Historická demografie

THE IMPACT OF WARS AND EPIDEMICS OF INFECTIOUS DISEASES ON SELECTED DEMOGRAPHIC PARAMETERS OF THE ROMAN CATHOLIC POPULATION IN LUBLIN IN THE 19th CENTURY

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Abstract: This study addresses the question of whether, and to what extent, wars and epidemics of infectious diseases affected selected demographic parameters of the Roman Catholic population of Lublin between 1811 and 1900. The analysis was based on vital statistics extracted from selected parish records in Lublin. The article aims to reconstruct the population's status and age structure, alongside key demographic indicators such as the Gross Reproduction Rate (GRR), Net Reproduction Rate (NRR), and life expectancy at birth. The method of Inverse Projection was employed. The simulations conducted provided insights into the processes of population reproduction, the long-term evolution of gross and net reproduction rates, and trends in life expectancy at birth (e_0). These demographic parameters and their dynamics were examined in the context of external factors potentially influencing demographic behaviour. A marked decline in vital indicators was observed as a consequence of the 1831 war with Russia and the associated cholera epidemic, as well as subsequent recurrences of the disease in the mid-19th century.

Keywords: Lublin, Inverse Projection, epidemics, demographic behaviour, vital statistics

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Introduction

The traditions of Polish research on demographic crises have their origins in the work of Professor Franciszek Bujak's team, initiated even before World War II (*Kronika klęsk elementarnych w Polsce*, 1937). The factors contributing to the emergence of such crises include wars, epidemics of infectious diseases, famines and, indirectly, sudden or extreme climatic events such as floods, earthquakes, hurricanes and fires. Nevertheless, the occurrence of these events did not always lead to a demographic crisis, understood as a sharp increase in mortality rates accompanied by a decline in the number of births and marriages. Although such factors were not invariably followed by demographic crises, they contributed to so-called environmental stresses affecting individuals and societies, and ultimately led to changes in demographic parameters that, in supposed "normal times", remained relatively stable. Often, multiple factors responsible for triggering demographic crises operated simultaneously, intertwined and reinforced one another. Famine frequently acted as an intermediary between war and epidemics. Warfare typically resulted in the destruction of farmland and livestock, leading to food shortages and famine, which, in turn, created conditions conducive to outbreaks of infectious diseases, as weakened human bodies were more susceptible to infection (Miodunka, 2024).

The aim of the article

The primary objective of this article is to determine whether, and to what extent, armed conflicts and epidemics of infectious diseases affected selected demographic parameters of the population of Lublin between 1811 and 1900. The preserved source material enabled the quantification of the intensity of these phenomena and their potential effects on the studied population, particularly during selected years of crisis: 1814, 1831, 1848, and 1892. The choice of these years was dictated both by the availability of sources and by the methodological limitations inherent in the approach adopted. These years were marked not only by an increased number of entries in death registers but also by the presence of additional information in the form of so-called incidental material – occasional annotations in parish registers that often recorded major events impacting the life of the local community.

It is also noteworthy that the vital statistics utilized in this study reveal significant increases in the recorded number of deaths during the periods 1852–1855, 1866, 1867, 1873, and 1881. These findings correspond with numerous historical accounts confirming the occurrence of armed conflicts, cholera and typhus epidemics, and famines in the region under investigation (Jastrzębowski, 1984; Rachwał, 2013).

The period selected for this study spans the years 1811–1900. The initial date is determined by the introduction, at the end of 1810, of new forms for the registration of births, marriages and deaths, following the Napoleonic model. This reform, combined with increased state supervision of civil registration, contributed to improved data accuracy and, consequently, greater reliability of the results obtained. The endpoint is determined by the 1897 census – the first and only comprehensive population census conducted in the Kingdom of Poland (Polish territories annexed by Russia) – the results of which serve as an important reference for evaluating the validity of estimates concerning the age structure and size of the population.[1] Furthermore, at the turn of the 20th century, transformative processes began to unfold in the Polish lands, leading to observable shifts in fertility and mortality patterns (Borowski, 1969; Ładogórski, 1972; Zamorski, 1991, 1993).

This article seeks to reconstruct the demographic status and age structure of Lublin's population. In combination with data on the number of births and deaths, this reconstruction enables the calculation of a broader set of demographic parameters, including fertility and mortality rates, as well as overall population growth. The simulations conducted provided insights into the processes of population reproduction and the long-term development of gross and net reproduction rates – an especially valuable contribution given the scarcity of such information for the Polish lands during the ancien régime and the 19th century (Rachwał, 2022).

The adopted method also allows for the estimation of average life expectancy at birth (e_0), a synthetic measure of mortality widely used as an indicator of the overall level of development of a given population. The obtained demographic parameters and their dynamics are analysed in relation to external factors that may have influenced their fluctuations. In other words, this study attempts to assess the extent to which environmental stressors may have impacted the demographic behaviour of Lublin's population in the 19th century.

The subject of the analysis is the population of Lublin (51°15'N 22°34'E). The city, the capital of the Lublin Voivodeship and County, is located in eastern Poland. It is the central hub of the Lublin agglomeration and the Lublin Metropolitan Area. In terms of population, it currently ranks eighth in Poland, with a population of over 330,000 inhabitants.[2] During the First Republic, the city played an important political, economic, and cultural role. In 1569, the Union of Lublin between Poland and Lithuania was concluded here, resulting in the establishment of the Polish-Lithuanian Commonwealth. The city experienced rapid development at the time, aided by its central location in the newly formed state. The military aggression and partition of the Polish-Lithuanian Commonwealth (by Austria, Prussia, and Russia) in 1795 brought the Lublin region under Austrian rule, as part of Western Galicia. At that time, Lublin was the second largest city, after Krakow, in the area occupied by the Austrians. At the end of the 18th century, its population was about 9,000 inhabitants (of all faiths). The nobility moved to the countryside, while foreign officials arrived in the city. In 1809, troops of the Duchy of Warsaw entered the city. Temporary Polish authorities were organized. Following the peace

[1] *Pervaâ vseobŝaâ perepis` naseleniâ Rossijskoj Imperii 1897 goda. Lûblinskaâ Guberniâ* LV. Sankt Peterburg, 1904.

