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Original Paper

CHILD MORTALITY TRENDS AND IN ASSOCIATION WITH MACROECONOMIC FACTORS IN THE BALTIC STATES (2008–2018)

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Child mortality indicators have historically been high in the Baltic States, and have decreased substantially over the last two decades, with the most rapid decline observed in Estonia. Prior research suggests there may be economic factors contributing to this. The primary objective of this study was to expand on the previous research by investigating the relationship between age specific child mortality indicators and macroeconomic indicators with the intent of developing a better understanding of the possible short- and long-term effects of global economic downturn on child mortality in the Baltics. Analysis was performed for the years 2008 to 2018, focusing on the aftermath of the global financial crisis of 2008. Significant associations were found for GDP and under-5 and 5–14 mortality in all Baltic States. Healthcare expenditure was associated with lower under-5 and 5–4 mortality in Estonia, but higher under-5 mortality in Latvia. Unemployment was associated with higher under-5 and 5–4 mortality in Lithuania. Factors related to healthcare spending policies in Estonia may have been a major factor in the country's success in rapidly decreasing child mortality.

Keywords: *infant mortality, perinatal mortality, GDP, unemployment.*

INTRODUCTION

Child mortality is a key indicator of population health and social development. Despite substantial progress since 2000, an estimated 4.8 million children still die before their fifth birthday each year, including more than 2 million newborns (UNICEF, 2024). These deaths are largely preventable and remain unequally distributed between countries. A growing body of evidence shows that infant and child mortality are shaped not only by proximate clinical and behavioural factors but also by broader social and economic conditions. Socioeconomic disadvantage, including poverty and social exclusion, is consistently associated with higher risks of neonatal and child death, and recent work from high-income countries demonstrates persistent inequalities across social and ethnic groups even in settings with universal health coverage (Reboucas *et al*, 2022). These patterns underscore the importance of understanding how macro-level determinants — such as national income, labour-market conditions, public spending and income distribution — translate into differences in survival for infants and children.

Macroeconomic conditions may influence child mortality through multiple pathways. Higher national income, typically measured as gross domestic product (GDP) per capita, is associated with lower infant and under-5 mortality, partly by enabling investments in health systems, education and basic infrastructure (Ray *et al.*, 2018). Several studies have reported that economic downturns and recessions, characterised by falling GDP and rising unemployment, are followed by deteriorations in neonatal, post-neonatal and under-5 mortality, particularly in poorer countries and where social protection is weak (Marutappu *et al.*, 2017). At the same time, health expenditure as a share of GDP is an important marker of societal commitment to health: higher

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current health spending is generally linked to reductions in child mortality, although the strength of this association varies across income groups and regions (Owusu *et al.*, 2021; Samarawickrama *et al.*, 2025).

Beyond average national wealth and spending, the distribution of resources within societies also appears to matter for child survival. Income inequality, commonly summarised by the Gini coefficient, has been associated with higher infant, under-5 and adolescent mortality in both wealthy nations and low- and middle-income countries, even after accounting for GDP (Collison *et al.*, 2007).

More recent regional analyses likewise report that greater income inequality is linked with higher neonatal mortality in the Americas, suggesting that unequal growth may limit the benefits of economic development for the most vulnerable children (Sanhueza *et al.*, 2024). Unemployment represents another critical macroeconomic indicator, determining the security of livelihoods for families with children. Rising unemployment may increase child mortality through pathways involving reduced household income, food and housing insecurity, caregiver stress, and cuts to social and health services, although empirical findings for specific age groups and regions remain mixed (Marutappu *et al.*, 2017).

Clearly, child and infant mortality is shaped by more than clinical care. Given these considerations, investigating how infant and child mortality respond to macroeconomic indicators such as GDP, healthcare expenditure, unemployment and income inequality is essential for designing effective, equity-oriented policies. Such analyses can help to clarify whether improvements in child survival are driven primarily by economic growth, by deliberate investments in health and social protection, or by how fairly resources are distributed across the population.

Examining potential associations is of particular interest in areas undergoing rapid economic and social change, such as the Baltic States, where understanding the macroeconomic determinants of infant and child mortality can inform strategies to sustain progress and reduce avoidable inequalities in child health. The region has experienced periods of robust economic expansion alongside deep economic contractions, including the 2008–2010 financial crisis and the more recent COVID-19 shock. These fluctuations have been accompanied by shifts in unemployment rates, public expenditure priorities, and widening or narrowing income inequality. While the Baltics share a broadly similar political and geographic context, their macroeconomic trajectories and investment patterns have differed in meaningful ways, potentially producing distinct impacts on child health outcomes.

