Arch Health Sci Res. 2025;12:1-7
DOI: 10.5152/ArcHealthSciRes.2025.25030

Original Article

The Effects of Health Expenditures on Socioeconomic Indicators and Health Status: A Canonical Correlation Analysis

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Cite this article as: Bulut C, Altıntaş T. The effects of health expenditures on socioeconomic indicators and health status: A canonical correlation analysis. *Arch Health Sci Res.* 2025, 12, 0030, doi: 10.5152/ArcHealthSciRes.2025.25030.

What is already known on this topic?

- *High levels of healthcare expenditures alone do not universally translate into better health outcomes. Research indicates that equitable distribution of services and effective policy implementation are necessary to ensure the efficiency of health spending, particularly in low- and middle-income countries.*
- *High levels of healthcare expenditures alone do not universally translate into better health outcomes. Research indicates that equitable distribution of services and effective policy implementation are necessary to ensure the efficiency of health spending, particularly in low- and middle-income countries.*
- *Canonical Correlation Analysis (CCA) has previously been employed to explore multivariate relationships in health-related research, but its application to the combined analysis of socioeconomic indicators and health status at the international level remains relatively limited.*

ABSTRACT

Objective: This study investigates the complex relationship between socioeconomic indicators and health outcomes across countries, with a particular focus on the role of healthcare expenditures in shaping public health.

Methods: Using 2019 data obtained from international sources such as the Organisation for Economic Co-operation and Development (OECD), World Bank, World Health Organization, and Eurostat, canonical correlation analysis was employed. Socioeconomic indicators—including population density, growth rate, unemployment rate, per capita Gross Domestic Product (GDP), and education level—were treated as independent variables, while health outcomes—such as infant mortality, life expectancy, noncommunicable disease mortality, immunization rates, and tobacco use—served as dependent variables. The analyses were conducted using SPSS 22.0, supported by Wilks' Lambda test statistics.

Results: The results indicate that key socioeconomic indicators, particularly education level, unemployment rate, and per capita GDP, significantly influence public health. Higher education levels are associated with improved health outcomes, while unemployment and lower economic indicators correspond to deteriorating health metrics. Increased healthcare spending correlates with reductions in infant mortality and improvements in life expectancy.

Conclusion: Socioeconomic conditions are integral to the design of effective and equitable health policies. Rather than merely increasing health expenditures, their strategic allocation is essential for meaningful improvements in public health. Educational advancement plays a pivotal role in reducing health disparities. Future research should explore comparative evaluations of healthcare systems using longitudinal and cross-national data.

Keywords: Canonical correlation analysis (CCA), healthcare expenditures, health indicators, health policies, socioeconomic indicators

Introduction

Healthcare services are a critical factor that directly affects the well-being of individuals and societies. The sustainability and efficiency of health systems are closely linked to the management of health expenditures.[1] The financing models of health expenditures in different countries vary depending on factors such as private and public spending, out-of-pocket payment rates, and the scope of general health insurance.[2] This diversity leads to significant differences in health indicators across countries, making it essential to understand the relationship between health policies and socioeconomic indicators.[3]

This study is derived from the PhD dissertation titled "Analysis of the Relationship between Socioeconomic Indicators and Health Indicators with Canonical Correlation" written by Dr. Canan Bulut.

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Received: February 15, 2025
Revision Requested: April 14, 2025
Last Revision Received: May 7, 2025
Accepted: June 25, 2025
Publication Date: November 21, 2025

What this study adds on this topic?

- *This study provides empirical evidence of a strong multivariate relationship between socioeconomic indicators and health outcomes, revealing that education level and unemployment rate are more influential than GDP in determining public health status across countries.*
- *The findings demonstrate that the effectiveness of health expenditures is contingent upon the socioeconomic context, suggesting that strategic investment in education and employment may enhance the impact of health spending on population health.*
- *By applying Canonical Correlation Analysis to cross-national data, this study offers a nuanced methodological contribution that enables a comprehensive understanding of how complex interactions between socioeconomic and health variables shape public health outcomes.*