[2] Główny Urząd Statystyczny, *Powierzchnia, liczba ludności i gęstość zaludnienia wg stanu na 1 stycznia 2023 roku*, https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc/powierzchnia-i--ludnosc-w-przekroju-terytorialnym-w-2023-roku,7,20.html (See XLSX file; access:22.04.2025).

of Schönbrunn, Lublin became a part of the Duchy of Warsaw. At the beginning of 1810, Lublin became the capital of the newly created Lublin Department. In 1815, Lublin found itself within the Kingdom of Poland, being a part of the Russian partition. In 1837 it became the capital of a governorate (gubernya). By 1873 the city's population had grown to nearly 29,000 and continued to increase, reaching more than 50,000 over the next quarter-century (Chachaj – Mącik – Szulc, 2017).

It should be emphasized that the demographic analyses conducted in this study pertain exclusively to the Roman Catholic population. Roman Catholics constituted the second largest religious group in Lublin during the period under investigation. The city was home to numerous churches and monasteries that served as important religious and cultural centres. Catholicism functioned not only as a religious affiliation but also as a key element of Polish national identity, particularly significant during the era of partitions. The first and only census conducted in the 19th century in the Kingdom of Poland revealed that, in 1897, Lublin had a total population of 50,385, consisting of 25,521 men and 24,864 women. Roman Catholics accounted for 19,354 individuals, representing over 38% of the total population. The Orthodox population was 5,752 people (11.4%), while adherents of other Christian denominations (including Lutherans and Baptists) totalled slightly over 1,000 individuals. The largest religious group within the urban community was the Jewish population, which, according to the census, comprised 24,280 individuals, accounting for 48.1% of the total (Pierwaja vseobščaja, 1904).

Sources and Research Method

The primary source material used in this study consists of the parish registers of Lublin parishes for the period 1811–1900. Due to the lack of preserved and complete vital statistics for other religious groups, the analysis focuses exclusively on the Catholic population. Fundamental changes in the legal status of such documentation were introduced with the adoption of the Napoleonic Civil Code in the study area. Starting from 1810, parish registers acquired the status of official civil records, although the responsibility for maintaining them remained with the clergy, who were formally appointed as civil servants. They were required to keep duplicate records of births (baptisms), marriages (weddings), and deaths (burials).

From a formal perspective, a key change concerned the structure of the source material: the earlier tabular format – with printed headings for the date of the event, name of the officiant, baptized, married, deceased, witnesses, godparents, their social status, and sometimes their profession – was replaced by narrative-style entries. However, the substantive scope of the recorded information remained largely unchanged.[3] Subsequent regulations governing civil registration were

[3] See: https://zdjecia.ksiegimetrykalne.pl/;
https://www.szukajwarchiwach.gov.pl/jednostka/-/jednostka/2228752 [dostęp: 02.01.2025].

incorporated into the Civil Code of the Kingdom of Poland of 1825 and the “Law on Marriage” of 1836.

The study draws on data from civil records currently kept in the State Archives in Lublin, as well as parish registers maintained in the archives of the following parishes: St. Nicholas, St. Paul, and the Archcathedral of St. John the Baptist and St. John the Evangelist. During the period under investigation, these three parishes collectively encompassed the entire Roman Catholic population of Lublin.[4] Since the beginning of 1811, data on natural population movements have been characterized by continuity and completeness, as confirmed both by the state of preservation of the source materials and by demographic indicators such as the birth-to-death ratio (B/D) and the birth-to-marriage ratio (B/M).[5] Over the course of the studied period, a total of 71,487 births, 16,486 marriages and 68,139 deaths were recorded in Lublin. The annual distribution of these events is presented in Table 1 and Figure 1.

An analysis of the curves depicting the components of natural population movement highlights the elevated mortality levels during the early years of the second decade of the 19th century, as well as sharp fluctuations observed in 1831, 1848, 1854, 1855, 1881, and 1892. These mortality spikes usually – but not always – corresponded with noticeable declines in the number of births. In contrast, fluctuations in the number of marriages were less pronounced.

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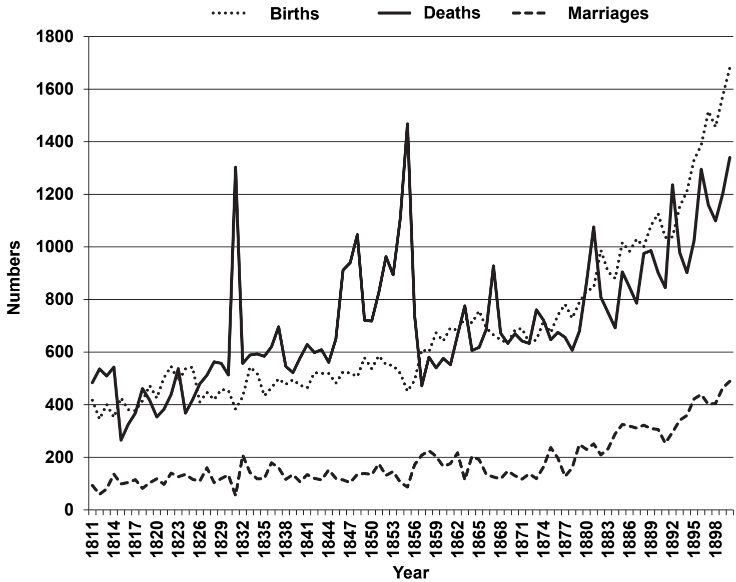
[4] State Archives in Lublin: Księgi urodzeń, małżeństw i zgonów z lat 1810–1900 (Books of births, marriages and deaths from 1810–1900) catalogue no. 35/1858/5, 8, 10–48, catalogue no. 35/1859/1–84. Księgi urodzeń, małżeństw i zgonów z lat 1810–1900 (Books of births, marriages and deaths from 1810–1900), catalogue no. 35/1860/1–24. (Books of births, marriages and deaths from 1810–1900), catalogue no. 35/1861/12–100. Parish Archives in Czwartek (Lublin św. Mikołaja/ St. Nicolaus): Liber baptisatorum/natorum 1805–1819; Liber copulatorum/matrimonium 1797–1862; Liber sepultorum/mortuorum 1809–1862 Parish Archives in Lublin pw. św. Michała/ St. Michael: Liber baptisatorum/natorum 1801–1816, 1807–1815; Liber copulatorum/matrimonium 1797–1828; Liber sepultorum/mortuorum 1803–1812; 1805–1812. Parish Archives in Lublin pw. św. Pawła/ St. Paul: Liber baptisatorum/natorum 1797–1825.