Previous analyses by Ebela *et al.* (2013) and Salber *et al.* (2019) have demonstrated associations between the macroeconomic status of the Baltic states and infant mortality since the independence from the former Union of Soviet Socialist Republics (USSR). However, the study by Ebela *et al.* (2013) analysed the time period from 1995 to 2010 and did not take into consideration the long-term consequences of the 2008 financial crisis which devastated the Baltic economies, while the study by Salber *et al.* (2019) analysed the time period 2010 to 2016, excluding the more immediate economic consequences of the global financial crisis. Taking this into consideration, the current study analyses these factors starting from 2008 with the beginning of the Latvian financial crisis and ending with 2018, thus fully encompassing the entire period of the financial crisis, the economic downturn that followed, and the gradual recovery of the Latvian economy under the mitigative measures that were implemented.

In 1995, only four years into the independence from the USSR, child mortality rates were significantly higher than the EU average (Fig. 1). Through commendable efforts directed both from within the countries as well as those coming internationally from the outside, all three managed to dramatically lower their rate of under-five mortality to less than 10 per 1000 live births by 2006. Although Lithuania and Estonia had roughly the same child mortality in 1995, the rapid progress made in Estonia since is astonishing. Estonia had dropped its under-5 mortality below the EU average by 2010. The decrease in under-5 mortality in Latvia and Lithuania was consistent but slower, reaching the EU average about a decade later (World Bank, 2024).

The goal of this study is to further investigate the relationship between rates of mortality and macroeconomic indicators, and to build upon the pre-existing body of research into macroeconomic indicators and their effect on child mortality. This is done by analysing child mortality rates stratified by age groups in the three Baltic states of Latvia, Estonia, and Lithuania covering the time period from 2008 to 2018, which is a time frame of particular interest representing recent economic history.

Based on previous research conducted by our team, this analysis will focus on macroeconomic parameters that are likely to be associated with child mortality: total GDP, GDP

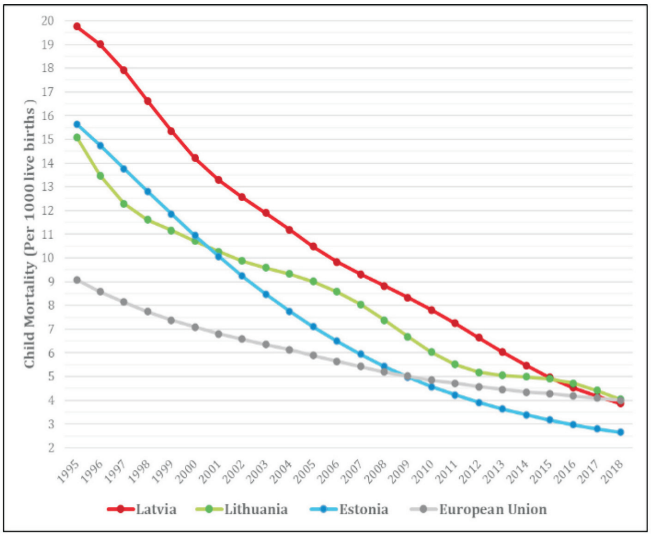


Fig. 1. Child mortality rates in the Baltic States (1995–2018). Data source: UNICEF, 2024.

per capita, rate of unemployment, total healthcare expenditure and the Gini coefficient. By investigating for a potential link with these indicators, it can be determined if they continued to play a role in influencing child mortality in the Baltic states between 2008 and 2018. Furthermore, by comparing the results of the current analysis with that of previous studies covering 1996 to 2016, we can see how financial and economic initiatives undertaken during the crisis and its aftermath may have affected child mortality.

MATERIALS AND METHODS

Data was collected from national and international statistical databases. National mortality data was sourced from databases maintained by departments of state for each of the three Baltic countries (*Latvijas Centrālā statistikas pārvalde, Lietuvos Statistika* and *Eesti Statistika*). Additional data was obtained from reputable opensource databases maintained by the World Health Organisation (WHO), the World Bank, and the Organisation for Economic Co-operation and Development (OECD).

