor diagnostic power of the test. However, the assessment of parameters for each variable from *the quarter of residence* group is statistically significant. The negative directions of the effects and odds ratios were lower than 1, which means that living in a quarter with good infrastructure (e.g., The Old Market Square) did not decrease the chance of death from cholera, and vice versa: living on the right bank of the Warta River – did not increase the chance of death from cholera (Table 3).

Table 3 Model Coefficients and Odds Ratios Explaining the Influence of the Quarter of Residence in Poznań on the Probability of Deaths from Cholera

Explanatory variables	Estimate	SE	+95 CL	–95% CL	OR (95%CI)
Old Market Square	-0.48	0.05	-0.58	-0.37	0.38 (0.31-0.48)*
City centre [a]					
Right bank of Warta	-0.22	0.04	-0.29	-0.15	0.64 (0.56-0.74)*
Quarters outside fortress	-0.33	0.06	-0.45	-0.21	0.51 (0.40-0.66)*

Abbreviations: SE – standard error; CL – confidence level; OR – odds ratio; CI – confidence interval

[a] Omitted category is reference group.

* Significant p<0.0001

This pattern was repeated when the deceased in hospitals and shelters were removed from the data material (these people could raise the cholera death statistics; Table 4).

Quarter of residence and profession influenced deaths from a specific cause (cholera/others) separately (quarter of residence: F=26.63, p<0.0001 and profession: F=5.97, p<0.0001) and jointly (quarter of residence X profession: F=6.68, p<0.0001). Meanwhile, quarter of residence influenced deaths from a specific cause (cholera/others) separately (F=18.60, p<0.0001) and

jointly with denomination (quarter of residence X denomination: F=4.36, p<0.05). No independent influence of the religion was noted (p>0.05).

Table 4 Model Coefficients and Odds Ratios Explaining the Influence of the Quarter of Residence in Poznań on the Probability of Deaths from Cholera (Patients from Hospitals Excluded from Material)

Explanatory variables	Estimate	SE	+95 CL	–95% CL	OR (95%CI)
Old Market Square	-0.51	0.06	-0.62	-0.40	0.36 (0.29-0.45)*
City centre [a]					
Right bank of Warta	-0.28	0.04	-0.36	-0.20	0.57 (0.49-0.67)*
Quarters outside fortress	-0.39	0.06	-0.51	-0.26	0.46 (0.35-0.69)*

Abbreviations: SE – standard error; CL – confidence level; OR – odds ratio; CI – confidence interval

[a] Omitted category is reference group.

* Significant p<0.0001

5. Discussion

During the 19th century, Poznań was a fortified city that effectively prevented its spatial development. The area within the fortifications was only 50 hectares large, out of which a major part was in the hands of the military (Topolski 1973). With time, the city started to suffer a shortage of free space, and at the end of the 19th century it was virtually suffocating within the walls and suffered from a lack of infrastructure. The death toll due to epidemics of infectious diseases, such as scarlet fever, typhoid, and measles was very high, especially among infants and young children (Kaniecki 2004; Kędelski 1994; Topolski 1973; Trzeciakowska and Trzeciakowski 1987). A modern water supply system was completed only in 1866, and the sewage system was constructed as late as at the end of the 19th century. In 1900, the fortification walls were demolished, which ultimately improved ecological conditions in the city (Kędelski 1986, 1994; Liczbińska 2009a, 2009b, 2011, 2015; Trzeciakowska and Trzeciakowski 1987).