[5] Based on the existing body of demographic-historical research on the evaluation and the use of continuous registration, it should be emphasized that the greatest value is found in those resources that are characterized by the parallel preservation of three data series, i.e., births, marriages, and deaths. This continuity is extremely important in conditions where there is no information or the information on the state of the population is limited,. This value, however, is not due to the mere fact of having natural movement figures, but to the possibility of verifying each other‘s completeness by means of frequently used demographic indicators (B/M, B/D, D/M). Under conditions of reliably kept records of natural movement, the three components are closely linked and allow one to assess the regularity of their fluctuations. The generally accepted correct indicator should be approximately 4–5 for the B/M ratio and around 1–1.4 for the B/D ratio. (Gieysztorowa 1976; Rachwał, 2019, 106).

FIGURE 1. VITAL STATISTICS IN ROMAN CATHOLIC POPULATION IN LUBLIN, 1811–1900



Sources: State Archives in Lublin: Księgi urodzeń, małżeństw i zgonów z lat 1810–1900, sygn. 35/1858/5, 8, 10–48, Catalogue No. 35/1859/1–84. Księgi urodzeń, małżeństw i zgonów z lat 1810–1900, Catalogue No. 35/1860/1–24. Księgi urodzeń, małżeństw i zgonów z lat 1810–1900, Catalogue No. 35/1861/12–100. Parish Archives in Czwartek (Lublin św. Mikołaja): Liber baptisatorum/natorum 1805–1819; Liber copulatorum/matrimonium 1797–1862; Liber sepultorum/mortuorum 1809–1862; Parish Archives in Lublin pw. św. Michała: Liber baptisatorum/natorum 1801–1816, 1807–1815; Liber copulatorum/matrimonium 1797–1828; Liber sepultorum/mortuorum 1803–1812; 1805–1812; Parish Archives in Lublin pw. św. Pawła: Liber baptisatorum/natorum 1797–1825.

The years associated with these demographic disruptions coincided with periods of armed conflict, famine and outbreaks of infectious disease epidemics in Lublin. At the beginning of the second decade of the 19th century, the city experienced the consequences of the war with Russia; in 1831, it endured the November Uprising and the first major cholera outbreak in the Kingdom of Poland. In the years 1854–1856, another severe cholera epidemic struck the population of Lublin, resulting in tragic demographic losses. Smaller, though still significant, outbreaks were recorded in the late 1860s, early 1880s, and 1890s (Rachwał, 2013).

In this study, the Inverse Projection (IP) method was employed to estimate the key demographic parameters. The foundational assumptions of this method were first articulated by Ronald D. Lee (1970) in his doctoral dissertation, which examined the influence of broad economic factors on the demographic transition in pre-industrial England. Since its initial formulation, the method has undergone several modifications and has been widely applied by scholars from various academic centres (Lee, 1974, 2004; McCaa and Barbi, 2004; Oeppen, 1993; Smith and Ng, 1982; Wrigley and Schofield, 1981).

The name "Inverse Projection" refers to the procedure traditionally used by demographers in population projections but applied here in a "reversed" manner. This reversal concerns the logic of the process, rather than a simple temporal inversion of calculations. In classical population projection, input data on fertility rates, mortality rates, and migration patterns are used to estimate future values of natural population movements and migratory flows. In contrast, inverse projection begins with raw data on natural population movements – births and deaths – and uses these to derive demographic indicators and reconstruct both the size and the age structure of the population. In its original, simplest form – which involves the fewest additional assumptions – the method requires data on the number of births, deaths, and the size and age structure of the population at the outset of the study period. However, given that historians rarely have access to reliable data on population structure in pre-statistical eras, it is often necessary to rely on age structures derived from model life tables and assumptions associated with the stable population model.

Accurate data on the number of births and deaths are essential for the reliability of the results obtained through the Inverse Projection method. The primary outputs of this method include mortality rates consistent with the observed aggregate death counts and reconstructed population sizes with detailed age structures. Based on these outputs, it is possible to calculate indicators such as life expectancy at birth (e_0) and the Gross Reproduction Rate (GRR) for any age at any point during the analysed period.

The core principle of the method is the allocation of aggregate death counts across different age groups in cases where no direct information on the age distribution of the deceased is available. The procedure unfolds as follows: when initiating a projection for a given period, the probabilities of death for successive age groups are multiplied by the size of the population in those age groups at the beginning of the period. The sum of these products yields the expected number of deaths for the analysed period. By comparing the expected number of deaths with the actual, empirically observed number, discrepancies are identified. In the next step, these discrepancies are not adjusted through direct modification of death probabilities, but rather through alterations in the mortality pattern across different age groups. This adjustment is made using the so-called mortality variability index. The mortality variability index also plays a critical control function. For example, when comparing two projection procedures based on identical initial parameters, population states, and numbers of births and deaths but differing mortality probability distributions, the procedure yielding a lower mortality variability index (calculated by squaring and summing the correction factors across the entire analysed period) is considered to provide a better fit between the model and the observed data.[6]

To streamline the calculations, a computer application – Populate, developed by Robert McCaa (1989), was utilized.[7] This software, since it incorporates all extensions of the classical R. Lee algorithm, significantly accelerates the simulation process compared to manual calculations. Its principal advantage lies in its flexibility, allowing researchers to maintain full control over the selection of variables at each stage of the projection. Additionally, Populate offers a built-in database of 200 model life tables (Coale and Demeny tables) that greatly facilitate the work. In practice, this means that if a researcher wishes to apply a model pattern of age-specific mortality probabilities, an age structure, or a fertility distribution, there is no need to manually input these data into a spreadsheet. Although projections are typically conducted for five-year periods, in this study, calculations were carried out for each individual year – which represents the first such attempt in Polish historical-demographic research. The practice of conducting projections for annual intervals was first introduced by Jean-Noël Biraben and Noël Bonneuil (1986), who demonstrated that, in "crisis" years such as epidemic outbreaks, data aggregation over longer intervals could lead to errors, obscuring year-to-year mortality fluctuations and distorting the reconstructed age structure of the affected population (Biraben and Bonneuil, 1986). Further important findings based on the use of Inverse Projection with annual intervals were presented by Patrick Galloway in his comparative study of the demographic transition in northern Italy during the 17th to 19th centuries.[8]

The Inverse Projection method has been subject to criticism, particularly in the context of demographic crises caused by epidemics of infectious diseases, famine, or wars. The reliance on model life tables for calculations during such periods carries a high risk of error. For instance, the interpolation of elevated mortality

[6] A detailed explanation of the assumptions behind R. Lee's method, along with the mathematical notation of the entire procedure, can be found in (Bród – Rachwał – Strzelecki, 2016).

