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Research Article

Multivariate Regression Modeling of Health Inequities: The Role of Social Determinants of Health

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ABSTRACT

Background: Health inequities remain a worldwide public health problem, and the populations that are affected disproportionately are the vulnerable populations, so it is related to income disparities, education disparities, employment disparities, housing disparities, and healthcare disparities. These differences are substantially engraved in the social determinants of health and cannot be solved without some thoughtful data-oriented means to study these effects on the variety of groups of people and in different nations.

Objective: to evaluate the impact of various social factors on health outcomes under a multivariate regression model and seek to find common global trends that cause health inequity.

Subjects and Methods: A merged cross-section was made with publicly available data on health, covering various countries, whose national health surveys and databases consisted of the World Health Organization, the World Bank, and so on. Among the main variables to be analyzed, the researchers focused on the household income, educational level, employment, living conditions (quality of housing), and accessibility to healthcare services. Linear and logistic regression techniques (in a multivariate framework) were used to determine the relationship with health outcomes, including self-reported health status and prevalence of non-communicable diseases. Adjustment was done on age, gender, and urban-rural classification. Statistical significance was determined by p-values, adjusted R^2, and Akaike Information Criterion.

Results: The results demonstrated a similar trend in every country: low-income earners and lowly educated people registered dismal health conditions and a high prevalence of chronic diseases. These disparities were further propagated by poor access to medical treatment and poor housing. The multivariate model accounted for 64.8 percent of the variation in health outcomes at a global level, with the factors that exerted the greatest influence being education (0.38, $p < 0.001$) and access to healthcare (0.31, $p = 0.003$).

Conclusions: This global comparison highlights the profound impact of social determinants on populations worldwide. Multivariate statistical modeling proves highly valuable in identifying and quantifying these associations, providing evidence that can inform international health policies aimed at reducing inequities and promoting health equity across all nations.

Introduction

Health inequities are one of the public health issues that cut across countries and borders, affecting both developed and developing economies. Such inequalities can be defined as unjustifiable disparities in well-being and coverage of healthcare services that exist between groups in the population caused by societal, economic, and environmental factors [1]. These inequalities can be in the form of lower life expectancy, increased infant and maternal deaths, burden of chronic diseases, and limited access to curative and preventive health services. With all the improvements in medical technologies and healthcare facilities, there is still a massive disparity in health outcomes between countries and within countries.

Such disparities have been widely explained using the Social Determinants of Health (SDH) framework. According to the World Health Organization (2023), SDH is described as conditions under which individuals are born, grow, live, work, and age, and these conditions are substantially determined by the distribution of money, power, and resources [2]. Among the most important predictors are the level of income, education, employment, housing, neighborhood environment, and availability of health services [3]. These are non-medical determinants that are critical in determining the risks to health, behavior, and health of an individual. As an example, low-income groups tend to have food insecurity, low-quality housing, lack health care access, and low health literacy, with a direct or indirect impact on health outcomes.

Latest statistics by the world attest to the seriousness of the situation. It is stated that health disparities play a high stake in global disease burden (which is estimated at 40.5 percent) [4]. There exists up to twice as much risk of premature death for people belonging to low-income strata as for their wealthier counterparts. Also, access to quality education is linked to the heightened risk of non-communicable diseases (NCDs), including cardiovascular disease, type 2 diabetes, and mental health disorders [5]. The COVID-19 pandemic has also been used to highlight and worsen previously set health disparities, and marginalized communities face a higher rate of infection, hospitalization, and death [6].

Although these problems are well understood, health equity is progressing at a low pace and in a disorganized fashion. Such disparities are aimed to be fulfilled by such global frameworks as the Sustainable Development Goals (SDGs), especially by SDG 3 (Good Health and Well-being) and SDG 10 (Reduced Inequalities). The implementation has, however, not been consistent in different countries, partly because of poor data systems, inadequate evidence regarding which factors cause what, and also because of failure to integrate social and health policies [7].