Values for the three Baltic States were obtained for the time period from 2008 to 2018: perinatal, neonatal, infant mortality and under-5 mortality (per 1000 live births), mortality among children aged 5–14 years (per 1000 children, hereafter, 5–14 mortality), total GDP, GDP per capita, total healthcare expenditure (HCE), rate of unemployment and Gini co-efficient.

Multiple linear regression analysis was used to examine possible associations between each mortality indicator (dependent variable) and macroeconomic indicators. Model fit was assessed using the ANOVA F-test, and individual predictors were evaluated using regression coefficients (B), 95% confidence intervals, and *p*-values. Analysis was repeated for each country. A *p*-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics Software version 26.

RESULTS

Several statistically significant associations were found between age specific child mortality indicators and macroeconomic factors in all three Baltic states. Statistically significant associations are shown in Table 1.

Total GDP and GDP per capita were both significantly associated with under-5 and 5-14 mortality in all three countries.

Healthcare expenditure was associated with under-5 mortality in Latvia. Healthcare expenditure was inversely associated with under-5 mortality and 5–14 mortality in Estonia. A borderline significant association was found between healthcare expenditure and neonatal mortality in Estonia ($p = 0.049$).

In Lithuania, under-5 and 5–14 mortality were associated with the rate of unemployment but were not associated with healthcare expenditure. In Estonia, however, the opposite was observed — under-5 and 5–14 mortality were associated with healthcare expenditure but not with unemployment.

No other associations were found for perinatal, neonatal and infant mortality with socioeconomic factors in the Baltic countries. As presented in Figures 2, 3 and 4, perinatal, neonatal, and infant mortality indicators exhibited a continuous

Table 1. Statistically significant associations between mortality indicators and macroeconomic factors

Mortality indicator	Country	Macroeconomic factors			
		Total GDP	GDP *per capita*	Healthcare expenditure	Unemployment
Neonatal mortality	Estonia	B = 0.00, t = 1.73, β = 15.29, $p = 0.15$	B = –0.00, t = -1.84, β = –16.39, $p = 0.13$	B = –0.12, t = -2.58, β = –0.72, **$p = 0.05$***	B = –0.17, t = -0.37, β = –0.08, $p = 0.73$
Under-5 mortality	Latvia	B = 0.002, t = 10.35, β = 1.90, **$p < 0.01$**	B = –0.003, t = -16.74, β = –2.35, **$p < 0.01$**	B = 0.15, t = 4.41, β = 0.36, **$p = 0.01$**	B = –0.26, t = t = –2.19, β = -0.05, $p = 0.08$
	Lithuania	B = 0.001, t = 5.47, β = 5.33, **$p < 0.01$**	B = –0.003, t = 7.02, β = –6.18, **$p < 0.01$**	B = 0.03, t = -0.98, β = –0.11, $p = 0.37$	B = 0.56, t = 3.64, β = 0.20, **$p = 0.02$**
	Estonia	B = 0.004, t = 8.54, β = 17.28, **$p < 0.01$**	B = –0.006, t = -9.08, β = –18.49, **$p < 0.01$**	B = –0.08, t = -5.23, β = –0.33, **$p < 0.01$**	B = 0.10, t = 0.63, β = 0.03, $p = 0.56$
5-14 Mortality	Latvia	B = 0.000, t = 7.27, β = 1.75, **$p < 0.01$**	B = –0.001, t = -13.0, β = –2.39, **$p < 0.01$**	B = 0.01, t = 1.29, β = 0.14, $p = 0.25$	B = 0.02, t = 0.56, β = 0.02, $p = 0.60$
	Lithuania	B = 0.000, t = 4.24, β = 7.62, **$p = 0.01$**	B = –0.001, t = -4.98, β = –8.09, **$p < 0.01$**	B = 0.03, t = 1.98, β = 0.41, $p = 0.10$	B = 0.25, t = 2.86, β = 0.28, **$p = 0.04$**
	Estonia	B = 0.001, t = 5.61, β = 15.62, **$p < 0.01$**	B = –0.002, t = -6.02, β = –16.87, **$p < 0.01$**	B = –0.022, t = -3.61, β = –0.32, **$p = 0.02$**	B = 0.04, t = 0.61, β = 0.04, $p = 0.57$

Neonatal mortality, under-5 mortality expressed per 1000 live births, 5–14 mortality expressed per 1000 children aged 5 years. GDP – gross domestic product, total in millions of Euros or *per capita*, healthcare expenditure – total healthcare expenditure as percentage share of GDP, unemployment – rate of unemployment as percentage of total population.

