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Identification of Demographic Crises and Evaluation of Their Intensity in the Kujawy Region (Central Europe) in the 19th Century

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Abstract: Mortality crises are periods of unusually high mortality resulted from a combination of epidemic episodes, climatic phenomena, historical events and sociopolitical factors. The most pronounced setback in the methodology applied to analyse mortality rates of historical populations is the inability to establish their size.

Reference publications do not provide unambiguous measures of the intensity and scale of mortality crisis periods. This problem was approached with the use of the Standardised Demographic Dynamics Rate (*SDDR*) whose value provides information about the condition of a population, disregarding the size of the group. Demographic crises were indicated and identified among the population living in the 19th century in central Poland in the rural parish. The analysis was based on data obtained from parish registers, made use of the measure expressing the ratio of the number of births to the number of deaths, without using the size of the group.

Results obtained from the analysis of data were set against the information about events causing a sudden growth in mortality derived from the widely-accessible literature. Value of the Standardised Demographic Dynamics Rate (*SDDR*) provides information aboutthe condition of a population, disregarding the size of the group. Nevertheless, only by combining the statistically obtained data with the information derived from written records it is possible to attempt to answer the question of the possible root cause of a demographic crisis.

Key words: epidemics, mortality crises, Standardised Demographic Dynamics Ratio (SDDR), Box-Cox transformation, historical demography

Original article

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Introduction

The analysis of the 16th–19th century mortality rates reveals the occurrence of repeated periods of sudden and dramatic increases in the number of deaths. Such violent short-run disturbances in the mortality pattern, referred to as mortality crises, their causes and effects on local communities, have been in the centre of attention ever since the interest in the possibility of research into record books appeared (Hinde 2010; Nelson 1991; Humphreys 1987; Landers 2006; Goubert 1960; 1968).

One of the definitions of the phenomenon states that „mortality crises are unusually high mortalities arising from a common, unusual, causal factor operating for a limited time across a given geographical area" (Bouckaert 1989). The death curve rockets and increased mortality lingers for a period of at least several months (Kuklo 2009). Researchers, however, tend to be in disagreement as to the choice of objective methods providing unambiguous identification of crisis periods and their intensity. The most pronounced setback in the methodology applied to analyse mortality rates of historical populations is the inability to establish their size, which stems from the very character of the analysed sources (parish registers, registers and statistics of deaths). Reference publications do not provide unambiguous measures of the intensity and scale of mortality crisis periods that would allow space-time comparison and the description of variation of the observed phenomena (Sawchuk et al. 2013; Kuklo 2009; Goubert 1968).

Consequently, both historians and demographers tend to apply the number of deaths, or less frequently – the number of conceptions, as the measure of demographic crises.

By general agreement, though, researchers point at the necessity to apply a variety of criteria of identification of crises themselves, as well as their intensity, depending on the population size and socio-economic discrepancies within its structure (e.g. urban-rural) (Turner 1973; Lebrun 1977; Hinde 2010; Sawchuk et al. 2013; Bouckaert 1989). Provided that the size of the population and length of the crises are known, crisis intensity index suggested by T. Hollingsworth (Hollingsworth 1979; Hinde 2010) can be applied. The important upside of this method is the possibility to determine the crisis intensity on the basis of the size of the deceased fraction of the population. There are, however, those who assume that during a crisis the number of deaths has increased by 1.5 up to 3 times in comparison to the monthly or yearly moving average for the period directly preceding the crisis. The moving average is calculated for the period of 9 to 25 years, sometimes discarding up to 4 extreme values. The calculation of the moving average may, at times, include periods preceding and following the alleged crisis year (Appleby 1978; Edvinsson 2015; Schofield 1972; Hoch 1998; Kuklo 2009; Hinde 2010; Turner 1973; Humphreys 1987; Lebrun 1977).

The main aim of our research was to indicate and identify demographic crises and/or revivals occurring in the 19th century among the catholic rural population in *North-Eastern Poland* and to suggest a classification allowing the assessment of the magnitude of those events.

The identification of crises was performed with investigating their underlining causes such as epidemics, wars or others. The identification and the evaluation of intensity was carried out according to Jaques Dupâquier (Dupâquier 1979), Pierre Goubert (Goubert 1968) and with the use of the Standardised Demographic Dynamics Rate (*SDDR*).

