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LONG-TERM TRENDS IN INFANT MORTALITY RATES IN POST-SOCIALIST EU COUNTRIES

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ABSTRACT

Motives: Post-socialist European countries experienced significant political turmoil and economic and social changes in the late 1980s and the early 1990s due to regime change. These changes had a profound impact on their subsequent socioeconomic and demographic development. Since infant mortality rates (IMRs) are closely related to socio-economic changes, this study was undertaken to determine whether these changes affected IMRs in the transitional period.
Aim: The aim of this study was to investigate the changes in IMRs in eleven post-socialist European countries that are currently European Union (EU) members, and to compare IMRs in these countries with the remaining EU Member States. The changes in the slope of the IMR trend line were determined by a joinpoint regression analysis. The influence of gross domestic product (GDP) per capita based on purchasing power parity (PPP) on IMRs in all EU countries was also examined.
Results: It was found that the collapse of the socialist regime increased IMRs in post-socialist EU countries, and that contrary to other EU Member States, the changes in GDP per capita PPP continue to have a significant impact on IMRs in post-socialist EU countries.

Keywords: infant mortality rates, political regime changes, socioeconomic changes, post-socialist EU countries, joinpoint regression analysis, GDP per capita PPP

INTRODUCTION

European post-socialist countries experienced extensive political turmoil and economic and social changes in the late 1980s and the early 1990s due to regime change, which affected their socioeconomic and demographic development. Socialist regimes collapsed due to the events that began in the "revolutionary year" of 1989 and peaked in 1991 when the Union of the Soviet Socialist Republics was dissolved. After more than four decades, the boundary separating the Eastern Bloc and Western Europe ceased to exist. The economic, social and political differentiation of Europe began to decline (Sobotka, 2003). Post-socialist countries transitioned from authoritarianism and central planning to democracy and a market economy. The transition process has been largely completed in the more developed post--socialist countries, but some issues, including legal and regulatory reforms, have not yet been resolved (Havrylyshyn et al., 2016). Radical economic and social transformations gave strong momentum

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to demographic changes in these countries (Sobotka, 2003). The profound demographic changes experienced by post-socialist European countries have been widely researched, including in studies investigating fertility and family formation (Berde & Drabancz, 2022; Billingsley & Duntava, 2017; Billingsley & Olah, 2022; Bleha & Ďurček, 2019; Brainerd, 2010; Frejka & Gietel-Basten, 2016; Graovac Matassi & Talan, 2021; Mynarska, 2010; Sobotka, 2003, 2011, 2017; Stropnik, 2007).

Numerous research studies have explored the main characteristics and trends in infant mortality rates (IMRs) in individual post-socialist European countries in the transition period. Gavurová et al. (2016) and Rosicova et al. (2011) discussed regional and ethnic differences in infant mortality in Slovakia, with particular emphasis on the Roma population. Analyses conducted in the Czech Republic in the transitional period focused mostly on differences in the risk factors for infant mortality and the key predictors of infant survival (Gerylovova & Holcik, 1997; Rychtaříková, 1999; Rychtaříková & Demko, 2001). Infant mortality trends and the key factors influencing infant mortality were also studied in other post-socialist countries, including Hungary (Nyári et al., 2015), Croatia (Graovac Matassi & Rogić, 2023; Rodin et al., 2010), Romania (Burlea, 2012), Bulgaria (Carlson & Tsvetarsky, 2000), and Poland (Genowska et al., 2015; Wróblewska, 2006).

In addition to infant mortality analyses performed at the country level, several studies compared IMRs among post-socialist states in Europe. Zaborskis et al. (1995) discussed infant and child mortality in Lithuania, Latvia and Estonia between 1988 and 1990, whereas Molikevych (2023) compared IMRs in Ukraine and Poland. Several authors discussed infant mortality trends in selected countries of Central and Eastern Europe, including differences in reporting infant deaths and the development of the health care system (Aleshina & Redmond, 2005; Nolte et al., 2004; Rychtaříková, 1995; Zatoński et al., 2006; Zylbersztejn et al., 2017). A review of the literature indicates that infant mortality in post-socialist European countries has attracted considerable interest in the scientific community, but the conducted studies differed widely in the main objectives and spatial coverage. However, infant mortality trends in post-socialist countries that are currently European Union (EU) Member States have never been investigated separately.

The IMR can be defined as "the number of deaths during the first year of life per 1,000 live births" (Weeks, 2005, p. 154). Similarly to under-five mortality, IMRs measure child survival, and they also reflect the social, economic and environmental conditions in which children (and others in society) live, including their health care (WHO, 2022). Infant mortality decreased significantly with an improvement in global health care, but less so in developing countries, especially in Sub-Saharan Africa, where the IMR is still high, mostly above 50 per 1,000. In 2020, Sierra Leone had the highest IMR in Africa at 80.1 per 1,000. In the EU, IMRs decreased in recent decades, but there are still some differences among the EU countries. Currently, the IMR is lowest in Estonia, Norway and Finland (below 2 per 1,000), and highest in Romania and Bulgaria, (above 5 per 1,000) (World Bank, 2022). Countries with a low IMR are generally characterized by high levels of education, high income (Weeks, 2005), and high values of the Human Development Index (HDI). The decrease in IMRs, in particular in the 20th century, has been well documented in the scientific literature. The main contributors to declining infant mortality include improved health and social conditions (antiseptic delivery, increased availability of pasteurized milk, availability of antibiotics, and advancements in perinatal medicine) (Drevenstedt et al., 2008; Riley, 2001). The decline in infant mortality is consistent with the postulates of the epidemiologic transition theory (McKeown, 2009; Olshansky & Ault, 1986).

