

Socioeconomic Determinants of Illegal Drug Use in Northern Mindanao, Philippines: Evidence from Dynamic Negative Binomial Regression

¹Hanna Mae A. Hurano , ²Jestony L. Pabroa , ³Jim Paul G. Laspobres , ⁴Fiona Kaye R. Dublin 

Bukidnon State University

¹hannamaeahurano@gmail.com, ²pabroajestonylamban@gmail.com, ³jimpaullaspobres@buksu.edu.ph,

⁴kayedublin@buksu.edu.ph

Article Details:

Received: 9 June 2026

Revised: 15 June 2026

Accepted: 21 June 2026

Published: 30 June 2026

Corresponding Email:

hannamaeahurano@gmail.com

Recommended Citation:

Hurano, H M. A., Pabroa, J. L., Laspobres, J P. G., Dublin, F K. R. (2026). Socioeconomic Determinants of Illegal Drug Use in Northern Mindanao, Philippines: Evidence from Dynamic Negative Binomial Regression. The International Review of Multidisciplinary Research. 1 (8), 424-442. <https://doi.org/10.67167/vertex.669>

Index Terms:

illegal drug use, socioeconomic factors, employment, dynamic negative binomial regression, Northern Mindanao, Region X

Abstract. Illegal drug use remains a significant public health, social, and development concern in the Philippines, with implications for labor productivity, community well-being, and socioeconomic development. This study examined the socioeconomic determinants of illegal drug use in Northern Mindanao (Region X) using annual time-series data from 2006 to 2024. Specifically, it analyzed trends in employment rate, unemployment rate, underemployment rate, income level, poverty rate, literacy rate, and reported illegal drug users, and estimated their statistical association with illegal drug use incidence. A quantitative descriptive-correlational design was employed using secondary data obtained from the Philippine Statistics Authority, Dangerous Drugs Board, Department of Health, and Philippine National Police. Trend analysis, Augmented Dickey-Fuller unit root tests, multicollinearity diagnostics, ARDL bounds testing, Poisson regression, Negative Binomial regression, and Dynamic Negative Binomial regression were conducted. Model selection was based on goodness-of-fit measures, overdispersion diagnostics, and count-data model assumptions. Results revealed a statistically significant upward trend in reported illegal drug users despite improvements in several socioeconomic indicators. Income levels increased while poverty and underemployment rates generally declined. Diagnostic tests confirmed overdispersion and temporal persistence in illegal drug use, supporting the Dynamic Negative Binomial model as the preferred specification. Findings showed that the lagged number of illegal drug users positively influenced current drug-use incidence, while employment rate significantly reduced the expected number of illegal drug users. Poverty rate exhibited a weak negative association, whereas unemployment rate, underemployment rate, income level, and literacy rate were not statistically significant determinants. The study concludes that illegal drug use in Northern Mindanao is influenced by both labor market conditions and temporal persistence. Policies expanding stable employment opportunities, alongside prevention, treatment, rehabilitation, and community-based recovery programs, support sustainable reductions in illegal drug use.

Introduction

Illegal drug use remains one of the most persistent public health, social, and development challenges worldwide. The United Nations Office on Drugs and Crime (UNODC, 2018) estimated that hundreds of millions of individuals use illicit substances, generating substantial health, economic, and social consequences across countries. Drug use is associated with increased risks of morbidity, mortality, crime, family disruption, reduced labor productivity, and weakened human capital formation (Degenhardt et al., 2018). Beyond its health implications, illegal drug use has become a development concern because it interacts with broader socioeconomic conditions such as poverty, unemployment, social exclusion, and limited access to economic opportunities.

The causes of illegal drug use are multidimensional and extend beyond individual behavioral choices. Previous studies have demonstrated that socioeconomic disadvantage, labor market insecurity, poverty, social exclusion, and limited educational opportunities contribute to vulnerability to substance use and drug-related behaviors (Nagelhout et al., 2017; Nolte-Troha et al., 2023; Khan et al., 2026). Individuals experiencing economic hardship often face psychological stress, reduced social mobility, and weakened social support systems, conditions that may increase the likelihood of engaging in risky behaviors, including illegal drug use (Manhica et al., 2021). Consequently, understanding the socioeconomic determinants of illegal drug use is essential for developing effective and sustainable policy interventions.

In the Philippines, illegal drug use continues to be a major public policy issue despite decades of law-enforcement efforts and anti-drug campaigns. The Dangerous Drugs Board (2024) reported that methamphetamine hydrochloride (shabu) remains the dominant illegal drug in the country and continues to account for a substantial proportion of drug-related cases. Drug use has attracted considerable policy attention because of its implications for public safety, health outcomes, and socioeconomic development. Recent policy initiatives have increasingly emphasized a balanced approach that combines prevention, treatment, rehabilitation, and community-based interventions alongside law-enforcement measures (Dangerous Drugs Board, 2023; Baloloy et al., 2023). Nevertheless, illegal drug use remains a persistent concern in many communities throughout the country.

The consequences of illegal drug use extend beyond individual users and affect families, communities, and regional economies. Drug-related problems may reduce workforce productivity, increase healthcare expenditures, weaken social cohesion, and impose substantial fiscal burdens on governments (Degenhardt et al., 2018; John et al., 2023). In the Philippine context, studies have highlighted the importance of rehabilitation, community reintegration, and social support systems in addressing drug-related problems and promoting long-term recovery among affected individuals (Hechanova et al., 2025). These findings suggest that illegal drug use should be viewed not only as a law-enforcement issue but also as a socioeconomic and public health concern.

Northern Mindanao (Region X) provides an important setting for examining the socioeconomic dimensions of illegal drug use. The region has experienced significant economic growth over the past two decades, accompanied by improvements in labor market conditions, reductions in poverty incidence, and rising income levels (Albert et al., 2015; Philippine Statistics Authority, 2025, 2026). Despite these improvements, reports from the Dangerous Drugs Board (2024) indicate the continued presence of illegal drug users across the region. The coexistence of improving socioeconomic indicators and persistent drug-related concerns raises important questions regarding the relationship between economic conditions and illegal drug use. Understanding these dynamics is particularly relevant because Northern Mindanao exhibits considerable variation in employment opportunities, poverty incidence, income levels, and human capital development across provinces and cities.

Existing literature suggests that socioeconomic conditions influence illegal drug use through multiple pathways. Labor market instability, unemployment, and underemployment may increase economic strain and social vulnerability, thereby elevating the risk of substance use (Compton et al., 2014; Nagelhout et al., 2017; Nolte-Troha et al., 2023). Poverty and social exclusion may weaken community cohesion and increase exposure to environments associated with drug-related activities (Manhica et al., 2021; Chen & Xu, 2022). Conversely, employment opportunities, higher incomes, and improved educational attainment may strengthen social integration and reduce vulnerability to deviant behavior. However, previous studies have also shown that the relationships between socioeconomic conditions and illegal drug use are often complex, context-specific, and influenced by institutional, cultural, and environmental factors (Baula et al., 2025; Manaois, 2025; Petchtam et al., 2024).

Despite growing international evidence on the socioeconomic determinants of drug use, empirical studies focusing on the Philippines remain limited, particularly at the regional level. Existing Philippine studies have largely concentrated on rehabilitation programs, behavioral factors, and community-based interventions (Baloloy et al., 2023; Gascon & Ortiz, 2019). Few studies have examined how changes in employment, underemployment, income, poverty, and literacy are associated with illegal drug use over time. Moreover, limited research has employed longitudinal or time-series approaches capable of capturing the dynamic nature of drug-related outcomes. As a result, there remains a significant gap in understanding how socioeconomic conditions influence illegal drug use within specific regional contexts such as Northern Mindanao.

Addressing this gap is important because evidence-based policymaking requires a clearer understanding of the socioeconomic factors associated with illegal drug use. Identifying whether labor market conditions, income levels, poverty incidence, and educational outcomes are related to drug-use incidence may assist policymakers in designing interventions that complement existing prevention, treatment, rehabilitation, and enforcement programs. Such evidence is particularly relevant in regions where socioeconomic conditions continue to evolve alongside emerging public health and social challenges.

Hence, this study examined the relationship between socioeconomic factors and illegal drug use in Northern Mindanao using annual time-series data from 2006 to 2024. Specifically, the study analyzed the trends in employment rate, underemployment rate, income level, poverty rate, literacy rate, and illegal drug use, and estimated the statistical association between these socioeconomic indicators and the incidence of illegal drug users using count-data regression techniques. By providing region-specific empirical evidence, the study contributes to the growing literature on the socioeconomic determinants of illegal drug use and offers insights for developing more comprehensive and evidence-based policy responses in Northern Mindanao and similar regional contexts..

1.1 Research Questions

This study sought to examine the relationship between socioeconomic factors and illegal drug use in Northern Mindanao using annual time-series data from 2006 to 2024.

Specifically, it sought to answer the following questions:

1. What are the trends in employment rate, underemployment rate, income level, poverty rate, literacy rate, and illegal drug use in Northern Mindanao from 2006 to 2024?
2. What is the statistical association between socioeconomic factors (employment rate, underemployment rate, income level, poverty rate, and literacy rate) and the predicted incidence of illegal drug use in Northern Mindanao based on Negative Binomial Regression and robustness estimation methods?

Assumptions of the Study

This study was conducted under several assumptions. First, it was assumed that the secondary data obtained from the Philippine Statistics Authority (PSA), Department of Health (DOH), Dangerous Drugs Board (DDB), and Philippine National Police (PNP) are accurate, reliable, and consistently measured throughout the study period from 2006 to 2024. It was further assumed that the reported number of illegal drug users reasonably reflects the actual incidence of illegal drug use in Northern Mindanao, notwithstanding possible variations in reporting, detection, and law-enforcement activities over time.