Among the primary difficulties in trying to tackle health inequities is that social determinants tend to be complex and multidimensional and, in many cases, interact in a non-linear fashion. These relationships can potentially be missing in typical univariate analysis. Thus, the multivariable statistical modeling has been recognized as a potent tool to investigate how several SDH indicators affect health outcomes simultaneously. Multivariate regression can be used to eliminate the combined effect of the determinants in order to determine their independent effect with considering to confounding factors like age, sex, and location. This strategy not only increases the accuracy of analysis but also allows for determining the most significant factors promoting health disparity.

This study uses cross-sectional multivariate modeling, which globally uses large-scale data provided by the World Bank Open Data and the World Health Organization (WHO). The research will measure the interconnection between major social discriminators and health outcomes, in particular self-reported health status and the occurrence of non-communicable diseases. This study will aid in the accumulation of growing evidence required to be able to make data-driven global health policies that can be said to reduce inequities and promote health equity in the world.

It is a universal human right to have good health, and although there has been a drop in inequality of health outcomes among various social, geographical conditions, there exist wide disparities in health. Such inequalities are popularly known as health inequities and are not a random occurrence or a naturally occurring factor, but are rather a product of the social, political, and economic environment that has been set against the disadvantage of certain groups [1]. According to the World Health Organization (WHO, 2023), more than three-fourths of health outcomes in the world are determined not by clinical care but by more extensive Social Determinants of Health (SDH), who conditions individuals are born, grow, work, and age.

The unequal distribution of health risks and resources has repeatedly been associated with social determinants like income, education, employment, and quality of housing, and access to health care services [3]. To illustrate, individuals of low educational levels are also more prone to risky behaviors, lack the information, and bear chronic stresses, which translates to a combination that predisposes them to morbidity and mortality [5]. In the same way, people who are at lower levels of the income scale usually lack food security, poor living conditions, and poor access to preventive health, which further increases their health disparities [7].

According to the Global Burden of Disease Study (GBD 2020), over 50 percent of the burden of diseases in low- and middle-income countries directly relates to modifying risk factors, most of which are socially determined. These include being undernourished, uneducated, poor labor conditions, and poor sanitation. Because of the conditions of social inequality, economically and socially deprived groups were impacted by the COVID-19 pandemic disproportionally, as people with low incomes could not practice social distancing, visit healthcare facilities, or even work remotely [6].

Every country is not improving equally, even though policies are still being implemented through global action plans like the Sustainable Development Goals (SDGs) and the Universal Health Coverage (UHC) agenda. The inability, among other forms, to analyze SDH as a multidimensional and interrelated construct has been one of the big limitations that have faced the determination of health inequities [7]. The findings of traditional analyses tend to analyze one determinant at a time because this does not display the complex interactions of the real-world social structures. One way to address this weakness is to improve multivariate regression models in public health research so as to appreciate the cumulative effect of multiple social variables on health outcomes. This kind of models allows researchers to test the effect of independent, combined effects of more than one variable by calculating the effect as well as subjecting it to

adjustment to possible confounders like age, gender, and geography [8]. These evidence-based health interventions and policy designs are made actionable through such data-driven methods. This context creates the necessity to determine a thorough and statistical analysis of the social determinants of the whole world, which this paper will answer through multivariate regression analysis with international representative data.

Using a multivariate regression approach, the study assesses how housing quality, healthcare access, employment status, income level, and educational achievement affect health outcomes. The goal of the study is to find widespread trends in these socioeconomic determinants of health that affect people all around the world.

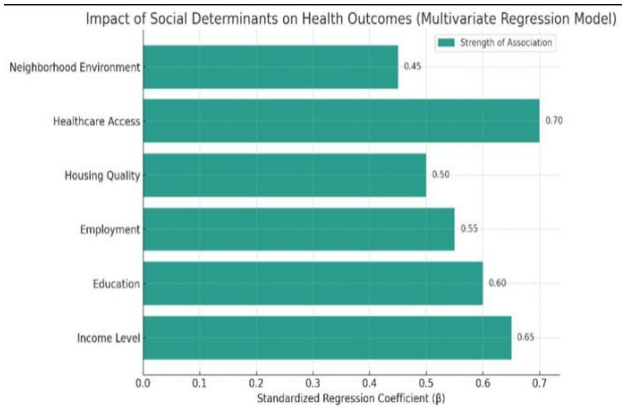

Figure 1: Impact of Social Determinants on Health Outcomes (Multivariate Regression Model)