B – unstandardised coefficient, t – t-value, β – standardised coefficient, *p* – *p*-value.

**p*-value of 0.049.

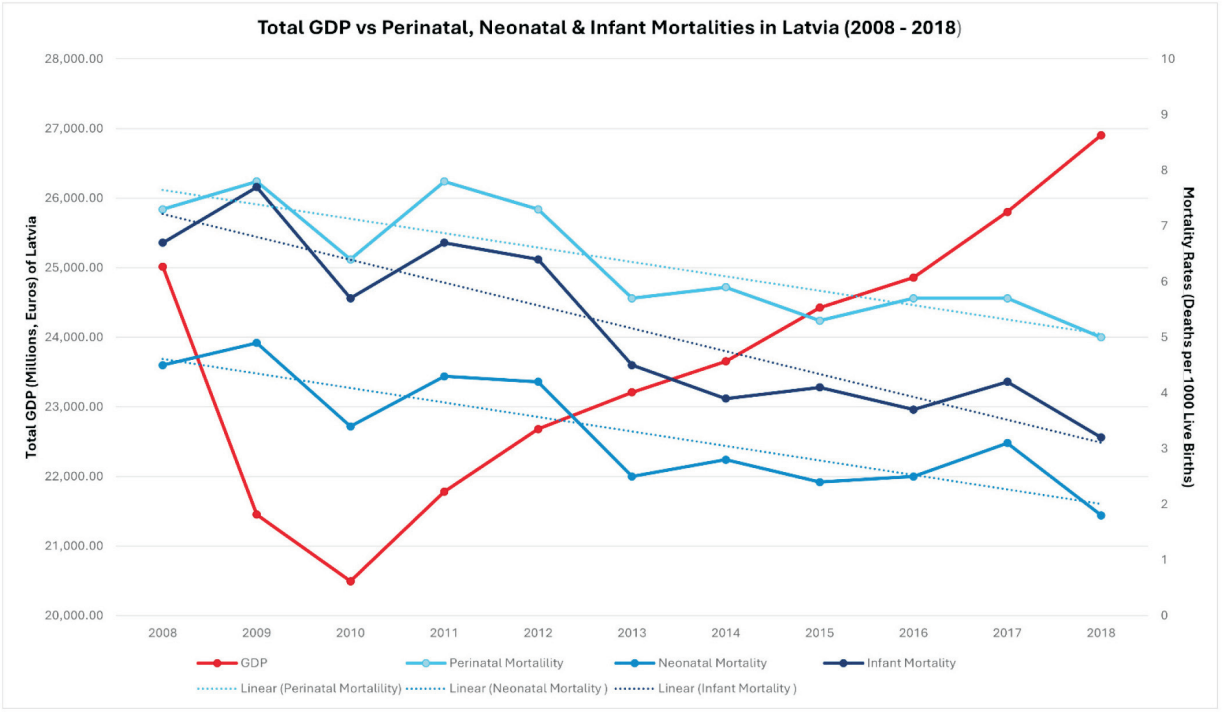


Fig. 2. Total GDP and perinatal, neonatal, and infant mortality in Latvia.