Infant mortality is regarded as one of the main indicators of a country's health status (Wang, 2002; Wertheimer-Baletić, 1999). Higher income is closely correlated with better health care. Life expectancy and infant mortality statistics indicate that wealthier people are healthier people (Hague et al., 2008; O'Hare et al., 2013; Preston, 1975; Pritchett & Summers, 1993; Weeks, 2005). Ending all preventable deaths

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under five years of age is also one of the outcome targets of Sustainable Development Goal 3. Income is important because the citizens of higher-income countries have better access to clean water, sanitation, and health care, and infants are provided with a nutritious and sanitary diet (diarrhea prevention) (Weeks, 2005). Income differentially impacts various causes of death, and diseases correlated with nutrition are more influenced by income levels. Economic development affects public health, education and nutrition, and it contributes to a decrease in mortality (Birchenall, 2007). Mortality and income are bound by a negative relationship, and high incomes are correlated with low mortality rates. The pooled estimate of the relationship between income and infant mortality before adjusting for covariates was determined at -0.95 (95% CI, -1.34 to -0.57) in developing countries, which implies that a 10% increase in the gross domestic product (GDP) per capita based on purchasing power parity (PPP) in a country with an IMR of 50 per 1,000 would decrease infant mortality by approximately 10%, thus reducing the IMR to 45 per 1,000 (O'Hare et al., 2013).

Considering the lack of research dealing with the IMR and the influence of GDP per capita PPP on the IMR of post-socialist countries, the present study was undertaken to examine this relationship in eleven post-socialist European countries that are currently EU Member States, both before and after the collapse of socialist systems (1980–2019). The results were compared with the EU-16 (EU 27 without the post-socialist countries) and EU-27 countries to determine differences and similarities in IMR trends between post-socialist countries and EU-16 and EU-27 countries. The main aim of this study was to examine changes in the slope of the IMR regression line in post-socialist EU countries by the joinpoint regression analysis. An attempt was made to answer two research questions. Did IMRs increase in post-socialist EU countries during the political and socioeconomic changes of the late 1980s and the early 1990s? Does the increase in GDP per capita based on PPP still drive a decrease in IMRs in post-socialist EU countries?

DATA AND METHODS

Infant mortality rates between 1980 and 2019 were analyzed in 11 post-socialist countries which are presently EU Member States as well as the EU-27 countries. Data for the analyzed period were obtained from the statistical office of the EU (Eurostat). According to the Eurostat methodology, infant mortality denotes the death of a live-born infant before the age of one year, and IMR is defined as the ratio of the number of deaths of children under one year of age in a given year to the number of live births in the same year, expressed per 1,000 live births (Eurostat, 2022). Data for GDP per capita PPP were obtained from the World Bank.

According to a number of authors, infant deaths were widely misreported in the former Soviet Union and in many of its successor states (see Aleshina & Redmond, 2005; Buckley, 1998; Velkoff & Miller, 1995; Yeganyan et al., 2001). The Soviet Union had a less rigorous definition of a live birth than the WHO (see Anderson & Silver, 1986). The most important difference was that a newborn had to breathe to be considered live-born (regardless of other evidence of life), and premature birth (under 28 weeks of gestation) and very low birth weight (under 1,000 grams) were considered as miscarriage if the infant survived for less than seven days.

There was also a suspicion that similar practices had been adopted in some countries of South-Eastern Europe, but there is no strong evidence that such practices were widespread (Carlson & Tsvetarsky, 2000; Rechel & McKee, 2003; Serbanescu et al., 2001). Given the fact that there is no univocal agreement on the extent to which infant deaths were underreported (most studies relied on surveys and estimates) in the former Soviet Union states and whether such practices were applied consistently in other post-socialist states, the present study relied on the official infant death statistics provided by Eurostat as the competent statistical institution. Attempts to recalculate the IMR for each country during the analyzed period extend beyond the scope of this paper.

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The study area included the following countries: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. Infant mortality rates were available for each country and each year of the analyzed period (1980–2019). Data were combined for all studied countries, and average values were computed, including for the EU-27 countries, except the United Kingdom in 2019. Luxembourg was regarded as an outlier due to high GDP per capita PPP which exceeded the sum of the third quartile and 1.5*interquartile values in all analyzed years (Senthamarai Kannan et al., 2015). Therefore, Luxembourg was excluded from the analysis, and in this study, the term "EU-27" denotes EU-28 countries (including the UK) without Luxembourg.

Joinpoint regression software (version 4.9.1.0, National Cancer Institute, USA) was used to analyze changes in infant mortality trends. The software takes trend data and fits the simplest joinpoint model that the data allow. For each six added values, users can set an additional joinpoint to the maximum, and six joinpoints were used as the maximum in the study. The location and number of significant joinpoints were determined using a log-linear model. The Average Annual Percent Change (AAPC), the Average Percent Change (APC), and the corresponding 95% Confidence Intervals (CI) were computed. These parameters were used to describe the magnitude of change in each identified trend. In the applied model, time (years) was the independent variable, and the IMR was the dependent variable. Standard error was also calculated for each trend and taken into consideration in the analysis. Statistical significance was determined in the Monte Carlo Permutation test. The significance of AAPC was determined at $p < 0.05$. In the program, AAPC and APC values are marked when the result is significantly different from zero at the alpha level of 0.05. Inflection points were identified for each range of data where a significant change occurred in the slope of the linear trend (Kim et al., 2001). The joinpoint regression analysis is widely used in analyses of mortality trends (Chaurasia, 2020).

The second analysis was conducted to examine the correlation between the IMR and GDP per capita PPP between 1995 and 2019 because data on GDP per capita PPP were not available for the period before 1995. Pearson's correlation coefficient (PCC) was calculated for each year and for 5-year intervals. The correlation between GDP per capita PPP and the IMR was presented graphically. Coefficients of determination (R^2) were also calculated for 5-year intervals. The values on both axes of the scatter plot with a regression line are shown in logarithmic scales. The model for the EU-27 was significant only in the first three 5-year intervals; therefore, only these periods were considered in the analysis. The log values of infant mortality displayed a linear function when the log values of GPD per capita PPP were used; therefore, a log-log transformation was used in the regression analysis of real income and infant mortality to determine the influence of a 10% increase in GDP per capita PPP on IMR (Benoit, 2011; Tacke & Waldmann, 2009). The natural logarithm (ln) was used for log transformation. A 10% increase in GDP per capita PPP increased IMR by eslope*ln(1.1) (Benoit, 2011). Although PCC and R2 were noticeably more significant after the log-log transformation, ln values are difficult to read, which is why the graphs are based on non-transformed values.