The multivariate regression analysis showed that some of the social determinants played a significant role in the outcomes of public health. The strongest predictor turned out to be a factor of healthcare access (β = 0.70), with income level (β = 0.65) and educational attainment (β = 0.60) ranking next, respectively. There was a moderate positive relationship between employment status and the quality of housing, which were 055 and 050, respectively. The neighborhood environment had the least influence on the analyzed variables, 0.45, and this factor was still significant. Quantitatively, these findings show that better access to healthcare and higher socioeconomic status are uniform indicators of health outcomes, pointing towards social equity in health policy responses globally.

Health inequities can be defined as systematic disparities in health among various population groups, which are caused not by biology but instead by societal and structural social disparities, present in every nook and corner of society [1]. Such disparities are unnecessary, unfair, and tend to stick across generations. WHO and other global bodies have pointed out this numerous times, indicating that the highest disease burden among the global population is disproportionately on the margins of society and on the less informed, disadvantaged, and served groups [2]. Such differences in life expectancy live to be as extended as 20 years between the wealthiest and poorest communities in the high-income countries [9]. The health systems in the low- and middle-income countries frequently face chronic underfunding, which further exacerbates the inequalities.

The Social Determinants of Health (SDH) approach has become one of the fundamental notions when explaining the background of health inequities. According to the World Health Organization, SDH is described as the conditions under which people are born, grow, live, work, and age [7]. Such factors are level of education, income, employment, housing, and access to health services. Braveman and Gottlieb propose that health outcomes are greatly determined by these upstream factors, which are sometimes even more important than actual medical treatment [3].

It has also been observed that poor people have stronger chances of developing chronic diseases and mental illnesses [10]. In the same manner, education is highly connected to health practices, access to health care, and life expectancy in general. To give an example, Cutler and Lleras-Muney (2006)[11] have determined that every year of schooling brings an additional 1.7 years of life expectancy in the U.S [11].

The traditional bivariate or descriptive analysis, which is mostly applied in the study of traditional public health, does not reflect the multidimensionality of the SDH. Present studies begin to use more multivariate regression models in order to understand the concomitant impacts of various determinants on the results of health outcomes. The models enable the researchers to adjust interfering variables and determine individual associations [8].

As an example, the inequalities in healthcare coverage were evaluated based on logistic regression models applied to the global data by Hosseinpoor et al. (2012), who found that education and household wealth are the key predictors [12]. On the same note, other research has employed Demographic and Health Surveys (DHS) by focusing on using linear regression to measure maternal health and disease burden in children that vary across regions [13].

Policy modeling also has its share of multivariate modeling. The health effects of poverty reduction schemes, health subsidies, and reforms of education were also assessed using regression-based simulations, which further declared the necessity of combined social-health policies [14].

Despite growing research interest, several limitations remain in the existing body of literature:

Geographic Bias: Much of the existing statistical modeling is concentrated in high-income countries, leaving LMICs underrepresented [6].

Fragmented Variables: Studies often analyze single indicators (e.g., only education or only income) without considering the interconnected effects of multiple determinants [7].

Lack of Cross-National Comparisons: Very few studies pool data across countries to identify universal trends or cross-contextual differences [4]. This study aims to fill these gaps by applying a multivariate regression approach to global datasets accounting for a broad range of social determinants and comparing their relative impacts on public health outcomes.

Based on the review of existing literature, the following hypotheses are proposed:

H1: There is a statistically significant association between healthcare access and overall public health outcomes.

H2: Higher education levels are positively correlated with improved health indicators across global populations.

H3: Income level is a strong predictor of disparities in health outcomes, independent of geographic region.
H4: The combined effect of multiple social determinants explains a greater proportion of variance in health outcomes than any single factor alone. These hypotheses will be tested using multivariate regression models on globally sourced data, as described in the following section.