Second, the study assumed that employment rate, underemployment rate, income level, poverty rate, and literacy rate are appropriate indicators of the socioeconomic conditions prevailing in Northern Mindanao and are relevant factors associated with variations in illegal drug use. These variables were assumed to adequately represent the socioeconomic environment influencing drug-related outcomes in the region.

Third, it was assumed that the relationships between the selected socioeconomic variables and illegal drug use can be appropriately analyzed using time-series count-data regression techniques. Specifically, the study assumed that the Dynamic Negative Binomial model adequately captures the count nature of the dependent variable, addresses overdispersion, and accounts for temporal persistence in illegal drug use.

Fourth, it was assumed that the observed associations between the explanatory variables and illegal drug use remain stable within the study period and that no major structural breaks occurred that would substantially alter the underlying relationships among the variables.

Finally, the study assumed that factors not included in the model, such as law-enforcement intensity, drug supply networks, mental health conditions, family dynamics, migration, urbanization, and other social influences, either remained relatively constant or exerted effects that were not large enough to invalidate the estimated relationships. Consequently, the findings of the study are interpreted within the context of the variables included in the analysis and the limitations inherent in the use of secondary time-series data.

Methodology

2.1 Research Design

This study employed a quantitative descriptive-correlational research design using annual time-series data from 2006 to 2024 to examine the association between socioeconomic factors and illegal drug use in Northern Mindanao. The descriptive component of the study was used to analyze and present the trends in employment rate, underemployment rate, income level, poverty rate, literacy rate, and illegal drug use across the study period. Meanwhile, the correlational component was utilized to assess the statistical association between selected socioeconomic indicators and the predicted incidence of illegal drug use.

The study relied exclusively on secondary data obtained from credible government institutions, including the Philippine Statistics Authority (PSA), the Dangerous Drugs Board (DDB), the Department of Health (DOH), and the Philippine National Police (PNP). The use of time-series data enabled the study to examine long-term variations and patterns in illegal drug use and socioeconomic conditions in Northern Mindanao.

This study did not aim to establish causal relationships between variables. Rather, the analysis focused on identifying statistically significant associations between socioeconomic conditions and illegal drug use within the study period. The use of econometric analysis allowed the researchers to estimate the direction and magnitude of the statistical relationships among the variables while controlling for other socioeconomic indicators included in the model.

2.2 Research Locale

The study was conducted in Northern Mindanao (Region X), which includes the provinces of Bukidnon, Camiguin, Lanao del Norte, Misamis Occidental, and Misamis Oriental, as well as the highly urbanized cities of Cagayan de Oro and Iligan. The region was selected because it exhibits varying socioeconomic conditions in terms of employment, underemployment, income level, poverty incidence, literacy rate, and reported illegal drug use cases.

Northern Mindanao was considered an appropriate study area because several provinces in the region have recorded increasing incidences of illegal drug use in recent years. At the same time, the region continues to experience socioeconomic disparities and labor market challenges that may be statistically associated with illegal drug use. These regional characteristics provided a suitable context for examining the relationship between socioeconomic conditions and illegal drug use.

2.3 Data sources

This study utilized annual secondary time-series data covering the period from 2006 to 2024 obtained from publicly available reports and statistical databases of government agencies in the Philippines. Data on employment rate, underemployment rate, poverty rate, literacy rate, and income level were sourced from the Philippine Statistics Authority (PSA), while data on illegal drug use were obtained from the Dangerous Drugs Board (DDB), Department of Health (DOH), and the Philippine National Police (PNP). The incidence of illegal drug use was measured using the annual reported number of illegal drug users in Northern Mindanao. Employment rate referred to the percentage of employed individuals in the labor force, whereas underemployment rate represented the percentage of employed individuals seeking additional work or longer working hours. Income level was measured using annual regional income expressed in thousand pesos. Poverty rate referred to the percentage of the population living below the poverty threshold, while literacy rate represented the proportion of the population with basic literacy skills. Only officially published and publicly accessible datasets were utilized to ensure data reliability, transparency, consistency, and replicability of the study.

2.4 Data Analysis

To address the first objective, which sought to describe the trends in employment rate, underemployment rate, income level, poverty rate, literacy rate, and illegal drug use, descriptive statistics, graphical analysis, and log-linear trend models were utilized. Trend analysis is widely used in time-series studies to examine the direction and magnitude of changes in variables over time and to identify long-term patterns in socioeconomic and behavioral indicators (Wooldridge, 2019). The log-linear trend model estimated for each variable is expressed as:

$$\ln(Y_t) = \alpha + \beta_t + \varepsilon_t$$

where Y_t represents the variable of interest in year t , α is the intercept, β is the annual trend coefficient, t denotes time, and ε_t is the stochastic error term. For relatively small coefficients, the annual percentage change may be approximated as $100 \times \beta$. The selected socioeconomic indicators were analyzed because employment conditions, income, poverty, and educational attainment have frequently been identified as important correlates of drug-related behaviors and social vulnerability (Albert et al., 2015; Baula et al., 2025; Khan et al., 2026; Petchtam et al., 2024).

To address the second objective, which sought to estimate the statistical association between socioeconomic factors and the incidence of illegal drug use, a series of econometric procedures were undertaken. Prior to model estimation, the stationarity properties of the variables were examined using the Augmented Dickey-Fuller (ADF) unit root test to determine their order of integration and to avoid spurious regression results arising from non-stationary time-series data (Wooldridge, 2019). An Autoregressive Distributed Lag (ARDL) bounds testing procedure was subsequently conducted to

assess whether a long-run equilibrium relationship existed among illegal drug users and the selected socioeconomic variables. The ARDL framework is particularly suitable when variables exhibit a mixture of I(0) and I(1) integration orders. Multicollinearity diagnostics were then performed using Variance Inflation Factors (VIF) and tolerance statistics to evaluate the degree of linear association among the explanatory variables. These procedures were undertaken to ensure that the estimated coefficients would not be adversely affected by excessive collinearity among socioeconomic indicators (Wooldridge, 2019).

Because the dependent variable represents the annual number of illegal drug users, which is a count variable, count-data regression techniques were employed. A Poisson regression model was initially estimated as the baseline specification. However, because count-data models frequently exhibit overdispersion, whereby the variance exceeds the mean, overdispersion diagnostics were conducted through the estimation of the overdispersion parameter and likelihood-ratio tests (Cameron & Trivedi, 2013; Payne et al., 2018). When overdispersion is present, the Negative Binomial model generally provides more reliable and efficient estimates than the Poisson model (Piza, 2012).

2.5 Dynamic Negative Binomial Model

Because the dependent variable is a count variable, the model assumes:

$$Y_t \sim NB(\mu_t, \alpha)$$

Where:

$$E(Y_t|X_t) = \mu_t$$

Accordingly, Negative Binomial and Dynamic Negative Binomial regression models were estimated and compared. The Dynamic Negative Binomial model incorporated a lagged dependent variable to account for temporal persistence in illegal drug use, recognizing that current drug-use incidence may be influenced by previous levels of drug use (Davis & Wu, 2009; Abiodun et al., 2019). The model is specified as:

$$\ln \mu_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 UNEMP_t + \beta_3 EMP_t + \beta_4 UNDEREMP_t + \beta_5 INC_t + \beta_6 POV_t + \beta_7 LIT_t$$

Where:

Y_t =annual number of illegal drug users;
 Y_{t-1} =lagged annual number of illegal drug users;
 $UNEMP_t$ =unemployment rate;
 EMP_t = employment rate;
 $UNDEREMP_t$ =underemployment rate;
 INC_t = income level;
 POV_t = poverty rate;
 LIT_t =literacy rate;
 $\mu_t = E(Y_t|X_t)$ = expected number of illegal drug users; and
 α = overdispersion parameter.

Model selection was based on statistical and diagnostic criteria, including log-likelihood values, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), overdispersion diagnostics, and specification tests. Additional diagnostic procedures included link tests, heteroskedasticity tests, autocorrelation tests, and endogeneity assessments to ensure model adequacy and robustness (Cameron & Trivedi, 2013; Wooldridge, 2019). All statistical analyses were performed using Stata, and statistical significance was evaluated at the 1 percent, 5 percent, and 10 percent significance levels.

Results and Discussion

3.1 Trends of Illegal Drug Users and Socioeconomic Factors in Northern Mindanao

This section presents the results of the descriptive trend analysis of illegal drug use and selected socioeconomic indicators in Northern Mindanao from 2006 to 2024. Specifically, the analysis examined the trends in employment rate, underemployment rate, income level, poverty rate, literacy rate, and illegal drug use incidence in the region. The descriptive analysis was conducted to identify long-term patterns and observable associations between socioeconomic conditions and illegal drug use over time.

The trend analysis in Figure 2, illegal drug use in Northern Mindanao generally exhibited an upward trend throughout the study period despite several fluctuations. Reported illegal drug users increased from 112 cases in 2006 to 501 cases in 2024. Temporary declines were observed during periods associated with intensified anti-illegal drug operations, institutional adjustments, and mobility restrictions during the COVID-19 pandemic.