The results obtained from the analysis of data concerning the residents of Kowal parish in the 19th century were set against the information about events causing a sudden growth in mortality in the local population derived from the widely-accessible literature (Dziki 2007b; 2007a; Rejmanowski 2001; Siudikas 1998; Wrębiak 2010; Korpalska 2011; Evans 1988; Puzyrewski 1899; Budnik 2008; Dorobek 1979; Winkle 1999; Włodarczyk 1998; Zasada 2006; Drozd-Lipińska, Bartczak, and Dziki 2021a; Dziki 2021) as well as the archives.

Material and methods

Historical Background

Kowal is a small town in the Eastern Kujawy region whose written historical records date back at least to the 12th century (Głowacki 2007). The people of the town itself, as well as that of the surrounding villages included in the parish (Fig. 1), largely lived off the land or, less frequently, craftsmanship (Gruszczyńska and Poraziński 2002; Dziki 2007a; 2021; Drozd-Lipińska 2021; Drozd-Lipińska, Bartczak, and Dziki 2021a).

Historical forces of the 19th-century Europe turned the commune of Kowal into a part of the Russian empire on the territory of the Kingdom of Poland (Zasada 2007; 2006). The harrowing political situation, combined with contributions regularly imposed on villages for the sake of marching armies, resulted in a profound economic crisis (Dziki 2007a; 2021). The situation of Kowal was further aggravated by its less-than-favourable location in relation to the existing communications network and the neighbourhood of the dynamically developing industrial centre – the city of Włocławek.

Fig. 1. Map of 19th of Kowal Parish

Consequently, the parish missed out on the benefits potentially flowing from the 19th-century industrial revolution (Dziki 2007a; 2021; Drozd-Lipińska, Bartczak, Dziki 2021a). Moreover, the 1869 administrative reform, depriving the town of its borough rights for nearly half a century, significantly worsened its economic position (Zasada 2006; Dziki 2007a; 2021; Drozd-Lipińska, Bartczak, Dziki 2021a). Given the above, it seems justified to categorise Kowal and the neighbouring villages scattered around the area of approx. 18 km as a "typical" agricultural area.

Data

The analysis was based on data obtained from record books kept by the Włocławek Branch of the National Archive in Toruń. The annual records from Kowal parish written in Polish or Russian contain information on christenings, deaths and weddings reported in the parish during a given year and provide an exact date of the event. On this basis, the information was gathered about 20124 births and 12971 deaths of the parishioners in 35 settlings, towns and villages in the parish of Kowal which happened in the period 1813–1909 (Table 1).

Table 1. Number of births and deaths in Kowal Parish in 1813–1909

Year	Births	Deaths	Year	Births	Deaths	Year	Births	Deaths	Year	Births	Deaths
1813	116	77	**1837**	178	152	**1861**	174	86	**1887**	256	174
1814	146	72	**1838**	159	100	**1862**	217	140	**1888**	256	153
1815	128	44	**1839**	163	82	**1863**	228	140	**1889**	248	179
1816	131	97	**1840**	146	95	**1864**	223	126	**1890**	282	188
1817	138	91	**1841**	161	106	**1865**	239	101	**1891**	246	227
1818	165	73	**1842**	177	101	**1866**	254	94	**1892**	245	206
1819	149	70	**1843**	182	143	**1867**	242	103	**1893**	282	255
1820	168	64	**1844**	163	105	**1868**	200	122	**1894**	283	202
1821	177	73	**1845**	205	77	**1869**	236	95	**1895**	264	125
1822	189	93	**1846**	163	141	**1870**	232	90	**1896**	280	100
1823	181	73	**1847**	160	166	**1871**	220	96	**1897**	295	145
1824	182	134	**1848**	132	162	**1872**	230	94	**1898**	292	136
1825	190	104	**1849**	155	128	**1873**	235	117	**1899**	261	249
1826	206	99	**1850**	189	101	**1874**	209	142	**1900**	323	208
1827	160	112	**1851**	160	83	**1875**	238	101	**1901**	276	180
1828	165	149	**1852**	149	334	**1876**	219	102	**1902**	298	179
1829	166	145	**1853**	178	155	**1879**	236	187	**1903**	306	188
1830	143	148	**1854**	145	167	**1880**	245	117	**1904**	293	146
1831	130	215	**1855**	110	191	**1881**	224	119	**1905**	272	138
1832	99	173	**1856**	151	137	**1882**	247	158	**1906**	275	162
1833	181	90	**1857**	171	154	**1883**	228	250	**1907**	283	134
1834	169	61	**1858**	174	140	**1884**	249	118	**1908**	273	150
1835	175	110	**1859**	214	120	**1885**	249	122	**1909**	284	178
1836	155	101	**1860**	164	77	**1886**	253	161	**Sum**	**20 124**	**12 971**

Moreover, the population size was established based on data from catholic directoriums kept in Dioecesan Archive in Włocławek. Then the mortality rate was calculated (Fig. 2).