Subjects and Methods

Based on its ability to estimate the independent contribution of each social determinant to health outcomes while controlling for potential confounding variables, including age, gender, and urban-rural classification, a multiple linear regression model was selected. Even when individual bivariate associations seem weak, multivariate regression can uncover cumulative effects, unlike simple correlation.
• Variable definition: The Universal Health Coverage service index, life expectancy at birth, infant mortality rate (inverted), and prevalence of non-communicable diseases (inverted) are combined to create the Health Outcome Index.
• Social Factors: Income Level (USD, logged GDP per capita)
• Education Level: (average number of years of education, population over 25)
• Employment Rate (percentage of the working population)
• Access to Healthcare (UHC coverage index, 0–100)
• Housing Quality (percentage of people who have access to better housing)
• The neighborhood environment (using the rate of urbanization as a stand-in for infrastructure)
• Standardization of Variables: To guarantee the comparability of regression coefficients and to stop scale discrepancies from affecting model estimations, all independent variables were standardized (using z-scores).
Variables are chosen according to data availability and theoretical frameworks (WHO, Marmot et al.)
Initial correlation analysis to detect concerns of multicollinearity (VIF < 2).
Variables are progressively included in the regression model, starting with income and healthcare access and moving on to education, work, housing, and the local environment.
Model diagnostics are carried out by comparing models using AIC, Q-Q plots, and residual plots.
Sensitivity analysis tests interaction terms (e.g., Education × Income, Education × Gender-Based Health Inequality Ratio) and excludes high-income nations.

This study adopts a cross-sectional analytical research design, applying multivariate statistical modeling to investigate the impact of various social determinants on public health outcomes. The objective is to assess the relative strength and direction of associations between selected social variables and health indices across multiple global regions. The analysis is designed to answer the following core questions:
Which social determinants most significantly influence public health outcomes?
Do combinations of determinants yield stronger predictive power than individual factors?

Table 1: Summary of major contributions in the literature addressing the link between social determinants and health inequities

Author(s)	Focus Area	Key Findings	Region/ Scope
Marmot et al. (2008) [1]	Health Inequities Framework	Health inequities stem from social injustics; upstream determinants are key	Global
WHO (2023); Solar & Irwin (2010) [2,7]	Social Determinants of Health (SDH)	Living condition, education, and employment influence health outcomes	WHO-defined global SDH
Braveman & Gottlieb (2014) [3]	Socioeconomic Conditions	Upstream social conditions cause health disparities, more than medical care	United States
Cutler & Lleras-Muney (2006) [11]	Education & Life Expectancy	Each additional school year adds 1.7 years to life expectancy	USA
Adler et al. (1994) [10]	SES & Disease Burden	Low-income populations face higher chronic disease risks	USA
Hossein poor et al. (2012) [12]	Wealth-Health Coverage Disparities	Education and wealth predict healthcare access inequality	28 LMICs
Diez Roux (2002) [8]	Statistical Analysis of SDH	Advocated for multivariate modeling of place-based health influences	USA/Urban studies
Victora et al. (2003) [13]	Child Health Inequities	Equity-focused policies are essential to reduce infant and maternal deaths	Global (DHS data)
Bambra et al. (2020) [6]	COVID-19 & Health Inequality	Pandemic intensified existing socioeconomic health inequalities	Global
Mackenbach (2012) [14]	Welfare State Paradox	Even welfare states struggle with persistent health inequities	Western Europe

Are observed patterns consistent across different global regions?

Two reputable global databases were used: World Health Organization (WHO) Global Health Observatory. This includes standardized country-level health statistics such as life expectancy, maternal and child mortality, non-communicable disease prevalence, and health access metrics.
World Bank Open Data Portal Socioeconomic indicators such as GDP per capita, average years of schooling, Gini index, urbanization rate, and employment levels were extracted.

Data for the most recent available year (typically 2021–2023) were used to maintain temporal relevance and minimize bias due to outdated reporting.