[7] The app, along with the user's guide, is posted on the University of Minnesota's website at: http://users pop umn edu/~rmccaa/populate/index htm [accessed 27. 12. 2024]. See also R McCaa, H P Brignoli, Populate: from births and deaths to the demography of the past, present and future, Minneapolis 1989. Version 2.9 of this program, developed in 1991, was used in the calculations.

[8] In the long term, the area was characterized by low birth rates, as well as relatively short yet stable life expectancy. The population of northern regions of Italy was characterized by high fertility at the beginning of the period under study, with equally high levels recorded only in the second half of the 19th century. The observed population growth was determined more by changes in fertility levels than mortality. The author indicated similarities in this regard to the results of English researchers from the Cambridge Group, although, as he acknowledged, the impact of mortality was greater in the Italian case (Galloway, 1994; Breschi, 1990).

rates typical for the youngest and oldest age groups may lead to an overestimation of deaths within these categories. A solution to this problem was proposed by Italian researchers, who employed empirically derived mortality patterns specific to disaster years (Bertino – Sonnino, 1995). A less precise, but more commonly adopted modification – also applied in this study – is the use of a conventional mortality threshold (for pre-industrial societies, approximately 40 deaths per 1,000 population). Below this threshold, deaths by age are distributed following the standard Inverse Projection procedure, whereas deaths exceeding this threshold are distributed evenly across all age groups. In this study, the latter approach was adopted, with the cut-off point for the crude death rate, above which the probability of death was assumed to be equal across all distinguished age groups, set at 37 deaths per a population of 1,000 individuals (Bonneuil, 1993).

In the case of Inverse Projection, the input data consist of raw values of natural population movement – specifically, the numbers of births and deaths (see Table 1 and Figure 1). In order to carry out the necessary calculations, additional information was required, including data on the age structure and population size at the beginning of the study period (in this case, for the year 1811), the age distribution of deaths (i.e., the order of deceased by age), and the distribution of fertility rates.

TABLE 1. ESTIMATED NUMBERS OF ROMAN CATHOLIC POPULATION IN LUBLIN, 1811–1900

Year	Population at the beginning of the period studied	Population in the middle of the period studied	Year	Population at the beginning of the period studied	Population in the middle of the period studied
1811	9528	9580	1856	12822	12814
1812	9632	9623	1857	12807	12989
1813	9614	9647	1858	13174	13302
1814	9679	9671	1859	13431	13617
1815	9663	9829	1860	13806	13962
1816	9998	10115	1861	14121	14316
1817	10234	10330	1862	14515	14654
1818	10427	10497	1863	14794	14903
1819	10569	10691	1864	15013	15200
1820	10815	10947	1865	15389	15595
1821	11081	11240	1866	15805	15949
1822	11401	11556	1867	16094	16107
1823	11713	11794	1868	16121	16253
1824	11875	12064	1869	16386	16533
1825	12257	12428	1870	16682	16838

1826	12601	12680	1871	16996	17172
1827	12759	12841	1872	17350	17507
1828	12924	12968	1873	17664	17766
1829	13012	13080	1874	17868	18027
1830	13148	13236	1875	18186	18362
1831	13325	12981	1876	18540	18739
1832	12645	12695	1877	18940	19172
1833	12746	12837	1878	19407	19641
1834	12929	13008	1879	19878	20111
1835	13088	13131	1880	20346	20513
1836	13174	13214	1881	20680	20751
1837	13255	13275	1882	20822	21097
1838	13296	13381	1883	21375	21644
1839	13467	13574	1884	21915	22205
1840	13682	13753	1885	22498	22755
1841	13824	13866	1886	23015	23288
1842	13908	13995	1887	23565	23896
1843	14082	14164	1888	24233	24463
1844	14246	14353	1889	24695	24964
1845	14460	14506	1890	25235	25573
1846	14553	14490	1891	25914	26241
1847	14428	14347	1892	26572	26711
1848	14267	14125	1893	26852	27179
1849	13984	14039	1894	27509	27908
1850	14094	14130	1895	28313	28720
1851	14167	14174	1896	29131	29438
1852	14181	14103	1897	29747	30191
1853	14026	13979	1898	30640	31091
1854	13933	13763	1899	31548	32014
1855	13594	13202	1900	32488	32946

Source: Own calculations using the IP method. Initial data see footnote 9.

These data, alongside the natural movement figures and the estimated initial population for 1811,[9] were derived from the United Nations model life tables

[9] To determine the state of the population at the start of the projection, the birth and marriage rates calculated on the basis of the natural movement figures for the years 1831–1840, and the data on the number of believers contained in the 1835 schema of the Lublin diocese (*Elenchus*

compiled by A. J. Coale and P. Demeny, including later modified and improved versions of their compilations.[10]

The scenarios assume that in the 19th century the life expectancy of a newborn (e_0) was 27.5 years (in the West Europe variant).[11] Each of these parameters corresponds to model values for partial death rates and the distribution of population age structure (Figure 2). The age structure selection additionally considered the growth rate, r, of 1% per year. The parameter for the average age of the mother at childbirth was assumed to be 29. This value corresponded to the following fertility levels: 0.018 for 15–19 years; 0.042 for 20–24 years; 0.056 for 25–29 years; 0.044 for 30–34 years; 0.028 for 35–39 years; 0.010 for 40–44 years; 0.002 for 45–49 years (McCaa – Brignoli, 1989: 27).[12] The projection process also assumed that populations were open to migration, hence the positive migration balance was estimated at 18 per 1,000 people per year.[13]

The level of migration was estimated based on the assumption that the final size of the Catholic population in Lublin was known. For this purpose, the

Universi Cleri Saecularis Dioecesis Lublinensis pro Anno Domini 1835, 1845, p. 7) were used. Next, the rate was extrapolated to the beginning of the second decade and, using the natural population movement figures, the initial state of the population was calculated. The final number accepted for further estimation was the arithmetic average of the population determined from the marriage and baptism rates – this amounted to 9,528 people. A similar procedure is discussed in detail in Rachwal, 2019.