In Poznań in the early 1800s, cholera epidemics occurred three times: in 1831, 1837, and 1848, and in the late 1800s, they swept through Poznań four times. Residents, doctors, and municipal services "learned" about epidemics on the example of those in the 1830s and in 1848. During the epidemic, the city was divided into health sectors, in which health commissioners appointed among the city's inhabitants controlled the health of the quarters' population. A cholera hospital was created for the infected ones. Residents were instructed on how to behave in the event of cholera outbreak, gatherings were forbidden, etc. The epidemic in 1831 claimed a total number of 556

people, the epidemic in 1837 caused over 300 deaths, and in 1848, 1,107 deaths (Kędelski 1994). During the epidemics in 1831, 1837, and 1848, the ratios of recovery to death were 68.6%, 47.5%, and 42%, respectively.[1]

Despite previous experiences with cholera epidemics, Poznań did not avoid the next ones in 1852, 1855, 1866, and 1873. The havoc and dynamics of the cholera epidemics were influenced by many factors, among which an important role was played by high population density, poor hygiene, lack of access to clean water intake, and all of them were additionally strengthened by high temperature. In the years of the cholera epidemics in the second half of the 19th century in Poznań, in the warmest months, i.e., in July and August, the maximum temperatures even exceeded 32°C (table 1; after: Smosarski 1925).

In 1852, 1855, and 1866 from May to September, the heat waves were recorded, which lasted 34, 18, and 34 days respectively (from Smosarski 1925). In 1852, more than 1,500 people died of cholera in just over a month of the epidemic. In 1855 and 1866, 2,211 and 1,344 people died in Poznań, respectively (source: see table 1). In 1852, 1855, and 1866, the recovery-to-death ratio was 37-50 % (Gerstenberger and Stasch 1935). Kedelski (1994) states that in 1831, deaths from cholera in Poznań affected 1.8% of the city's inhabitants; in 1837, 1.1%; in 1848, 2.5%; and in 1852 and 1866, 3.9% and 2.4% respectively (Kedelski 1994, 260-3). It was only in 1873 that just 60 people died from cholera, which was undoubtedly influenced by the improvement of water quality, as there were already waterworks in the city (Kaniecki 2004). The role of clean water intake in the reduction of mortality from water-borne diseases was already confirmed by previous studies in which, after opening waterworks in some parts of the city, post-neonatal mortality significantly decreased and the value of life expectancy of a new-born increased. It was especially visible in the poorest quarters of the city, located on the right bank of the Warta River (Liczbińska 2011). In the following years, especially after 1900, the ecological situation in the city significantly improved along with the further improvement of infrastructure. In 1912–1913, the length of the water supply network increased from 29 km to 176 km, and the number of connected homes from 1,233 to 2,829 (Sobczak 1979). The improvement of ecological conditions in Polish cities located in the Prussian Empire was caused mainly by the construction of water supply and sewage systems, which finally translated into the reduction of water-borne diseases. In Wroclaw and Gdańsk in 1888–1889, for example, the length of the waterworks was 157.9 km and 71.4 km respectively, with 6,242 and 4,215 properties in the city connected to it respectively. In 1912–1913, the length of the water supply network increased in Wrocław and Gdańsk to 423 km and to 174.9 km respectively, with 11,128 and 7,330

[1] The ratios of recovery to death in 1831 and 1837 derived from Gerstenberger and Stasch 1935; the ratio of recovery to death in 1848 is based on the author's own calculations of the adequate numbers provided by Boras and Trzeciakowski 1971, 188-289

properties connected to the water supply system respectively (Sobczak 1979).[2] In 1912, the length of the sewage network in Poznań was 105 km; whereas in Wroclaw and Gdańsk, the length was 343 km and 111 km respectively (Sobczak 1979). It is worth adding that in the Kingdom of Poland in the same period, only Warsaw had a proper sewage network. Also, such towns of the Kingdom of Poland as Płock, Włocławek, Brzeziny, Kalisz, Częstochowa, and Dąbrowa Górnicza had partial sewage systems. In Galicia, the sewage network was expanded only in Lvov (in 1911 – 90 km of waterworks), and in Krakow (in 1900 – only 32 km of sewers; Sobczak 1979).