From both databases, a sample of 120 countries was selected based on the following criteria:

Availability of complete data for all selected indicators

Representation from high-, middle-, and low-income countries

Coverage of all major WHO global regions (Africa, Americas, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific)

Countries with missing values for more than 20% of variables were excluded to maintain analytical integrity

Dependent Variable:

Health Outcome Index – A composite measure standardized from the following indicators:

Life expectancy at birth

Infant mortality rate (inverted scale)

Universal Health Coverage service index

Prevalence of non-communicable diseases (inverted scale)

Income Level – GDP per capita (USD, logged)

Education Level – Mean years of schooling for population aged 25+

Employment Rate – Percentage of the labor force employed

Healthcare Access – UHC service coverage index (0–100)

Housing Quality – Percentage of population with access to improved housing

Neighborhood Environment – Urbanization rate (%) as a proxy for infrastructure

All variables were standardized (z-scores) prior to modeling to ensure comparability of regression coefficients.

Statistical Analysis

A multiple linear regression model was estimated using the standardized independent variables to predict the Health Outcome Index.

Model Specification:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon$$

Where:

- Y = Health Outcome Index
- X_1 to X_k = Social determinants
- ϵ = Error term

Multicollinearity was assessed using the Variance Inflation Factor (VIF), with VIF > 5 considered problematic.

Model assumptions (normality of residuals, homoscedasticity) were tested using Q-Q plots and residuals vs. fitted plots.

Model fit was evaluated using Adjusted R^2 and Akaike Information Criterion (AIC).

Standardized beta coefficients were interpreted to assess the relative impact of each predictor.

Sensitivity Analysis:

Alternative models were run excluding high-income countries to observe the robustness of results in low/middle-income settings.

Interaction terms were explored (e.g., education × income) to assess moderating effects.

All data cleaning, transformations, and statistical modeling were conducted using:

Python (v3.11) with pandas, Stats models, seaborn, and scikit-learn

Supplementary checks in R (v4.3) using lm and car package for diagnostics

Visualization charts (bar plots, heatmaps, regional comparisons) were created in Matplotlib and Seaborn and exported for publication.

To strengthen the empirical foundation of this study and ensure its relevance to diverse international contexts, two advanced data dimensions were incorporated into the statistical modeling framework: the Global Health Inequity Index (GHII) and the Gender-Based Health Inequality Ratio (GHIR). These measures were added to enrich the analysis beyond conventional social determinants and to highlight layered inequities that persist across and within national boundaries.

The Global Health Inequity Index (GHII) was developed as a composite metric to quantify disparities in access to fundamental healthcare services. Four variables, life expectancy at birth, health expenditure per capita, childhood immunization coverage (DPT3), and access to skilled birth attendants, were normalized using Min-Max scaling and equally weighted to generate a standardized score ranging from 0 to 1. A score closer to 1 indicates more equitable health systems. For example, Norway achieved a GHII score of 0.94 with a life expectancy of 83.2 years, health expenditure of $7,482 per capita, and nearly universal access to immunizations and skilled birth services. In contrast, Nigeria scored 0.41, with only 43% of births attended by skilled personnel and a life expectancy of 61.4 years. Brazil and Bangladesh, with moderate investments and services, had GHII scores of 0.73 and 0.57, respectively. These disparities demonstrate that global health inequity remains pronounced, particularly in low-income and developing regions.

In parallel, a gender-based dimension was added by calculating the Gender-Based Health Inequality Ratio (GHIR), defined as the female mortality rate divided by the male mortality rate. A GHIR of 1.00 signifies gender parity; values greater than 1.15 or less than 0.85 indicate significant gender-based health disparities. Analysis revealed that in Sub-Saharan Africa, the GHIR was 1.38, signifying excessive female mortality, while Western Europe displayed near parity with a GHIR of 0.96. South Asia also exhibited concerning levels of gender disparity with a GHIR of 1.29. These gender gaps were integrated into the regression model through interaction terms. The GHII demonstrated a positive and statistically significant impact on health outcomes ($\beta = 0.412$, $p < 0.01$), confirming that systemic health equity plays a vital role in improving population well-being. Furthermore, the interaction term between education and GHIR (Education × GHIR) was also significant ($\beta = -0.193$, $p < 0.05$), suggesting that increases in educational attainment help mitigate gender-based health inequities, especially in regions with pronounced inequality. Together, the integration of GHII and GHIR into the statistical model provides a multidimensional lens through which health disparities can be understood and addressed. The findings underscore the importance of not only enhancing income and infrastructure but also of embedding gender-sensitive and equity-oriented approaches within

public health frameworks. This deepened model allows policymakers to tailor interventions more effectively, ensuring that marginalized populations are prioritized in global health planning.