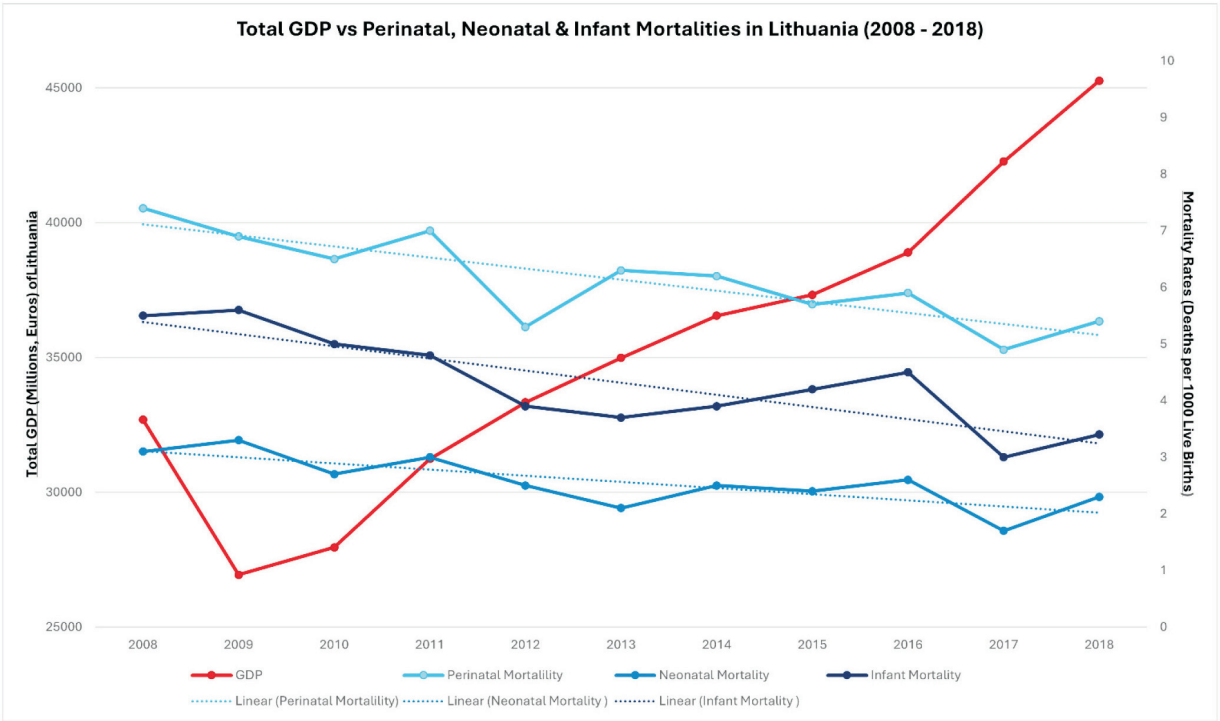


Fig. 3. Total GDP and perinatal, neonatal, and infant mortality in Lithuania.

downward trend from 2008 to 2018 that was not significantly affected by the rapid decline and subsequent gradual recovery of GDP across the three Baltic States.

DISCUSSION

GDP and mortality indicators. Strong associations were observed between GDP and under-5 mortality in all three Baltic States, which reaffirms the findings of the previous studies published by Ebela *et al* (2013) and Salber *et al* (2019). Higher GDP *per capita* was associated with lower mortality rates.

Salber *et al* (2019) described a statistically significant association between GDP and perinatal mortality for 2010 to 2016 in Latvia and Estonia, as well as infant mortality in Latvia alone during that same time period, while we ob-

