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The Impact of Human Development Components on Poverty Reduction: A Comparative Analysis Across Provinces in Java, Indonesia Using Linear Mixed Models

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Abstract: This study examines the impact of Human Development Index (HDI) components: education, health, and expenditure on poverty levels across provinces in Java, Indonesia. Using secondary data from the Indonesian Bureau of Statistics and applying a Linear Mixed Model approach, this research captures both cross-sectional and temporal variations across regions. The findings reveal that education and expenditure have a significant negative effect on poverty, indicating that improvements in human capital and economic capacity contribute to poverty reduction. Conversely, the health index shows a positive and significant relationship with poverty, suggesting a non-linear and complex interaction influenced by structural and demographic factors. The model demonstrates moderate explanatory power, with a pseudo R-squared value of 0.479, indicating that nearly half of the variation in poverty can be explained by the selected variables. These results highlight that poverty is a multidimensional phenomenon requiring integrated policy interventions. The study contributes to the literature by decomposing HDI into its components and employing a multilevel analytical approach to better understand regional disparities in development outcomes.

Keyword: Human Development Index; Poverty; Education; Health; Expenditure; Linear Mixed Model; Regional Disparities; Indonesia; Java

INTRODUCTION

Indonesia is a country that adopts a decentralized governance system as regulated in Law Number 23 of 2014 concerning Regional Government. Decentralization is defined as the delegation of authority from the central government to regional governments to regulate and manage governmental affairs based on the principle of regional autonomy. The implementation of this policy since 1999 has been expected to enhance development effectiveness through a more contextual, participatory, and responsive approach to local community needs. Within this framework, regional governments play a strategic role in

promoting development that is not only oriented toward economic growth but also toward improving the overall quality of life of the population. Modern development is no longer measured solely by economic indicators but also through a human development approach. This concept places humans at the center of development, both as subjects and objects, with the primary objective of enhancing capacity, productivity, and well-being. The Human Development Index (HDI), developed by the United Nations Development Programme, is a composite indicator used to measure human development achievements through three main dimensions: health, education, and a decent standard of living (UNDP, 2023). These dimensions are interrelated and contribute significantly to determining quality of life and individuals' ability to access economic opportunities.

Conceptually, human development is closely linked to poverty reduction. Education improves human capital, health enhances productivity, and expenditure reflects the economic capacity of households. However, the relationship between human development and poverty is not always linear. In practice, improvements in HDI are not necessarily followed by significant reductions in poverty levels, indicating the complexity of interactions among development variables (Barro, 2001; Bloom & Canning, 2008; Deaton & Heston, 2010).

Java Island, as the center of national economic activity, contributes the largest share to Indonesia's Gross Domestic Product (GDP). However, this economic dominance does not necessarily reflect an equitable distribution of welfare. Data from the Central Bureau of Statistics indicate that Java remains the region with the largest number of poor people in Indonesia, exceeding 12 million individuals (BPS, 2025). In addition, there are variations in human development achievements across provinces in Java, suggesting disparities in welfare distribution. To further illustrate the relationship between human development and poverty, Table 1 presents a comparison of the Human Development Index (HDI) and poverty rates across provinces in Java.

Table 1. Comparison of Human Development Index and Poverty Rate Across Provinces in Java

Province	HDI	Poverty Rate (%)	Category
DKI Jakarta	83.08	5.61	High HDI – Low Poverty
DI Yogyakarta	81.55	12.74	High HDI – High Poverty
West Java	74.43	8.61	Medium HDI – Medium Poverty
Central Java	73.88	>10	Medium HDI – High Poverty
East Java	74.09	>10	Medium HDI – High Poverty
Banten	74.48	5.75	Medium HDI – Low Poverty

As shown in Table 1, the relationship between HDI and poverty is not entirely linear. While provinces such as DKI Jakarta exhibit high HDI accompanied by low poverty rates, DI Yogyakarta presents an anomaly, with high HDI but relatively high poverty levels. Similarly, provinces such as Central Java and East Java demonstrate relatively high poverty despite having moderate HDI values. This pattern suggests that improvements in human development do not automatically translate into poverty reduction, highlighting the complexity of the relationship between these variables.

This phenomenon indicates that improvements in human development do not automatically lead to reductions in poverty. This condition may be influenced by various factors, including income inequality, regional economic structures, and limited access to employment opportunities. Therefore, the relationship between HDI and poverty is complex and multidimensional, and cannot be fully explained using an aggregate approach alone. In this context, it is important to examine the role of each HDI component education, health, and expenditure individually in influencing poverty levels. This approach enables the identification of the most dominant factors, as well as how these variables interact within a

regional context. Furthermore, the presence of heterogeneity across regions in Java highlights the need for analytical methods capable of capturing such variations more accurately. Therefore, this study employs a Linear Mixed Model approach to analyze the impact of HDI components on poverty levels. This method is chosen because it can accommodate regional heterogeneity and capture unobserved variations within the model. Consequently, this study is expected to provide a more comprehensive understanding of the dynamics between human development and poverty, as well as serve as a basis for formulating more effective and evidence-based development policies.