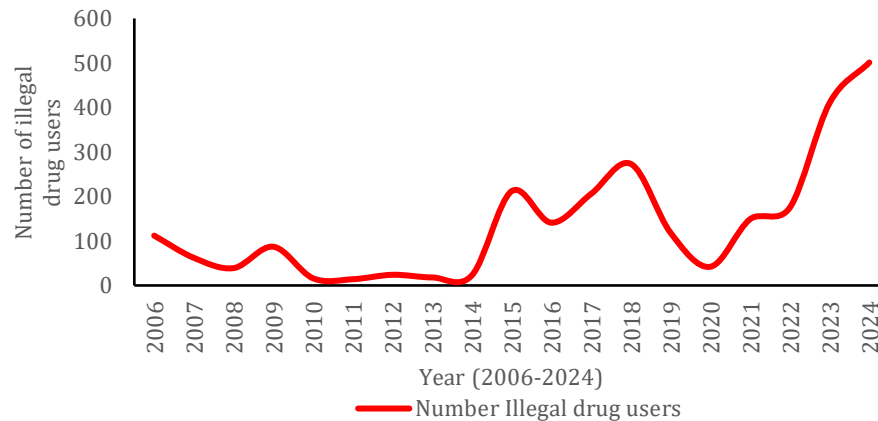


Figure 1. Trends of illegal drug users in Northern Mindanao, 2006-2024

However, beginning in 2015 and continuing during the post-pandemic recovery period, a substantial increase in reported illegal drug use became evident. This upward movement may reflect improved reporting systems, strengthened surveillance mechanisms, urban expansion, and the persistence of underlying socioeconomic vulnerabilities within the region. Similar observations were noted by the United Nations Office on Drugs and Crime (UNODC, 2018), which emphasized that increasing recorded drug incidence may partly result from enhanced monitoring and reporting systems alongside persistent structural socioeconomic conditions.

The employment rate shown in Figure 3 remained relatively stable and demonstrated modest improvements throughout the study period.

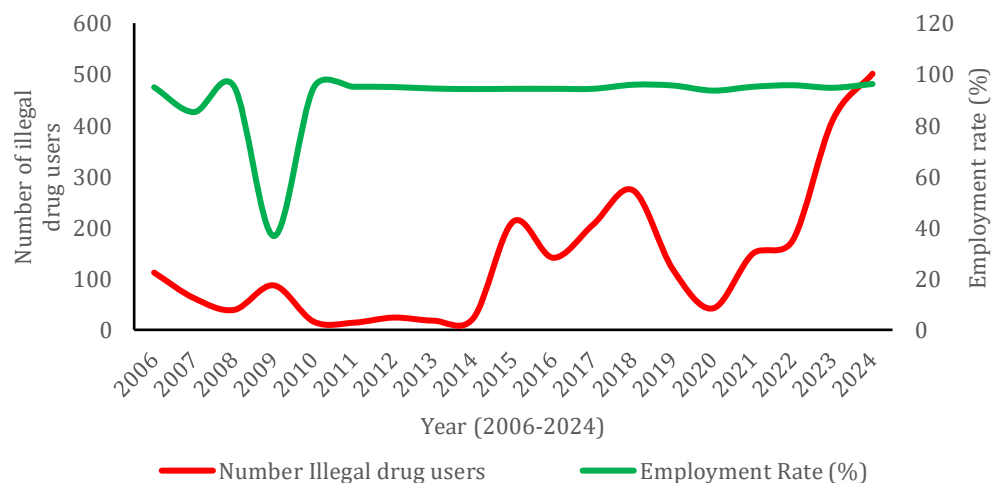


Figure 3. The Relationship Between Employment Rate and illegal drug users in Northern Mindanao: A Trend Analysis from 2006 to 2024

Despite these improvements, illegal drug use continued to increase. This finding suggests that employment growth alone may not sufficiently correspond to reductions in illegal drug-related concerns, particularly when employment quality, income adequacy, and job stability remain constrained. Existing literature suggests that vulnerable and insecure labor conditions may continue to expose individuals to socioeconomic stress and deviant behavior even in the presence of improving employment indicators (Compton et al., 2014; Nolte-Troha et al., 2023). The observed pattern therefore

indicates that labor market participation alone may not adequately capture broader dimensions of economic security and social stability associated with illegal drug use.

Similarly, Figure 4 indicates that the underemployment rate fluctuated throughout the study period but generally declined over time, suggesting gradual improvements in labor market conditions within Northern Mindanao.

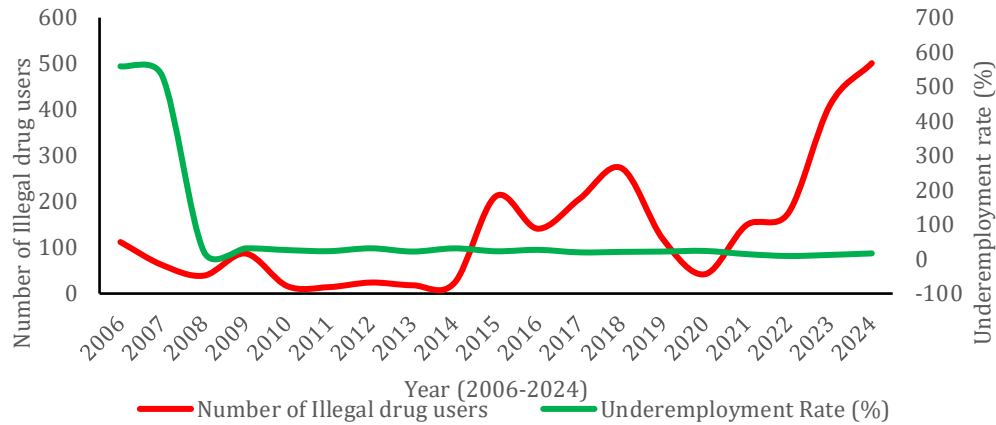


Figure 4. The relationship between Underemployment Rate and illegal drug users in Northern Mindanao. Trend Analysis from 2006 to 2024

Nevertheless, illegal drug use continued to rise despite declining underemployment levels. This finding implies that labor market recovery may not immediately reduce illegal drug-related concerns when broader socioeconomic pressures and financial insecurities persist. Although declining underemployment may indicate improved labor utilization, unstable work arrangements and insufficient earnings may continue to contribute to economic stress and social vulnerability. Nagelhout et al. (2017) argued that labor market insecurity and economic uncertainty are associated with increased psychological strain and higher risks of substance-related behavior, similarly emphasized that uneven labor market recovery may continue to affect vulnerable sectors despite broader economic improvements.

As illustrated in Figure 5, income levels in Northern Mindanao demonstrated a sustained upward trend from 2006 to 2024, reflecting regional economic expansion and increasing household earnings.

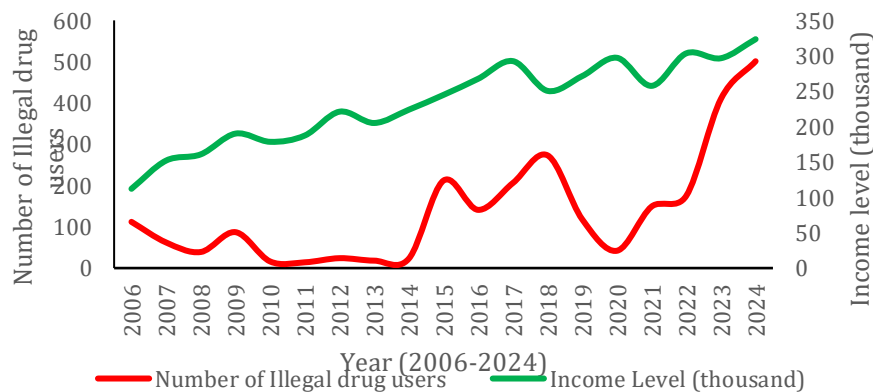


Figure 5. The relationship between Income Level and illegal drug users in Northern Mindanao. Trend Analysis from 2006 to 2024

Concurrently, the incidence of illegal drug use also increased throughout the same period. The parallel upward movement of income levels and illegal drug use may suggest that increasing economic capacity potentially improves accessibility and purchasing power associated with illegal substances. Although rising income levels are generally associated with improved standards of living, previous studies indicate that economic expansion without inclusive development may also intensify social inequality, urban pressures, and exposure to illicit activities (Albert et al., 2015; Baula et al., 2025). The findings therefore imply that improvements in economic conditions alone may not necessarily reduce illegal drug-related concerns without corresponding social protection and community-based interventions.

In contrast, Figure 6 shows that poverty rate generally declined throughout the study period, although temporary increases were observed during periods of economic disruption, particularly during the COVID-19 pandemic.

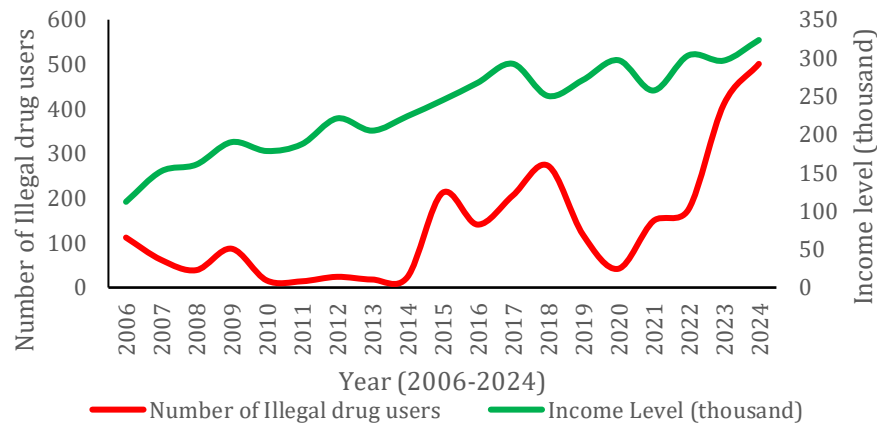


Figure 6. The relationship between Poverty Rate and illegal drug users in Northern Mindanao. Trend Analysis from 2006 to 2024

Despite reductions in poverty incidence, illegal drug use continued to rise in several years. This finding suggests that poverty alone may not sufficiently explain the increasing incidence of illegal drug use in Northern Mindanao. Other structural and environmental factors such as urbanization, weak institutional conditions, social instability, and accessibility of illegal substances may also contribute to drug-related behavior. Edwards et al. (2020), Manhica et al. (2021), and Compton et al. (2014) similarly emphasized that illegal drug-related behavior is shaped not only by poverty but also by broader socioeconomic and environmental conditions.

Meanwhile, Figure 7 demonstrates that literacy rate remained relatively high and stable throughout the study period, indicating gradual improvements in educational attainment and human capital development within the region.