As historical studies indicate (e.g., Boras and Trzeciakowski 1971; Trzeciakowska and Trzeciakowski 1987) the ecological conditions in Poznań differed among the city quarters, which influenced the number of deaths from cholera. The analyses of the epidemic in 1831 showed that on the right bank of Warta, in such suburbs as Chwaliszewo, Śródka, Ostrówek, Zawady, and Tum, all belonging to the Catholic parish of St. Margaret, deaths from cholera accounted for 32.7% of all deaths in the city. In the light of the same data, deaths from cholera in the suburbs belonging to the parish of St. Martin (streets: Rybaki, Strzelecka, St. Martin) accounted for 25.2%; the parish of St. Mary Magdalene, encompassing the streets around the market square, accounted for 19.2% of all deaths.[3] In 1837, the high numbers of deaths on the right bank of Warta were nothing new, but high mortality was also recorded in the suburbs of St. Martin, although, in the light of the description of the doctors operating there at that time, this place was "considered the healthiest part of the city [...] which did not seem to be conducive to the spread of the epidemic" (from Gerstenberger and Stasch 1935, 44-5). The results presented in this study, based on data on cholera deaths during four cholera epidemics in Poznań in the late 1800s, revealed that the better quarter of residence did not guarantee the lack of risk of morbidity and death from cholera and vice versa. On the right bank of the Warta River the ecological situation was very poor: parishioners used shallow wells, which were often tainted with harmful sewage from cesspits, gutters, and rubbish sites. There were also primitive street gutters with ineffective drainage, which were full of stagnant contaminated water during summer heat periods. People did their laundry in the nearby Cybina River, which was a source of drinking water (Kaniecki 2004). High rates of deaths from cholera were also recorded in the city centre in the areas outside the market square (see table 2). Although wealthier inhabitants from Poznań lived there, the place was overcrowded, and the further away

[2] Generally, Polish cities under the Prussian administration benefited from improvement in urban infrastructure in the second half of the 19th century; modern water supply systems were developed and sewage systems were constructed, which finally led to better health conditions and better ecological situation than in the lands controlled by Austria and Russia (e.g., Gehrmann 2011; Vögele, 1994, 1998, 2000; Vögele and Woelk 2002).

[3] The author's calculations based on numbers published in Gerstenberger and Stasch (1935, 41).

from the market square, the worse the access to clean water intake was (Kaniecki 2004). Importantly, there were two hospitals In the city centre. The first one was established in the first half of the 19th century in the former Bernardine Convent building and run by nuns. The second one was the city hospital located on Szkolna Street and opened in 1854 (Kaniecki 2004). Their presence could additionally have increased the number of deaths from cholera, or in general – the number of deaths from other causes; see also: Liczbińska 2009b). Meanwhile, the area located around the Old Market Square and the streets adjacent to it were privileged in terms of infrastructure. The city's market square had wells providing a supply of clean spring water carried by pipelines from sources located outside the city, and, in 1832, a wooden water aqueduct was built in this area (Kaniecki 2004; Liczbińska 2009a, 2009b). Unfortunately, the area around the market square was a place of a large rotation of people, and this was where travelers usually stayed. For example, cholera was probably brought to one of the taverns in the Old Market Square in June 1866 by rafters from Szczecin (Trzeciakowska and Trzeciakowski 1987). The outbreak of the epidemic in the richer city centre confirmed that the beliefs that cholera attacked only the poorest classes were wrong (Liczbińska 2009b). Earlier studies confirmed high mortality rates from infectious diseases also in the area of the market square. The frequency of deaths from infectious diseases of gastrointestinal tract, as typhoid, was there at the level of 5%, which was significantly greater than, for example, on the right bank of the Warta (Liczbińska 2009b).