METHOD

This study employs a quantitative approach with an explanatory research design to examine the impact of Human Development Index (HDI) components on poverty levels. Unlike conventional linear regression, this study adopts a Linear Mixed Model (LMM) to capture hierarchical data structures and regional heterogeneity. The data used in this study are secondary data obtained from the Indonesian Central Bureau of Statistics (BPS), covering human development indicators and poverty levels across provinces in Java. The unit of analysis consists of six provinces—DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, and Banten—observed over multiple periods in a panel data structure combining cross-sectional and time-series dimensions. The selection of the Linear Mixed Model is based on the nature of the data, which exhibit both cross-sectional and temporal variations. LMM allows the incorporation of both fixed effects and random effects, enabling the model to account for unobserved heterogeneity across regions. Therefore, LMM is considered more robust than conventional multiple regression in estimating relationships within limited panel datasets (Gelman & Hill, 2007).

Variables and Measurement

The study includes one dependent variable and three independent variables. The dependent variable is the poverty rate, measured as the percentage of the population living below the poverty line. The independent variables consist of the education index, health index, and expenditure index, which represent the core components of the HDI. The education index is measured using mean years of schooling and expected years of schooling. The health index is measured by life expectancy, while the expenditure index is based on adjusted real per capita expenditure (BPS, 2023). To ensure clarity in variable measurement, the operational definitions are presented in Table 2.

Table 2. Operational Definition of Variables

No	Variable	Type	Indicator	Unit	Source
1	Poverty	Dependent (Y)	Percentage of poor population	%	BPS
2	Education Index	Independent (X1)	Mean years of schooling, expected years of schooling	Index	BPS
3	Health Index	Independent (X2)	Life expectancy	Index	BPS
4	Expenditure Index	Independent (X3)	Adjusted real per capita expenditure	Index	BPS

Model Specification

The Linear Mixed Model used in this study is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_i + \varepsilon_{it}$$

where Y_{it} represents the poverty rate in region i at time t , X_{1it} , X_{2it} , and X_{3it} represent the education, health, and expenditure indices, respectively. β_0 is the intercept, $\beta_1, \beta_2, \beta_3$ are regression coefficients, u_i denotes the random effect capturing unobserved regional characteristics, and ε_{it} is the error term.

Data Structure

To provide a clearer understanding of the dataset, the structure of the data is summarized in Table 3.

Table 3. Data Structure

Description	Value
Number of observations	1,428
Unit of analysis	Districts/Cities
Hierarchical level	Province → District/City
Time period	2012–2024
Data type	Panel data (cross-section and time series)
Analytical method	Linear Mixed Model

Data Analysis Technique

The data analysis is conducted in two stages. First, descriptive analysis is used to examine the general characteristics and trends of the variables. Second, inferential analysis is performed using the Linear Mixed Model to test the effects of independent variables on poverty, both partially and simultaneously. Statistical significance is assessed using t-tests for individual fixed effects, while overall model significance is evaluated using F-tests. Additionally, model performance is assessed using goodness-of-fit indicators, including log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). The use of the Linear Mixed Model provides advantages in capturing regional heterogeneity and improving parameter estimation accuracy. Therefore, the results are expected to offer more reliable insights into the relationship between human development and poverty across regions in Java.

RESULTS AND DISCUSSION

Results

1. Descriptive Statistics

Descriptive analysis was conducted to provide an initial overview of the characteristics of the study variables, including poverty rate, education index, health index, and expenditure index across districts and cities in Java. The results reveal substantial variation across regions in both poverty levels and human development indicators. In general, poverty rates vary significantly across provinces. Urban areas such as DKI Jakarta exhibit relatively low poverty levels, averaging around 5.61%, while regions with stronger rural characteristics, such as DI Yogyakarta and Central Java, show higher poverty rates, exceeding 10% in several districts. This pattern reflects disparities in welfare influenced by differences in economic structure and levels of urbanization. From an educational perspective, the education index tends to be higher in urban areas compared to rural regions. Major cities such as Yogyakarta and South Tangerang report education index values above 75, whereas several districts in Central Java and West Java remain within the range of 55–60. This variation indicates unequal access to and quality of education across regions.

