# Modeling the effect of expenditure on higher education on economic growth

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*Abstract:* - The relevance of the article is due to the recently increasing inter-determinism of the economy and education and the significance of the study of the effectiveness of investment in human capital as a strategic resource for economic progress and sustainable economic development. The purpose of the article is to analyze and model the impact of spending on higher education on economic growth in the EU and Russia. The methodological basis of the study is testing the author's hypothesis and econometric modeling of the impact of macroeconomic indicators - economic factors that quantitatively characterize the state of the higher education system on the resulting gross domestic product per capita as an indicator of economic growth according to 27 countries of the European Union and the Russian Federation. The research hypothesis about the positive impact of expenditure on higher education on economic growth in the EU and Russia was confirmed. It was found that the growth rates of the founding countries of the EU were different from post-soviet members. The highest response for Russia is observed in terms of expenditures on higher education in GDP and in the volume of high-tech exports, accounting for which will allow building a balanced education and innovation policy in Russia. The prediction of the models obtained on the statistical data of Russia shows the possibility of a significant growth of GDP per capita with an increase in expenditures on higher education with an appropriate congruent development of the institutional environment.

*Key-Words:* Sustainable development, higher education, higher education spending, economic growth, European Union, Russia, econometric modelling

Received: March 15, 2026. Revised: April 11, 2026. Accepted: May 16, 2026. Published: November 4, 2026.

## 1 Introduction

Under the contemporary trends of post-industrialization, softization, servitization, and informatization, the rates of economic growth are increasingly determined by the scale and pace of development in priority areas of science and technology, the degree of advancement of scientific and production technologies, as well as the level of education and qualifications of the workforce at all levels. Consequently, economic growth largely depends on the education system, within which these processes are initiated, supported, and further developed. International experience demonstrates that the contribution of technological change to economic growth in developed countries is currently estimated at 20–40% of annual GDP growth.

It is generally accepted that human capital has a significant impact on the economic growth, it has become a strategic resource for economic progress, and without investment in it, it is impossible to achieve sustainable economic development. Education is of great importance for the development of human capital, innovation potential, economic and socio-cultural development of both regional and national economies in general. The role of the importance of higher education in recent decades determines the relevance of studies that allow assessing their impact on human capital and economic growth.

The aim of the study is to research the hypothesis of the impact of expenditure on higher education on the economic growth of the EU and Russia using econometric methods. For this, the following research tasks were solved:

• study of the possibilities and limitations of the econometric modeling of the of higher education impact in assessing the rates of economic growth in international and Russian experience;

• identification of a set of relevant indicators and variables to determine the correlations that reflect the higher education impact on economic growth;

• approbation of the developed model on the data of the EU countries (separately for the groups of the "Founders countries of the EU" and the countries that were members of the Council for Mutual Economic Assistance (CMEA) and joined the EU after 1990);

• modeling the growth of GDP per capita and predicting the resulting models on the statistical data of the Russian Federation.

Modern economics offers many theories and models linking education to economic growth. The direct impact of education on economic growth is expressed through improvements in human capital. However, the indirect impact can also be expressed through improvements in other indicators at the micro and macro levels (Fig. 1)

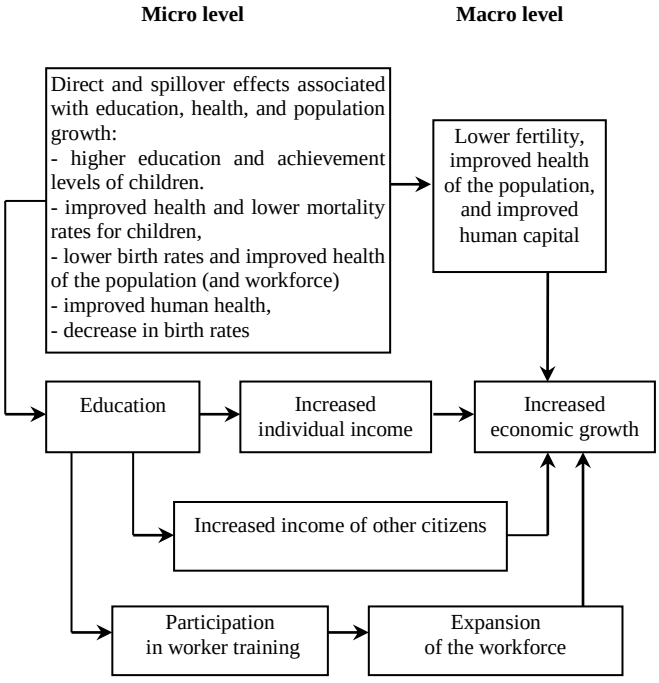



Fig. 1: The effect of higher education on economic growth
*Source: created by the authors*