The quarter of residence in Poznań was not the only factor influencing the death rate from cholera, as it was related to other socioeconomic factors, such as profession. Workers and (small) craftsmen died from cholera more often than other professional groups, which could be related to their place of residence. MANCOVA confirms the interplay between quarter of residence and profession in affecting on deaths from specific causes. The worst living conditions had poor working-class population concentrated in extremely overcrowded quarters located on the right bank of Warta (e.g., Liczbińska 2009a, 2009b, 2011, 2015). Workdays in industrial plants became increasingly longer and working conditions deteriorated. In many craft workshops, a twelve-hour workday was often extended to sixteen hours. No protective equipment was installed in factories and workshops, and the number of accidents increased. The poor health condition of workers deteriorated due to terrible living conditions and bad nutrition. In 1900, almost 45% of the Poznań population lived in single-room, narrow, damp, and unheated houses, and one room was inhabited by 5 to 12 people (Łuczak 1965). Access to medical care was only for wealthier and better educated groups of society, living in the city centre, especially around the Old Market Square (Kędelski 1986). The presented research also indicates that women died more often than men due to cholera (see table 2). Certain professions were particularly at risk of

contracting cholera and death. As a water-borne disease, cholera could have strongly affected people working with water.[4] In the light of the research on contemporary populations, gender differences in morbidity and mortality due to cholera are related to the division of social roles between women and men: women more frequently than men had contact with contaminated water when running households, washing children, and caring for sick family members (Agtini et al. 2005; Durana 1995; Rancourt 2013; Tutu et al. 2019). It was mainly girls and women who took care of the household and children and worked in hospitals taking care of the sick (Liczbińska, unpublished data). Children accounted for a large percentage of the deceased. Earlier research showed that in the group aged 2-14, the frequency of deaths due to cholera was 5.5-9% of all deaths in this age category (Liczbińska 2009a).

The presented research also shows that during the four epidemics that hit Poznań in the late 1800s, Catholics died more often due to cholera than Protestants. Gerstenberger and Stasch (1935), who investigated the cholera epidemic in Poznań in 1837, came to the same conclusions. In 1837, deaths from cholera accounted for 1.32% of deaths among Catholics, and 0.6% among Protestants (Gerstenberger and Stasch 1935, 44). Gerstenberger and Stasch (1935, 64) also stated that in 1837, the ratio of cholera deaths recorded among Catholics to deaths recorded among Protestants was 2.2:1, and thus exceeded the average death rate in the Catholic population. In 19th-century Poznań, another factor was associated with religious denomination – it was the *quarter of residence*. Protestants, mainly Germans, belonged to rich middle class, bourgeoisie, entrepreneurs, and influential intelligentsia, inhabiting the wealthier quarters such as the city centre or the area outside the walls. Catholics, mainly Poles, more frequently belonged to poorer classes, workers, and lower middle class. In Poznań, many of them lived in the neglected areas of the right bank of the Warta River (Liczbińska 2009a, 2009b, 2011).

6. Conclusions

In the late 1800s, Poznań was a neglected and overcrowded city closed within the fortress. The lack of clean drinking water intake, sewage systems, low level of medical care, and high population density contributed to frequent epidemics of infectious diseases, including cholera, which took a heavy toll regardless of quarter of residence, religion, and social background. At that time, Poznań was unable to supply water of adequate quality and in quantities to all its inhabitants (Kaniecki 2004). Although the Old Market Square was the only place in the city where there were wells with clean water, only a small group of residents had access to them. The majority of inhabitants used

[4] MANCOVA: sex X occupation $F=4.79$, $p<0.05$.

biologically and chemically contaminated water for consumption. The cholera deaths rates during the epidemics in 1852, 1855, 1866, and 1873 as well as during the earlier epidemics, in 1831, 1837, and 1848, were not only a result of water-related issues, but a result of many factors that were strongly interlinked. The profession was to some extent related to the quarter of residence or religion, whereas religion was related to nationality, etc. Additionally, there was a large migration of people from outside the city and movement between quarters (trade, work, service, etc.). That is why living in privileged quarters did not guarantee the lack of morbidity and protection from death due to cholera and, on the other hand, living in the neglected district did not increase the chance of death from cholera. Virtually until the end of the 19th century, the sanitary conditions in Poznań were so poor that they favoured epidemics of infectious diseases.

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