The health index, in contrast, shows relatively lower variation compared to other variables. Most regions record values above 80, suggesting that health development is more evenly distributed. However, some fluctuations remain, particularly in areas with limited access to healthcare services. Meanwhile, the expenditure index exhibits the highest level of variation among the variables. Urban regions such as DKI Jakarta show significantly higher per capita expenditure levels, exceeding 60, while several districts in West and Central Java remain below 35. This highlights disparities in purchasing power across regions. Overall, these findings suggest that economic disparities are more pronounced than social disparities, as reflected by the higher variability in expenditure and poverty compared to education and

health. This heterogeneity provides a strong justification for the use of the Linear Mixed Model, which is capable of capturing regional differences that cannot be fully explained by conventional regression approaches. To summarize the descriptive findings, Table 4 presents the key statistical indicators.

Table 4. Descriptive Statistics

Variable	Mean	Std. Dev	Min	Max
Poverty	8.61	2.98	2.07	17.96
Education	63.67	6.89	53.84	86.52
Health	81.92	3.00	76.68	88.54
Expenditure	38.15	9.44	26.89	69.73

2. Multicollinearity Test

To ensure the reliability of the model, a multicollinearity test was conducted using tolerance and Variance Inflation Factor (VIF) values. The results are presented in Table 5.

Table 5. Multicollinearity Test

Variable	Tolerance	VIF
Education	0.328	3.053
Health	0.781	1.281
Expenditure	0.351	2.846

The results indicate that all variables have tolerance values greater than 0.10 and VIF values well below the threshold of 10. This confirms that there is no serious multicollinearity issue in the model, and each independent variable contributes distinct information in explaining poverty variation.

3. Model Fit and Goodness of Fit

The Linear Mixed Model results indicate that the model demonstrates an acceptable level of fit. The value of -2 Restricted Log Likelihood is 7312.81, with an Akaike Information Criterion (AIC) of 7314.81 and a Bayesian Information Criterion (BIC) of 7320.07. Lower AIC and BIC values indicate that the model achieves an optimal balance between goodness of fit and model complexity. Furthermore, the Pseudo R-squared (both marginal and conditional) is 0.479, suggesting that approximately 47.9% of the variation in poverty levels can be explained by the included variables. This indicates that the model has moderate explanatory power. The model fit indicators are summarized in Table 6.

Table 6. Goodness of Fit

Indicator	Value
-2 Log Likelihood	7312.81
AIC	7314.81
BIC	7320.07
Pseudo R ² (Marginal)	0.479
Pseudo R ² (Conditional)	0.479

4. Fixed Effects Estimation

The results of the fixed effects estimation show that all independent variables significantly influence poverty levels.

Table 7. Linear Mixed Model Results (Fixed Effects)

Variable	Coefficient (B)	Std. Error	t-value	Sig.
Intercept	28.022	1.765	15.875	0.000
Education	-0.299	0.018	-16.426	0.000
Health	0.049	0.023	2.108	0.035
Expenditure	-0.071	0.012	-5.947	0.000

The education index has a negative and highly significant effect on poverty ($\beta = -0.299$, $p < 0.001$), indicating that improvements in education are associated with reductions in poverty levels. Similarly, the expenditure index also shows a negative and significant effect ($\beta = -0.071$, $p < 0.001$), confirming the importance of economic capacity in reducing poverty. Interestingly, the health index exhibits a positive and significant effect ($\beta = 0.049$, $p = 0.035$), suggesting a more complex relationship between health and poverty that may be influenced by structural and demographic factors.

5. Simultaneous Effect Test (Type III Test)

The results of the Type III test indicate that all independent variables jointly have a significant effect on poverty levels.

Table 8. Type III Test Results

Variable	F-value	Sig.
Education	269.802	0.000
Health	4.444	0.035
Expenditure	35.369	0.000

These results confirm that the model is statistically significant as a whole and capable of explaining variations in poverty across regions.

Discussion

1. The Effect of Education on Poverty

The findings indicate that the education index has a negative and significant effect on poverty. This result aligns with human development theory, which emphasizes education as a key driver in improving human capital. Individuals with higher levels of education tend to have greater access to employment opportunities and higher income levels, thereby reducing their likelihood of falling into poverty. Empirically, this finding is consistent with previous studies by Barro (2001) and Psacharopoulos and Patrinos (2004), which highlight the significant contribution of education to productivity enhancement and poverty reduction. In the context of Java, this suggests that improvements in educational quality and accessibility play a crucial role in reducing poverty, particularly by increasing workforce competitiveness in the formal sector. Moreover, education contributes to improving individuals' economic decision-making capabilities, including financial management and long-term investment behavior. This reinforces the long-term effect of education in promoting sustainable poverty reduction.