## 2 Problem Formulation

The theoretical basis for assessing the impact of education spending on economic growth is presented in the works of the classics of political economy, who considered the costs of improving the qualifications of an employee as capital [1].

The development of the theory of human capital and the study of the mutual influence of education and economic growth from these positions, as well as the emergence of a new branch of economic knowledge "economics of education" made it possible to determine the quantitative contribution of education in economic development and growth. In the middle of the XX century these issues have been explored in [2], [3], [4], [5], which have had a major impact on the increase in education spending by international organizations such as the International Monetary Fund and the World Bank. Researches by [6], [7], [8], [9], [10], 11], [12], [13] highlighted the role of education in the socio-economic development of countries and provided the foundations for analyzing an investment in education.

Numerous modern international studies provide the connection between the spread of higher education in various countries of the world and positive dynamics of economic growth and determine the degree of influence of higher education on economic indicators in the modern world economy [14] [15], [16], [17], [18], [19], [20], [21], [22]. For example, it was found that the contribution of education to the growth of national income in the United States and European countries is 12-29%, and an improvement in the quality of the labor force led to a 14% increase in real national income in the United States [4]. Studies have empirically determined the relationship between the spread of education in various countries of the world and the beginning of economic growth; the time lag between the implementation of reforms in the education sector and the beginning of significant economic growth is 25-30 years [7]. Government spending on education by 1% increases average economic growth by 0.201% based on World Bank research from 1960 to 2000 for 23 developed countries [12].

The Organization for Economic Co-operation and Development research has found that a 1% increase in spending on education leads to a 0.35% increase in a country's gross domestic product. In recent decades, there is an increase in public and private spending on higher education in the world. In OECD countries, public spending on education accounts for 13.3% of total expenditures; they have increased over the past 10 years by more than 23%, while in Russia they have doubled [23].

Despite the generous empirical evidence of the positive impact of investment in higher education on economic growth, there is a need to justify public spending on education in the face of their scarcity in any country, so this issue is widespread in modern research and arouses constant research interest.

Aspects of a quantitative assessment of the impact of spending on higher education on the

growth of the country's gross domestic product as an indicator of its economic growth in domestic practice remain poorly understood. This study continues the search for methods and tools for assessing the quantitative characteristics and effectiveness of the higher education system.

## 3 Materials and Methods

To achieve the objectives of the study, a system of aggregated relevant indicators was formed that characterize the impact of spending on higher education on the development of the economy of the countries of the European Union and Russia. The statistical, econometric, graphical, coefficient and correlation-regression methods of analysis were used.

It should be noted that in this study the term "higher education" is interpreted as a synonym for tertiary education according to the International Standard Classification of education. For the empirical analysis, statistical data from the World Bank, the Organization for Economic Cooperation and Development, Eurostat and the Federal State Statistics Service of the Russian Federation were used.

The analyzed subject of the study was the indicators of 28 member states of the European Union. After a preliminary analysis of the dataset, Luxembourg was excluded from consideration, as having the highest GDP per capita, it is disturbing in the aggregate, i.e. is an anomalous object. Due to the different scales of the educational systems of 27 European countries, the values were normalized by switching to relative indicators, while the basis for comparison was GDP, population size, the volume of the entire indicator, etc.

It is also taken into account significant differences in economic development between the called "Founders countries of the EU" and countries that were members of the Council for Mutual Economic Assistance (CMEA), and that joined the European Union after 1990.

To test the existence of such a pattern when considering the impact of government spending on education on economic development, a dummy variable D was introduced, which takes a value equal to one in the case of ex-CMEA countries and a value equal to zero for the rest of the aggregate countries (Table 1).

