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Female Education and the Convergence of Under-Five Mortality in the European Union

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Abstract: Objectives: This study examines whether female education contributes to reducing disparities in under-five mortality across European Union member states. **Prior Work:** Existing research identifies female education as an important determinant of child health and development, but its role in reducing cross-country health disparities remains underexplored. **Approach:** Using annual data for 2000–2023, the study applies a dynamic panel model with fixed effects to test beta convergence in under-five mortality and assess the influence of female education on convergence dynamics. **Results:** The findings indicate convergence in under-five mortality across member states. However, female education does not significantly affect the speed of convergence, and no consistent regional differences are observed between Central and Eastern European countries and other member states. **Implications:** Educational expansion alone may be insufficient to reduce health disparities without broader institutional and socioeconomic support. **Value:** The paper contributes to research on sustainable development, education, and health inequality by examining the relationship between female education and mortality convergence within the European integration process.

Keywords: women's education; sustainable development; child survival; regional cohesion; social inequality

JEL Classification: I15; I25; O47; O57

1. Introduction

Female education has long been recognized as a fundamental driver of socioeconomic development and public health improvement (Todaro & Smith, 2020). Across both developed and developing economies, higher levels of women's educational attainment are associated with lower fertility rates, improved maternal and child health outcomes, increased labor market participation, and stronger institutional development (Balaj et al., 2021; Wang, 2021). In particular, education has been found to enhance women's capacity to access healthcare services, adopt healthier behaviors, and make informed decisions regarding child nutrition and healthcare utilization, thereby contributing to improved child survival outcomes (Amoah & Asamoah, 2022; Kaffenberger & Pritchett, 2021; Kien & Nguyen, 2024).

The belief that educating women generates benefits extending beyond the individual to families and society has long shaped development thinking and is embedded in contemporary global policy

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frameworks, including the Sustainable Development Goals (SDGs). For instance, SDG Target 4.5 aims to eliminate gender disparities in education by expanding women's human capital and is complemented by Target 3.2 on reducing under-five mortality and Target 3.7 on improving access to sexual and reproductive healthcare services, including family planning, information, and education (United Nations, 2017; Sachs et al., 2025). Together, these targets are consistent with the view that female education operates as a key transmission channel through which improvements in child survival are expected to be achieved, based on the premise that women's educational attainment can strengthen access to health information and services and improve decision-making within households.

Although empirical evidence consistently shows a negative relationship between maternal education and under-five mortality across countries, the extent to which female education contributes to reducing cross-country disparities in health outcomes remains inconclusive (Balaj et al., 2021; Luong et al., 2024; Wang, 2021). This issue is particularly relevant within the European Union (EU), where substantial regional disparities persist despite improvements in population health.

Central and Eastern European (CEE) countries continue to exhibit higher under-five mortality rates compared to many Western European member states (Genowska et al., 2021; Sachs et al., 2025). These persistent gaps may reflect deeper structural and historical differences in development trajectories despite EU convergence objectives and cohesion policies (Hrzic et al., 2021). As noted by Tomka (2024), post-socialist Central and Eastern Europe did not follow a fully linear convergence path with Western Europe under globalization and European integration, but instead retained distinct institutional configurations shaped by state socialist legacies.

At the same time, available data suggest that substantial improvements in female educational attainment have occurred across the EU over recent decades (Eurostat, 2026), alongside convergence in child mortality rates (Genowska et al., 2021). Yet it remains unclear whether improvements in female education translate into faster convergence in child health outcomes across countries or whether such effects are constrained by structural and institutional differences. Against this background, the EU integration process raises important questions about the mechanisms through which female education influences child survival and whether it contributes to the reduction of cross-country health inequalities. Specifically, this study addresses the following research questions:

- Does female education significantly contribute to the convergence of under-five mortality rates across European Union countries?
- Do higher levels of female education accelerate reductions in mortality gaps between countries with different initial levels of child mortality?
- Do the effects of female education on mortality convergence differ between Central and Eastern European countries and other European Union member states?