[10] https://www.un.org/development/desa/pd/data/model-life-tables.

[11] For calculations, the one with the parameter e_0 = 90 was selected as the extreme table. For the probability of death for people from age groups, as well as the initial age structure, see: https://www.un.org/development/desa/pd/data/model-life-tables [access: 28/06/2024]. The e_0 values observed in Poland seem to differ from those observed in Western Europe. For example, in the Swiss Lucerne in the 1730s, the life expectancy of a newborn exceeded 38 years, in later periods it decreased, but remained above 30 years almost all the time, to cross the 38-year mark again in the third decade of the 19th century (Balthasar, 1988). In Geneva these values were even higher. In the period 1550–1599, e_0 amounted to 28.9 years, in the first half of the 17th year – 32, 7, in the second half of the 17th century – 36.1, in the period 1700–1749 – 43.5 yrs., and in the next fifty years – it was over 48 years; in the first half of the 17th century – 32.7 yrs., in the second half of it –36.1 yrs., in the period 1700–1749 – 43.5 yrs., and in the next fifty years – over 48 years (Letsch, 2017).

[12] In the parish of Zollikon (the Zurich canton), the average age of mothers at the time of childbirth was in 1561–1699 – 30.5 years, in 1700–1749 – 30.3 years, while 32.1 years in the second half of the 18th century (Letsch, 2017). In France in the 18th century, this value fluctuated for about 30 years, then dropped to 27 years, and from the mid–19th century it began to increase, reaching the level of 29 years (Caselli – Vallin – Wunsch, 2006). In Krakow in the 1880s, women giving birth were on average 28 years old, but by the end of this century this average had increased to over 29 years (Ogórek, 2018).

[13] Description of the implementation and operation of the R Lee algorithm (formula 18). For the Populate program see (McCaa, 1989; McCaa – Barbi, 2004).

number of Catholics recorded in the diocesan directory in 1900, amounting to 33,705 individuals, was used (Catalogus, 1901). The Populate tool applied the age structure of migrants who arrived in Stockholm in 1841 for the calculations. The age distribution for successive five-year age intervals was as follows: 0–4 years: 0.065; 5–9 years: 0.045; 10–14 years: 0.040; 15–19 years: 0.100; 20–24 years: 0.200; 25–29 years: 0.200; 30–34 years: 0.200; 35–39 years: 0.075; 40–44 years: 0.030.[14]

Results and Discussion

The use of the IP method allows, among other things, for estimates of the size of the population at the beginning and middle of each period, along with the age structure of the population. According to the developed model, at the beginning of the analysed period, the Catholic population of Lublin was about 9,528 people (Table 2). A clear decline was already noted in the middle of 1831, and at the beginning of 1832. The population at the time was 12,981 and 12,645, respectively. Another marked decline in the population occurred at the end of 1848 and continued into the following year. An even more pronounced decline occurred in the estimates for 1854 and 1855. While the population was over 14,000 at the beginning of 1853, by the middle of 1856 it had declined by nearly 9%. In subsequent years, a gradual increase in population size was observed, not stopped in the years for which there is source-confirmed information on the cholera outbreaks, i.e. 1881 and 1892. It should be noted that the only possible verification of the reliability of the data obtained from statistical sources exists on the basis of diocesan schemas, which contain aggregate data on the number of believers. In 1900, it showed a population of 33,750 for the study area, which is only slightly more than 2% more numerous than the estimated data (Ecclesiarum et Utriusque Cleri, 1901).

An important complement to the population size estimates is the analysis of its structure, particularly the age structure. In societies of the ancien régime – that is, before the demographic transition – population characteristics included a high proportion of young people, persistently high birth rates, equally high mortality rates, and only minor fluctuations in life expectancy. In the 19th century, primarily in Western Europe, this pattern began to change under the influence of a variety of factors. One clear, long-term effect was the progressive aging of the population (Kopczyński, 2006; Dyson, 2011; Bengtsson and Scott, 2011).