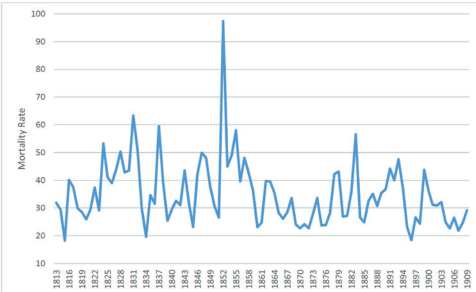


Fig. 2. Values of crude death rates [‰] for Kowal Parish (1813–1909)

The credibility of historical records, and thus their usefulness for our analysis, was tested by making a reference to findings made by Polish and French researchers (Gieysztorowa 1976; Goubert 1960), according to which the percentage of newborn deaths for the period concerned ought to stand at 30% of the total mortality rate. Following the commonly agreed opinion (Sułowski 1962; Kaczmarski 1967; Budnik 2005; Gieysztorowa 1976; Kuklo 2009), that register books of marriages were among the most diligently maintained record books, indicators relating the number of births to the number of marriages as well as the number of deaths to the number marriages were calculated. It was assumed that the ratio of the number of births to the number of marriages (B/M) of 5.0 and that of the number of deaths to the number of marriages (D/M) of 3.0 proved the correct and conscientious maintenance of the records, thus enabling further processing of the data obtained (Gieysztorowa 1962; 1976; Sułowski 1962; Kuklo 2009; Kaczmarski 1967; Budnik 2005).

Methodology Description

The analysis made use of the formula, put forward by J.L. Dupâquier (Dupâquier 1979), makes it possible to classify the intensity of a crisis using the number of deaths, the average value and the standard deviation. According to the assumption, the calculated intensity index falling into intervals 1–2 stands for a minor crises and the subsequent intervals stand formoderate (2–4), high (4–8), major (8–16), super crises (16–32) and catastrophes (32+).

Next, according to Goubert (Goubert 1968), the moment in which the number of deaths has increased twofold during the year regarded as the crisis one in comparison to the preceding 12 months, and the number of conceptions has decreased by 1/3, was regarded to be the onset of a crisis.

The last method was the determination the level of balancing the number of births to the number of deaths – the Demographic Dynamics Rate (*DDR*) – (Holzer 2003) for every year. The assumption about the normal character of the analysed yearly and monthly series of the DDR was statistically verified with the Shapiro–Wilk test (Shapiro, Wilk 1965; Razali, Wah 2011) typically used to prove a hypothesis that a given sample comes from a normal distribution. The analysis was performed on the level of statistical significance $\alpha = 0.05$. It is frequently stated that one of the basic requirements for particular models to be applicable is the normality of the series of data (Sakia 1992; Ajdacic-Gross et al. 2006). The series of demographic data do not tend to have the normal distribution and, as such, they are subject to log transformation, frequently with disputable results (Shang 2015). Bishai and Opuni (Bishai, Opuni 2009) highlighted the importance of selection of an appropriate method of data transformation for the research involving the comparison of various demographic indices. Similarly, H. Booth (Hyndman and Booth 2008), followed by H.L. Shang (Shang 2015), argued that a correctly chosen transformation is prerequisite for correct modelling and predicting various demographic parameters and occurrences.

Therefore all the analysed series were normalised and the values of indicators (*x*) were next subjected to the Box-Cox transformation (Box and Cox 1964; 1982; Bartczak, Glazik, Tyszkowski 2014). With the use of the transformation the skewness of the distribution pattern was eliminated and so were other difficult-to-analyse properties. Selected transformations of the series of monthly values are depicted graphically on the Quantile-Quantile plot (Fig. 3). The effectiveness of the transformation was subsequently re-tested by Shapiro-Wilk test. It is worth mentioning that value 1 of the *DDR* after the transformation, disregarding the λ parameter, takes the value of 0. The applied standardisation process enables the comparison of a number of series characterised by various input data – both in respect of their scale and the unit of measurement. All the above considerations concerning the properties of the normal distribution were used for the sake of classification of the calculated demographic dynamics rates and using them to evaluate the intensity of mortality crises.