RESULTS AND DISCUSSION

Joinpoint regression analysis

The socialist regime collapsed between 1989 and 1991, and the analyzed countries experienced profound political and economic changes, including a transition from a centrally planned economy to a market economy (Lavigne, 1999). Socialist regimes had a clear impact on infant mortality. Infant mortality was much higher in authoritarian than democratic countries. Between 1950 and 1990, infant mortality remained high even in wealthy dictatorships (Besley & Kudamatsu, 2006; Navia & Zweifel, 2003; Przeworski et al., 2000). Infant mortality often increases in periods of economic downturn (economic

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shocks) (Brainerd & Cutler, 2005; Cutler et al., 2002; Langer et al., 1991).

As expected, in the analyzed period (1980–2019), the average IMR in the EU-27 was highest in 1980 (15.7 per 1,000) and lowest in 2019 (3.4 per 1,000; same as in 2018). The average IMR in all post-socialist countries which are currently EU Member States was also highest in 1980 (19.9 per 1,000) and lowest in 2019 (3.7 per 1,000; same as in 2018). Even greater variations were noted when the post-socialist EU countries were excluded from the analysis. In the EU-16, the average IMR was highest in 1980 (12.8 per 1000) and lowest in 2019 (3.2 per 1000, it was already as low as 3.23 in 2014). The difference between the highest IMR values was significant: in 1980, the IMR in the EU-16 was 7.1 per 1000 lower than in 11 post-socialist EU countries.

In the group of the analyzed post-socialist EU countries, the IMR was highest in Romania in each year of the examined period (1980–2019), where it peaked in 1980 (29.3 per 1,000) and 1987 (28.9 per 1,000). In contrast, the lowest IMR was noted in Slovenia (in 27 out of 40 records). Slovenia's IMR was highest in 1980 (15.3 per 1,000) and lowest in 2012 and 2015 (1.6 per 1,000), and a similarly low IMR was noted only in Estonia in 2018 and 2019. In the first few years of the analyzed period, the lowest IMRs were noted in Slovenia, Lithuania, Latvia, and Czechia, and in successive years (1987–2002), the IMR was lowest in Slovenia. In the last years of the examined period, Slovenia, Estonia and Czechia took turns as countries with the lowest IMR. An overall decrease in IMRs was observed in all post-socialist EU countries in the past four decades (AAPC = -4.5; 95% CI, -4.8 to -4.1), and it proceeded more rapidly than in the EU-16 (AAPC = -3.5; 95% CI, -3.9 to -3.1) (Table 1).

Three joinpoints (1989, 1992 and 2006) can be clearly identified in the data calculated for the EU-27 countries (AAPC = -3.9; 95%CI -4.2 to -3.6) (Table 1). The slope of the trend line was steepest in the third interval (1992–2006; APC = -5.2; 95% CI, -7.0 to -5.3) and flattest in the second interval (1989–1992; APC = -1.5; 95% CI -4.6 to -1.8) (Fig. 1). The results for the second interval were not significantly different from zero at the alpha level of 0.05 due to the impact of changes in IMRs in post-socialist EU countries. A clear decrease in IMR values was noted in the entire EU-27, which could be attributed to social welfare policies and the development welfare state systems. Welfare systems and policies differ across the studied

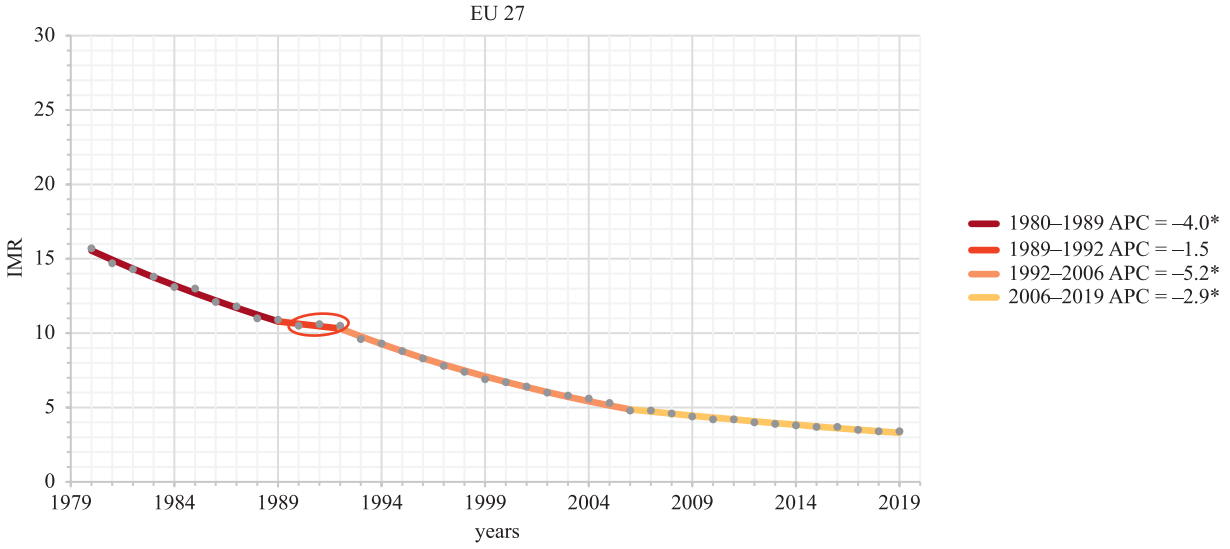

Fig. 1. Infant mortality rates in the EU-27, 1980–2019
* significantly different from zero at the alpha level of 0.05
Note: Red circle indicates changes (increase) in the IMR in the year during, or close to, the fall of the socialist regime.
Source: own elaboration based on Eurostat data (Eurostat, 2022).