The impact of health expenditures on public health should be considered alongside economic and social indicators. Per capita health expenditures, the share of health spending in gross domestic product (GDP), and the balance between public and private expenditures are fundamental elements that shape the structure of health systems in different countries.[4] Additionally, socioeconomic indicators such as the unemployment rate, education level, income distribution, and population growth rate directly influence access to healthcare services and the efficiency of health expenditures.[5]

The World Health Organization (WHO) defines the primary objectives of health systems as effectiveness, efficiency, and equity (WHO, 2020[6]). However, economic and political disparities among countries pose significant challenges to achieving these goals. Previous studies emphasize that both protective and risk factors interact in shaping health outcomes.[5,7]

Protective factors such as higher education, greater income, and well-targeted public health expenditures contribute to improved access to healthcare and healthier lifestyles. In contrast, risk factors like unemployment, income inequality, and low educational attainment are associated with poorer health outcomes and limited service utilization.

The interaction between these factors is not merely additive but synergistic, meaning that the presence of one risk or protective factor may amplify the effects of others. For example, education not only directly improves health literacy but also mediates the impact of unemployment or poverty on health.[3] This study builds upon such frameworks to explore how socioeconomic structures influence public health through a multivariate lens.

In this context, analyzing the effects of health expenditures on socioeconomic indicators is crucial for guiding health policies. This study employs canonical correlation analysis (CCA) to determine the relationship between health expenditures and economic and social indicators. The main research question is to what extent health expenditures are associated with various socioeconomic factors and how these expenditures influence health indicators.

The theoretical foundation of this research is grounded in the intersection of health economics and social determinants of health. In particular, 3 major frameworks guide the selection and grouping of variables:

1. Health demand theory explains how individuals make choices about healthcare utilization based on economic constraints and incentives.[8]
2. Health systems model emphasizes the structure and financing of healthcare systems, focusing on how systemic factors like healthcare expenditure levels influence health outcomes (Anderson & Hussey, 2001).
3. Socioeconomic determinants theory highlights the impact of broader societal factors—such as education level, income inequality, and population growth—on health status.[5,7]

Based on these frameworks, the independent variable set (set 1) includes socioeconomic indicators—population density, population growth rate, unemployment rate, per capita GDP, and education level—which reflect individuals' and societies' capacity to access and utilize healthcare services. The dependent variable set (set 2) consists of health status indicators—infant mortality, life expectancy, mortality due to noncommunicable diseases (NCD), immunization rate, and tobacco use—that reflect the outcome of healthcare access and effectiveness.

These variables are analyzed together to assess the multivariate interactions between socioeconomic structures and public health outcomes across countries. Canonical correlation analysis is particularly well-suited for this purpose as it allows the identification of complex, multidimensional relationships between these theoretically distinct but empirically interdependent constructs.[9,10]

This method identifies the strongest relationships between 2 distinct data sets, contributing to a better understanding of the interaction between health policies and social policies. This research evaluates the impact of health expenditures by utilizing data from 219 countries on socioeconomic indicators and healthcare spending. The scientific contributions of this study can be summarized as follows:

1. It provides new findings for health policies by analyzing the relationship between health expenditures and socioeconomic indicators.
2. It highlights the differences between developed and developing countries, offering policy recommendations for global health governance.
3. It fills gaps in the literature by employing advanced statistical methods such as CCA.

The analyses conducted within this scope will reveal how health expenditures shape not only budgetary allocations but also economic development, social welfare, and sustainable health policies.

Table 1. Main and Sub-Variables Used in the Study

Set No.	Main Variables	Sub-Variables	Variable Description	Variable Code
Set 1	Socioeconomic indicators	Socioeconomic indicators	Population density	G2
			Population growth rate	G3
			Unemployment rate	G5
			Gross national product (GNP) ($)	G6
			Education (bachelor's degree or equivalent, age 25+)	G8
			Education (secondary education)	G9
Set 2	Health indicators	Health status indicators	Set 2A group	
			Mortality rate	G11
			Life expectancy at birth	G14
			Under-5 mortality rate	G15
			Infant mortality rate	G16
			Maternal mortality rate	G18
			Set 2B	
			Cause of death according to noncommunicable diseases (NCD)	G21
			Suicide mortality rate	G19
			Mortality rate due to noncommunicable diseases (ages 30-70)	G22
			Mortality rate due to noncommunicable diseases (ages 30-70)	G20
			Set 2C	
			Adolescent fertility rate	G23
			Crude birth rate	G24
			Total fertility rate	G25