The probability of occurrence of a particular value of the Standardised Demographic Dynamic Rate (the area under the density curve of the normal distribution) was used as the basis for classification (Table 2). It was assumed that a crisis year was defined by the value below or equal to -0.61 (differentiating between crises classified as "Very –", "Anomalous –" and "Extreme-"). Values of -0.61 to 0.61 stand for the years in which neither positive nor negative factors influencing the population reproduction process were observed

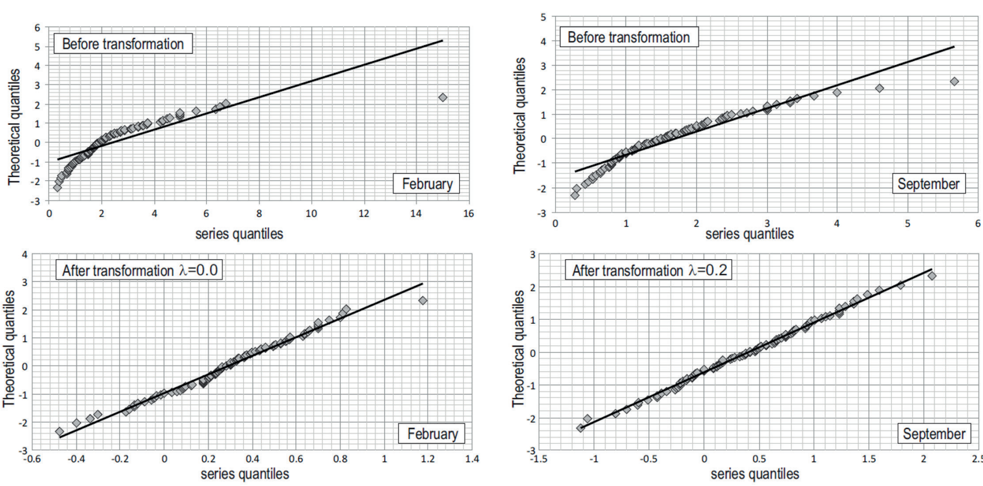


Fig. 3. *Q-Q* plot for the normal distribution of selected series of monthly demographic dynamics index for Kowal Parish (1813–1909) before and after Box-Cox transformation

Table 2. The classification of the probability of the frequency of the occurrence of a value in *SDDR*

Classification	Times the standard deviation from the mean	Probability [%]
Extreme+	≥1.97	2.5
Anomalous+	1.15 ÷ 1.96	10
Very+	0.61 ÷ 1.14	15
Normal	0.60 ÷ -0.60	45
Very-	-0.61 ÷ -1.14	15
Anomalous-	-1.15 ÷ -1.96	10
Extreme-	≤-1.97	2.5

Source: Own study.

(such factors either did not appear or they were mutually offset). Following the normalisation and standardisation procedure, the variability of indicators (Standardised Demographic Dynamics Rate – *SDDR*) in time was depicted with the use of a moving trend (segment, crawling). Next, the structural parameters of the function were estimated for each segment. The number of segments in one series is *n-k+1* and the linear functions for each segment are as follows: $\hat{y}_1 = a_1 + b_1 t$ *for* $1 \le t \le k$; $\hat{y}_2 = a_2 + b_2 t$ for $2 \le t \le k+1$; .... ; $\hat{y}_{n-k+1} = a_{n-k+1} + b_{n-k+1} t$ for $n-k+1 \le t \le n$. The analysis was performed for the constant $k = 15$ years. All calculations were performed using the analytics software package Statistica 13.3.

Results

Dupâquier's Crises Intensity Ratio (*DCIR*) was enabled to identified twelve years of minor, eight years of formoderate and two years of high crises. In nine years *DCIR* reached values between -2 to – 1 (1833, 1834, 1839, 1850, 1851, 1860, 1866, 1895, 1907) and once yearly value was below -2 (1896) (Fig. 4).