This study contributes to the literature by shifting the focus from average effects of female education on child health to its role in explaining cross-country convergence in under-five mortality within a β -convergence framework in the European Union. In particular, the paper sheds light on whether female education affects the speed of convergence in mortality rates and whether this relationship depends on initial mortality levels and regional heterogeneity across member states.

The remainder of the paper is structured as follows. Section 2 reviews the theoretical and empirical literature on female education and child health and develops the conceptual framework. Section 3 presents the data and empirical methodology, including the β -convergence specification and interaction terms used to capture heterogeneous effects. Section 4 reports and discusses the empirical results. Section 5 concludes with policy implications and directions for future research.

2. Theoretical and Conceptual Issues

The nexus between female education and health outcomes have been explored by several scholars from different disciplines including historians, demographers, health care practitioners, development practitioners, and economists.

2.1. Female Education and Child Health Outcomes

A large body of literature identifies female education as one of the most important social determinants of child health and survival. The foundational contribution of Caldwell (1979) established that maternal education operates as a “central connecting factor” that enhances the effectiveness of other determinants of child survival, including sanitation, nutrition, and healthcare utilization. Subsequent empirical work has consistently confirmed that female education improves child health outcomes through multiple reinforcing mechanisms.

At the micro level, education increases women’s access to and processing of health-related information, which leads to more informed health behaviors and improved household health investment decisions (Lindeboom et al., 2009; Kien & Nguyen, 2024; Kaffenberger & Pritchett, 2021). Educated women are more likely to recognize symptoms of illness, adopt preventive healthcare practices, and utilize formal healthcare services effectively. Education also strengthens cognitive skills and literacy, which improves the ability to understand medical guidance and health campaigns (Kaffenberger, 2020).

Beyond informational channels, female education affects child health through socioeconomic pathways. Higher educational attainment increases the likelihood of employment in higher-paying and more stable occupations, thereby improving household income and increasing access to healthcare services (Amoah & Asamoah, 2022). Education is also associated with improved hygiene practices, dietary choices, and infant care behavior, all of which contribute directly to reductions in avoidable child deaths (Amoah & Asamoah, 2022; Wu, 2022). Overall, empirical evidence suggests that each additional year of schooling is associated with lower child and under-five mortality rates, although the magnitude of this effect varies across contexts (Amoah & Asamoah, 2022; Wu, 2022).

A growing strand of the literature further emphasizes that the quality of education may matter more than the quantity, as literacy and functional knowledge are more directly linked to health behavior than formal schooling years alone (Kaffenberger, 2020). This highlights that education operates not merely as a structural input but as a multidimensional capability affecting health outcomes.

Table 1. Education

Author(s)	Mechanism / Finding
Caldwell (1979)	Maternal education strengthens and integrates other determinants of child survival
Lindeboom et al. (2009); Kien & Nguyen (2024); Kaffenberger & Pritchett (2021)	Education improves access to and use of health information, leading to better health decisions
Amoah & Asamoah (2022)	Education increases likelihood of higher-income employment, improving access to healthcare
Amoah & Asamoah (2022)	Knowledge of illness and childcare increases application of health practices
Amoah & Asamoah (2022)	Education improves hygiene and nutrition practices, reducing preventable deaths

Wu (2022)	Additional years of schooling reduce child mortality rates
Kaffenberger (2020)	Literacy reduces child mortality; education quality matters more than quantity
Kien & Nguyen (2024); Shorette & Burroway (2022)	Effects of education on child mortality are context-dependent

Source: Authors' own synthesis

The evidence summarized in Table 1 highlights three consistent patterns in the literature. First, female education operates through multiple reinforcing channels, including information access, income effects, and behavioral change. Second, the magnitude of its impact varies depending on both the quality of education systems and the socioeconomic context in which education is embedded. Third, several studies emphasize that the effects of female education are context-dependent, suggesting that institutional and structural factors may mediate its impact on child health outcomes (Kien & Nguyen, 2024; Shorette & Burroway, 2022). These findings collectively suggest that while female education is a robust determinant of child survival, its effects are neither uniform nor automatic across different institutional environments.