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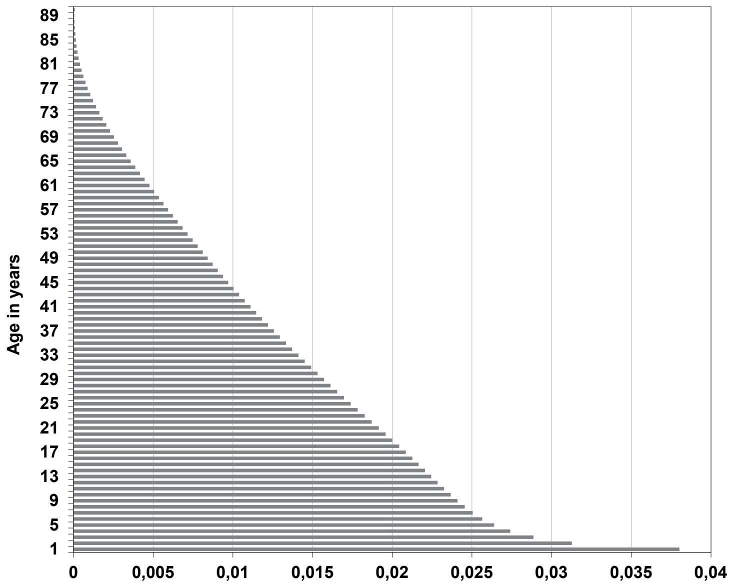
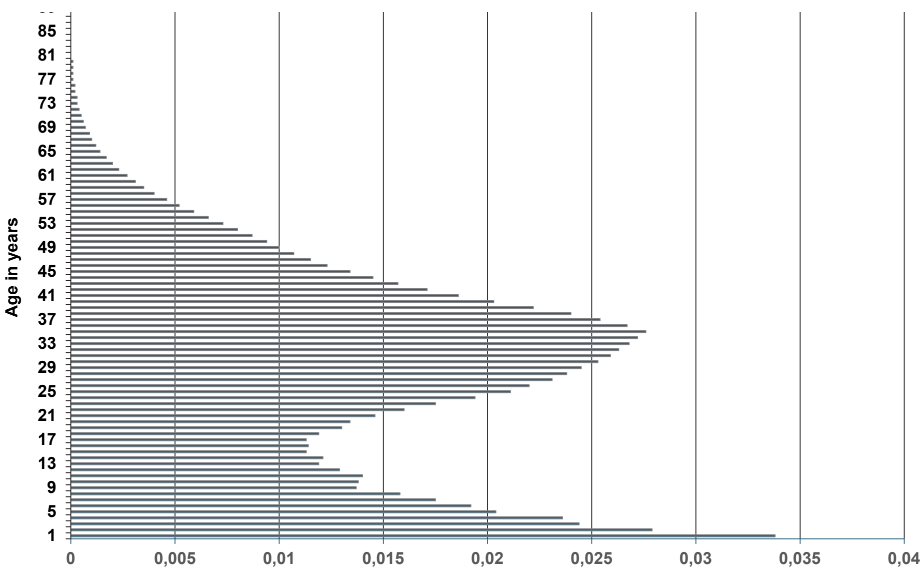
[14] See: https://users.pop.umn.edu/~rmccaa/populate/populate.htm; R. McCaa and H. P. Brignoli describe the entire procedure of the algorithm‘s operation regarding the inclusion of a specified level of migration (McCaa – Brignoli, 1989: 37). The same age structure of migrants was used by English researchers in their population projection in the monumental work dedicated to the history of England’s population from the 16th to the 19th century (Wrigley – Schofield, 1981).

FIGURE 2. AGE STRUCTURE IN ROMAN CATHOLIC POPULATION IN LUBLIN IN 1811



Source: Own calculations using the IP method. Initial data see footnote 9.

FIGURE 3. AGE STRUCTURE IN ROMAN CATHOLIC POPULATION IN LUBLIN IN 1900



Source: Own calculations using the IP method. Initial data see footnote 9.

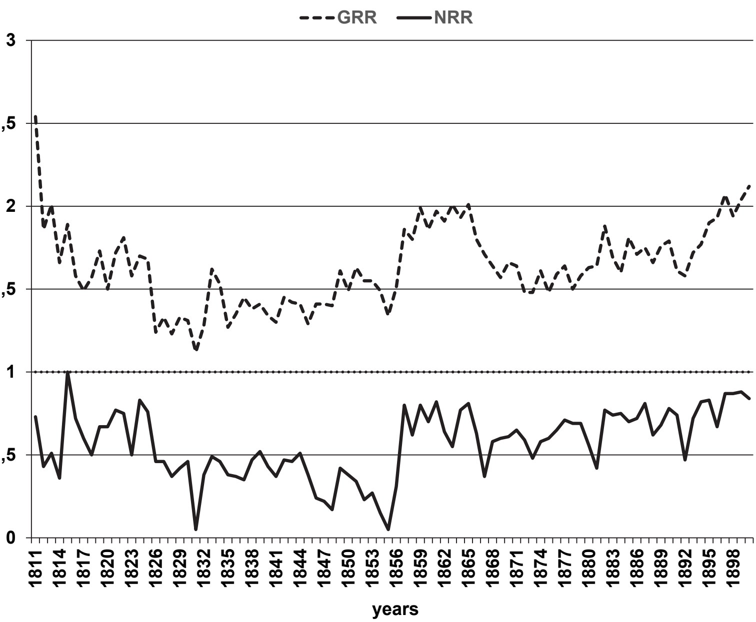
An analysis of the age structure of Lublin's population during the 19th century suggests that it initially conformed to a progressive population model, with a predominance of the youngest age groups – a pattern graphically reflected in the wide base of the age pyramid. However, over time, the situation evolved, and by the end of the century, the age pyramid had taken on a form corresponding to that of a stagnant population model. In the final year of the projection, 1900, the proportion of children under the age of 14 had declined to slightly over 26% (see Figure 3).

At that time, a significant proportion of Lublin's population consisted of migrants, whose age structure substantially influenced the overall shape of the city's age pyramid. As previously established, the migration rate into Lublin was approximately 18 per 1,000 inhabitants per year. It was assumed that the largest group of migrants comprised individuals aged 20–34 (McCaa and Brignoli, 1989). This cohort exhibited a relatively low probability of death, which allowed a significant share of its members to move into older age groups over time. Consequently, a notable presence of individuals aged 30 and 40 can be observed within the parish population. In contrast, in the older age groups, the number of individuals declined sharply due to the increasing probability of death and the decreasing likelihood of surviving into subsequent age classes.

Two measures of fertility were employed in this study: the Gross Reproduction Rate (GRR) and the Net Reproduction Rate (NRR). The GRR is defined as the average number of daughters a woman would bear over her entire reproductive lifespan, assuming she survived through her childbearing years. In contrast, the NRR reflects the average number of daughters born to a woman, adjusted for age-specific fertility and mortality rates observed in a given year. An NRR equal to 1 indicates that each generation of mothers produces exactly enough daughters to replace themselves within the population. An NRR greater than 1 characterizes a population with reproductive performance above replacement level, whereas an NRR less than 1 indicates a reproductive performance below replacement level. It is important to note that in the pre-statistical era, under conditions of high mortality, the GRR could significantly exceed the NRR (Caselli – Vallin – Wunsch, 2006; Frątczak – Ptak-Chmielewska, 2014; see also the definition provided by UNData: https://data.un.org/Glossary.aspx?q=Net+reproduction+rate+(surviving+daughters+per+woman).