Material and Method

In this study, CCA is employed to examine the relationship between socioeconomic indicators and health indicators of countries worldwide. The CCA is an advanced statistical method used to determine multidimensional relationships between a set of independent variables and a set of dependent variables.[9] This analysis serves as a powerful tool in revealing the impact of countries' socioeconomic structures on health indicators.[10]

This table presents the primary and sub-variables utilized in the study, categorized into socioeconomic indicators (set 1) and health indicators (set 2). All subgroups of set 2 (set 2A, set 2B, and set 2C) fall under the category of health status indicators. These variables serve as the basis for analyzing the association between socioeconomic conditions and health outcomes.

Research Model and Methodology

Socioeconomic indicators (independent variables): Population density, population growth rate, unemployment rate, per capita GDP, education level (Table 1).

Health indicators (dependent variables): Infant mortality rate, life expectancy at birth, mortality rate due to NCD, immunization rate, prevalence of tobacco use (Table 1).

Within the scope of the research model, the relational survey model has been adopted to explain the relationships between health indicators and socioeconomic indicators.[11] This model is a quantitative research design used to determine the relationships between 2 or more variables and provides an in-depth analysis aimed at understanding causal relationships between variables (Figure 1).[12]

The study utilizes data related to health and socioeconomic indicators from various countries worldwide. The sample consists of up-to-date data obtained from international databases such as OECD, World Bank, WHO, Worldometer, and Eurostat. Due to the impact of the COVID-19 pandemic in 2020 on global health data, the most recent and complete data from 2019 has been used for analysis.

Data Collection and Analysis Process

The data was collected between March 2022 and August 2022 and analyzed using SPSS 22.0 (IBM SPSS Corp.; Armonk, NY, USA) statistical software. The following steps were conducted during the data analysis process (Table 2).

Ethical Considerations

This study is based entirely on publicly available secondary data obtained from international organizations and does not involve human participants, patient data, or clinical trials. Therefore, ethical

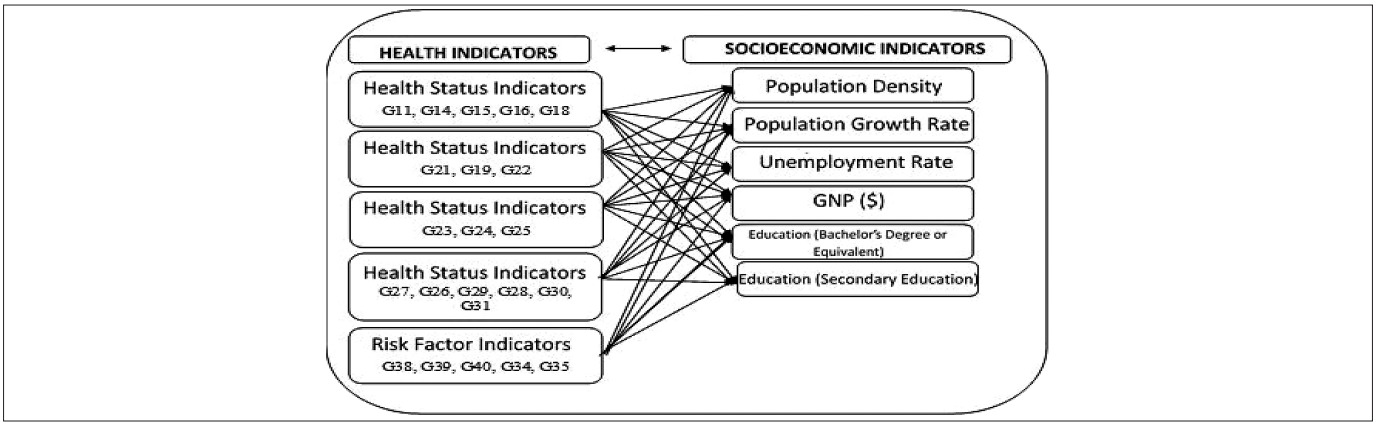

Figure 1. Research model.