2.2. Theoretical Underpinnings of Health Convergence and B-Convergence in Mortality Outcomes

A growing empirical literature examines whether cross-country disparities in health outcomes diminish over time, often drawing on the concept of β -convergence, originally developed in growth theory by Barro and Sala-i-Martin (1992). In this framework, convergence refers to the process through which economies or countries become more similar in key socioeconomic or demographic outcomes as they develop (Gabrielli, 2021).

Within this tradition, β -convergence occurs when countries with initially higher levels of a given outcome experience faster subsequent improvements than those with lower initial levels, implying a negative relationship between initial conditions and subsequent growth or improvement rates (Eurofound, 2021; Sala-i-Martin, 1992). However, recent studies suggest that convergence processes are neither automatic nor uniform, but instead depend on structural conditions such as institutional quality, social policy frameworks, and the degree of political and economic integration (Martin et al., 2025).

Empirically, β -convergence is typically assessed using panel or cross-sectional regression models in which the growth or change in an outcome is regressed on its initial level. This approach has been widely applied to health indicators, including life expectancy and child mortality, to assess whether international health inequalities are narrowing over time.

Within the European context, convergence in health outcomes has been widely documented. Improvements in child and infant mortality rates across European Union member states suggest a general process of health convergence, driven in part by the diffusion of medical technologies, improvements in healthcare systems, and EU cohesion policies (Hrzic et al., 2021; Mackenbach et al., 2015). Although convergence in socioeconomic and health outcomes is an explicit objective of the European Union (EC, 2024, 2025), substantial heterogeneity persists across member states. In particular, Central and Eastern European countries continue to lag their Western and Northern European counterparts in several health indicators, including infant and under-five mortality rates, indicating that convergence remains incomplete and uneven.

While the convergence literature extensively documents the existence of β -convergence in health outcomes, it pays limited attention to the determinants of convergence speed. Consequently, little is known about whether social determinants of health, such as female education, contribute to faster reductions in cross-country disparities. Most existing studies conceptualize education primarily as a determinant of health levels rather than as a factor shaping the dynamic adjustment process toward convergence. As a result, the role of female education in influencing the speed of mortality convergence remains an open empirical question, which this study investigates.

2.3. Conceptual Framework

Building on the literature reviewed above, this study develops a conceptual framework in which female education influences under-five mortality through multiple interconnected channels and contributes to cross-country convergence dynamics within the European Union.

At the centre of the framework is female education, which is conceptualized as both a direct and indirect determinant of child survival (Figure 1). The direct channel reflects the role of education in enhancing health literacy, increasing awareness of preventive healthcare practices, and improving women's ability to access, interpret, and utilize health-related information. Through these mechanisms, educated women are better positioned to make informed decisions regarding child health, nutrition, and healthcare utilization (Lindeboom et al., 2009; Kaffenberger & Pritchett, 2021; Kien & Nguyen, 2024).