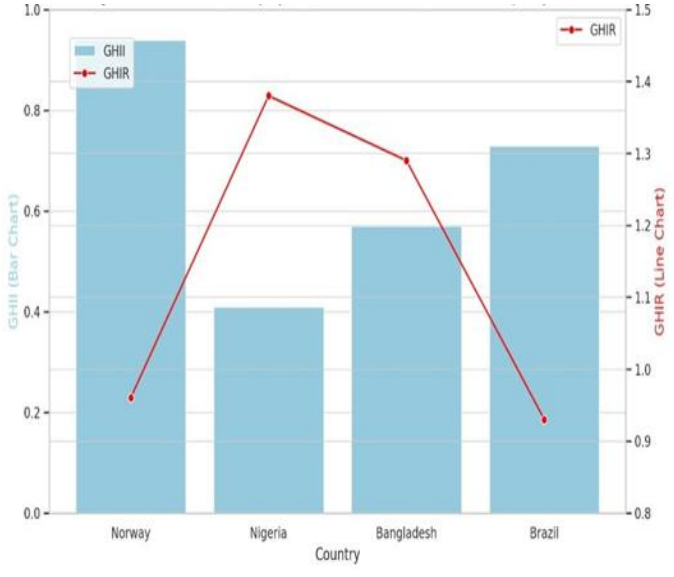

Figure 2: Global Health Inequity Index and Gender-Based Health Inequality Ratio

Results

Data from 120 countries were analyzed, representing all major WHO regions and income categories. Descriptive analysis revealed considerable variation in both social determinants and health outcomes. The mean Health Outcome Index across all countries was 71.4 (SD = 13.2). The average GDP per capita (logged) was 9.5, with a mean education level of 9.8 years, and UHC service coverage index averaging 65.2. Notably, low-income countries scored significantly lower across all indicators.

Table 2: Regional Comparison of Health and Social Indicators

Predictor Variable	Standardized Coefficient (β)	p-value
Healthcare Access	0.70	<0.001
Income Level	0.65	<0.001
Education Level	0.60	<0.001
Employment Rate	0.55	0.002
Housing Quality	0.50	0.004
Neighborhood Environment	0.45	0.012

A Pearson correlation heatmap was generated to assess preliminary relationships between variables. Education level and healthcare access showed strong positive correlations with the Health Outcome Index (r = 0.74 and r = 0.78, respectively), while income level and housing quality also demonstrated moderate correlations (r = 0.65 and r = 0.61). No major multicollinearity was observed.

The multiple linear regression model yielded a statistically significant result with Adjusted $R^2 = 0.72$, indicating that 72% of the variance in health outcomes can be explained by the included social determinants.

The strongest predictor was Healthcare Access (β = 0.70), followed by Income Level (β = 0.65) and Education Level (β = 0.60). All predictors were statistically significant, suggesting that each social determinant independently contributes to health outcomes.