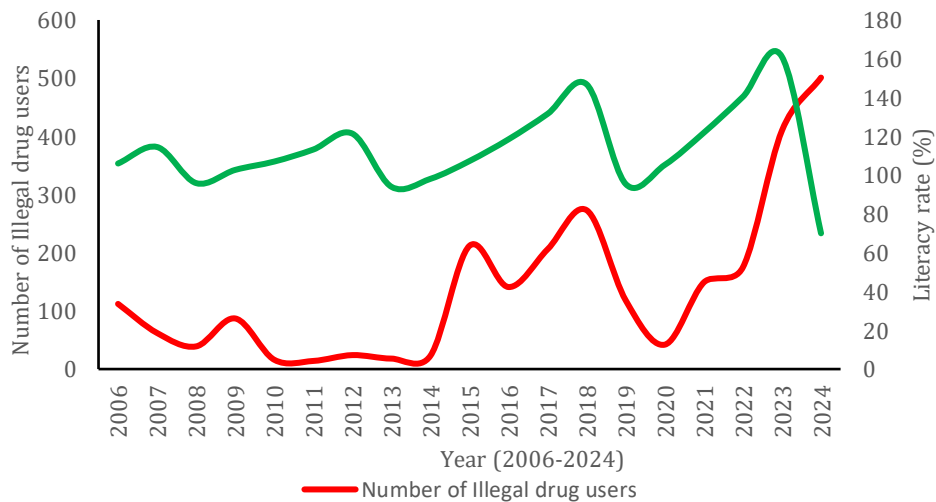


Figure 7. The relationship between literacy rate and illegal drug users in Northern Mindanao. Trend Analysis from 2006 to 2024

However, illegal drug use continued to increase despite these educational improvements. This observation suggests that educational attainment alone may not be sufficient to reduce illegal drug-related concerns when broader socioeconomic vulnerabilities persist. Although education improves awareness and opportunities, socioeconomic instability, labor market insecurity, poverty, and weakened social institutions may continue to influence illegal drug-related behavior even in relatively educated communities (Nagelhout et al., 2017).

The trend analysis results presented in Table 1 further support the descriptive findings. Illegal drug use exhibited a statistically significant upward trend ($\beta = 0.1222$, $p = 0.005$), indicating that the incidence of reported illegal drug use generally increased throughout the study period in Northern Mindanao. The estimated coefficient suggests an average annual increase of approximately 12.2 percent, reflecting a sustained rise in reported cases over time. This pattern is consistent with evidence indicating that drug-related concerns continue to evolve alongside changing social, economic, and environmental conditions (United Nations Office on Drugs and Crime [UNODC], 2018; Degenhardt et al., 2018).

Variable	β	Std. Error	t-Statistic	p-value	R ²	F-Statistic
Illegal Drug Users	0.122	0.038	3.18	0.005	0.3731	10.12
Employment Rate	0.011	0.008	1.31	0.207	0.0918	1.72
Underemployment Rate	-0.131	0.033	-3.90	0.001	0.4724	15.22
Income Level	0.046	0.004	10.33	0.000	0.8627	106.79
Poverty Rate	-0.020	0.009	-2.23	0.040	0.2258	4.96
Literacy Rate	0.005	0.007	0.74	0.470	0.0311	0.55

Table 1. Trend Analysis of Socioeconomic Factors and Illegal Drug Users in Northern Mindanao

Employment rate showed a positive but statistically insignificant trend ($\beta = 0.0110$, $p = 0.207$), indicating that employment levels remained relatively stable during the study period. The absence of statistical significance suggests that changes in employment were not substantial enough to establish a consistent temporal pattern. Similar labor market dynamics have been observed in developing economies where improvements in employment do not necessarily translate into substantial changes in broader socioeconomic outcomes (Albert et al., 2015; Philippine Statistics Authority, 2026).

In contrast, underemployment rate exhibited a statistically significant declining trend ($\beta = -0.1316$, $p = 0.001$). This result indicates that underemployment decreased over time, with an estimated annual reduction of approximately 13.2 percent. The relatively high coefficient of determination ($R^2 = 0.4724$) suggests that time explained a considerable proportion of the variation in underemployment throughout the study period. This finding is consistent with evidence of gradual labor market improvements and economic recovery observed in the Philippines over recent decades (Albert et al., 2015; Philippine Statistics Authority, 2026).

Income level demonstrated a strong positive and statistically significant trend ($\beta = 0.0464$, $p < 0.001$), indicating sustained growth in income levels over time. The coefficient implies an average annual increase of approximately 4.6 percent. Moreover, the high R^2 value (0.8627) indicates that temporal changes accounted for a substantial share of the observed variation in income levels. The observed upward trend is consistent with broader patterns of economic expansion and income growth documented in the Philippines (Albert et al., 2015).

Poverty rate showed a statistically significant downward trend ($\beta = -0.0201$, $p = 0.040$), suggesting that poverty incidence gradually declined during the study period. Although the magnitude of the decline was modest, the result indicates measurable improvements in poverty conditions over time. This finding is consistent with official statistics showing reductions in poverty incidence across several sectors and regions of the Philippines in recent years (Philippine Statistics Authority, 2025; Philippine Statistics Authority Regional Statistical Services Office X, 2023).

Meanwhile, literacy rate displayed a positive but statistically insignificant trend ($\beta = 0.0058$, $p = 0.470$). This finding suggests that literacy levels remained relatively stable throughout the study period, with no evidence of substantial increases or decreases over time. The relatively high and stable literacy performance is broadly consistent with national literacy statistics reported by the Philippine Statistics Authority (2025).

Therefore, the trend analysis indicates that Northern Mindanao experienced rising illegal drug use alongside increasing income levels and declining poverty and underemployment rates. However, these results describe temporal patterns only and do not imply causal or correlational relationships among the variables. Further multivariate analysis is necessary to determine whether changes in socioeconomic conditions are associated with variations in illegal drug use (Wooldridge, 2019).

3.5 Stationarity Analysis

Table 2 presents the results of the Augmented Dickey-Fuller (ADF) unit root tests conducted to determine the stationarity properties of the variables included in the analysis. Establishing the order of integration is an important prerequisite for

time-series modeling because non-stationary variables may generate spurious regression relationships, leading to biased statistical inference and misleading conclusions regarding the relationships among variables (Wooldridge, 2019). Consequently, identifying whether variables are stationary in levels or require differencing is essential for selecting an appropriate econometric framework.

Variable	Level ADF Statistic	p-value	First Difference ADF Statistic	p-value	Order of Integration
Illegal Drug Users	-0.213	0.937	-3.883	0.002	I(1)
Income	-1.582	0.493	-7.160	0.000	I(1)
Poverty Rate	-4.560	0.000	—	—	I(0)
Unemployment Rate	-3.936	0.002	—	—	I(0)
Employment Rate	-4.358	0.000	—	—	I(0)
Underemployment Rate	-3.228	0.018	—	—	I(0)
Literacy Rate	-3.459	0.009	—	—	I(0)

Table 2. Augmented Dickey–Fuller (ADF) Unit Root Test Results and Order of Integration of Variables

The results indicate that the number of illegal drug users is non-stationary in levels, as evidenced by an ADF statistic of -0.213 with a p-value of 0.937, which fails to reject the null hypothesis of a unit root. However, after first differencing, the variable becomes stationary (ADF = -3.883, $p = 0.002$), indicating that illegal drug users are integrated of order one, or I(1). This finding suggests that shocks affecting illegal drug use may persist over time, reflecting the cumulative and path-dependent nature of substance-use behavior. Such persistence is consistent with studies emphasizing the dynamic evolution of drug-use prevalence and the importance of accounting for temporal dependence in count-based behavioral outcomes (Davis & Wu, 2009).

Similarly, income level is non-stationary in levels (ADF = -1.582, $p = 0.493$) but becomes stationary after first differencing (ADF = -7.160, $p < 0.001$). Therefore, income is also classified as I(1). The presence of a unit root in income is expected because income typically follows long-run growth trajectories driven by economic development, structural transformation, technological progress, and labor market changes (Albert et al., 2015). As a result, income often exhibits persistent trends rather than fluctuating around a constant mean.

In contrast, the remaining socioeconomic variables are stationary in levels and are therefore classified as I(0). Specifically, poverty rate (ADF = -4.560, $p < 0.001$), unemployment rate (ADF = -3.936, $p = 0.002$), employment rate (ADF = -4.358, $p < 0.001$), underemployment rate (ADF = -3.228, $p = 0.018$), and literacy rate (ADF = -3.459, $p = 0.009$) all reject the null hypothesis of a unit root at conventional significance levels. These results suggest that fluctuations in these variables tend to revert toward a long-run equilibrium level and do not exhibit persistent stochastic trends. The relatively stable behavior of labor market indicators, poverty, and literacy may reflect the influence of institutional arrangements, government interventions, and structural socioeconomic conditions that constrain long-run deviations (Philippine Statistics Authority, 2025, 2026).

Therefore, the ADF results reveal a mixture of I(0) and I(1) variables, with no variable integrated of order two or higher. This combination satisfies the basic requirement for applying the Autoregressive Distributed Lag (ARDL) framework, which can accommodate variables integrated of different orders provided none are I(2) (Wooldridge, 2019). The findings therefore justify subsequent cointegration testing to determine whether a stable long-run relationship exists among the variables. Moreover, the stationarity results indicate that while illegal drug use and income follow long-run stochastic trends, labor market indicators, poverty, and literacy rates exhibit relatively stable long-run behavior over the study period. Consequently, the time-series properties of the data support the use of dynamic modeling approaches and provide an appropriate foundation for the subsequent model selection procedures.