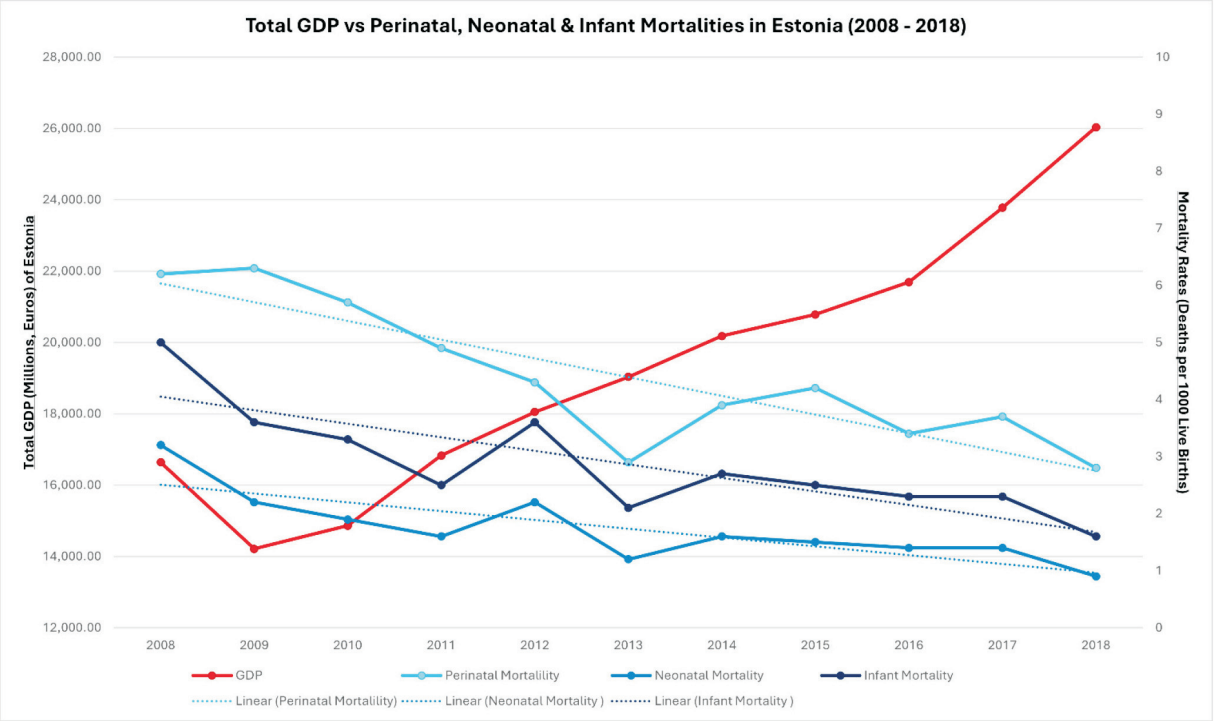


Fig. 4. Total GDP and perinatal, neonatal, and infant mortality in Estonia.

served no such associations for 2008 to 2018. This could indicate that the association was present for several years and not for the entire time period, with dilution of the observed effect over 11 years as opposed to 7 years.

It is reassuring that perinatal, neonatal, and infant mortality seem not to be tied to macroeconomic factors in the Baltic states, with the singular exception of a borderline significant association observed for neonatal mortality in Estonia. Despite the shrinking of the Baltic economy due to economic crisis, infant and perinatal mortalities did not increase significantly and in some years even decreased. This indicates that maternal and new-born health programmes and support systems function well despite economic instability.

There are certain drawbacks to using GDP to assess overall prosperity of the average citizen, and the GINI coefficient helps to account for differences in wealth distribution, which could be masked by the single metric provided by the concept of GDP. However, we were not able to find an association between differences in wealth distribution (GINI) and mortality indicators for the studied time period as well as in previous studies.

Healthcare expenditure and mortality indicators. When interpreting the effects of GDP, it is important to also analyse healthcare expenditure, as countries with comparatively lower GDP may have higher healthcare expenditure and vice versa.

Previous studies described correlations between healthcare expenditure and under-5 mortality in the three Baltic States, as well as for perinatal mortality in Lithuania. Curiously, our analysis confirmed this finding for Latvia and Estonia, but not Lithuania. When looking at the nature of the association, in Estonia higher healthcare expenditure was associated with a decrease in under-5 mortality, 5–14 mortality, and a borderline significant decrease in neonatal mortality ($p = 0.049$). For Latvia, the association with under-5 mortality was significant but higher expenditure was not associated with a decrease in mortality.

The low mortalities recorded in Estonia and the apparent difference between the other two Baltic states can be attributed, at least partially, to Estonia's healthcare spending policies. During the 11 years examined, Estonia spent an average of 6.2% of its GDP on health care while during that same time Latvia spent an average of 5.8% and Lithuania spend an average of 6.5%. Despite this, Estonian under-5 mortality has been substantially lower than both Latvia and Lithuania since 2005. In 2018, it was roughly 70% lower in Estonia when compared to Latvia and Lithuania. As such, research into how Estonian healthcare structure and policies have translated into such low mortalities would be invaluable.

Unemployment and mortality indicators. When it comes to unemployment, the study by Salber *et al* (2019) found associations between infant and under-5 mortality in both Latvia and Lithuania. In our study unemployment was associated with mortality only in Lithuania, reconfirming the previously identified relationship with under-5 mortality and additionally with 5–14 mortality. No relationship was found for unemployment and child mortality indicators in Latvia. This could mean that the effects of unemployment in Latvia were more contained than in Lithuania, with less significant effects on mortality indicators over a longer time period.

Understanding why unemployment is linked to child mortality in Lithuania but not the other Baltic States would require further investigation, with explanations likely found in differences in welfare systems during this time period. Possibilities include differences in the generosity and accessibility of unemployment benefits, child care subsidies and social assistance. Long-term effects could be associated by differences in the success of mitigative measures implemented at a national level, including the efficacy of social transfer and targeted family support, buffering children from adverse effects. Unemployment can also affect child mortality through psychosocial mechanisms, with household stress increasing the risk of neglect and child injury, with older children (5–14 years) arguable more vulnerable to external causes of death.