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countries, which could explain the higher IMR values in post-socialist EU countries during the studied period (Onambele et al., 2019).

Three joinpoints (1991, 1994 and 2006) were identified in the results for the EU-16 countries (Fig. 2). APC was determined at -4.2 (95%CI -4.5 to -4.0) in the first interval (1980–1991), -6.4 (95% CI -11.0 to -1.5) in the second interval (1991–1994), -4.4 (95% CI -5.5 to -5.2) in the third interval (1994–2006), and -1.3 (95%CI -1.8 to -0.7) in the fourth and last

Table 1. Joinpoint regression analysis of infant mortality rates in post-socialist EU countries, EU-16, and EU-27 countries in 1980–2019

Country/ Group od countries	Analyzed period				First interval				Second interval				Third interval			
	Years	AAPC	95% CI		Years	APC	95% CI		Years	APC	95% CI		Years	APC	95% CI	
EU 27	1980–2019	-3,9	-4,2	-3,6	1980–1989	-4,0	-4,2	-3,7	1989–1992	-1,5	-4,6	1,8	1992–2006	-5,2	-5,5	-5,0
EU 16	1980–2019	-3,5	-3,9	-3,1	1980–1991	-4,2	-4,5	-4,0	1991–1994	-6,4	-11,0	-1,5	1994–2006	-4,4	-4,9	-4,0
Post-socialist EU countries	1980–2019	-4,5	-4,8	-4,1	1980–1989	-3,7	-4,0	-3,4	1989–1992	1,2	-3,2	5,8	1992–2019	-5,3	-5,5	-5,2
Bulgaria	1980–2019	-3,2	-3,7	-2,8	1980–1986	-5,3	-7,0	-3,6	1986–1997	1,1	0,1	2,1	1997–2019	-4,8	-5,2	-4,3
Croatia	1980–2019	-4,4	-5,3	-3,6	1980–1986	-4,1	-5,5	-2,8	1986–1989	-9,2	-19,0	1,7	1989–2019	-4,0	-4,4	-3,7
Czech Republic	1980–2019	-4,6	-5,5	-3,6	1980–1989	-5,0	-5,4	-4,5	1989–1992	-2,0	-8,5	5,0	1992–2000	-10,2	-11,6	-8,8
Estonia	1980–2019	-5,6	-6,4	-4,8	1980–1994	-1,1	-2,0	-0,2	1994–2019	-8,1	-9,3	-6,9	–	–	–	–
Hungary	1980–2019	-4,9	-5,8	-3,9	1980–1982	-8,2	-12,4	-3,7	1982–1985	1,8	-3,4	7,3	1985–1988	-8,3	-13,4	-2,9
Latvia	1980–2019	-4,0	-4,9	-3,1	1980–1988	-4,0	-6,1	-1,8	1988–1994	7,9	3,2	12,8	1994–2019	-6,7	-7,3	-6,0
Lithuania	1980–2019	-4,0	-5,3	-2,7	1980–1989	-4,4	-5,6	-3,2	1989–1992	15,6	-0,9	34,7	1992–1997	-9,5	-13,5	-5,3
Poland	1980–2019	-5,0	-5,2	-4,7	1980–1992	-2,9	-3,1	-2,8	1992–2000	-9,6	-10,3	-8,8	2000–2019	-4,2	-4,6	-3,9
Romania	1980–2019	-4,3	-5,2	-3,3	1980–1984	-6,1	-9,0	-3,2	1984–1987	5,8	-5,0	17,7	1987–2002	-2,8	-3,4	-2,3
Slovakia	1980–2019	-3,5	-4,1	-3,0	1980–2008	-4,3	-4,6	-4,1	2008–2019	-1,4	-3,4	0,6	–	–	–	–
Slovenia	1980–2018	-5,3	-6,1	-4,5	1980–1984	-1,4	-4,6	2,0	1984–1996	-7,3	-8,4	-6,2	1996–2019	-4,9	-6,0	-3,8

Country/ Group od countries	Fourth interval				Fifth interval				Sixth interval			
	Years	APC	95% CI		Years	APC	95% CI		Years	APC	95% CI	
EU 27	2006–2019	-2,9	-3,4	-2,5	–	–	–	–	–	–	–	–
EU 16	2006–2019	-1,3	-1,8	-0,7	–	–	–	–	–	–	–	–
Post-socialist EU countries	–	–	–	–	–	–	–	–	–	–	–	–
Bulgaria	–	–	–	–	–	–	–	–	–	–	–	–
Croatia	–	–	–	–	–	–	–	–	–	–	–	–
Czech Republic	2000–2013	-4,0	-5,3	-2,7	2013–2019	1,5	-3,4	6,6	–	–	–	–
Estonia	–	–	–	–	–	–	–	–	–	–	–	–
Hungary	1988–1991	-1,0	-7,5	5,9	1991–1994	-9,1	-16	-2	1994–2019	-4,9	-5,2	-4,5
Latvia	–	–	–	–	–	–	–	–	–	–	–	–
Lithuania	1997–2019	-4,9	-5,7	-4,2	–	–	–	–	–	–	–	–
Poland	–	–	–	–	–	–	–	–	–	–	–	–
Romania	2002–2019	-6,7	-7,6	-5,8	–	–	–	–	–	–	–	–
Slovakia	–	–	–	–	–	–	–	–	–	–	–	–
Slovenia	–	–	–	–	–	–	–	–	–	–	–	–

Note: significantly different from zero at the alpha level of 0.05
Source: own elaboration based on Eurostat data (Eurostat, 2022).