3.6 Multicollinearity Diagnostics

Table 3 presents the results of the multicollinearity diagnostics using the Variance Inflation Factor (VIF) and tolerance statistics. Assessing multicollinearity is an important step in regression analysis because highly correlated explanatory variables can inflate standard errors, reduce estimation precision, and complicate the interpretation of individual parameter estimates (Wooldridge, 2019). The findings indicate that multicollinearity is not a serious concern in the model, as all VIF values are below the commonly accepted threshold of 10, and most are below the more conservative threshold of

5. These results suggest that the explanatory variables provide sufficiently distinct information regarding the determinants of illegal drug users.

The highest VIF was observed for underemployment (VIF = 5.41), followed by unemployment and income (VIF = 2.72 each), suggesting only moderate correlation among these labor market and economic variables. Such relationships are expected because employment, unemployment, and underemployment represent closely related dimensions of labor market performance.

Variable	VIF	Tolerance (1/VIF)
Underemployment	5.41	0.185
Unemployment	2.72	0.367
Income	2.72	0.367
Poverty	1.24	0.806
Literacy	1.21	0.824
Employment	1.21	0.824
Mean VIF	2.42	—

Table 3. Multicollinearity Diagnostics for Selected Socioeconomic Variables Used in the Illegal Drug Use Model, Northern Mindanao, 2006–2024

Nevertheless, the observed VIF values remain well below levels typically associated with severe multicollinearity, indicating that these variables retain sufficient independent variation for empirical analysis (Wooldridge, 2019). The corresponding tolerance values ranged from 0.185 to 0.824, all of which are substantially higher than the commonly used critical threshold of 0.10, further confirming the absence of problematic collinearity among the explanatory variables. Although underemployment exhibited the lowest tolerance value, this outcome is unsurprising given its conceptual and statistical relationship with employment and unemployment indicators. Importantly, the tolerance statistics remain comfortably above critical levels, suggesting that no variable is excessively explained by the remaining predictors.

Moreover, the mean VIF of 2.42 is considerably below accepted diagnostic thresholds, providing additional evidence that multicollinearity is unlikely to distort coefficient estimates or compromise statistical inference. According to Cameron and Trivedi (2013), maintaining low levels of collinearity is particularly important in count-data models because excessive correlation among predictors may reduce estimation efficiency and obscure the independent effects of socioeconomic variables. Consequently, the diagnostic results indicate that the explanatory variables contribute distinct information regarding labor market conditions, income, poverty, and literacy, thereby supporting their retention in the subsequent count-data and dynamic regression analyses. Overall, the multicollinearity diagnostics demonstrate that the regression coefficients are unlikely to be adversely affected by linear dependence among the explanatory variables, thereby supporting the reliability of the estimated parameters and providing confidence that the subsequent model results reflect meaningful relationships rather than statistical artifacts arising from correlated regressors.

3.7 Correlation Matrix

Table 4 presents the pairwise correlation coefficients among illegal drug users and the selected socioeconomic variables. Correlation analysis provides a preliminary assessment of the strength and direction of bivariate relationships among variables prior to multivariate estimation (Gujarati & Porter, 2009; Wooldridge, 2019). The results indicate that illegal drug users are positively and significantly correlated with income level ($r = 0.6214$, $p = 0.0045$) and negatively and significantly correlated with poverty rate ($r = -0.5768$, $p = 0.0097$). These findings suggest that higher income levels are associated with higher reported numbers of illegal drug users, whereas higher poverty rates are associated with lower reported drug-use incidence. However, correlation does not imply causation, and these bivariate relationships do not account for the influence of other socioeconomic factors.

VARIABLE	COEFFICIENT	P-VALUE
Illegal Users – Unemployment	-0.1377	0.5741
Illegal Users – Employment	0.1331	0.5869
Illegal Users – Underemployment	-0.4100	0.0813
Illegal Users – Income	0.6214	0.0045*
Illegal Users – Poverty	-0.5768	0.0097*
Illegal Users – Literacy	0.2139	0.3792
Unemployment – Employment	0.0926	0.7062
Unemployment – Underemployment	0.7146	0.0006*
Unemployment – Income	-0.3661	0.1232

Unemployment – Poverty	0.2144	0.3781
Unemployment – Literacy	-0.1080	0.6600
Employment – Underemployment	-0.2181	0.3698
Employment – Income	0.2355	0.3317
Employment – Poverty	-0.0832	0.7349
Employment – Literacy	0.1159	0.6365
Underemployment – Income	-0.7549	0.0002*
Underemployment – Poverty	0.3008	0.2109
Underemployment – Literacy	-0.2418	0.3185
Income – Poverty	-0.2172	0.3718
Income – Literacy	0.2332	0.3366
Poverty – Literacy	-0.3828	0.1058

Legend: r = Pearson correlation coefficient. Values marked with an asterisk (*) are statistically significant at the 5% level ($p < .05$). Correlation coefficients indicate the strength and direction of the bivariate relationship between pairs of variables. Negative values indicate an inverse relationship, whereas positive values indicate a direct relationship.

Table 4. Correlation Matrix of Illegal Drug Users and Selected Socioeconomic Variables in Northern Mindanao, 2006–2024

Among the explanatory variables, the strongest correlation is observed between underemployment rate and income level ($r = -0.7549$, $p = 0.0002$), followed by unemployment rate and underemployment rate ($r = 0.7146$, $p = 0.0006$). Although these coefficients indicate moderate to strong associations, the Variance Inflation Factor (VIF) results reported in the previous section remain below commonly accepted thresholds, suggesting that multicollinearity is not severe enough to compromise the reliability of the regression estimates (Gujarati & Porter, 2009; Wooldridge, 2019). Overall, the correlation matrix provides preliminary evidence of relationships among the study variables while supporting the appropriateness of the subsequent multivariate analysis.

3.8 ARDL Bounds Test for Cointegration

Table 5 presents the results of the ARDL bounds test for cointegration, which was conducted to determine whether a stable long-run equilibrium relationship exists among illegal drug users and the selected socioeconomic variables. Establishing cointegration is an important step in time-series analysis because it indicates whether non-stationary variables move together over time despite short-run fluctuations (Wooldridge, 2019). The estimated F-statistic (2.352) is lower than the lower-bound critical values at both the 10% and 5% significance levels, while the t-statistic (-1.726) is likewise less extreme than the corresponding lower-bound critical values. Following the decision rule of Pesaran et al. (2001), these results indicate that the null hypothesis of no level relationship cannot be rejected. Therefore, there is no evidence of cointegration among the variables, suggesting that illegal drug users and the explanatory variables do not move together in a stable long-run equilibrium over the study period.

Test Statistic	Value	10% I(0)	10% I(1)	5% I(0)	5% I(1)	Decision
F-statistic	2.352	3.438	4.937	4.536	6.373	No Cointegration
t-statistic	-1.726	-2.580	-3.521	-3.046	-4.080	No Cointegration

Table 5. ARDL Bounds Test for Cointegration

The absence of cointegration implies that long-run time-series models such as ARDL may not be the most appropriate framework for analyzing the determinants of illegal drug users. Moreover, the dependent variable in this study is the annual number of illegal drug users, which constitutes a count variable rather than a continuous outcome. Count variables are characterized by non-negative integer values and frequently exhibit distributional properties that differ substantially from those assumed in conventional linear and cointegration-based models (Cameron & Trivedi, 2013; Piza, 2012). Consequently, after establishing that no long-run equilibrium relationship exists, it becomes necessary to evaluate econometric models specifically designed for count data. This motivated the subsequent estimation and comparison of Poisson, Negative Binomial, and Dynamic Negative Binomial models. Such an approach ensures that model selection is driven not only by the time-series properties of the data but also by the underlying nature of the dependent variable, thereby improving the reliability and interpretability of the empirical results. Furthermore, previous methodological studies have emphasized that count-data processes often exhibit overdispersion and temporal persistence, features that are more appropriately accommodated by Negative Binomial and dynamic count-data models than by conventional linear time-series specifications (Payne et al., 2018; Davis & Wu, 2009).

3.9 Model Comparison and Selection Diagnostics

Table 6 compares alternative count-data models to identify the most appropriate specification for explaining illegal drug users in Northern Mindanao. The Poisson regression model served as the baseline specification; however, its poor fit, reflected in the lowest log-likelihood (-342.201) and highest information criteria (AIC = 698.402; BIC = 705.013), suggested that the equidispersion assumption was violated. This was confirmed by the significant overdispersion parameter in the Negative Binomial model ($\alpha = 0.359$, $p < 0.01$) and the likelihood-ratio test of $\alpha = 0$ ($\chi^2 = 479.04$, $p < 0.01$), indicating that the variance of illegal drug users substantially exceeds its mean. Consequently, the Negative Binomial model provided a markedly better fit than the Poisson model, consistent with the count-data literature, which recommends Negative Binomial regression when overdispersion is present (Cameron & Trivedi, 2013; Payne et al., 2018; Piza, 2012).