Table 2. Data Analysis Process

Steps	Description of Data Analysis Steps
Step 1	Missing data analysis was performed to assess the pattern and proportion of missingness. For variables with less than 5% missing data, mean substitution was applied, as it provided a simple and effective method without significantly distorting the variance.[13] In cases where missingness exceeded this threshold, the variable was excluded from multivariate analysis to preserve model reliability.
Step 2	Normality assumptions were evaluated for each variable prior to conducting the Canonical Correlation Analysis (CCA). Skewness and kurtosis values were calculated, and all variables were found to fall within the acceptable range of ±2, indicating approximate normality.[24] Additionally, the Shapiro–Wilk test was applied to assess multivariate normality. Although minor deviations were observed in a few variables ($P < .05$), given the large sample size and the robustness of CCA to moderate violations of normality,[9] the data were deemed suitable for analysis. Multicollinearity among independent and dependent variables was assessed through correlation matrices and the calculation of Variance Inflation Factor (VIF) values. The correlation matrices revealed no pairwise correlations exceeding $\|r\| > 0.80$, and all VIF values were found to be below 2.5, indicating acceptable inter-variable relationships.[9] These results confirmed the appropriateness of the dataset for CCA and ensured the reliability of the canonical functions.
Step 3	Canonical Correlation Analysis (CCA) was applied to reveal multivariate relationships between independent and dependent variable sets.[10]
Step 4	The statistical significance of relationships was determined using the Wilks' Lambda test.

committee approval was not required. However, all data sources have been appropriately cited, and research integrity principles have been followed.

Findings

This section presents the results of the CCA conducted to determine the relationship between socioeconomic indicators and health status indicators. Within the scope of the analysis, the effects of socioeconomic variables on health indicators were examined, and significant relationships were identified.

The findings indicate that socioeconomic factors play a crucial role in determining health outcomes. In particular, variables such as education level, unemployment rate, and per capita GDP exhibit notable effects on health indicators.

Education level emerged as the most influential variable in the CCA, exhibiting a strong negative relationship with mortality-related indicators. This suggests that higher education contributes significantly to public health by improving health literacy, encouraging preventive behaviors, and increasing the ability to navigate healthcare systems.[3]

Unemployment rate also showed a substantial negative impact on health outcomes. This is consistent with existing literature, which links unemployment to psychological distress, reduced healthcare access, and increased vulnerability to chronic conditions.[14]

Interestingly, per capita GDP showed a relatively weak direct association with health outcomes. This finding supports the idea that economic growth alone does not guarantee improvements in population health unless accompanied by equitable resource distribution and accessible health services.[15]

These results collectively underscore the importance of targeting social and economic determinants in health policymaking, beyond focusing solely on healthcare funding.

This table presents the CCA results for the relationships between socioeconomic indicators and health status indicators. The table includes values for correlation coefficients, eigenvalues, Wilks' statistic, *F* values, degrees of freedom (df_1, df_2), and significance levels (*P*-values) for both set 2A and set 2B. The statistical significance of the canonical functions was tested using Wilks' Lambda statistics. In set 2A, the Wilks' Lambda value was 0.059 ($P < .001$), indicating that the relationship between socioeconomic indicators and health status indicators was statistically significant. Similarly, in set 2B, the Wilks' Lambda value was 0.061 ($P < .001$), confirming the multivariate significance of the canonical relationships. These results demonstrate the strength and validity of the associations identified through the CCA. This table illustrates the overall relationship between socioeconomic indicators and health status indicators. The highest canonical correlation coefficient is 0.931, and this relationship is statistically significant ($P < .001$). This finding suggests that socioeconomic factors have a strong influence on health indicators (Table 3).