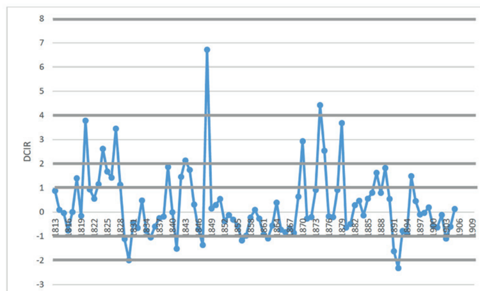


Fig. 4. Values of Dupâquier's Crises Intensity Ratio for Kowal Parish (1813–1909)

Research procedure based on Goubert method allowed to identify only two crises years – 1816 and 1852.

In the third method (*SDDR*), based on yearly (Fig. 5) and monthly (homogenous) (Fig. 6) demographic dynamics ratio values, the distribution of most series of monthly indicators was brought to normality by means of the Box-Cox transformation. The Table 2 presents the obtained values of the parameter *λ* necessary for appropriate selection of the function transforming the series. Finally, 27 years of crises mortality have been identified for the population of Kowal (17 "Very –"; 6 "Anomalous –"; 4 "Extreme-":) (Fig. 5, Table 3).

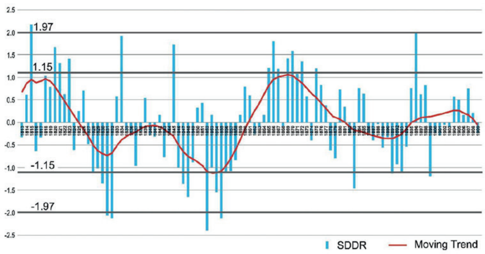
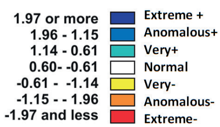


Fig. 5. Values and trend of Standarised Demografic Dynamic Ratio for Kowal Parish (1813–1909)



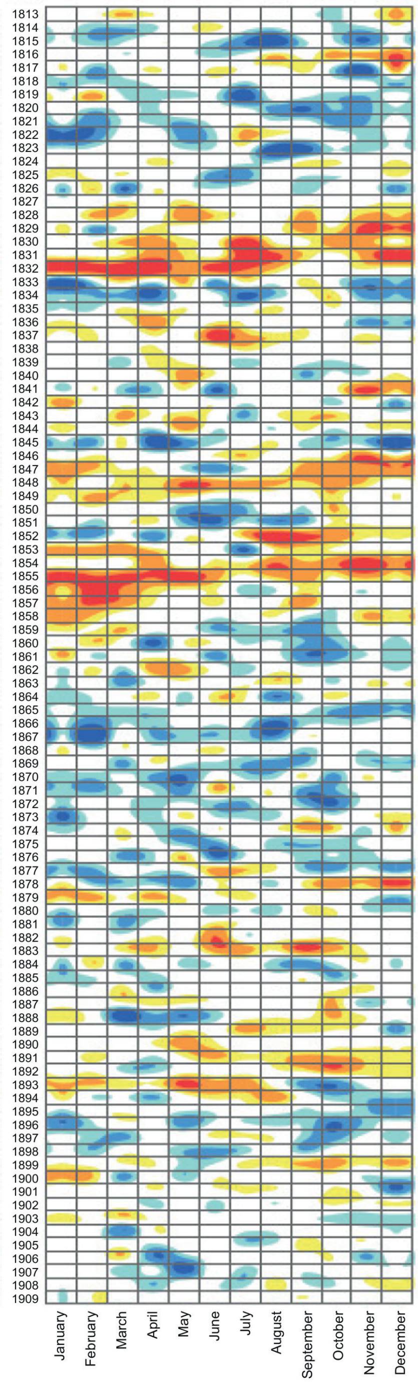


Fig. 6. Values of the monthly Standarised Demographic Dynamics Ratio (*SDDR*) for Kowal Parish (1813–1909)

Table 3. Values of λ parameter for the monthly and yearly Demographic Dynamics Ratio for Kowal Parish (1813–1909)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
λ	0.2	0.0	0.3	-0.1	0.0	-0.2	-0.1	0.2	0.2	0.0	-0.2	0.0	0.9

Source: Own study.