Table 1. EU countries, included in the sample

| Indicators | Countries formerly members of the CMEA | Founders countries of the EU |
|---|---|---|
| D - dummy variable | equally in unit | equally to zero |
| Member States of the European Union | BGR, HUN, LVA, LTU, POL, ROU, SVK, CZE, EST | AUT, BEL, GBR, GRC, DEU, DNK, ITA, IRL, ESP, CYP, LUX, MLT, NLD, PRT, SVN, FRA, FIN, HRV, SWE |

*Source: created by the authors.*

The dataset of selected indicators was divided into three blocks (Table 2). Per capita GDP (in current USD) was taken as Y.

Table 2. Blocks of the analyzed indicators

| |
|---|
| **Block EX:** characterize government spending on higher education (tertiary) |
| EX1 – Current education expenditure, tertiary (% of total expenditure in tertiary public institutions) |
| EX2 – Education spending, tertiary (% of GDP) |
| EX3 – Government expenditure per student, tertiary (% of GDP per capita) |
| EX4 - Research and development expenditure (% of GDP) |
| **Block ED:** characterizes the level of education of the population, the state of the system of higher education (tertiary), the return from the scientific sphere |
| ED1 – Classroom teachers and academic staff by education level (1 000) |
| ED2 – Students enrolled in tertiary education by education level (1 000) (% gross) |
| ED3 – School enrollment, tertiary (% gross) |
| ED4 – Population by educational attainment level (1 000) (Tertiary education (levels 5-8)) |
| ED5 – Employment rates by educational attainment level (%) (Tertiary education (levels 5-8)), % |
| **Block SC:** characterizes the impact on the development of the economy of the scientific sphere |
| SC1 – Researchers in R&D (per million people) |
| SC2 – Patent applications, residents (per million people) |
| SC3 – High-technology exports (% of manufactured exports) |
| SC4 – Scientific and technical journal articles (% gross) |

*Source: created by the authors.*

It is also taken into account the lag of the effect of spending on higher education in 4-7 years, which means that after graduation students will enter the labor market, adapt in the workplace, and begin to create added value. The factors from the ED block operate in a similar way, with the exception of the factors ED4 and ED5, which should be taken with a lag of 1 period. As for the SC block, the indicators included in it will influence the growth rate with a lag of 1 year.

Correlation and regression analysis was used to identify significant dependencies and to analyze the econometric model; the STATISTICA package was used for calculations.

# 4 Problem Solution

Correlation analysis was carried out, the results of which is a matrix of paired correlation coefficients presented in Table 3.

Table 3. Matrix of paired correlation coefficients of variable blocks Y, EX, ED, SC

| | Y | EX1 | EX2 | EX3 | EX4 | ED1 | ED2 | ED3 | ED4 | ED5 | SC1 | SC2 | SC3 | SC4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Y | 1,00 | | | | | | | | | | | | | |
| EX1 | 0,14 | 1,00 | | | | | | | | | | | | |
| EX2 | **0,74** | 0,17 | 1,00 | | | | | | | | | | | |
| EX3 | **0,46** | 0,36 | **0,52** | 1,00 | | | | | | | | | | |
| EX4 | **0,71** | 0,26 | **0,73** | **0,44** | 1,00 | | | | | | | | | |
| ED1 | 0,03 | 0,14 | 0,17 | 0,15 | 0,08 | 1,00 | | | | | | | | |
| ED2 | -0,06 | -0,21 | 0,14 | 0,14 | 0,17 | -0,04 | 1,00 | | | | | | | |
| ED3 | 0,17 | -0,32 | 0,21 | **-0,39** | 0,37 | -0,01 | **0,51** | 1,00 | | | | | | |
| ED4 | **0,53** | -0,15 | **0,55** | 0,15 | **0,39** | 0,05 | 0,30 | 0,30 | 1,00 | | | | | |
| ED5 | 0,17 | 0,37 | **0,47** | 0,34 | 0,27 | 0,23 | -0,21 | -0,34 | 0,11 | 1,00 | | | | |
| SC1 | **0,79** | 0,06 | **0,80** | 0,37 | **0,89** | -0,04 | 0,22 | **0,45** | **0,50** | 0,21 | 1,00 | | | |
| SC2 | 0,25 | -0,09 | 0,03 | 0,24 | 0,30 | 0,16 | -0,18 | -0,15 | -0,04 | 0,17 | 0,15 | 1,00 | | |
| SC3 | **0,61** | -0,10 | 0,36 | 0,32 | 0,24 | -0,03 | -0,20 | -0,20 | 0,28 | 0,30 | 0,34 | 0,27 | 1,00 | |
| SC4 | 0,30 | -0,30 | 0,02 | 0,16 | 0,24 | 0,00 | -0,26 | -0,07 | 0,06 | 0,01 | 0,16 | **0,81** | 0,29 | 1,00 |
| The given criteria, coefficients and parameters are statistically significant at the 5% level.. | | | | | | | | | | | | | | |