This table presents the standardized canonical correlation coefficients for socioeconomic indicators (set 1) and health status indicators (set 2A and set 2B). The results indicate the strength and direction of the relationships between these variables, highlighting the influence of socioeconomic factors on health outcomes. In this table, a strong and negative relationship is observed between education level and mortality rate ($\beta = -0.911$). Additionally, GDP appears to have a weak association with health indicators ($\beta = -0.012$). In set 2B, mortality rates due to road traffic accidents have been found to be inversely proportional to education level (Table 4).

This table presents the canonical loadings for socioeconomic indicators (set 1) and health status indicators (set 2A and set 2B). The results indicate the strength and direction of the relationships between these variables, highlighting the influence of socioeconomic factors on health outcomes.

Canonical loadings and standardized canonical coefficients were examined to understand the contribution of each variable to the

Table 3. Canonical Correlation Analysis (CCA) Results for Socioeconomic Indicators and Health Status Indicators (Set 2A-Set 2B)

		Correlation	Eigenvalue	Wilks Statistic	*F*	SD 1	SD 2	*P*
Set 2A	1	0.931	6.484	0.059	2.668	30 000	78 000	.000
	2	0.589	0.532	0.444	0.933	20 000	67 282	.550
	3	0.520	0.371	0.680	0.730	12 000	55 852	.717
	4	0.242	0.062	0.932	0.261	6000	44 000	.952
	5	0.097	0.009	0.991				
Set 2B	1	0.892	3.904	0.061	3.987	24 000	77 959	.000
	2	0.671	0.821	0.300	2.328	15 000	63 894	.010
	3	0.633	0.670	0.546	2.118	8000	48 000	.052
	4	0.296	0.096	0.912	0.801	3000	25 000	.505

Table 4. Standardized Canonical Correlation Coefficients for Socioeconomic Indicators and Health Status Indicators (Set 2A-Set 2B)

	Variable	Coefficient
Set 1 (Socioeconomic indicators)	Population density	0.101
	Population growth rate	0.061
	Unemployment rate	−0.097
	Gross national product (GNP) ($)	−0.012
	Education (bachelor's degree or equivalent, age 25+)	−0.067
	Education (secondary education)	−0.911
Set 2A (Health status indicators)	Mortality rate	−1.009
	Life expectancy at birth	0.129
	Under-5 mortality rate	−0.684
	Infant mortality rate	0.566
	Maternal mortality rate	0.123
Set 1 (Socioeconomic indicators)	Population density	0.074
	Population growth rate	0.396
	Unemployment rate	0.030
	Gross national product (GNP) ($)	0.049
	Education (bachelor's degree or equivalent, age 25+)	−0.101
	Education (secondary education)	−0.775
Set 2B (Health status indicators)	Mortality rate due to road traffic accidents	0.348
	Mortality rate due to NCD (ages 30-70)	−0.324
	Cause of death due to NCD	−0.566
	Suicide mortality rate	−0.356

NCD, noncommunicable diseases.

canonical functions. In set 2A, the variable with the highest loading was secondary education level (−0.989), followed by mortality rate (−0.990) and unemployment rate (−0.251). These results suggest that the first canonical variate captures the inverse relationship between education and mortality, highlighting the critical role of educational attainment in improving health outcomes and reducing mortality rates (Table 5).

In set 2B, the most influential variables included secondary education level (−0.919), cause of death due to NCD (−0.867), and suicide mortality rate (−0.611). This indicates that the second canonical variate is primarily shaped by NCD burdens and their strong association with socioeconomic disadvantage (Table 5).

Substantively, these canonical functions reflect latent dimensions of health inequality and social vulnerability. Higher educational attainment appears to act as a protective buffer against adverse health outcomes, while unemployment and lower economic resources are consistently associated with elevated mortality. These variates can therefore be interpreted as underlying indicators of socioeconomic resilience and risk, which align with the theoretical assumptions outlined in the study (Table 5).

This table presents the explanation levels of socioeconomic indicators and health status indicators based on CCA. The values indicate how much variance in set 1 (socioeconomic indicators) and set 2 (health indicators) is explained by their respective canonical variables and by each other.