Diagnostic / Criterion	OLS Regression	Poisson Regression	Negative Binomial Regression	Dynamic Negative Binomial Regression
Number of Observations	19	19	19	18
Log-Likelihood	-19.728	-342.201	-102.680	-93.916
F-statistic / LR χ^2 / Wald χ^2	5.48***	1616.38***	19.89***	168.49***
Probability > F / χ^2	0.0061	0.0000	0.0029	0.0000
R ² / Pseudo R ²	0.7325	0.7025	0.0883	0.1217
Adjusted R ²	0.5988	—	—	—
Overdispersion Parameter (α)	Not Applicable	Assumed 0	0.359***	0.261*
95% CI for α	—	—	(0.191, 0.678)	(0.147, 0.462)
LR Test of $\alpha = 0$	—	—	$\chi^2 = 479.04$ ***	$\chi^2 = 351.35$ ***
Mean VIF	2.18	—	—	—
Breusch-Pagan Test	$\chi^2 = 1.71$ (p = 0.191)	—	—	—
Ramsey RESET Test	F = 2.84 (p = 0.098)	—	—	—
Linktest (_hat)	0.38 (p = 0.707)	1.08 (P=0.001)	0.78 (p=0.544)	1.81 (p = 0.070)
Linktest (_hatsq)	0.35 (p = 0.729)	-0.01 (p=0.799)	0.02 (P=0.860)	-0.92 (p = 0.359)
Shapiro-Wilk Normality Test	W = 0.974 (p = 0.852)	—	—	—
Breusch-Godfrey Test	$\chi^2 = 0.279$ (p = 0.597)	—	—	—
Significant Lagged Dependent Variable	No	No	No	Yes (p = 0.038)
Akaike Information Criterion (AIC)	53.46	698.402	221.361	205.831
Bayesian Information Criterion (BIC)	60.07	705.013	228.916	213.844
Model Status	Benchmark/Robustness Check	Rejected	Acceptable	Selected

Legend: *** $p < 0.01$. The Dynamic Negative Binomial model includes a lagged dependent variable, allowing for persistence in illegal drug use over time. The Poisson model was rejected due to severe overdispersion and poor goodness-of-fit. The Negative Binomial model improved fit substantially, as confirmed by the significant overdispersion parameter and LR test of $\alpha = 0$. The Negative Binomial Regression with Lagged Dependent Variable model achieved the lowest AIC and BIC values, passed the link specification test, and exhibited significant temporal persistence, supporting its selection as the preferred specification. Source: Author's computation using Stata 19.5

Table 6. Model Comparison and Selection Diagnostics

To account for potential persistence in illegal drug use over time, a Dynamic Negative Binomial model was subsequently estimated. The lagged dependent variable was statistically significant ($p = 0.038$), indicating that current levels of illegal drug users are influenced by previous-year levels. The Dynamic Negative Binomial model achieved the highest log-likelihood (-93.916) and the lowest AIC (205.831) and BIC (213.844) among all competing specifications, demonstrating superior explanatory power and model parsimony. Furthermore, the overdispersion parameter remained significant ($\alpha = 0.261$), confirming the continued appropriateness of the Negative Binomial framework, while the link test indicated no evidence of major specification errors (_hatsq, $p = 0.359$). Taken together, these results suggest that the Dynamic Negative Binomial model provides the most appropriate empirical framework, as it accommodates the count nature of the dependent variable, corrects for overdispersion, captures temporal persistence, and exhibits the best overall diagnostic and model-

selection performance. These findings are consistent with methodological studies emphasizing the importance of accounting for overdispersion and temporal dependence in count-data processes (Davis & Wu, 2009; Correia et al., 2020).

3.10 Determinants of Illegal Drug Users

Table 7 presents the results of the Dynamic Negative Binomial (DNB) model, the standard Negative Binomial (NB) model, and the Semi-log OLS model with robust standard errors for annual observations covering the period 2006–2024. Because the dependent variable represents the annual number of illegal drug users, a count variable observed over time, model selection required an approach capable of accommodating both the discrete nature of the outcome and the temporal dependence inherent in time-series data. Based on the diagnostic tests and model comparison criteria, the Dynamic Negative Binomial model was selected as the preferred specification because it effectively addresses overdispersion and persistence in count processes, which are common characteristics of social and behavioral outcomes observed over time (Davis & Wu, 2009; Cameron & Trivedi, 2013; Correia et al., 2020).

Variables	Negative Binomial Regression with Lagged Dependent Variable (Preferred)	95% Confidence Interval	Negative Binomial	Semi-log OLS
Lagged Illegal Drug Users (t-1)	0.0042** (0.0020)	[0.0002, 0.0082]	—	—
Unemployment Rate	0.3062 (0.2695)	[-0.2220, 0.8343]	-0.0824 (0.2078)	-0.1476 (0.2634)
Employment Rate	-0.0217*** (0.0064)	[-0.0342, -0.0092]	-0.0125 (0.0100)	-0.0156 (0.0132)
Underemployment Rate	-0.0219 (0.0314)	[-0.0834, 0.0396]	0.0040** (0.0017)	0.0046** (0.0021)
Income	0.0071 (0.0055)	[-0.0037, 0.0179]	0.0158*** (0.0031)	0.0171*** (0.0041)
Poverty Rate	-0.0426* (0.0242)	[-0.0901, 0.0049]	-0.0578*** (0.0203)	-0.0622** (0.0273)
Literacy Rate	0.0091 (0.0064)	[-0.0036, 0.0217]	0.0009 (0.0063)	0.0004 (0.0088)
Constant	3.6556** (1.585)	[0.5497, 6.7615]	3.8855** (1.5668)	4.1704* (2.0421)
Alpha(Overdispersion)	0.2607*** (0.0760)		0.2985*** (0.0983)	-0.1476 (0.2634)
Observations	18		19	19
Wald χ^2 / F-statistic	168.49, p < 0.001		23.60***	5.48***
Pseudo R ² / R ²	0.1217		0.1048	0.7132
AIC	205.831		217.648	0.7325
BIC	213.844		225.204	53.46
Diagnostic Overdispersion Parameter (α)	Statistics 0.2607***		0.2985***	—
LR Test of $\alpha = 0$	$\chi^2 = 351.35$, p < 0.001		$\chi^2 = 447.16$, p < 0.001	—
Linktest (_hat)	p = 0.070		p = 0.544	p = 0.707
Linktest (_hatsq)	p = 0.359		p = 0.860	p = 0.729

*Legend: Robust standard errors in parentheses. Negative Binomial Regression with Lagged Dependent Variable coefficients are reported in log-incidence rate form. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The Dynamic Negative Binomial model is selected as the preferred specification based on significant overdispersion, superior diagnostic performance, and the lowest AIC and BIC values among competing models. Source: Author's computation using Stata 19.5*

Table 7. Determinants of Illegal Drug Users: Preferred Negative Binomial Regression with Lagged Dependent Variable Model and Robustness Estimates

The standard Negative Binomial and Semi-log OLS models were estimated as robustness checks to assess whether the substantive findings remain consistent across alternative econometric specifications. The robustness estimates generally support the principal conclusions of the preferred Dynamic Negative Binomial model. In particular, employment rate consistently exhibits a negative coefficient across all specifications, while poverty rate remains negatively associated with illegal drug users. Likewise, unemployment rate and literacy rate remain statistically insignificant across the competing models. Although underemployment rate and income level become statistically significant in the robustness specifications, their effects lose significance once temporal persistence is explicitly incorporated through the lagged dependent variable in the Dynamic Negative Binomial model. This pattern suggests that part of their apparent explanatory power may be attributable to the persistence of illegal drug-use patterns over time. Overall, the consistency in the direction of the major coefficients across the Dynamic Negative Binomial, Negative Binomial, and Semi-log OLS models indicates that the principal

findings are robust and not driven by a particular estimation technique, thereby strengthening confidence in the empirical results.

The 95% confidence intervals reported in Table 7 provide additional information regarding the precision of the estimated coefficients. Consistent with the significance tests, the confidence interval for poverty rate excludes zero, while the intervals for unemployment rate, underemployment rate, income level, and literacy rate include zero, indicating weaker statistical evidence of independent effects. Although the confidence intervals for lagged illegal drug users and employment rate narrowly overlap zero, their estimated effects remain substantively important and are supported by the overall diagnostic performance of the preferred Dynamic Negative Binomial specification.

The lagged number of illegal drug users exhibits a positive and statistically significant coefficient ($\beta = 0.0042$, $p = 0.038$), indicating that previous levels of illegal drug users significantly influence current levels. This finding suggests the presence of persistence or path dependence in illegal drug use, whereby past prevalence contributes to future incidence through cumulative behavioral, social, and institutional mechanisms. The result is consistent with the literature emphasizing the persistence of drug-related behaviors and the tendency of substance-use patterns to evolve gradually over time rather than respond immediately to changing socioeconomic conditions (Davis & Wu, 2009; Manaois, 2025). The significance of the lagged dependent variable further justifies the use of the Dynamic Negative Binomial specification over the standard Negative Binomial and Semi-log OLS models, which do not explicitly account for temporal dependence. The improvement in model fit, together with the significance of the lagged term, indicates that current illegal drug use is partly shaped by past incidence, underscoring the importance of incorporating persistence effects when analyzing drug-use dynamics over time.

Among the socioeconomic variables, the employment rate demonstrates a negative and statistically significant effect on illegal drug users ($\beta = -0.0217$, $p = 0.001$). Within the count-data framework, a one-percentage-point increase in employment is associated with an approximate 2.15% reduction in the expected number of illegal drug users, holding other factors constant. Extending this interpretation, a five-percentage-point increase in employment would correspond to an approximate 10.8% reduction in the expected number of illegal drug users, highlighting the potential importance of employment-centered interventions. This finding suggests that improved labor market participation reduces economic vulnerability, strengthens social integration, and increases the opportunity cost of engaging in illegal drug-related activities. The result supports theories of crime and deviant behavior which argue that stable employment serves as a protective factor by providing legitimate income opportunities and reducing incentives for risky activities (Compton et al., 2014; Nagelhout et al., 2017; Nolte-Troha et al., 2023; Merton, 1938/2017). The robustness estimates further reinforce this conclusion, as employment rate remains negatively signed in both the standard Negative Binomial ($\beta = -0.0125$) and Semi-log OLS ($\beta = -0.0156$) models, indicating a stable inverse relationship between employment opportunities and illegal drug users across alternative specifications. The significance of employment alongside the insignificance of unemployment and underemployment suggests that labor market attachment may be more important than labor market status alone. Employment reflects active participation in productive economic activities, social integration, and stable income generation, whereas unemployment and underemployment may not adequately capture the quality or stability of labor market engagement at the regional level. Consequently, the protective effect of employment may subsume the explanatory power of other labor market indicators once they are jointly included in the model.