The multi-year span which was investigated revealed a few long-lasting harrowing periods for the local population (Table 4). The first one, recorded in Twenties of the 19th century (as 1822, 1824, 1827–1832 according to *DCIR* and 1824 and 1828–1832 and 1837 according to *SDDR*), seems to have been an upshot of a harsh economic and political situation prevailing in the region following the outbreak of the anti-Russian uprising in November 1830, which engulfed the Kowal parish. A thorough investigation of historical sources suggests a direct link between extremely high/low values of the ratios, particularly in 1831 (annual number of births = 130; annual number of deaths = 215; *DCIR* = 3.45; *SDDR* = -2.07;) and 1832 (annual number of births = 99; annual number of deaths = 173; *SDDR* = -2.13) and a cholera epidemic (1831–1832) which broke out after Russian troops had been sent into the region in order to supress the uprising (Puzyrewski 1899; Włodarczyk 1998). This period was proceeded by one crisis year – 1816 (identified according to all three methods), year after Napoleon's defeat, when soldiers was marched back from France to Russland through Kujavy Land (Dziki 2018; Drozd-Lipińska, Bartczak, and Dziki 2021a; 2021b) and after the Fourth Partition of Poland.

The second long-lasting period of low reproduction rate was recorded in Forties-Fifties of the 19th century (1843, 1846–1848 and 1852 according to *DCIR*; 1843, 1846–1849, 1852–1858 according to *SDDR*, 1852 according to Goubert), which must have been an aftermath of the situation in place in the mid-1840s (food crisis triggered by failing harvest and mass damage to potato plantations) (Myszczyszyn 2013) which preceded the outbreak of the 1848 cholera epidemic (Włodarczyk 1998) and

Table 4. Classification of crises mortality and demographic revivals in Kowal Parish (1813–1909) (*SDDR* method)

Classification	Times the standard deviation from the mean	Number of occurrences
Extreme+	≥1.97	2
Anomalous+	1.15 ÷ 1.96	12
Very+	0.61 ÷ 1.14	16
Normal	0.60 ÷ -0.60	40
Very-	-0.61 ÷ -1.14	17
Anomalous -	-1.15 ÷ -1.96	6
Extreme-	≤ -1.97	4

Source: Own study.

then another wave of the disease that decimated the population of Kujawy in 1852 (Rejmanowski 2001; Włodarczyk 1998). The latter sparked the third successive "High" /"Extreme-" demographic crisis and an increase in the value of the DCIR to 6.72 and a drop in the value of the *SDDR* to -2.39 in 1852 (annual number of births = 149; annual number of deaths = 334), the highest/lowest level recorded in the researched period. The next evident "Extreme-" demographic crisis according to *SDDR* method was recorded in 1855 (*SDDR* = -2.13; annual number of births = 110; annual number of deaths = 191) and, again, it is tied with the appearance of cholera in the area (unidentified by *DCIR* or Goubert's method) (Włodarczyk 1998).

The two last long-lasting mortality crises periods were observed in the late 19th century. Seventies (1874 and 1878–79 according to *DCIR* and 1878–19 according to *SDDD*) and Nineties (respectively: 1891, 1893, 1899 and 1891–1893, 1899) were unfavourable, but it must be noted that the late 19th century manifests a universal tendency to shorten the negatively-marked periods and to diminish the intensity of their negative impact on the population (Fig. 4–6). This may have been caused by the weakening impact of epidemics on the level of mortality owing to improved sanitation and fast-developing medicine. The moving trend for the decade (based on *SDDR* values) suggests the occurrence of several adverse factors, yet successfully offset by various social phenomena like the population migration (Szczechowicz 2013; Jura 2002).

At this stage of research it is not possible to connect sudden increase of *DCIR* value in 1878 (*DCIR* = 4.42) and 1910 (*DCIR* = 2.35) with specific historical or economic event, while increase/decrease of ratios values in 1883 (*DCIR* = 3.68; *SDDR* = -1.46) should be a consequence of some kind of epidemic, as described before (Drozd-Lipińska, Klugier, Kamińska-Czakłosz 2015).

While analysing the distribution of the *SDDR* in an annual cycle (Fig. 6), one is prone to observe that events having an adverse impact on the population do not display any seasonal character lasting up to several months. An example of such an event is the demographic crisis which started in September 1829 and did not finish until July 1832, during which period the *SDDR* stood at the level below -2.00 for as many as 11 months. July 1830 and April 1832 marked the moments of the most severe crisis with the *SDDR* of -3.24 (monthly number of births = 3; monthly number of deaths = 12) and -3.05 (monthly number of births = 7; monthly number of deaths = 26) respectively. The situation was largely repeated in 1854 and 1855 with very low monthly values of the indicator, though the relation of births to deaths was not as dramatically negative as it had been two decades before. The distribution of the indicator in the yearly cycle took a very interesting form in 1852. During the first six months of the year the ratio of births to deaths remained in the positive area with the peak value of the *SDDR* of 1.85 in April. On the other hand, the period from July to October was an extremely unfavourable time for the investigated population with the bottom value of the *SDDR* of 3.37 observed in August 1852 (monthly number of births = 11; monthly number of deaths = 210), which was the lowest level for the whole period included in the research.