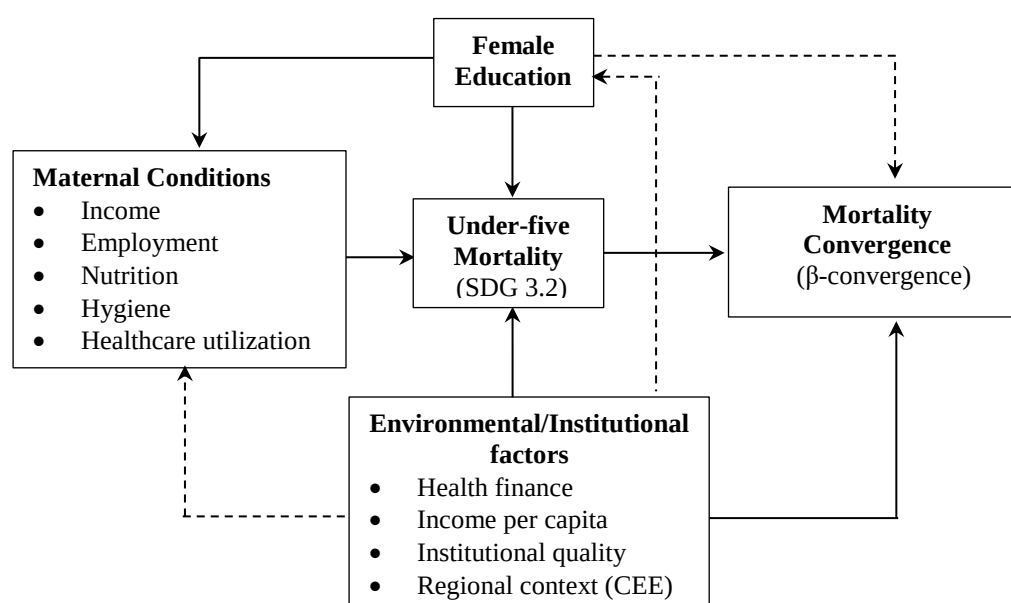


Figure 1. Framework for Investigating the Effects of Female Education on Child Mortality Convergence

Solid arrows: Established causal pathways supported by existing literature.

Dashed arrows: Contextual influences and convergence relationships examined in this study.

The indirect channel operates through maternal conditions, which act as an important mediating mechanism linking female education to child survival outcomes. Higher levels of educational attainment are associated with improved employment opportunities, higher household income, greater autonomy in household decision-making, and enhanced knowledge of childcare practices (Amoah & Asamoah, 2022; Caldwell, 1979). These improvements contribute to better maternal and child nutrition, improved hygiene and sanitation practices, greater utilization of healthcare services, and increased investment in

children's wellbeing. Consequently, maternal conditions provide a key pathway through which female education translates into lower levels of under-five mortality (Wu, 2022; Kien & Nguyen, 2024).

In addition to individual and household-level mechanisms, the framework incorporates environmental and institutional factors, including healthcare finance, accessibility and quality of healthcare systems, institutional capacity, public health infrastructure, and broader socioeconomic conditions. These factors influence child survival directly by shaping access to healthcare services and the effectiveness of public health interventions. At the same time, they may influence educational opportunities and condition the extent to which female education can be translated into improved health outcomes (Shorette & Burroway, 2022; Sachs et al., 2025). Consequently, the relationship between female education and child survival is not expected to be uniform across countries but may vary according to differences in institutional and developmental contexts.

The outcome variable within the framework is under-five mortality, which serves as a widely used indicator of population health, child wellbeing, and sustainable development. The reduction of under-five mortality is explicitly recognized under Sustainable Development Goal Target 3.2, which aims to end preventable deaths of newborns and children under five years of age by 2030 (United Nations, 2017). In this regard, under-five mortality provides an appropriate measure through which to evaluate the broader developmental benefits associated with female education.

The framework extends beyond the conventional analysis of mortality levels by incorporating a fifth component, namely mortality convergence. Drawing on the β -convergence literature (Barro & Sala-i-Martin, 1996), convergence refers to a process whereby countries with initially higher levels of under-five mortality experience faster subsequent reductions than countries with lower initial mortality levels, leading to a narrowing of cross-country disparities over time. Within this dynamic perspective, female education is hypothesized to influence not only the level of under-five mortality but also the speed at which mortality gaps between countries are reduced.

Finally, the framework recognizes that convergence processes may differ across regions of the European Union. Historical and institutional differences between Central and Eastern European countries and other EU member states may influence the extent to which improvements in female education translate into reductions in child mortality and contribute to convergence. Accordingly, this study investigates whether female education affects the relationship between initial mortality levels and subsequent mortality outcomes and whether these effects vary across regional contexts.

The conceptual framework provides the basis for the empirical model developed in this study. The data, methodology, and model specifications used to test these relationships are presented in the following section.

3. Methodology and Model Specification

This adopted a quantitative research design to investigate the role of female education in shaping under-five mortality and convergence dynamics across European Union member states over the period 2000–2023. To examine whether convergence dynamics differ between Central and Eastern European countries and other EU member states, the EU-27 countries were divided into two groups namely Central and Eastern Europe (CEE) and other EU member states. The CEE countries include Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia.