When examining the explanation levels, the variance explained within set 1 is calculated as 0.263, while the variance explained within set 2A is 0.415. In the analysis related to set 2B, education level and unemployment rate account for 41.9% of the variance in health status indicators. The results of the CCA revealed a strong multivariate relationship between socioeconomic indicators and health status indicators. The

Table 5. Canonical Loadings for Socioeconomic Indicators and Health Status Indicators (Set 2A-Set 2B)

	Variable	Canonical Loading
Set 1 (socioeconomic indicators)	Population density	0.092
	Population growth rate	0.401
	Unemployment rate	−0.251
	Gross national product (GNP) ($)	−0.117
	Education (bachelor's degree or equivalent, age 25+)	−0.595
	Education (secondary education)	−0.989
Set 2A (health status indicators)	Mortality rate	−0.990
	Life expectancy at birth	−0.149
	Under-5 mortality rate	0.555
	Infant mortality rate	0.561
	Maternal mortality rate	0.671
Set 1 (socioeconomic indicators)	Population density	0.087
	Population growth rate	0.574
	Unemployment rate	−0.086
	Gross national product (GNP) ($)	−0.059
	Education (bachelor's degree or equivalent, age 25+)	−0.584
	Education (secondary education)	−0.919
Set 2B (health status indicators)	Mortality rate due to road traffic accidents	0.734
	Mortality rate due to NCD (ages 30-70)	−0.112
	Cause of death due to NCD	−0.867
	Suicide mortality rate	−0.611

NCD, noncommunicable diseases.

highest canonical correlation coefficient was 0.931 in set 2A, indicating a very strong relationship, while Wilks' Lambda = 0.059, $P < .001$ confirmed statistical significance. This suggests that the canonical variates explain a substantial proportion of shared variance across the 2 sets.

Specifically, the explanation level for health indicators (set 2A) was 41.5%, and for socioeconomic indicators, it was 26.3%, indicating that health outcomes are more strongly influenced by socioeconomic factors than vice versa.

These findings are consistent with those of Marmot (2005) and Braveman & Gottlieb (2014), who emphasize the impact of social determinants such as education and income on mortality and life expectancy. Furthermore, in a comparative study using a similar multivariate approach, Cutler and Lleras-Muney (2010) reported a canonical correlation coefficient of 0.84 when analyzing the relationship between education and health behaviors—slightly lower than our results, but in the same direction.

The strength of these results provides strong empirical support for policy approaches that integrate socioeconomic improvements as a means of achieving better public health outcomes (Table 6).

The results obtained from this study are consistent with existing findings in the literature.[6,7] The data provide significant insights for shaping health policies and guiding public expenditures.

Table 6. Explanation Levels of Socioeconomic Indicators and Health Status Indicators (Set 2A-Set 2B)

	Canonical Variables	Set 1 by Self	Set 1 by Set 2	Set 2 by Self	Set 2 by Set 1
Set 2A	1	0.263	0.228	0.415	0.359
Set 2B	1	0.255	0.203	0.419	0.334

Discussion

In this study, the relationships between socioeconomic indicators and health indicators of countries worldwide were examined using the CCA method. The findings indicate that socioeconomic variables have a significant impact on health indicators. In particular, factors such as education level, unemployment rate, and per capita GDP were found to have strong associations with health status indicators. These findings are largely consistent with previous studies in the literature.[16,17]

The results of this study suggest that education level is inversely related to mortality rates. As the level of education increases, individuals' health literacy improves, access to healthcare services becomes easier, and the adoption of healthier lifestyles becomes more feasible.[3,8] Indeed, Braveman and Gottlieb (2014) emphasize that low education levels, combined with low income, lead to limited access to healthcare services, which in turn negatively impacts health indicators.

Another notable finding is the negative impact of the unemployment rate on health indicators. Unemployment directly affects individuals' income levels, limiting their access to healthcare services and reducing their quality of life.[18] Research suggests that long-term unemployment has detrimental effects on both physical and mental health.[14,19] This finding aligns with our study results, confirming a positive relationship between unemployment rates and mortality rates.