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interval. The IMR did not increase in the EU-16 in the studied period. The slope of the trend line was steepest in the second interval and flattest in the fourth interval.

Two joinpoints (1989 and 1992) were identified in the results for post-socialist EU countries (Fig. 3). APC was determined at -3.7 (95% CI, -4.0 to -3.4) in the first interval and at 1.2 (95% CI, -3.2 to 5.8) in the second interval, which points to an overall increase in IMRs in this group of countries. Despite the fact that these results did not differ significantly from zero at the alpha level of 0.05, IMRs in post-socialist

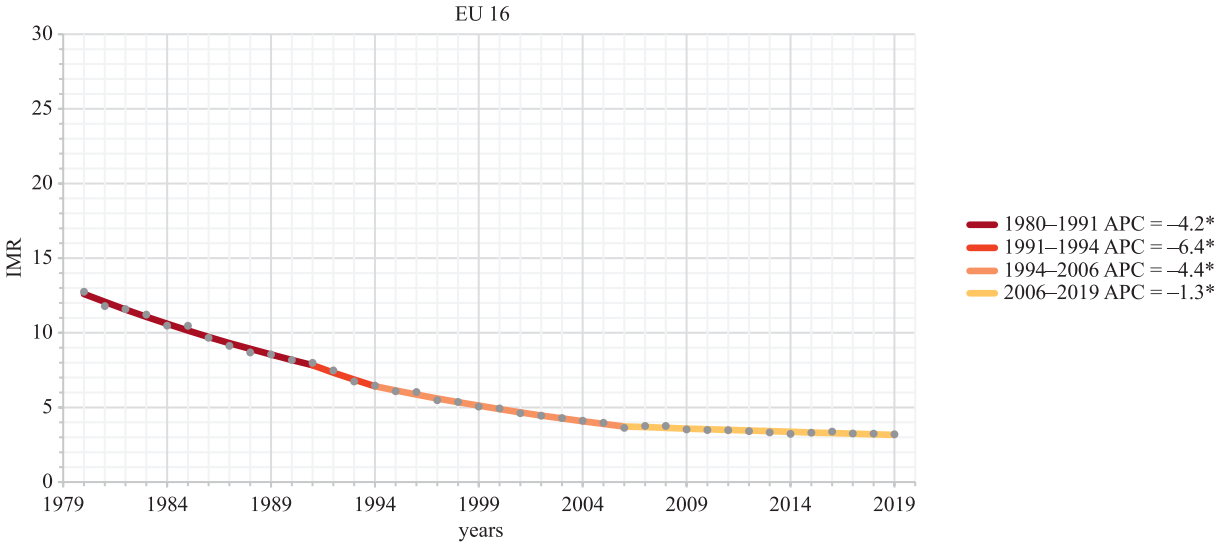

Fig. 2. Infant mortality rates in the EU-16, 1980–2019
* significantly different from zero at the alpha level of 0.05
Source: own elaboration based on Eurostat data (Eurostat, 2022).

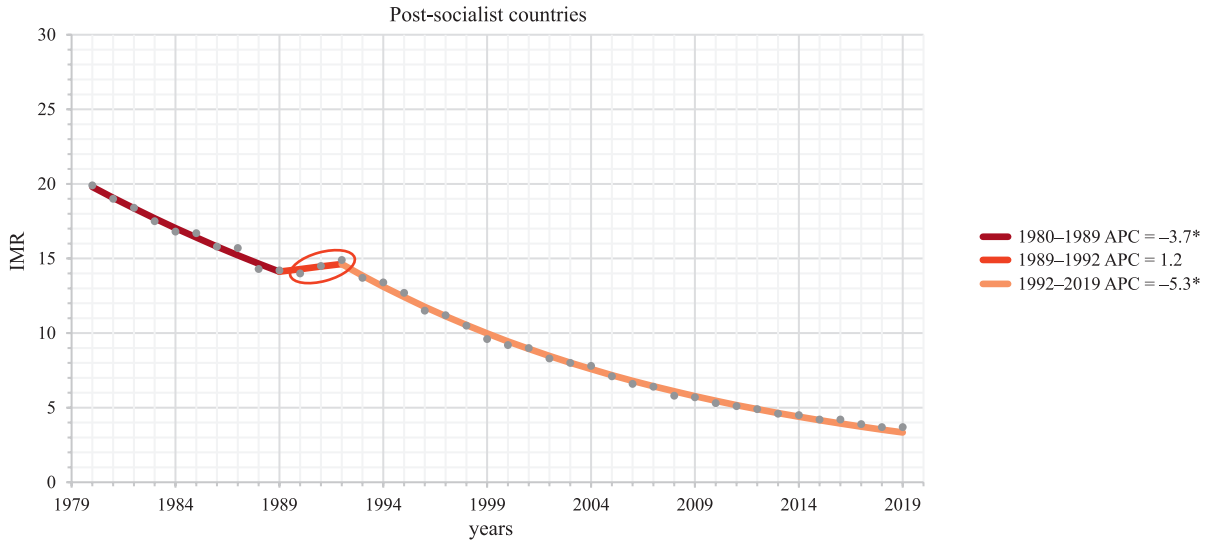

Fig. 3. Infant mortality rates in post-socialist EU countries, 1980–2019
* significantly different from zero at the alpha level of 0.05
Note: Red circle indicates changes (increase) in the IMR in the year during, or close to, the fall of the socialist regime.
Source: own elaboration based on Eurostat data (Eurostat, 2022).