*Source: calculated by the authors in the STATISTICA package*

According to the presented data, several variables affect the dependent variable: these are EX2, EX3, EX4, ED4, SC1, SC3. Also, there is multicollinearity between these variables. Therefore, the combined use of factors in one model is impossible. The way to eliminate the identified problem is to select a combination of factors that do not correlate with each other, therefore, a model of the form was built:

$$Y = f(EX2; SC3) + E$$

where E – errors (deviations) of the model.

Also, such factors EX4 and SC1 have a significant influence on the dependent variable, unfortunately, they cannot be included in one model, but two separate equations can be built. At the same time, in order to increase the multiple correlations, we introduce into the equation a fictitious slope variable characterizing the stratification of the existing set:

$$Y = f(EX4; EX4D) + E$$

EX4D

$$= \begin{cases} EX4_i, if\ the\ country\ was\ part\ of\ the\ CMEA\ or\ the\ USSR \\ 0, in\ other\ cases \end{cases}$$

$$Y = f(SC1; SC1D) + E$$

SC1D

$$= \begin{cases} SC1_i, if\ the\ country\ was\ part\ of\ the\ CMEA\ or\ the\ USSR \\ 0, in\ other\ cases \end{cases}$$

Introducing a dummy slope variable into the model will test the hypothesis of more modest success in the Eurozone countries that joined it in the 2000s.

Table 3. Results of econometric models

| N | Model | R | $R^2$ | F |
|---|---|---|---|---|
| 1 | Y = -12455,7 + 22868,8·EX2 + 1041,1·SC3 + E | 0,825 | 0,680 | 25,562 |
| 2 | Y = 15632,2 + 11126,6·EX4 - 10387,7·EX4D + E | 0,803 | 0,645 | 21,833 |
| 3 | Y = 11640,79 + 6,28·SC1 - 4,58·SC1D + E | 0,858 | 0,713 | 33,350 |
| The given criteria, coefficients and parameters are statistically significant at the 5% level | | | | |

*Source: calculated by the authors in the STATISTICA package*

The obtained models show statistically significant results, as the multiple coefficient of determination (R2) indicates that more than 65% of the variation in Y is described by the factors included in the model. The actual value of the F-test of Fisher indicates that the resulting models are statistically significant at the 5% level.

The interpretation of the resulting models is as follows. The simulation results are shown in Figures 2 and 3.

**Model No. 1.** With an increase in spending on tertiary education by 1% of GDP (EX2), the value of GDP per capita on average increases by 22868.8 USD, provided that other factors remain constant. In turn, an increase in high-tech exports by 1% of exports (SC3) leads to an increase in GDP per capita by USD 1,041.

Since the model includes two factors, it is possible to assess which of them has the greatest influence, for this we proceed to the analysis of standardized regression coefficients:

$$Y = 0{,}600 \cdot EX2 + 0{,}390 \cdot SC3 + E$$

The value of the coefficient for the first variable is greater (0.600> 0.390), we conclude that the EX2 variable has the greatest influence on Y.

**Model No. 2.** An increase in spending on research and development by 1% of GDP leads to an increase in GDP per capita in the "Founders countries of the EU" of the EU by USD 11,126.6. The negative sign of the variable differentiation parameter of the slope coefficient of the straight line indicates that in the ex-CMEA countries that became part of the EU after the collapse of the USSR, the influence of the factor under consideration on Y is less, i.e. we have an increase of USD 738.9 (obtained as follows: 11126.6-10387.7). This change is graphically implemented in Figure 2.