The empirical approach builds on the β -convergence framework, which tests whether countries with higher initial levels of under-five mortality experience faster subsequent reductions, leading to a gradual

narrowing of cross-country disparities. To extend this framework, the study integrates female education into a dynamic panel specification that allows for both level effects and convergence effects. The empirical model is specified as follows:

Equation 1. Empirical Model Specification

$$\ln(U5MR_{it}) = \alpha + \beta \ln(U5MR_{i,t-1}) + \delta FE_{it} + \theta (FE_{it} \times \ln(U5MR_{i,t-1}) + \phi(CEE_i \times \ln(U5MR_{i,t-1})) + \psi(CEE_i \times FE_{it} \times \ln(U5MR_{i,t-1})) + \gamma Z_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where $U5MR_{it}$ denotes under-five mortality in country i at time t , FE_{it} represents female education, and CEE_i is a time-invariant dummy identifying Central and Eastern European countries. Z_{it} is a vector of control variables (lnGNI per capita, lnHF, and Institutions), μ_i captures country fixed effects, λ_t captures time fixed effects, and ε_{it} is the idiosyncratic error term.

Table 2. Variables, Definitions, and Data Sources

Variable	Definition / Measurement	Expected Role in model	Data Source
Under-five mortality $\ln(U5MR_{it})$	Number of deaths before age five per 1,000 live births (log-transformed in estimation)	Dependent variable (health outcome) and convergence indicator	Sachs et al. (2025)
Female education (FE)	Mean years of schooling for females	Key explanatory variable	UNDP (2025)
$\ln(U5MR_{i,t-1})$	One-period lag of log U5MR	Captures β -convergence mechanism	Constructed
CEE dummy	Binary variable = 1 for Central and Eastern European EU member states, 0 otherwise	Captures regional heterogeneity in convergence and structural differences	Constructed
lnGNI per capita	Gross National Income Per Capita (2021 PPP\$)	Control for income level and development	UNDP (2025)
Health finance (lnHF)	Public health financing (HF1)	Controls for healthcare system investment	Eurostat
Institutions	Index measuring institutional and productive capacity performance	Controls for governance and institutional environment	UNCTADstat (2026)
Time fixed effects	Year dummies capturing global shocks and common trends	Control variable (unobserved time variation)	Constructed
Country fixed effects	Country-specific time-invariant effects	Control variable (unobserved heterogeneity)	Constructed

3.1. Estimation Approach

The model is estimated using a fixed-effects panel data approach. Country fixed effects (μ_i) control for time-invariant heterogeneity across countries, such as historical development patterns, cultural factors, and geographic characteristics. Time fixed effects (λ_t) account for common shocks and global trends affecting all countries, including technological progress in healthcare, international policy changes, and macroeconomic cycles.

Because the inclusion of a lagged dependent variable in a fixed-effects panel may generate dynamic panel bias, additional robustness checks were conducted using System GMM estimators developed by Manuel Arellano and Stephen Bond (Cottrell & Lucchetti, 2026). To ensure the validity of the estimator instrument sets are collapsed to limit instrument proliferation, year dummies are included to account for

EU-wide shocks, Arellano–Bond tests are used to check for serial correlation, and the Hansen test is used to assess instrument validity using Gretl (Cottrell & Lucchetti, 2026).

Due to harmonized Eurostat health financing data being available for all EU countries only from 2014, health expenditure (lnHF) is included in an extended specification for the post-2014 period as a robustness check whereas lnHF is excluded from the full model from 2000–2023. Across both specifications, we find that the model exhibits a strong explanatory power, with within R-squared values exceeding 0.99, indicating that the included covariates and fixed effects explain a substantial share of within-country variation in under-five mortality. Joint significance tests confirm that the regressors are jointly statistically significant in both models ($p < 0.001$), while tests for country and time fixed effects strongly reject the null of homogeneous intercepts and no time effects, respectively. This confirms the appropriateness of the fixed-effects framework and the presence of both cross-country heterogeneity and common temporal shocks. The coefficients remain stable across the full-sample and post-2014 specifications, indicating that the inclusion of health expenditure does not materially alter the estimated relationship between female education and mortality convergence. The next section presents and discusses the key results of the study.