The lack of association found between unemployment and infant mortality is commendable, indicating that the support system for infants and maternal health was stable and was not as affected by the increase in unemployment. Overall, the effects of unemployment on child mortality in Latvia seem to have been more contained than in Lithuania, with less long-term consequences.

Wider implications and ramifications. All things considered, it is highly likely that the mortality of children older than one year of age will remain tied, either directly or indirectly, to the economic status of the Baltic States for the foreseeable future and that reasonable preparation should be considered to proof health services against severe economic downturns. Since 2018, immense progress has been made when it comes to child mortality indicators, with more recent aggregated data from 2023 showing that under-5 mortality is below the EU average (3.8 per 1000 live births) in all three Baltic States, yet differences remain, with rates of 2.11 in Estonia, 2.96 in Latvia and 3.38 per 1000 live births in Lithuania (UNICEF, 2024; World Bank, 2024).

Taking into account the previous analyses conducted on this topic, as well as the results of the current analysis, it would be useful to conduct a comparable evaluation of the time following 2018, with particular attention to the years of the COVID-19 pandemic.

CONCLUSIONS

The main findings of the analysis for the time period between 2008 and 2018 were:

1. Total GDP and GDP *per capita* was associated with under-5 and 5–14 mortality Latvia, Lithuania and Estonia, but not with perinatal, neonatal and infant mortality. Overall, higher GDP *per capita* was associated with lower mortality in these categories.

2. Higher healthcare expenditure was associated with lower under-5 and 5–14 mortality in Estonia, yet in Latvia it was associated with higher under-5 mortality (higher expenditure did not result in a reduction of under-5 mortality).

3. Higher unemployment rates were associated with higher under-5 and 5–14 mortality in Lithuania.

Factors relating to healthcare spending policies in Estonia could be an important explanation for the country's success in rapidly decreasing child mortality indicators. It would be of additional interest to investigate, in depth, any differences in healthcare spending policies between the Baltic States. A continuation of the analysis of the years following the studied time period, also addressing any potential effects of the COVID-19 pandemic, would be valuable.

SUPPLEMENTARY MATERIALS

Supplementary Tables (Tables S1–S21).

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BĒRNU MIRSTĪBAS TENDENCES SAISTĪBĀ AR MAKROEKONOMISKIEM FAKTORIEM BALTIJAS VALSTĪS (2008–2018)

Bērnu mirstības rādītāji Baltijas valstīs vēsturiski bijuši augsti, taču pēdējo divu desmitgažu laikā tie būtiski samazinājušies, ar visstraujāko kritumu Igaunijā. Iepriekšējie pētījumi liecina, ka šo tendenci varētu ietekmēt ekonomiskie faktori. Šī pētījuma galvenais mērķis bija paplašināt iepriekšējos pētījumus, analizējot sakarības starp bērnu mirstības rādītājiem un makroekonomiskajiem rādītājiem, lai labāk izprastu globālās ekonomiskās lejupslīdes iespējamo īstermiņa un ilgtermiņa ietekmi uz bērnu mirstību Baltijas valstīs. Analīze tika veikta par periodu no 2008. līdz 2018. gadam, īpašu uzmanību pievēršot 2008. gada globālās finanšu krīzes sekām. Visās Baltijas valstīs tika konstatētas statistiski nozīmīgas saistības starp iekšzemes kopproduktu (IKP) un mirstību bērniem līdz 5 gadu vecumam, kā arī bērniem vecumā no 5 līdz 14 gadiem. Lielāki veselības aprūpes izdevumi bija saistīti ar zemākiem mirstības rādītājiem bērniem līdz 5 gadu vecumam un vecumā no 5 līdz 14 gadiem Igaunijā, savukārt Latvijā tie bija saistīti ar augstāku mirstību bērniem līdz 5 gadu vecumam (lielāki veselības aprūpes izdevumi nemazināja mirstību Latvijā). Bezdarba līmenis bija saistīts ar augstākiem mirstības rādītājiem bērniem līdz 5 gadu vecumam un vecumā no 5 līdz 14 gadiem Lietuvā. Faktori, kas saistīti ar veselības aprūpes finansēšanas politiku Igaunijā, iespējams, bijuši nozīmīgs iemesls valsts panākumiem straujā bērnu mirstības samazināšanā.