The upper regression Y = 15632.2 + 11126.6 × EX4 was formed for the countries that were originally part of the EU (formed the European Union).

The lower regression Y = 15632.2 + 738.9 × EX4 is formed for the countries that joined the EU after the collapse of the USSR. As we can see from the figure, the "new countries" lag significantly behind the founders of the EU, i. e. GDP per capita growth in this subset of countries under the influence of the EX4 factor occurs on a smaller scale. In addition to the above, it should be recalled that the EX4 variable enters the model as a lagged one, with a delay of 5 years; accordingly, an increase in research and development costs will bring a tangible effect only in the medium term.

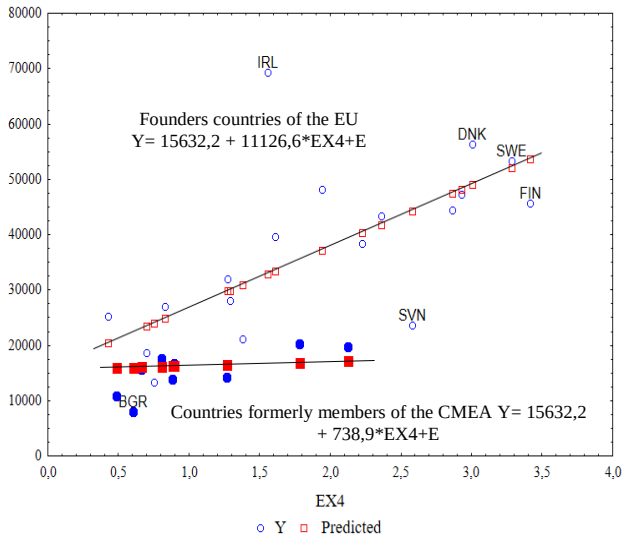



Fig. 2: Results of modeling the dependence Y = f (EX4; EX4D) + E

*Source: created by the authors, calculated by the authors in the STATISTICA package*

**Model No. 3.** An increase in the number of researchers in the field of R&D per 1 person per million citizens leads to an increase in GDP per capita in the "Founders countries of the EU" by USD 6.28, while in the ex-CMEA countries, the effect will be the only USD 1.7 (i.e. obtained in the following way 6.28 - 4.58). This is graphically implemented in Figure 3.

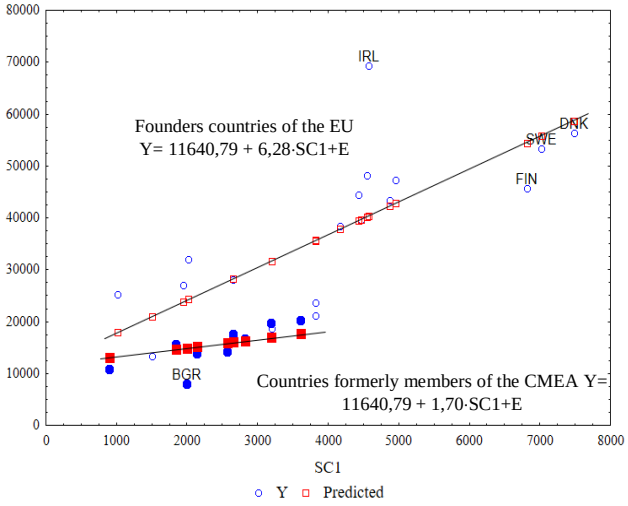



Fig. 3: Results of modeling the dependence Y = f (SC1; SC1D) + E

*Source: created by the authors, calculated by the authors in the STATISTICA package*

The result obtained is similar to model No. 2, as the partial regression for the "Founders countries of the EU" is higher than in the case of the ex-CMEA member countries. Thus, the economies of the countries that joined the European Union in the 2000s are less effective in responding to the impact of the SC1 variable, which is much less sensitive.

The obtained models are statistically significant; on their basis, it is possible to carry out modeling and forecast the development of Russia's GDP and its response to the growth of spending on financing higher education. To do this, we substitute the values observed in the Russian Federation in the same periods into the obtained models (Table 4).