4. Results and Discussion

This section presents the empirical findings from the fixed-effects estimations of under-five mortality convergence across European Union member states. The results are presented and discussed in accordance with the three research questions guiding the study. Firstly, the analysis examines whether under-five mortality rates exhibit β -convergence across EU countries. Second, it assesses whether female education contributes to the convergence process by accelerating reductions in mortality gaps in the EU. Third, it evaluates whether the effects of female education on mortality convergence differ between Central and Eastern European (CEE) countries and other EU member states. Throughout the discussion, findings from the full-sample specification (2000–2023) are compared with those from the post-2014 robustness specification that incorporates health expenditure.

Table 3. Fixed-effects Regression Results (Dependent Variable: $\ln(U5MR)$)

Model: Fixed effects

Included 27 cross-sectional units

Time-series length: minimum 10, maximum 23

Dependent variable: $\ln U5mr$

Standard errors clustered by unit

Variable	Full Sample (2000–2023)	Robustness Specification (2014–2023)
Constant	0.4277 (0.2808)	−0.2379 (0.3147)
Female education (FE)	0.0039 (0.0104)	−0.0106 (0.0148)
Ln (GNI per capita)	−0.0322 (0.0258)	0.0323 (0.0268)
Institutional quality	−0.0013 (0.0011)	−0.0006 (0.0012)
lnHF	-	0.0087 (0.0160)
$\ln(U5MR_{i,t-1})$	0.9836*** (0.0456)	0.8526*** (0.0794)
$FE \times \ln(U5MR_{i,t-1})$	−0.0014 (0.0038)	0.0097 (0.0067)
$CEE \times \ln(U5MR_{i,t-1})$	included in full model structure (insignificant)	-
$CEE \times FE \times \ln(U5MR_{i,t-1})$	-	0.0004 (0.0022)

Time dummies	Yes	Yes
Country fixed effects	Yes	Yes
Observations	621	441
Countries	27	27
Within R ²	0.9955	0.9941

Robust standard errors clustered by country in parentheses. *** $p < 0.01$.

4.1. Does Female Education Contribute to the Convergence of Under-Five Mortality Rates Across EU Countries?

The first objective of this study was to investigate whether female education significantly contribute to the convergence of under-five mortality rates across European Union countries. We find evidence of beta-convergence in under-five mortality across EU member states (Table 3). In the full-sample specification, the coefficient on lagged under-five mortality is 0.853 ($p < 0.001$), while in the post-2014 robustness specification it increases to 0.984 ($p < 0.001$). The statistical significance of this variable indicates a high degree of persistence in mortality levels over time.

Within the β -convergence framework, the magnitude of the coefficient suggests that convergence occurs gradually rather than rapidly. Although disparities in child mortality persist, particularly between some Central and Eastern European countries and their Western European counterparts, our results suggest a gradual narrowing of these differences over time. Our results suggest that countries with initially relatively higher mortality levels at beginning of the study period continue to improve over time, but the adjustment process remains slow, thereby reflecting the cumulative nature of improvements in child health. This finding is broadly consistent with previous studies showing that health outcomes tend to converge more slowly than economic indicators because changes in mortality are influenced by long-term demographic, institutional, and behavioural factors.

Although, there is evidence of β -convergence, female education does not have a significant impact on under-five mortality rates. The estimated coefficient on female education is negative in the full-sample specification (-0.0106) but positive in the post-2014 robustness specification (0.0039). However, neither coefficient is statistically significant. These findings suggest that, after controlling for country fixed effects, time effects, and other socioeconomic determinants, female educational attainment does not exert a robust direct effect on under-five mortality within the European Union.

This result suggests that improvements in female educational attainment alone are not systematically associated with reductions in under-five mortality across European Union countries during the period under study. The absence of a statistically significant direct effect is consistent with the possibility that the impact of female education operates primarily through indirect channels or is conditioned by broader institutional and socioeconomic factors.

4.2. Do Higher Levels of Female Education Accelerate Reductions in Mortality Gaps?

In addition to analyzing the direct effect of female education on under-five mortality rates in the EU, we also investigated whether female education contributes to the convergence process by accelerating reductions in mortality disparities across countries. We find that female education does not significantly impact the speed of convergence in under-five mortality in the EU.