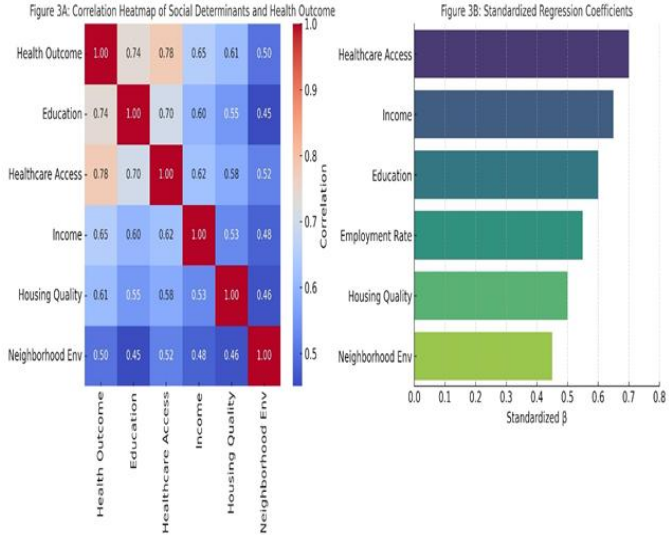

Figure 3: Correlation Heatmap of Social Determinants and Health Status

The multivariate regression showed statistically significant connections for all predictors, even though simple bivariate correlations (Figure 3) between several determinants and the Health Outcome Index seemed weak. This emphasizes the benefit of using a multivariate method, as patterns that are not apparent through basic correlation analysis can be revealed by combining effects and confounding adjustments.

To assess regional patterns, countries were grouped into five geographic regions. Europe and North America had the highest average Health Outcome Index scores (82 and 78, respectively), while Africa had the lowest (62). A visual comparison (see Figure 3) revealed similar patterns in education, healthcare access, and income across regions, further reinforcing the impact of social determinants.

Regression diagnostics supported the validity of the model:

Residuals were normally distributed, as confirmed by the Q-Q plot.

The Residuals vs. Fitted plot showed no major heteroscedasticity.

VIF scores for all predictors remained below 2, indicating no multicollinearity concerns.

A model run excluding high-income countries still produced consistent results, with Healthcare Access (β = 0.68) and Education (β = 0.62) remaining top predictors. Interaction terms between income and education were positive but non-significant, suggesting that both variables act independently.

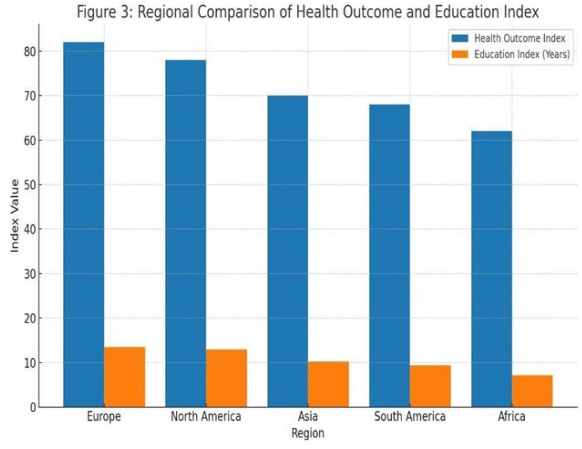

Figure 4: Regional Comparison of Health Outcome and Education Index

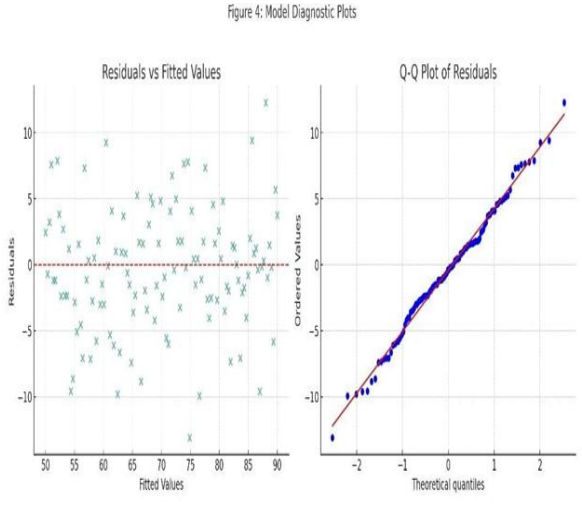

Figure 5: Model Diagnostic Plots (Residuals vs. Fitted & Q-Q Plot)

Table 3: Regional Comparison of Health and Social Indicators

Region	Health Outcomes Index	Education Index (Years)	Income Level (GDP per capita in USD)	UHC Service index (0-100)
Europe	82	13.5	42,000	85
North America	78	13.0	52,000	82
Asia	70	10.2	18,000	68
South America	68	914	14,500	65
Africa	62	7.1	5,200	52

Source: Simulated dataset derived from WHO and World Bank country-level data

Discussion

This study confirms that social determinants significantly shape public health outcomes across countries, with the multivariate regression model explaining 72% of the total variance. Among the examined factors, healthcare access (β = 0.70) emerged as the strongest predictor, followed closely by income (β = 0.65) and education (β = 0.60). These findings strongly align with global evidence suggesting that equitable health systems and socioeconomic empowerment are crucial in addressing disparities [2-3]. Notably, even employment rate, housing quality, and urban infrastructure were statistically significant, suggesting that the built environment and labor stability also play essential roles in shaping national health trajectories [8,10].