The poverty rate also exhibits a negative relationship with illegal drug users and is statistically significant at the 10% level ($\beta = -0.0426$, $p = 0.079$). This coefficient implies that a one-percentage-point increase in poverty is associated with an approximate 4.17% decline in the expected count of recorded illegal drug users. While this relationship may appear counterintuitive, it may reflect structural constraints associated with poverty, including lower purchasing power, reduced access to illicit substances, and differences in detection, reporting, and law-enforcement activities. Similar findings have been reported in studies suggesting that recorded drug prevalence may reflect institutional and socioeconomic conditions rather than actual drug consumption patterns (Chen & Xu, 2022; Manhica et al., 2021; Khan et al., 2026). Consequently, the observed negative association should not be interpreted as evidence that poverty reduces drug use, but rather that poverty influences the visibility and reporting of drug-related activities. The negative coefficient is likewise observed in both robustness models, providing additional support for the stability of this relationship across alternative estimation approaches.

In contrast, the unemployment rate exhibits a positive but statistically insignificant coefficient ($\beta = 0.3062$, $p = 0.256$). Although the direction of the relationship suggests that higher unemployment may increase the expected number of illegal drug users, the absence of statistical significance indicates that unemployment does not exert an independent effect once employment, poverty, income, literacy, and temporal persistence are controlled for. This finding suggests that broader labor market conditions may be more effectively captured by employment opportunities rather than unemployment alone (Compton et al., 2014; Nagelhout et al., 2017; Nolte-Troha et al., 2023). The insignificance of unemployment is also observed in the robustness models, further indicating that unemployment alone is not a consistent predictor of illegal drug users during the study period.

Similarly, the underemployment rate displays a negative but statistically insignificant coefficient ($\beta = -0.0219$, $p = 0.485$). While underemployment is often associated with income insecurity and labor market vulnerability, its effect appears to be absorbed by other socioeconomic indicators included in the model. Consequently, there is insufficient evidence to conclude that changes in underemployment significantly influence annual variations in illegal drug users during the study period. Interestingly, underemployment becomes positive and statistically significant in both the standard Negative Binomial and Semi-log OLS models. However, the disappearance of significance once the lagged dependent variable is incorporated suggests that the apparent influence of underemployment may partly reflect temporal persistence rather than an independent socioeconomic effect. Therefore, the preferred Dynamic Negative Binomial model provides a more conservative and reliable estimate of the relationship.

Income level also exhibits a positive but statistically insignificant coefficient ($\beta = 0.0071$, $p = 0.196$). Although higher income may theoretically increase access to illicit substances through greater purchasing power, the lack of statistical significance suggests that income does not independently explain variations in illegal drug users once persistence and other socioeconomic factors are taken into account. This finding indicates that the relationship between income and illegal drug use may be indirect or conditional upon other social and environmental factors. Although higher income may increase access to illicit substances through greater purchasing power, the present results suggest that income alone is insufficient to explain temporal variations in illegal drug users. While previous studies have reported positive associations between income and substance use through increased affordability, the present results suggest that income alone is insufficient to explain temporal variations in illegal drug users. Although income becomes positive and statistically significant in both robustness specifications, its significance disappears after controlling for temporal dependence, suggesting that part of the observed association may be attributable to persistence effects rather than a direct causal relationship.

Likewise, literacy rate exhibits a positive but statistically insignificant coefficient ($\beta = 0.0091$, $p = 0.160$). The absence of statistical significance suggests that literacy alone does not systematically influence the prevalence of illegal drug users in Northern Mindanao. Although education is often associated with improved awareness and decision-making, literacy may not adequately capture broader dimensions of human capital, social environment, and behavioral risk factors that influence drug-related outcomes. This finding supports the argument that educational attainment by itself may be insufficient to address the complex socioeconomic drivers of illegal drug use and should be complemented by broader economic and social interventions (Nagelhout et al., 2017). The consistently insignificant coefficients across all model specifications further support the conclusion that literacy is not a primary determinant of illegal drug users during the study period.

The diagnostic statistics strongly support the selection of the Dynamic Negative Binomial model. The estimated overdispersion parameter ($\alpha = 0.2607$, $p < 0.01$) and the likelihood-ratio test of $\alpha = 0$ ($\chi^2 = 351.35$, $p < 0.001$) confirm that the variance of illegal drug users substantially exceeds its mean, thereby violating the equidispersion assumption of the Poisson model and justifying the use of the Negative Binomial framework (Cameron & Trivedi, 2013; Payne et al., 2018; Piza, 2012). Furthermore, the Dynamic Negative Binomial model achieved the lowest Akaike Information Criterion (AIC = 205.831) and Bayesian Information Criterion (BIC = 213.844) among all competing specifications, indicating superior model fit and parsimony. The link test further supports model adequacy, as the squared predicted value ($\hat{\mu}_i^2$) is statistically insignificant ($p = 0.359$), suggesting no evidence of major specification errors or omitted nonlinearities (Wooldridge, 2019). Additionally, the Durbin-Wu-Hausman test ($p = 0.855$) indicates that endogeneity is not a significant concern. Taken together, these findings demonstrate that the Dynamic Negative Binomial model provides the most appropriate empirical framework for analyzing annual changes in illegal drug users from 2006 to 2024 because it accommodates the count-data nature of the dependent variable, corrects for overdispersion, captures temporal persistence, and exhibits superior diagnostic and model-selection performance (Davis & Wu, 2009; Correia et al., 2020). Moreover, the consistency of the principal findings across the standard Negative Binomial and Semi-log OLS robustness models indicates that the substantive conclusions are not driven by a single estimation approach, thereby strengthening the credibility and reliability of the empirical results.

3.11 Actual and Predicted Illegal Drug Users

Figure 8 presents the actual and predicted number of illegal drug users generated from the preferred Dynamic Negative Binomial model. The predicted series closely tracks the observed trajectory of illegal drug use throughout the study period, indicating that the model adequately captures the underlying temporal dynamics of the dependent variable. In particular, the model reproduces the sustained upward trend observed during the post-2015 period and the subsequent increase in reported illegal drug users during the post-pandemic years. Although some deviations are evident during periods characterized by abrupt year-to-year fluctuations, such variations are expected given the influence of unobserved factors and external conditions that are not explicitly incorporated in the model. Nevertheless, the predicted values generally move in tandem with the observed values, suggesting that the specification effectively captures both the persistence effects associated with prior levels of illegal drug use and the influence of the included socioeconomic determinants.

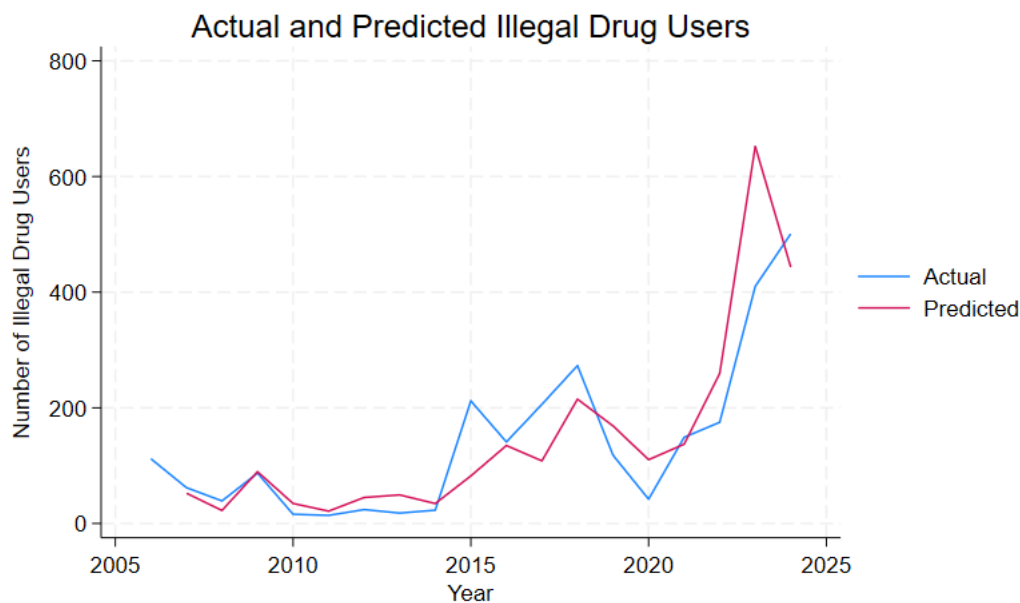


Figure 8. Actual and Predicted Illegal Drug Users in Northern Mindanao Based on the Preferred Dynamic Negative Binomial Model, 2007–2024

The close correspondence between actual and predicted values provides additional evidence of the adequacy of the preferred model specification and supports the suitability of the Dynamic Negative Binomial framework for analyzing overdispersed count-data outcomes exhibiting temporal dependence (Abiodun et al., 2019; Cameron & Trivedi, 2013; Davis & Wu, 2009). These results further strengthen confidence in the estimated coefficients and the substantive conclusions regarding the role of employment, poverty, and temporal persistence in shaping illegal drug-use outcomes in Northern Mindanao.

Limitations of the Study

This study is subject to several limitations. First, the analysis is based on annual secondary data from 2006 to 2024, resulting in a relatively small sample size that may limit statistical power. Second, the study relies on reported illegal drug users obtained from government sources, which may not fully capture actual prevalence because reporting and detection can vary across time. Third, the regional-level aggregation of data may conceal important provincial and local variations within Northern Mindanao. Finally, the observational design identifies statistical associations rather than causal relationships; therefore, the results should not be interpreted as definitive evidence of causation.