2. The Effect of Health on Poverty

Interestingly, the results show that the health index has a positive and significant effect on poverty, which contradicts conventional theoretical expectations that improved health should reduce poverty. This unexpected finding may be explained by several factors. First, improvements in health indicators, such as life expectancy, do not necessarily translate directly into increased economic welfare. In some cases, longer life expectancy may lead to a

higher proportion of non-productive age populations, thereby increasing the economic burden on households. Second, this result may reflect structural imbalances, where improvements in healthcare services are not accompanied by sufficient job creation. Consequently, healthier individuals may still face limited access to income-generating opportunities. Third, in the context of Java, the health variable may have an indirect effect on poverty, mediated by other factors such as education and economic conditions. Therefore, the relationship between health and poverty is complex and non-linear, highlighting the need for integrated policy approaches.

3. The Effect of Expenditure on Poverty

The expenditure index demonstrates a negative and significant effect on poverty, indicating that higher levels of per capita expenditure are associated with lower poverty levels. This finding is consistent with economic theory, which considers expenditure as a proxy for income and overall welfare. The results also align with studies by Deaton and Heston (2010) and Dollar and Kraay (2002), which emphasize that income growth has a direct impact on poverty reduction, particularly among low-income populations. In the context of Java, this suggests that economic factors play a dominant role in determining poverty levels compared to other dimensions. Furthermore, the high variation in expenditure observed in the descriptive analysis indicates disparities in purchasing power across regions. This strengthens the argument that poverty alleviation policies should focus on increasing income levels while ensuring more equitable economic distribution.

4. Implications of the Mixed Model Approach

The application of the Linear Mixed Model in this study proves effective in capturing regional heterogeneity that cannot be explained by conventional regression models. The Pseudo R-squared value of 0.479 indicates that nearly half of the variation in poverty can be explained by the model, while the remaining variation is influenced by other factors not included in the analysis, such as regional economic structure, policy differences, and socio-cultural conditions. Thus, the mixed model approach provides a more nuanced understanding of regional disparities, which is particularly relevant in the Indonesian context, where significant variations exist across regions. This methodological approach enhances the robustness and reliability of the findings.

CONCLUSION

This study examines the impact of Human Development Index components education, health, and expenditure on poverty levels across provinces in Java using a Linear Mixed Model approach. The results indicate that the model has moderate explanatory power, with a Pseudo R-squared value of 0.479, suggesting that nearly half of the variation in poverty can be explained by the selected variables. Partially, education and expenditure indices are found to have negative and significant effects on poverty, highlighting the importance of human capital development and economic capacity in reducing poverty. Education contributes by enhancing workforce skills, while expenditure reflects improved economic welfare that directly reduces vulnerability to poverty.

Conversely, the health index shows a positive and significant effect on poverty, indicating a non-linear relationship influenced by structural and demographic factors. This suggests that improvements in health alone are insufficient to reduce poverty without parallel improvements in economic opportunities and income generation. Simultaneously, all independent variables significantly affect poverty levels, confirming that poverty is a multidimensional phenomenon shaped by the interaction of education, health, and economic

factors. Therefore, an integrated development approach is essential for effective poverty reduction.

Policy Implications

The findings of this study offer several important policy implications for regional governments. First, improving the quality and equity of education should be a top priority. Governments need to enhance access to education, particularly in rural and underdeveloped areas, while also improving educational infrastructure and teaching quality. Expanding vocational education and skill-based training programs is essential to align workforce capabilities with labor market demands. Second, economic policies should focus on increasing income levels and purchasing power. This can be achieved through the development of local economic sectors, support for small and medium enterprises (SMEs), and the creation of inclusive employment opportunities. Targeted social assistance and social protection programs are also crucial in reducing vulnerability to poverty. Third, the positive relationship between health and poverty highlights the need for integrated policy approaches. Improving healthcare access must be accompanied by policies that enhance productivity and employment opportunities. Coordination between health, education, and economic policies is essential to maximize the impact on poverty reduction. Fourth, a place-based policy approach should be strengthened, considering the heterogeneity across regions in Java. Uniform policies are unlikely to be effective in addressing region-specific challenges. Therefore, local governments should design context-specific strategies tailored to regional characteristics and development potentials.

Future Research

This study has several limitations that provide opportunities for future research. First, the model includes only three HDI components and does not capture all factors influencing poverty. Future studies should incorporate additional variables such as unemployment rates, income inequality (Gini ratio), economic structure, and institutional factors to provide a more comprehensive analysis. Second, although this study employs a Linear Mixed Model, further analysis using more advanced panel data techniques, such as dynamic panel models or spatial econometrics, could provide deeper insights into interregional interactions. Third, this study is purely quantitative and does not consider qualitative dimensions that could enrich the understanding of poverty dynamics. Future research is encouraged to adopt mixed-method approaches to provide a more holistic analysis. Finally, the study is limited to Java, which opens opportunities for comparative studies with other regions in Indonesia to better understand the broader relationship between human development and poverty at the national level.

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