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EU countries changed in the examined period. The identified joinpoints occurred precisely at the time when the socialist regime collapsed. Most Eastern Bloc countries declared independence or experienced the fall of the socialist regime between 1989 and 1991. During that period, the IMR increased in all post-socialist EU countries (per 1,000). The IMR increased from 13.6 in 1988 to 16.9 in 1991 in Bulgaria, from 10.7 in 1990 to 11.6 in 1992 in Croatia, from 10.0 in 1989 to 10.8 in 1990 in Czechia, from 12.3 in 1990 to 15.7 in 1992 in Estonia, from 11.0 in 1988 to 17.6 in 1992 in Latvia (Latvia's IMR peaked in 1995 at 18.8 per 1,000), from 10.2 in 1990 to 16.3 in 1992 in Lithuania, from 14.8 in 1990 to 15.6 in 1991 in Hungary, from 19,3 in 1989 to 19.4 in 1990 in Poland, from 25.4 in 1988 to 26.9 in 1991 in Romania, from

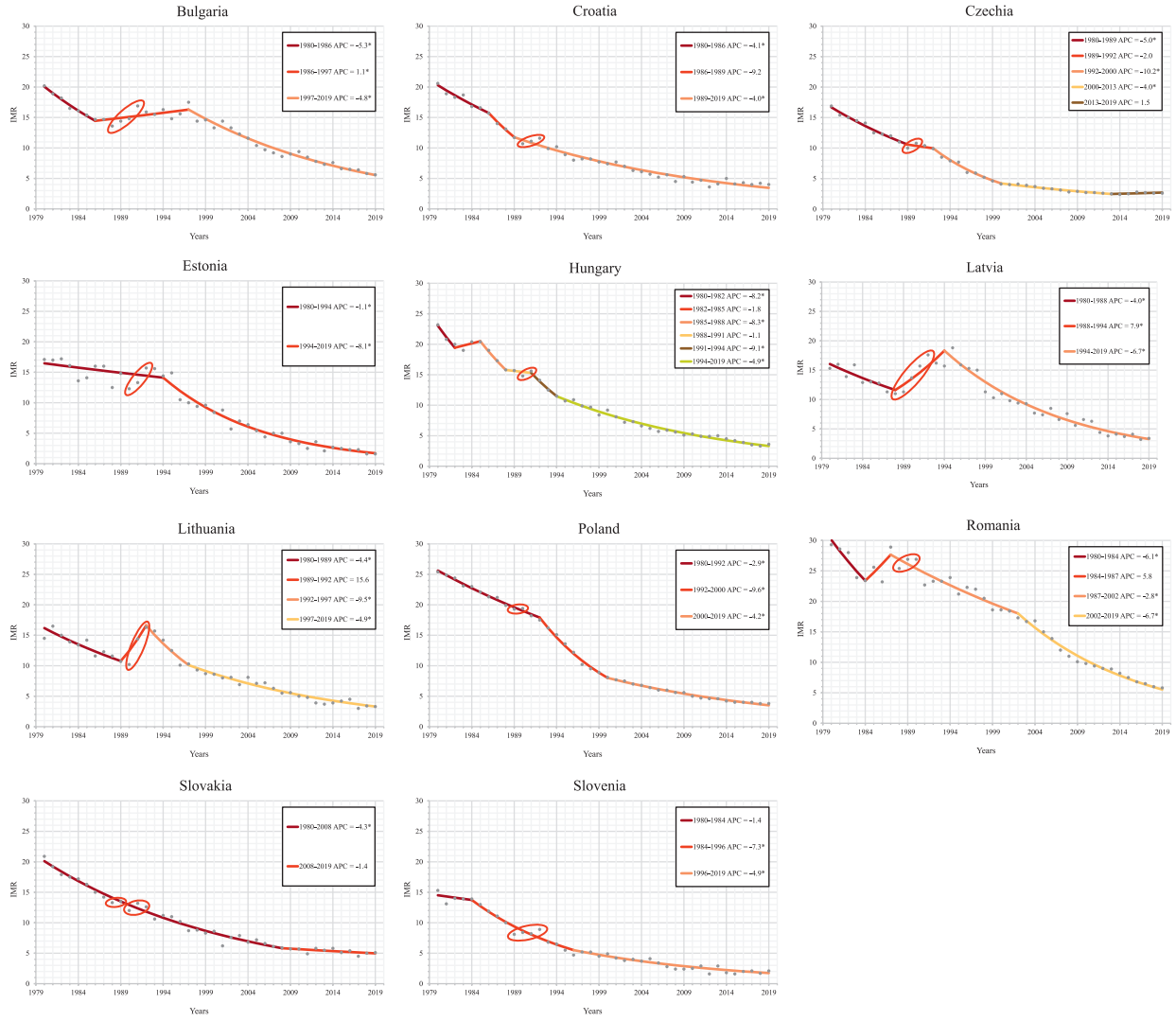

Fig. 4. Infant mortality rates in 11 post-socialist EU countries, 1980–2019
* significantly different from zero at the alpha level of 0.05
Note: Red circles indicate changes (increase) in the IMR in the years during or close to the collapse of the socialist regime.
Source: own elaboration based on Eurostat data (Eurostat, 2022).

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13.3 in 1988 to 13.5 in 1989 in Slovakia, and from 8.1 in 1989 to 8.9 in 1992 in Slovenia.

On average, the IMR increased from 14.0 in 1990 to 14.9 in 1992 in post-socialist EU countries. The greatest increase in the IMR was reported in the Baltic countries. A considerable increase was also noted in Bulgaria and Romania. It took Bulgaria more than 10 years to bring its IMR to the previous level (13.6 per 1,000 in 1998; 13.3 per 1,000 in 2002), and Romania was faced with a similar challenge (23.4 per 1,000 in 1984, 21.2 per 1,000 in 1995). Latvia was one of the Baltic countries which experienced a similar problem (IMR of 11.0 per 1,000 in 1988, 10.3 per 1,000 in 2000) (Fig. 4). The observed increase in the IMR was clearly linked with the fall of the socialist regime. In the third and final interval (1992–2019), APC reached -5.3 (96% CI, -5.5 to -5.2), which indicates that the decrease in IMRs proceeded most rapidly in this period or that it accelerated after the collapse of the socialist regime. The rapid decrease in IMR values in this period could be attributed to economic development and social and political reforms that led to changes in public health policies (Onambele et al., 2019). According to Asandului et al. (2014) (as cited by Onambele et al., 2019), demographic and socioeconomic factors which are closely related to health factors could explain the decline in IMR values in Central and Eastern European countries.