Table 4. Results of building predictions (Predicted) for Russia

| N | Model | Predic-ted value | -95,0% CL | +95,0% CL |
|---|---|---|---|---|
| 1 | Y = -12455,7 + 22868,8·0,87 + 1041,1·10,7 | 18580,4 | 13386,2 | 23774,6 |
| 2 | Y = 15632,2 + 11126,6·1,05 - 10387,7·1,05 | 16408,1 | 9962,6 | 22853,6 |
| 3 | Y = 11640,79 + 6,28·3131,1 - 4,58·3131,1 | 16969,9 | 9356,1 | 24583,7 |
| Implications for Russia: EX2 = 0,87, SC3 = 10,7, D=1, EX4 = 1,05, EX4D=1,05·1=1,05, SC1 = 3131,1, SC1D=3131,1·1=3131,1 | | | | |

*Source: created by the authors, calculated by the authors in the package STATISTICA*

The results indicate that GDP per capita is increasing to USD 18,580, for comparison in 2017 the value of this indicator was USD 10,743, which is 42% lower than the predicted value.

Thus, the greatest response of the dependent variable for Russia is observed in the case of a two-factor model with variables EX2 (Expenditure on tertiary education, in% of GDP) and SC3 (Volume of high-tech exports, % of export volume). They are important regulated markers of the national economy, accounting for which will allow building a balanced educational and innovation policy in Russia.

# 5 Discussion

Comparing the dependences obtained by us with the results of foreign authors, it should be noted that the model No. 1 obtained in this study (Y '= f (EX2; SC3) + E) partially coincides with the results of the specialists of the International Monetary Fund and V. Blankenau [12] in terms of quantitative assessment of the positive impact on GDP of spending on education. In addition, we were able to identify additional factors (characterizing science and education) influencing the growth of the economy, which were not previously reflected in the studies of domestic and foreign authors:

1) GDP per capita of the member states of the European Union is influenced by the analyzed indicators of all three blocks: Block EX (3 indicators show a strong influence), Block ED (1 indicator) and Block SC (2 indicators). Given the presence of multicollinearity, three models were built, the first model includes two quantitative variables, the second and third models include one quantitative factor and one dummy variable;

2) the negative value of the coefficient for the dummy variable in the models indicates that the CMEA countries differ in growth rates from the EU founding countries, confirming the significant influence of institutional conditions on the rates of economic growth;

3) the resulting econometric models show that with an increase in quantitative factors, the resultant variable will grow, i.e. their positive impact is observed, thus, the research hypothesis about the positive impact of spending on higher education on economic growth was confirmed;

4) testing and predicting the obtained models on statistical data from Russia shows the possibility of a significant increase in GDP per capita with an increase in spending on higher education, of course, with a corresponding congruent development of the institutional environment.

# 6 Conclusion

The conducted research allows us to draw the following conclusions. The research hypothesis about the positive impact of spending on higher education on economic growth was confirmed and the difference between the growth rates of the "Founders countries of the EU" and the countries of ex-CMEA members was determined. Prediction of the obtained models on the statistical data of Russia showed the possibility of a significant increase in GDP per capita with an increase in spending on higher education with a corresponding congruent development of the institutional environment.

The applied aspect of the application of the results of the study is important in the modern conditions of economic development; there is a very high need for a high level of qualifications and the latest knowledge and competencies of human capital, requiring increased investment in education. And the tasks of the higher education system in any country are in the readiness and possible provision of the needs for highly qualified specialists for the needs of the post-industrial society and economy.

Therefore, in the long term, investment in professional development and spending on education is one of the effective mechanisms for accelerating economic growth. Thus, the conducted empirical studies have shown that an increase in funding for the higher education sector is one of the levers to accelerate economic growth, which must be taken into account when implementing a policy in the field of higher education and justifying the amount of spending on higher education.

**Declaration of Generative AI and AI-assisted Technologies in the Writing Process**

During the preparation of this work, the author(s) utilized artificial intelligence (AI) technologies solely for the purpose of linguistic refinement and grammatical correction. Following the application of these tools, the author(s) comprehensively reviewed, verified, and edited the resulting text. The author(s) maintain full accountability and responsibility for the accuracy, integrity, and final content of the publication.

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**Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)**

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

**Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself**

No funding was received for conducting this study.

**Conflict of Interest**

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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