The management and financing models of health expenditures appear to influence a country's health indicators. While the findings suggest that per capita GDP has a relatively weak effect on health outcomes, the interpretation should be approached with caution. It is important to note that the effectiveness of health systems may depend more on the equitable distribution of healthcare access and the efficiency of policies rather than economic magnitude alone.[1,15]

Although developed countries often invest more in healthcare, our analysis does not imply a direct causal link between health expenditures and improved life expectancy. Instead, it supports the notion that effective policy implementation and educational attainment may play a mediating role in achieving better health outcomes. Therefore, broad generalizations about the impact of healthcare spending should be avoided without context-specific analysis.

The findings also highlight that education level is one of the most significant determinants of health indicators. This underscores the importance of education policies in improving health outcomes. As education levels increase, individuals develop greater health awareness, leading to the widespread adoption of preventive health behaviors.[20] WHO (2020) reports also support this, indicating that individuals with higher education levels tend to live longer and healthier lives.

Strengths and Limitations

The findings of this study are largely consistent with similar research in the literature. For instance, studies by Marmot and Wilkinson (2006) highlight the determinant role of socioeconomic factors in health inequalities. Similarly, Cutler and Lleras-Muney (2010) emphasize the positive effects of education on health indicators, showing that individuals with higher education levels tend to lead healthier lives.

This study makes several contributions to the literature. First, it is one of the limited studies that examine the relationships between socioeconomic and health indicators across countries using CCA. Additionally, by utilizing up-to-date data from international databases such as OECD, World Bank, WHO, and Eurostat, this research provides a detailed analysis of the causal relationships between health indicators and socioeconomic variables.[21]

This research has certain limitations. The data used in the study is from the year 2019, meaning that the effects of the COVID-19 pandemic on health expenditures and health indicators were not assessed. Future studies incorporating more recent data that account for the impact of the pandemic will contribute to a more comprehensive understanding of these relationships.[22]

Conclusion

The findings of this study clearly demonstrate that socioeconomic factors play a critical role in shaping health policies. Increasing education levels, strengthening health literacy, and reducing income inequalities emerge as priority policy areas for improving public health. A higher level of education facilitates access to healthcare services, enhances health awareness, and promotes preventive health behaviors. Additionally, economic policies aimed at reducing unemployment will directly contribute to the improvement of health indicators by enabling individuals to benefit more effectively from healthcare services.

The research findings indicate that simply increasing health expenditures is not sufficient; rather, these expenditures must be used efficiently and effectively. Increasing public health expenditures is particularly important for reducing infant mortality rates and increasing life expectancy. However, the effective management of health expenditures is not solely dependent on budget increases but requires the proper allocation of resources and an efficient healthcare system. In this context, the impact of socioeconomic factors on the effective utilization of health expenditures should be considered, and determinant variables such as income level, unemployment rate, and education should be placed at the core of health policies.

Future research should utilize larger datasets to analyze different healthcare systems from a comparative perspective and evaluate the long-term effects of health policies. In particular, examining the impact of global pandemics and economic crises on health expenditures and socioeconomic factors will be crucial for identifying the vulnerabilities of health systems and making them more resilient.

In conclusion, the strong relationship between health indicators and socioeconomic indicators suggests that health policies should not be limited to investments in the healthcare sector alone but should also be supported by education, economic, and social policies. To achieve sustainable improvements in public health, a holistic policy approach should be adopted, and long-term, strategic, and effective policies should be developed while considering individuals' socioeconomic conditions. This study contributes to shaping health policies by highlighting the connection between health expenditures and socioeconomic development.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: This study is based entirely on publicly available secondary data obtained from international organizations and does not involve human participants, patient data, or clinical trials. Therefore, ethical committee approval was not required.

Informed Consent: This study is based entirely on publicly available secondary data obtained from international organizations and does not involve human

participants, patient data, or clinical trials. Therefore, informed consent was not required.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – C.B.; Design – C.B., T.A.; Supervision – T.A.; Resources – C.B.; Materials – C.B.; Data Collection and/or Processing – C.B.; Analysis and/or Interpretation – C.B., T.A.; Literature Search – C.B.; Writing Manuscript – C.B.; Critical Review – T.A.; Other – C.B.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

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