According to our estimates, the highest number of daughters per corresponding generation of women of childbearing age (including childless women) was recorded at the beginning of the study period in 1811 (2.54) and 1813 (2,01). Equally high were also values of GRR in 1863 and 1865. GRR values above 2 were still observed in 1897, 1899, and 1900. However, the arithmetic mean GRR for the entire period was 1.63, with a median value of 1.62. The minimum GRR value recorded was 1.12. An analysis of the GRR curve indicates that environmental stresses had a particularly strong impact on the decline of this rate. In 1831 – the year when the first cholera epidemic broke out in the study area – the GRR dropped to 1.12, the lowest value recorded in the first half of the 19th century. A distinct rebound and subsequent rise in the GRR values were observed in the years immediately following the epidemic. Another pronounced decline occurred during the cholera epidemic of 1855, when the GRR fell to 86% of the level recorded during 1851–1854. In the following years, fluctuations in the GRR were less pronounced. Throughout the entire study period, the Net Reproduction Rate (NRR) remained below 1, supporting the observation that, during the ancien régime, cities were often described as "death houses" (See Galley, 1995; Kearns, 1988). The mean NRR value was only 0.57 (median 0.60), and it reached 1.0 only once, in 1815. Periods of environmental stress had a particularly harsh impact on the NRR values. For instance, during the cholera epidemic year of 1831, the NRR fell dramatically to just 0.05. Significant decreases in the NRR were also recorded during other epidemic years: 1848, 1854, and 1855. Detailed values of the corresponding rates are presented in Table 4.

FIGURE 4. VALUES OF GROSS REPRODUCTIVE RATES AND NET REPRODUCTIVE RATES IN LUBLIN, 1811–1900



Source: Own calculations using the IP method. Initial data see footnote 9.

TABLE 2. LIFE EXPECTANCY AT BIRTH IN ROMAN CATTHOLIC POPULATION IN LUBLIN, 1811–1900

Year	e_0	Year	e_0	Year	e_0
1811	19.5	1841	19	1871	25.3
1812	16.3	1842	21	1872	25.3
1813	17.6	1843	20.9	1873	21
1814	15.6	1844	23.1	1874	23.2
1815	34.8	1845	19.4	1875	26
1816	29.2	1846	13.2	1876	26
1817	25.9	1847	12.6	1877	27.8
1818	21	1848	10.7	1878	29.9
1819	24.8	1849	17.7	1879	27.9
1820	28.9	1850	17.6	1880	22.4
1821	28.6	1851	15.3	1881	17.6
1822	26.4	1852	12.3	1882	26.1
1823	20.7	1853	13.4	1883	28
1824	31.6	1854	9.8	1884	30.4
1825	28.9	1855	6.2	1885	24.8
1826	23.4	1856	15	1886	26.8
1827	22.1	1857	27.4	1887	29.6
1828	19.5	1858	22.5	1888	24.1
1829	20.3	1859	26	1889	24.7
1830	22.3	1860	24.4	1890	27.9
1831	6.6	1861	26.7	1891	29.5
1832	19.3	1862	22	1892	19.9
1833	19.9	1863	18.9	1893	26.8
1834	20	1864	25.5	1894	30
1835	19.4	1865	25.9	1895	28.1
1836	18.5	1866	22.8	1896	22.7
1837	16.6	1867	15.7	1897	27
1838	21.8	1868	22.8	1898	28.8
1839	23.4	1869	24.3	1899	27.5
1840	20.9	1870	23.7	1900	25.6

Source: Own calculations using the IP method. Initial data see footnote 9.

The application of the Inverse Projection (IP) method also enabled the estimation of e_0 (life expectancy at birth), a key indicator of mortality that reflects the overall health conditions of a community. A lower e_0 value corresponds to higher mortality levels. A crucial question, therefore, is how external shocks affected e_0 values during the period under study. Throughout the 19th century, e_0 in Lublin remained at a generally low level. The average e_0 value for the period analysed slightly exceeded 24 years (Table 4). In 1815, e_0 reached its maximum value of 34.8 years. In contrast, significantly reduced values were observed in 1814 and 1831. The devastation caused by the movement of armies during the November Uprising, combined with the spread of cholera and typhoid epidemics among military forces and civilians, led to a drastic drop in life expectancy – by nearly 70% compared to the average of the preceding five years. Similarly low e_0 values were recorded in the mid-1850s, particularly in 1855, during another severe cholera outbreak. By contrast, much smaller declines in e_0 were observed in 1881, during one of the last cholera epidemics of 19th-century Lublin.

Conclusion

The source material combined with the application of the Inverse Projection (IP) method made it possible to reconstruct several key demographic parameters characterizing the Roman Catholic community of Lublin in the 19th century. A comparison of the levels and temporal changes of these parameters with historical information on armed conflicts and infectious disease epidemics clearly demonstrated their significant impact on the demographic trends of the studied population. At the beginning of the analysed period, the Roman Catholic population of Lublin was over 9,500 individuals. A marked decline in the number of residents was already evident by mid-1831 and at the beginning of 1832, attributable to the combined effects of war and the first cholera outbreak. Significant population declines were also recorded at the end of 1848 and in the following year, as well as in the period between 1854 and 1855. In subsequent years, a gradual recovery in population size was observed.

The estimated GRR values reflected the effects of environmental shocks. In 1831, the GRR fell to 1.12, the lowest value recorded in the first half of the 19th century. In 1855, during another cholera wave, the GRR dropped to 86% of the average value recorded for the years 1851–1854.

The average NRR for the entire century was only 0.57 (median 0.6), and it reached the replacement level (1.0) only once, in 1815. Successive cholera epidemics in 1831, 1848, 1854, and 1855 had a substantial impact on further reductions of the NRR. The e_0 parametezr remained consistently low throughout the 19th century. The average life expectancy at birth was 24 years, with the highest value recorded in 1815 (34.8 years). Conversely, significantly lower e_0 values were observed in 1814 and particularly during the catastrophic year of 1831, when life expectancy fell to just 6.6 years, indicating a demographic collapse relative to the average of the preceding five years. Similarly low e_0 values were observed in the mid-1850s, with the lowest figure – 6.2 years – recorded in 1855.