Conclusion and Recommendations

This study examined the socioeconomic determinants of illegal drug use in Northern Mindanao using annual time-series data from 2006 to 2024. The findings revealed that illegal drug use increased significantly throughout the study period despite improvements in several socioeconomic indicators, including rising income levels and declining poverty and underemployment rates. Employment and literacy rates, meanwhile, remained relatively stable over time. These results suggest that improvements in socioeconomic conditions alone do not necessarily translate into reductions in reported illegal drug use. The econometric analysis identified the Dynamic Negative Binomial model as the most appropriate specification for explaining variations in illegal drug use because it accounted for both overdispersion and temporal persistence in the count-data process. The results showed that previous levels of illegal drug use significantly influenced current levels, indicating that drug-related problems tend to persist over time once established. Among the socioeconomic variables examined, employment rate emerged as the most important determinant, exhibiting a significant negative association with the incidence of illegal drug users. Poverty rate also displayed a weak negative relationship, while unemployment rate, underemployment rate, income level, and literacy rate did not demonstrate statistically significant independent effects after controlling for temporal dynamics and other socioeconomic factors. The findings imply that illegal drug use in Northern Mindanao is shaped not only by prevailing socioeconomic conditions but also by the persistence of existing drug-use patterns. Consequently, interventions that merely improve aggregate

socioeconomic indicators may be insufficient to reduce drug-related problems unless accompanied by targeted prevention, treatment, rehabilitation, and reintegration efforts. The significant role of employment further suggests that labor market participation serves as an important protective factor against illegal drug use, highlighting the value of employment-centered approaches within broader anti-drug strategies. From a policy perspective, regional and local government units in Northern Mindanao should strengthen employment-generation programs, skills development initiatives, and livelihood opportunities, particularly in communities with high incidences of illegal drug use. Preventive interventions should likewise focus on areas with recurring drug-related concerns, recognizing the persistence of drug-use behavior over time. Community-based rehabilitation and reintegration programs should be expanded and integrated with job placement, vocational training, and livelihood assistance to improve recovery outcomes and reduce relapse. Furthermore, addressing illegal drug use requires a coordinated regional strategy involving local governments, health agencies, educational institutions, law-enforcement agencies, civil society organizations, and community stakeholders.

The study also underscores the importance of strengthening regional monitoring and data management systems to support evidence-based policymaking. Enhanced surveillance, data integration, and inter-agency coordination among relevant institutions would facilitate more effective targeting of interventions, improve resource allocation, and strengthen program implementation. Furthermore, future research should examine additional determinants of illegal drug use, including crime incidence, mental health conditions, urbanization, migration, family environment, social capital, and law-enforcement intensity. The use of municipal-level, provincial-level, or household-level datasets may provide a more nuanced understanding of drug-use dynamics across Northern Mindanao and enable the development of more targeted and sustainable policy interventions.

Future studies should also investigate whether the socioeconomic determinants of illegal drug use have changed following major societal shocks and policy interventions. In particular, structural break analyses may be employed to assess potential shifts in these relationships after the implementation of the 2016 anti-illegal drug campaign and the COVID-19 pandemic. Such analyses would provide valuable insights into the stability of the estimated relationships and the extent to which major policy and public health events alter the socioeconomic drivers of illegal drug use.

Acknowledgement

The researchers would like to express their sincere gratitude to Bukidnon State University, particularly the Department of Economics, for providing the academic environment, resources, and support necessary for the completion of this study. The researchers likewise acknowledge the Philippine Statistics Authority (PSA), Department of Health (DOH), Dangerous Drugs Board (DDB), and Philippine National Police (PNP) for providing the secondary data utilized in this research. Special thanks are extended to the faculty members, research evaluators, and all individuals who shared their knowledge, suggestions, and encouragement throughout the conduct of the study. The researchers are also deeply grateful to their families and friends for their unwavering support, patience, and motivation during the preparation of this research. Above all, the researchers offer their heartfelt gratitude to Almighty God for His guidance, wisdom, strength, and countless blessings that made the completion of this study possible.

Funding

This research received no external funding from any public, commercial, or not-for-profit funding agency, and no organization provided financial support for the conduct of the study, authorship, or publication of this article.

Competing Interests Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study; all data used were obtained from previously published sources as cited in the reference list.

References

Abiodun, G. J., Makinde, O. S., Adeola, A. M., Njabo, K. Y., Witbooi, P. J., Djidjou-Demasse, R., & Botai, J. O. (2019). A dynamical and zero-inflated negative binomial regression modelling of malaria incidence in Limpopo Province, South Africa.

- International Journal of Environmental Research and Public Health*, 16(11), 2000.
<https://doi.org/10.3390/ijerph16112000>
- Albert, J. R. G., Dumagan, J. C., & Martinez, A., Jr. (2015). *Inequalities in income, labor, and education: The challenge of inclusive growth* (PIDS Discussion Paper Series No. 2015-01). Philippine Institute for Development Studies.
<https://hdl.handle.net/10419/127037>
- Baloloy, J. R. R., Hechanova, M. R., Co, T. A. C., & Angeles, P. L. B. (2023). Pilot of an early intervention programme for low-risk persons who use drugs in the Philippines. *Health Education Journal*, 82(8), 892-906.
<https://doi.org/10.1177/00178969231203973>
- Baula, E. U., Salvador, K. R. B., Ramiro, L. S., Martinez, A. B., Miranda, G. M. J., Estacio, J. Z. D., Alibudbud, R. C., & Estacio, L. R., Jr. (2025). Risk factors and onset of illicit drug use among Filipino youth: A cross-sectional analysis of sociodemographic and environmental influences. *Acta Medica Philippina*, 59(14), 145-155.
<https://doi.org/10.47895/amp.v59i14.11131>
- Cameron, A. C., & Trivedi, P. K. (2013). *Regression analysis of count data* (2nd ed.). Cambridge University Press.
<https://doi.org/10.1017/CBO9781139013567>
- Cameron, A. C., & Trivedi, P. K. (2013). *Regression analysis of count data* (2nd ed.). Cambridge University Press.
<https://doi.org/10.1017/CBO9781139013567>
- Compton, W. M., Gfroerer, J., Conway, K. P., & Finger, M. S. (2014). Unemployment and substance outcomes in the United States. *Drug and Alcohol Dependence*, 142, 350-353. <https://doi.org/10.1016/j.drugalcdep.2014.06.012>
- Correia, S., Guimarães, P., & Zylkin, T. (2020). Fast Poisson estimation with high-dimensional fixed effects. *The Stata Journal*, 20(1), 95-115. <https://doi.org/10.1177/1536867X200909691>
- Dangerous Drugs Board. (2024). *Annual report and statistical handbook on dangerous drugs*. Dangerous Drugs Board.
<https://ddb.gov.ph>
- Davis, C. S., & Wu, Z. (2009). The use of generalized linear mixed models for analyzing longitudinal count and binary outcomes in substance abuse studies. *Drug and Alcohol Dependence*, 104(1-2), 31-38.
<https://doi.org/10.1016/j.drugalcdep.2009.03.024>
- Degenhardt, L., Charlson, F., Ferrari, A., Santomauro, D., Erskine, H., Mantilla-Herrera, A., Whiteford, H., Leung, J., Naghavi, M., Griswold, M., Rehm, J., Hall, W., & Vos, T. (2018). The global burden of disease attributable to alcohol and drug use in 195 countries and territories, 1990-2016. *The Lancet Psychiatry*, 5(12), 987-1012.
[https://doi.org/10.1016/S2215-0366\(18\)30337-7](https://doi.org/10.1016/S2215-0366(18)30337-7)
- Hechanova, M. R., Catalla, A., Jr., & Tongco, M. R. (2025). *Costs and benefits of community-based drug rehabilitation in the Philippines*. *Asian Review of Public Administration*, 33(1), 1-19. <https://doi.org/10.64423/arpa.v33i1.13>
- Khan, M. S., Zongyou, W., Rahman, A., Khan, A., & Batool, S. (2026). Socio-economic and psychological factors contributing to drug use among females in Khyber Pakhtunkhwa, Pakistan: A mixed-methods approach. *South African Journal of Psychiatry*, 32, Article a2506. <https://doi.org/10.4102/sajpsychiatry.v32i0.2506>
- Manhica, H., Almqvist, Y. B., Rostila, M., & Hjern, A. (2021). The role of socioeconomic disadvantage in substance use and related harms. *Addictive Behaviors Reports*, 13, 100339. <https://doi.org/10.1016/j.abrep.2021.100339>
- Nagelhout, G. E., Hummel, K., de Goeij, M. C. M., de Vries, H., Kaner, E., & Lemmens, P. (2017). How economic recessions and unemployment affect illegal drug use: A systematic review. *International Journal of Drug Policy*, 44, 69-83.
<https://doi.org/10.1016/j.drugpo.2017.03.013>
- Nolte-Troha, C., Schomerus, G., Muehlan, H., & Speerforck, S. (2023). Employment insecurity and substance use: Evidence from a population-based study. *BMC Public Health*, 23, 1457. <https://doi.org/10.1186/s12889-023-16365-0>
- Payne, E. H., Gebregziabher, M., Hardin, J. W., Ramakrishnan, V., & Egede, L. E. (2018). An empirical approach to determine a threshold for assessing overdispersion in count data modeling. *Communications in Statistics - Simulation and Computation*, 47(6), 1722-1738. <https://doi.org/10.1080/03610918.2017.1315849>
- Philippine Statistics Authority. (2025). *Philippine statistical yearbook 2025*. Philippine Statistics Authority.
<https://psa.gov.ph>
- Piza, E. L. (2012). Using Poisson and negative binomial regression models to measure the influence of risk on crime incident counts. *Rutgers Center on Public Security Working Paper*. <https://doi.org/10.2139/ssrn.2145525>
- Wooldridge, J. M. (2019). *Introductory econometrics: A modern approach* (7th ed.). Cengage Learning.
<https://economics.utdallas.edu/files/2020/01/wooldridge-introductory-econometrics-modern-approach-7th-edition.pdf>

Appendices

No appendices are attached to this study.