The interaction term between female education and lagged under-five mortality is statistically insignificant in both specifications. In the full-sample model, the coefficient is positive (0.0097), while in the robustness specification it is negative (−0.0014). The lack of statistical significance indicates that female education does not systematically influence the speed at which mortality gaps between countries close over time. In other words, higher levels of female education do not appear to systematically accelerate or decelerate the reduction of mortality gaps between countries.

While previous research consistently identifies female education as an important determinant of child health outcomes, our results indicate that its role in explaining differences in convergence rates is limited. Our results further suggest that factors that reduce mortality levels may not necessarily be the same factors that drive convergence in mortality outcomes.

The absence of a significant convergence effect may indicate that the benefits of female education operate primarily through indirect mechanisms, including household income, health knowledge, healthcare utilisation, and child-care practices. It may also reflect the marginal impact of further educational improvements on child mortality due to the already relatively high levels of educational attainment and healthcare access observed across EU member states.

4.3. Do the Effects of Female Education on Mortality Convergence Differ Between Central and Eastern European Countries and Other EU Member States?

Finally, we investigated whether the relationship between female education and mortality convergence differs between Central and Eastern European countries and other EU member states. To examine this possibility, the model includes interaction terms involving the CEE dummy variable. The coefficient on the interaction between female education, lagged mortality, and CEE status is positive but statistically insignificant (0.00039). This result indicates that female education does not exert a significantly different effect on mortality convergence in CEE countries compared with the rest of the European Union.

Similarly, there is no evidence that convergence dynamics differ systematically between CEE and non-CEE countries once other socioeconomic and institutional factors are taken into account. Although descriptive evidence suggests that mortality rates remain higher in the CEE, our empirical results indicate that the role of female education in shaping convergence patterns is broadly similar across EU regions.

These findings are noteworthy given arguments that post-socialist countries continue to exhibit distinct institutional and developmental trajectories despite decades of European integration. Our results further suggest that while structural differences may persist across regions, they do not translate into statistically detectable differences in the relationship between female education and child mortality convergence.

The control variables included in our models do not exhibit statistically significant effects in either specification. This suggests that short-run within-country variation in GDP per capita, institutional quality, and health expenditure do not significantly influence under-five mortality once country-specific characteristics and common time effects are controlled for.

5. Conclusion

This study examined the role of female education in shaping the convergence of under-five mortality rates across European Union member states over the period 2000–2023. While the relationship between

female education and child health outcomes is well established in the development literature, less is known about whether improvements in female educational attainment contribute to reducing disparities in child mortality between countries. Accordingly, the study addressed three research questions: whether female education contributes to the convergence of under-five mortality rates across EU countries, whether higher levels of female education accelerate reductions in mortality gaps, and whether these effects differ between Central and Eastern European (CEE) countries and other EU member states. To investigate these questions, the study employed a dynamic panel β -convergence framework estimated using fixed-effects techniques, incorporating interaction terms to assess the influence of female education on convergence dynamics and to explore potential regional heterogeneity within the European Union.

Our findings provide strong evidence of convergence in under-five mortality across European Union member states. However, contrary to expectations derived from the development and public health literature, female education does not appear to significantly influence the speed of convergence in child mortality. Neither the direct effect of female education nor its interaction with initial mortality levels is statistically significant, and there is no evidence that these relationships differ systematically between Central and Eastern European (CEE) countries and other EU member states.

At first glance, these findings appear inconsistent with a substantial body of research documenting a negative association between female education and child mortality (Caldwell, 1979; Balaj et al., 2021; Amoah & Asamoah, 2022; Kien & Nguyen, 2024). Much of this literature argues that education improves child survival by increasing health literacy, enhancing access to information, promoting healthier behaviours, and strengthening women's decision-making capacity within households. From this perspective, higher levels of female educational attainment should contribute to improved child health outcomes and potentially accelerate reductions in mortality disparities.

However, an important distinction must be made between the level effects of education and its convergence effects. Most existing studies examine whether more educated women experience better health outcomes or whether countries with higher educational attainment exhibit lower mortality rates. In contrast, the present study investigates whether differences in female education explain the rate at which mortality gaps between countries close over time. These are conceptually distinct questions. Female education may contribute to lower mortality levels overall without necessarily influencing the speed of convergence across countries.