Supplementary materials

TABLE 3. VITAL STATISTICS FOR ROMAN CATHOLIC POPULATION IN LUBLIN, 1811–1900

Year	Births	Weddings	Deaths	Year	Births	Weddings	Deaths
1811	417	93	484	1856	493	172	739
1812	345	59	536	1857	609	208	472
1813	401	80	509	1858	601	225	581
1814	352	136	543	1859	673	204	540
1815	426	99	265	1860	642	165	576
1816	381	104	325	1861	692	176	552
1817	377	115	368	1862	683	217	665
1818	415	82	461	1863	729	114	776
1819	473	103	417	1864	711	204	606
1820	425	118	353	1865	757	191	618
1821	503	97	383	1866	692	135	687
1822	546	140	439	1867	665	125	928
1823	488	126	537	1868	647	118	672
1824	536	135	368	1869	634	148	633
1825	543	116	419	1870	684	130	670
1826	410	109	479	1871	690	117	642
1827	447	160	512	1872	635	137	633
1828	419	104	563	1873	647	119	761
1829	458	119	557	1874	717	164	721
1830	454	133	513	1875	674	237	647
1831	383	54	1303	1876	741	197	675
1832	430	208	557	1877	782	127	656
1833	543	142	589	1878	729	160	607
1834	519	118	593	1879	789	249	679
1835	434	119	584	1880	833	230	865
1836	464	179	620	1881	845	251	1076
1837	499	160	696	1882	988	209	809
1838	477	116	546	1883	906	232	751
1839	495	134	522	1884	880	289	692
1840	474	107	578	1885	1017	325	905
1841	464	134	629	1886	983	319	847
1842	522	120	598	1887	1030	311	786

1843	519	114	609	1888	1001	322	975
1844	519	152	561	1889	1081	309	986
1845	482	120	650	1890	1127	306	902
1846	525	114	912	1891	1036	254	845
1847	520	104	940	1892	1038	295	1236
1848	507	135	1047	1893	1153	341	979
1849	579	139	721	1894	1211	359	902
1850	537	134	718	1895	1332	422	1024
1851	586	175	827	1896	1387	439	1295
1852	553	131	963	1897	1516	401	1159
1853	549	146	894	1898	1456	405	1099
1854	519	105	1109	1899	1574	464	1202
1855	451	87	1468	1900	1681	489	1340
1811–1900	x	x	x	x	71487	16486	68139

Sources: State Archives in Lublin: Księgi urodzeń, małżeństw i zgonów z lat 1810–1900, sygn. 35/1858/5, 8, 10–48, Catalogue No. 35/1859/1–84. Księgi urodzeń, małżeństw i zgonów z lat 1810–1900, Catalogue No. 35/1860/1–24. Księgi urodzeń, małżeństw i zgonów z lat 1810–1900, Catalogue No. 35/1861/12–100. Parish Archives in Czwartek (Lublin św. Mikołaja): Liber baptisatorum/natorum 1805–1819; Liber copulatorum/matrimonium 1797–1862; Liber sepultorum/mortuorum 1809–1862 Parish Archives in Lublin pw. św. Michała: Liber baptisatorum/natorum 1801–1816, 1807–1815; Liber copulatorum/matrimonium 1797–1828; Liber sepultorum/mortuorum 1803–1812; 1805–1812. Parish Archives in Lublin pw. św. Pawła: Liber baptisatorum/natorum 1797–1825.

TABLE 4. VALUES OF GROSS REPRODCTIVE RATE (GRR) AND NET REPRODUCTIVE RATE (NRR) OF ROMAN CATTHOLIC POPULATION IN LUBLIN, 1811–1900

Year	Gross Reproduction Rate (GRR)	Net Reproduction Rate (NRR)	Year	Gross Reproduction Rate (GRR)	Net Reproduction Rate (NRR)
1811	2.54	0.73	1856	1.51	0.31
1812	1.86	0.43	1857	1.86	0.8
1813	2.01	0.51	1858	1.8	0.62
1814	1.66	0.36	1859	1.99	0.8
1815	1.89	1	1860	1.86	0.7
1816	1.58	0.72	1861	1.97	0.82
1817	1.49	0.6	1862	1.91	0.64
1818	1.57	0.5	1863	2.01	0.55
1819	1.73	0.67	1864	1.93	0.77
1820	1.5	0.67	1865	2.01	0.81
1821	1.72	0.77	1866	1.8	0.63
1822	1.81	0.75	1867	1.71	0.37
1823	1.58	0.5	1868	1.64	0.58
1824	1.7	0.83	1869	1.57	0.6
1825	1.68	0.76	1870	1.66	0.61
1826	1.24	0.46	1871	1.64	0.65
1827	1.33	0.46	1872	1.48	0.59
1828	1.23	0.37	1873	1.48	0.48
1829	1.33	0.42	1874	1.61	0.58
1830	1.31	0.46	1875	1.48	0.6
1831	1.12	0.05	1876	1.59	0.65
1832	1.28	0.38	1877	1.64	0.71
1833	1.62	0.49	1878	1.5	0.69
1834	1.53	0.46	1879	1.58	0.69
1835	1.27	0.38	1880	1.63	0.56
1836	1.35	0.37	1881	1.64	0.42
1837	1.45	0.35	1882	1.88	0.77
1838	1.38	0.47	1883	1.69	0.74
1839	1.41	0.52	1884	1.6	0.75
1840	1.34	0.43	1885	1.81	0.7
1841	1.3	0.37	1886	1.71	0.72
1842	1.45	0.47	1887	1.75	0.81

1843	1.42	0.46	1888	1.66	0.62
1844	1.41	0.51	1889	1.76	0.68
1845	1.29	0.38	1890	1.79	0.78
1846	1.41	0.24	1891	1.61	0.74
1847	1.41	0.22	1892	1.58	0.47
1848	1.4	0.17	1893	1.72	0.72
1849	1.61	0.42	1894	1.77	0.82
1850	1.49	0.38	1895	1.9	0.83
1851	1.63	0.34	1896	1.93	0.67
1852	1.55	0.23	1897	2.07	0.87
1853	1.55	0.27	1898	1.94	0.87
1854	1.49	0.15	1899	2.04	0.88
1855	1.34	0.05	1900	2.12	0.84

Source: Own calculations using the IP method. Initial data see footnote 9.

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