In the joinpoint analysis, several results were not significantly different from zero at the alpha level of 0.05. In most cases, these values were noted during the fall of the socialist regime. For instance, in Czechia, APC reached -2.0, but 95% CI ranged from -8.5 to 5 (second interval, 1989–1992), whereas Lithuania was an extreme example, where APC reached 15.6 and 95% CI ranged from -0.9 to 34.7 (second interval, 1989–1992).

The increase in mortality (including infant mortality) could be related to the difficulties experienced by the analyzed countries in the period of socioeconomic and political transition (economic crisis, rising unemployment, lower living standards, decline in health care services) (Wertheimer-Baletić, 2000). Several research studies have shown that the collapse of socialist health care system, decrease in health care spending, and mass privatization programs could have significantly contributed to the post-socialist mortality crisis (Budhdeo et. al., 2015; Paniccià, 2000; Stuckler et al., 2009; Velkova et al., 1997). In the literature, Durkheim's concept of social disintegration is also regarded as an important social determinant of the post-socialist mortality crisis. Several cross-country studies revealed that different measures of social disintegration (including crime, divorce, or loss of control over one's life) are significantly and positively associated with mortality. Social disintegration has often been presented as a situation where people do not have the necessary resources to achieve desirable goals (Scheiring et al., 2019).

Political regimes have a pronounced impact on IMRs. Regardless of the estimation method or the applied model, infant mortality is much higher in authoritarian regimes than in democratic societies. Differences in infant mortality persist even when regimes are matched for exogenous conditions (Przeworski et al., 2000).

Correlation between IMR and GDP per capita PPP

The IMR is considered a robust indicator of the overall social welfare which reflects a country's socioeconomic status and quality of health care (Navia & Zweifel, 2003; Rosenberg, 2018). Income is an important factor that directly or indirectly affects health care. Income influences a country's living standards, including housing, sanitation, consumption, quality of life, and health, whereas infant mortality is an important indicator of a country's overall health status. The IMR is influenced by several factors, including sanitation, immunization, nutrition, genetic status, abortion rate, consumption of alcohol, drugs and tobacco, income, social disparities, access to health care, and war, which implies that all environmental and socioeconomic factors have a major impact on the IMR (Andrews et al., 2008; Corman & Grossman, 1985). An increase in GDP

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per capita contributes to equal distribution of wealth. In developed countries, the health status of the adult population is positively correlated with economic prosperity (Kammerlander & Schulze, 2021). In high-income countries, the IMR is bound by a significant and negative relationship with real GDP per capita. The IMR of a country decreases as it becomes rich and powerful (Erdoğan et al., 2013). An increase in GDP is also correlated with lower IMR values (Ensor et al., 2010; Muldoon et al., 2011; Prisco et al., 2015; Tavares, 2017; Zakir & Wunnava, 1999).

Pearson's correlation coefficient is a measure of the linear correlation between two data sets. This parameter was calculated (after log-log transformation) for the EU-27 and 11 post-socialist EU countries for each year of the analyzed period (1995–2019). Between 1995 and 2009, PCC for the EU-27 was below or very close to -0.70 (Table 2), which points to a strong negative correlation between GDP per capita PPP and IMR. A strong correlation was observed in the first three 5-year intervals (1995–1999, 2000–2004, and 2005–2009) when PCC was below -0.70. An even stronger correlation was noted in post-socialist countries (-0.89 to -0.78) during the entire period of the analysis (Table 3). The values of PCC ranged from -0.87 to -0.82 in all five intervals, and such a strong correlation could be attributed to lower GDP per capita PPP and higher IMR in post-socialist EU countries. In these countries, the average GDP per capita PPP was still not high enough to prevent a decrease in the IMR. When a country reaches a high level of development, the increase in GDP per capita PPP has a negligent impact on infant mortality. Income and child mortality show a significant counter relationship, and consequently, infant mortality and GDP per capita PPP become detached (O'Hare et al., 2013; Preston, 1975; Schell et al., 2007).

The least-square regression line is the line that minimizes the sum of the squares of the vertical distance between the line and data points (Moore & Notz, 2021). Therefore, the average expected IMR for a given GDP per capita PPP can be calculated based on the IMR of the EU-27 countries (including post-socialist EU countries) for their GDP per capita PPP. If a country is above the regression line, the infant survival rate is below the average, and vice versa, if a country is below the regression line, the infant survival rate is above the average. Two

Table 2. Pearson's correlation coefficient for the EU-27, 1995–2019

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
PCC	-0,85	-0,80	-0,80	-0,80	-0,80	-0,76	-0,72	-0,74	-0,74	-0,73	-0,72	-0,69	-0,75
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
PCC	-0,68	-0,72	-0,62	-0,63	-0,55	-0,47	-0,50	-0,41	-0,42	-0,31	-0,33	-0,33	
Interval	1995-1999		2000-2004		2005-2009		2010-2014		2015-2019				
PCC	-0,82		-0,74		-0,73		-0,57		-0,37				

Note: PCC>-0.7
Source: own elaboration based on Eurostat (2022) and World Bank (2022) data.

Table 3. Pearson's correlation coefficient for 11 post-socialist EU countries, 1995–2019

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
PCC	-0,84	-0,78	-0,83	-0,84	-0,86	-0,83	-0,86	-0,85	-0,86	-0,86	-0,84	-0,85	-0,89
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
PCC	-0,84	-0,85	-0,79	-0,88	-0,82	-0,78	-0,82	-0,79	-0,78	-0,85	-0,81	-0,79	
Interval	1995-1999		2000-2004		2005-2009		2010-2014		2015-2019				
PCC	-0,84		-0,86		-0,87		-0,84		-0,82				

Source: own elaboration based on Eurostat (2022) and World Bank (2022) data.