The absence of a significant convergence effect is consistent with arguments that the relationship between education and health is highly context dependent. As noted by Shorette and Burroway (2022), the effectiveness of education in improving health outcomes depends on the broader social, economic, and institutional environment in which individuals live. Similarly, Kien and Nguyen (2024) argue that educational attainment alone may be insufficient to improve child health outcomes where access to healthcare services, public health infrastructure, and socioeconomic opportunities remain constrained. In such contexts, education can enhance individual capabilities, but the translation of those capabilities into improved health outcomes depends on complementary institutional conditions.

This interpretation is particularly relevant within the European Union. Unlike many studies conducted in low-income and lower-middle-income countries, EU member states generally exhibit high levels of educational attainment, widespread access to primary healthcare, and relatively low child mortality rates. Consequently, the marginal effect of additional educational attainment may be smaller than in settings where basic health knowledge and healthcare access remain limited. As under-five mortality

approaches relatively low levels, further improvements may depend less on educational attainment and more on the quality of healthcare systems, institutional effectiveness, and broader social policies.

The findings may also reflect the existence of threshold effects. Kaffenberger and Pritchett (2021) argue that educational quality may be more important than years of schooling in generating developmental outcomes. Similarly, Kaffenberger (2020) suggests that improvements in literacy and learning outcomes may matter more than formal educational attainment alone. If educational expansion in the European Union has been accompanied by relatively limited variation in educational quality across countries, additional gains in educational attainment may have limited explanatory power for differences in child mortality convergence.

The results further suggest that convergence in mortality outcomes may be driven by factors operating at the supranational level rather than by differences in educational attainment. The European Union has implemented a range of cohesion, health, and social policies aimed at reducing disparities across member states. These include investments in healthcare infrastructure, regional development programmes, and broader efforts to strengthen social protection systems. Such mechanisms may contribute directly to convergence in health outcomes, thereby reducing the relative importance of education as a determinant of convergence speed.

The lack of significant differences between CEE and other EU member states is also noteworthy. The literature often emphasizes the distinctive historical and institutional trajectories of post-socialist countries (Tomka, 2024; Hrzic et al., 2021). Although these countries continue to exhibit somewhat higher mortality rates on average, the results suggest that the role of female education in shaping mortality convergence does not differ systematically across EU regions. This may indicate that the effects of European integration, policy harmonization, and institutional modernization have reduced regional differences in the relationship between education and child health.

Importantly, the findings should not be interpreted as evidence that female education is unimportant for development or public health. Rather, they suggest that the contribution of female education to reducing health disparities may depend on complementary socioeconomic and institutional conditions. This interpretation is consistent with Caldwell's (1979) argument that maternal education operates through multiple intermediate mechanisms rather than functioning as an isolated determinant of child survival. Education may therefore remain a necessary but not sufficient condition for convergence in health outcomes.

From a theoretical perspective, the study contributes to the literature by extending the analysis of female education beyond its average effects on health outcomes. While previous research has primarily focused on the relationship between education and mortality levels, this study examines whether education contributes to the reduction of disparities between countries. The results indicate that factors explaining improvements in health outcomes are not necessarily the same factors that explain convergence in those outcomes. This distinction represents an important contribution to both the education and development literatures.

Overall, the findings suggest that improving female educational attainment, although desirable and central to the SDGs, may not be sufficient to reduce cross-country disparities in child health outcomes. Therefore, achieving health convergence within the European Union may require a broader policy approach that combines investments in education with improvements in institutional quality, healthcare systems, and socioeconomic development.

Despite the novelty of this study, one limitation of this study is that female education is measured using average years of schooling and therefore does not capture differences in educational quality. Second,

the analysis focuses on macro-level relationships and does not identify individual-level mechanisms linking education and child health. Third, the relatively low variation in mortality rates across EU countries may reduce the ability to detect statistically significant effects. Future research should therefore examine how education interacts with these structural factors and whether the quality of education, rather than educational attainment alone, plays a more significant role in shaping health convergence.

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