Table 5. Years of crises mortality in Kowal Parish (1813–1909)

Year	DCIR	SDDR	Goubert
1816	Minor	Very -	+
1822	Minor		
1824	Formoderate	Very -	
1827	Minor		
1828	Formoderate	Very -	
1829	Minor	Very -	
1830	Minor	Anomalous -	
1831	Formoderate	Extreme -	
1832	Minor	Extreme -	
1837		Very -	
1843	Minor	Very -	
1846	Minor	Very -	
1847	Formoderate	Anomalous -	
1848	Minor	Anomalous -	
1849		Very -	
1852	High	Extreme -	+
1853		Very -	
1854		Anomalous -	
1855		Extreme -	
1856		Very -	
1857		Very -	
1858		Very -	
1874	Formoderate		
1878	High	Very -	
1879	Formoderate	Very -	
1883	Formoderate	Anomalous -	
1891	Minor	Very -	
1892		Very -	
1893	Minor	Very -	
1899	Minor	Anomalous -	
1910	Formoderate		

Discussion

Illnesses of endemic or epidemic character used to be among the most significant regulators of the natural population movement in the pre-industrial era. Their kind and frequency of appearance evolved throughout centuries following cultural transformations. The transformations of the social patterns of health and illness characteristic of subsequent historical periods are known, after A. R. Omran (Omran 1971), as "epidemiological transitions". The 19th century saw a gradual decrease in infectious disease mortality and, at the same time, an increase in the number of deaths resulting from civilization illnesses and other external reasons which became the main cause of deaths. Waves of epidemics which had haunted Europe for centuries, now gave way to chronic and degenerative diseases related to the ageing population. Growing industrialisation brought about civilisation diseases, allergies and depression (Gagnon 2012). This change, known as the second epidemiological transition, was first observed in Sweden, England and Wales, Germany, France and Italy in the mid-19th century and is directly associated with the ongoing industrial revolution, technological development, improved sanitation and progress in medicine (Barrett et al. 1998; Omran 1971). The area of modern Poland did not experience this transition until later time when, as suggested by A. Budnik in her research on Greater Poland (Budnik 2008), rapid industrialisation process took place in Poznań area in the period 1875–1880. The rural populations of Greater Poland waited for this same transition for two decades until the late 19th century (1896–1900) as was the case with Kujawy region. The present research indicates that the onset of the transition in this area fell on the last five years of the 19th century when the epidemics, which had regularly decimated the population, suddenly stopped being the main factor shaping the mortality patterns. Interestingly, then, the second epidemiological transition in the rural community of Kujawy was not delayed by the economic underdevelopment of the region resulting from specific political, economic and social conditioning of this part of the Russian partition (Dziki 2007b; 2021; Drozd-Lipińska, Bartczak, Dziki 2021b; 2021a).

The period directly preceding the second epidemiological transition was the time of many sudden increases in the number of deathsfalling into the category of demographic crises. The methods described earlier in the article enable researchers to identify them in a relatively precise manner without investigating their root causes (Miodunka 2013; Hinde 2010; Kuklo 2009; Appleby 1978; Edvinsson 2015; Turner 1973; Schofield 1972; Hoch 1998; Humphreys 1987; Lebrun 1977). A further analysis of sources other than record books – annuals, diaries, letters, legal documents, or later, daily press, makes it possible to tie the periods of increased mortality with epidemic episodes, climatic phenomena or historical events (Sawchuk et al. 2013), sometimes also offering a chance to capture the phenomenon of social selectivity (SES) which may have resulted in differing rates of mortality between rural and urban communities, or between various social classes (Healey 2008; Breschi, Manfredini, Fornasin 2011).