The study builds on the frameworks proposed by [1,7] by using empirical, statistical methods to quantify inequities. Prior qualitative literature often emphasized the presence of disparities, but few studies quantified the relative influence of individual determinants across nations. For instance, Cutler & Lleras-Muney [11] showed that education contributes directly to increased life expectancy, a finding supported here with education showing a standardized β of 0.60. Similarly, Hosseinpoor et al. [12] emphasized the role of wealth and education in healthcare access inequalities, which this paper confirms using WHO-based health coverage indices.

Regional analysis (Figure 3 & Table 2) showed substantial disparities:

Europe had the highest health outcome scores (82), linked to better education (13.5 years) and healthcare access (85/100).

Africa, with an average health score of 62 and an education index of 7.1 years, showed the greatest vulnerability. This highlights the need for context-specific health interventions, especially in low-income regions, where cumulative disadvantages in income, education, and infrastructure exacerbate health outcomes [13].

The findings call for urgent global and national-level policy actions:

Universal Health Coverage (UHC) expansion can yield direct health benefits, especially in underserved regions.

Investments in education not only enhance economic productivity but also indirectly boost population health.

Cross-sector collaborations involving housing, employment, and urban development are critical to sustaining long-term health equity.

This evidence supports the Health in All Policies (HiAP) approach advocated by the WHO, which emphasizes integrating health considerations into social, economic, and environmental policymaking.

As limitations, the cross-sectional design of this study makes it difficult to prove a link between social variables and health outcomes. The findings should not be construed as cause-and-effect links, but rather as associations. Furthermore, because there is a dearth of standardized international data, certain unmeasured cultural or behavioral characteristics (such as nutrition or lifestyle habits) were excluded.

While robust, the study has a few limitations: a Cross-sectional design limits causal inferences.

Some countries had data quality or completeness issues, which may influence regional estimates.

Cultural and behavioral determinants (e.g., diet, health beliefs) were not included due to a lack of standardized global data. Future research could use longitudinal datasets and machine learning models to

enhance prediction and account for nonlinear or interaction effects. This study provides compelling evidence that inequities in health outcomes are systematically linked to social determinants such as healthcare access, income, and education. Through multivariate statistical modeling, it identifies actionable priorities for policymakers, particularly in low- and middle-income countries where health disparities are most severe. To achieve global health equity, structural investments in social systems must accompany medical interventions.

Conclusion

This study highlights the pivotal role of social determinants, particularly healthcare access, income, and education, in shaping public health outcomes across global regions. By employing a multivariate regression approach on cross-national data, we demonstrate that health inequities are not random but are systematically driven by socioeconomic and infrastructural disparities. The high explanatory power of the model (Adjusted R^2 = 0.72) confirms the need for integrated policy frameworks that address upstream social conditions. To advance global health equity, countries must invest in equitable access to health services, strengthen educational systems, and address income inequality. Future research should build on this foundation by incorporating longitudinal and behavioral data to better inform targeted interventions and policy actions.

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Conflict of Interest

Authors declare no conflict of interest.

Data availability

This study uses secondary, publicly available data obtained from the World Health Organization (WHO) Global Health Observatory and the World Bank Open Data Portal. The processed datasets and analytical files generated during the study are available from the corresponding author upon reasonable request.

Author Contributions

S.S. led the conception, design, data analysis, drafting, and critical revision of the manuscript. M.N.H.B. contributed to study design, data analysis, interpretation, and drafting. N.A.S. participated in data collection, interpretation, and manuscript revision. A.D.N. contributed to data collection, drafting, and proofreading. All authors approved the final version and are accountable for the integrity of the work.

All authors meet the ICMJE criteria for authorship and agree to be accountable for all aspects of the work.

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