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Fig. 5. Regression lines for IMR based on GDP per capita PPP in the EU-27 in 5-year intervals between 1995 and 2009 (red dots represent 11 post-socialist EU countries, and blue dots represent the remaining 16 EU countries)
Source: own elaboration based on Eurostat (2022) and World Bank (2022) data.

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Table 4. Influence of the increase in GDP per capita PPP on the IMR, 5-year intervals, 1995–2019 (in %)

	Increase in GDP PC PPP	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
EU 27	1	-0,79	-0,74	-0,86	-0,70	-0,45
	10	-7,24	-6,87	-7,91	-6,49	-4,19
EU 16	1	-0,79	-0,11	-0,35	-0,09	-0,08
	10	-7,29	-1,06	-3,27	-0,94	-0,78
Post-socialist EU countries	1	-1,19	-1,31	-1,69	-1,96	-1,95
	10	-10,80	-11,86	-15,08	-17,24	-17,17

Note: p>0.005
Source: own elaboration based on Eurostat (2022) and World Bank (2022) data.

separate analyses were conducted for the EU-27 and post-socialist EU countries.

The analysis of post-socialist EU countries revealed interesting results. As stated before, PCC exceeded -0.7 in 2010; therefore, regression was not analyzed in detail in the following years. In the first three intervals (1995–1999, 2000–2004 and 2005–2009), PCC was below -0.72, R^2 ranged from 0.68 to 0.53, and P values were below 0.005, which points to a strong correlation between these variables. In these intervals, Bulgaria, Romania, and Latvia were consistently above the regression line, and Slovakia joined this group of countries in the third interval (2005–2009). The remaining post-socialist EU countries were below the regression line in these intervals. Despite the fact that GDP per capita PPP was low in the countries above the line, their IMR should have been even lower.

All post-socialist EU countries are on the left side of the scatter plot with lower GDP per capita PPP values. Czechia and Slovenia are the only exceptions because their GDP per capita PPP was considerably higher and IMRs were lower and closer to the EU-27 average (Fig. 5). In the EU-27, PCC was higher than -0.7 in 2010 when the average GDP per capita PPP exceeded USD 30,000 and the average IMR decreased below 4.4 per 1,000.

The analysis revealed that a 10% increase in GDP per capita PPP induced a significantly greater decrease in the IMR in post-socialist EU countries than in the EU-16. In the first interval (1995–1999), a 10% increase in GDP per capita PPP decreased the IMR by 7.29% in the EU-16 and by 10.8% in post-socialist EU countries, and the corresponding decrease in the EU-27 was nearly identical to that noted in the EU-16. In the last interval (2015–2019), a 10% increase in GDP per capita PPP led to only a 0.78% decrease in the IMR in the EU-16, but the corresponding decrease in post-socialist EU countries reached 17.17% (Table 4).

CONCLUSIONS

The analysis revealed a significant decrease in IMRs in all studied countries. During the entire analyzed period (1980–2019), IMRs were higher in post-socialist EU countries than in the remaining EU Member States (EU-16), in particular at the beginning of the examined period, but these differences were less pronounced at the end of the analyzed period. Notable differences were also observed between post-socialist EU countries, where IMRs were highest in Romania and lowest in Slovenia. During the entire analyzed period, the AAPC was more pronounced in post-socialist EU countries (-4.5) than in the EU-16 (-3.5). Three joinpoints were identified for the EU-16 and the entire EU (EU-27), whereas two joinpoints were identified for post-socialist EU countries. In the EU-16, a decrease was observed in all analyzed intervals, whereas an increase was noted in post-socialist EU countries between 1989 and 1992 (APC = 1.2). Despite the fact that the result did not differ significantly from zero at the alpha level of 0.05, a certain change (increase) was noted in IMRs during the collapse of socialist systems, which answers our first research question.

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Numerous research studies have shown that the IMR is influenced by various socioeconomic factors and that an increase in income leads to a decrease in infant mortality; therefore, the correlation between the IMR and GDP per capita PPP was analyzed between 1995 and 2019 (because GDP per capita PPP was not available for previous years). The calculated values of PCC revealed a strong negative correlation between GDP per capita PPP and the IMR in the EU-27 in the first three 5-year intervals (1995–2009). A weaker correlation was observed in the following years because the IMR decreased considerably, whereas income continued to increase. In contrast, a strong negative correlation was noted in post-socialist EU countries in the entire period of the analysis (1995–2019), which indicates that the average GDP per capita PPP is still not high enough to prevent a decrease in IMRs. Czechia and Slovenia were the only exceptions because their GDP per capita PPP was considerably higher and IMRs were lower and closer to the EU-27 average. An additional analysis also revealed that a 10% increase in GDP per capita PPP induced a much greater decrease in IMRs in post-socialist EU countries than in the EU-16. Between 2015 and 2019, a 10% increase in GDP per capita PPP led to only a 0.78% decrease in the IMR in the EU-16, but the corresponding decrease in post-socialist EU countries reached 17.17%. These findings answer our second research question. The study revealed notable differences in IMRs and income between post-socialist EU countries and the EU-16, but the trends in selected post-socialist EU countries (notably Czechia and Slovenia) were far more similar to those observed in the EU-27 than in the remaining post-socialist EU countries, in particular in Romania and Bulgaria which still lag behind other EU Member States. The observed trends and differences could be further investigated using different indicators, in particular those related to health care.

The main limitation of this study is the quality of data for the former Soviet republics because some researchers have suggested that the official IMR data were underreported due to differences in methodology. The second limitation stems from the fact that GDP per capita PPP is an important, but not the only factor that influences IMRs. Regardless of these limitations, the study provides relevant conclusions on IMR trends in the analyzed countries.

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Note: The results of this study were presented in a poster during a scientific conference.

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