Most of the identified 19th-century demographic crises were triggered by Asian cholera whose recurrent waves decimated the population of Europe since 1817 (Smith 1978; Straszak-Chandoha 2008; 2013; Rüttimann and Loesch 2012). All of the 5 (in 1817–1823; 1826–1837; 1846–1862; 1864–1875, 1883–1896 (Siudikas 1998) or in 1817–1823; 1826–1837; 1841–1862; 1864–1875; 1882–1896 (Winkle 1999)) or 6 (in 1817–1823; 1826–1837; 1842–1859; 1863–1875; 1881–1896; 1899–1923 (Evans 1988)) strikes of epidemics would decrease the number of marriages due to a natural tendency to postpone vital decisions for better times. Initially, the number of births dropped, yet the number of conceptions went up periodically at the peak moments of an epidemic, which may have been a result of tightening family bonds in harsh times (Kuklo 2009; Miodunka 2013). Owing to this mechanism, at the final stages of an epidemic an increased number of christenings were often recorded, though it was not a rule. Cholera epidemics observed and recorded in Poland (Czapliński 2012; Berner 2008; Budnik, Liczbińska 1997; Liczbińska, Sosinko, Budnik 2007; Liczbińska 2009; 2013; Piasecki 1990; Wrębiak 2010; Rejmanowski 2001; Korpalska 2011; Dorobek 1979; Włodarczyk 1998) perfectly correspond to demographic crises which occurred in 1831–1832, 1848 and 1852 on a given area.

Sources suggest a correlation between the growth in the number of deaths, a decline in the number of marriages and conceptions and an increase in grain prices or the periods of food crises (Appleby 1973; Nelson 1991; Miodunka 2013; Humphreys 1987). Historically, epidemic diseases would frequently strike following periods of famine when the levels of immunity in the population was greatly lowered (Kuklo 2009; Gieysztorowa 1976; Lebrun 1977).

Negative environmental factors are reflected in historical sources especially in relations to the 1840s and the late 1870s. During the first crisis period of 1828–1832 the population of the parish of Kowal most probably failed to resist the negative influence of economic hardships and resulting famine, which led to an increased number of deaths combined with a decreased number of conceptions. Simultaneously, the weakened population became more susceptible to the upcoming waves of epidemics brought by the Russian troops in 1831 and still decimating the population of Kujawy in the following year (Puzyrewski 1899; Włodarczyk 1998).

Similarly, negative events of economic character (food crisis of the mid-1840s caused by failing harvest and widespread damage to potato plantations) (Myszczyszyn 2013) scarred the population of Kowal for the whole period of 1846-1857 marked by three waves of cholera epidemics in 1848 (Włodarczyk 1998), 1852 and 1855 when another demographic crisis appeared (Rejmanowski 2001; Włodarczyk 1998).

Conclusions

The article was an attempt to identify and evaluate the intensity of demographic crises occurring among the catholic rural population in the 19th century. Identification and evaluation of mortality crises in Polish population was carried, thus far, for Gdansk, Warsaw, Poznan and Gubin (17th–18th Centuries) (Guzowski, Kuklo, Poniat 2016; Kuklo 2009). Guzowski et al. (Guzowski, Kuklo, and Poniat 2016) mentioned, that Dupâquier's method works better for years when epidemics and plagues have occurred at significant intervals. Otherwise, the high number of deaths in previous years overestimates the average. Furthermore *DCIR* values are based only on number of deaths and could falsify results during rapid increase in the population size. Hence it seems that Standardised Demographic Dynamics Rate, based both deaths and births numbers, could be the better method to crises identification.

Goubert's method, because of its poor sensitivity, turned out to be the least useful for crises identification in such small, rural population.

Standardised indices are widely used to identify and evaluate the level of intensity of events also in other fields of natural sciences such as climatology

(McKee, Doesken, Kleist 1993; Guttman 1999; Karavitis et al. 2011; Łabędzki 2007; Bonaccorso et al. 2003) or hydrology (Bartczak, Glazik, and Tyszkowski 2014). Standardised index in demography, based on births and deaths numbers, provides information about the condition of a population, disregarding the size of the group. Nevertheless, only by combining the statistically obtained data with the information derived from written records is it possible to attempt to answer the question of the possible root cause of a demographic crisis.

Conflict of interests

All authors declared no conflict of interests.

Authors' contribution

AD-L, AB, MK performed modelling work; AD-L, AB, TD analysed output data; AD-L and AB wrote the manuscript with assistance of MK and TD. All authors substantially contributed to revisions.

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