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Impact of Socio-Economic Factors on the Prevention of Mother-to-Child Transmission of HIV in Nigeria: A Logistic Regression Approach

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Abstract
Mother-to-child transmission (MTCT) of HIV is the predominant mode of HIV infection among children, occurring during pregnancy, childbirth, or breastfeeding. Without any intervention, the likelihood of HIV transmission from an infected mother to her child ranges between 15% to 45% This study aims to determine the significant socio-economic factors that influence the prevention of MTCT of HIV in Nigeria. Data were collected from a sample of 15,284 women, aged 15-49, across 36 states, from a total population of 41,821. Key variables analyzed include condom use, HIV incidence, educational status, occupation, and means of transportation, employment status, literacy, income status, and the practice of limiting sexual intercourse to one uninfected partner. This research focused on a subset of variables: literacy, condom use, and limiting sexual intercourse to one uninfected partner. The logistic regression model, along with the Wald test and goodness-of-fit test, was employed to assess the impact of these factors on MTCT of HIV. The assumptions of the logistic regression model—such as appropriate outcome structure, observation independence, absence of multicollinearity, linearity of independent variables and log odds, and a large sample size—were tested and found to be valid. The results indicate a significant relationship between the selected socio-economic factors and the prevention of MTCT of HIV in Nigeria. It is concluded that these factors play a crucial role in reducing the risk of mother-to-child transmission of HIV in Nigeria.

Keywords: Socio-Economic Factors, HIV Incidence, Means of Transportation, Employment Status, Goodness-of-Fit Test.

Introduction
HIV/AIDS remains one of the most pressing public health issues globally, with approximately 36.7 million people living with HIV by the end of 2016, including 1.8 million new infections and 1 million HIV-related deaths (UNAIDS, 2017). Mother-to-child transmission (MTCT) of HIV is the primary pathway through which children

become infected with the virus, occurring during pregnancy, childbirth, or breastfeeding (De Cock, 2000). Without treatment or intervention, the risk of MTCT ranges from 15% to 45%, posing a significant global public health challenge (NACA, 2019).

The African continent, particularly sub-Saharan Africa, bears the heaviest burden of the HIV epidemic, accounting for nearly two-thirds of the global total of new HIV infections. This region also experiences high HIV infection rates among pregnant women, ranging from 15% to 40% in countries with the highest overall prevalence. Women of reproductive age comprise over 55% of HIV-infected adults, making MTCT a critical area of concern (UNAIDS, 2017). The impact of HIV on maternal and child health is profound, with HIV-infected pregnant women facing increased risks of intrapartum and postpartum complications, and in some southern African countries, HIV-related opportunistic infections have become a major cause of maternal mortality (UNAIDS, 2017).

In Nigeria, MTCT of HIV represents a significant portion of new infections. Despite ongoing efforts, the coverage of Prevention of Mother-to-Child Transmission (PMTCT) services remains far below the targeted universal coverage of 80%, which was set as part of the National Strategic Plan (NSP) to achieve the virtual elimination of MTCT by 2021 (NACA, 2019). This shortfall in service coverage continues to hinder progress toward meeting these critical health objectives. The impact of maternal HIV infection in Nigeria extends to neonatal outcomes, with infants born to HIV-positive mothers more likely to experience low birth weight, preterm birth, and other complications that increase the risk of neonatal mortality.

Addressing the socio-economic factors that contribute to MTCT of HIV in Nigeria requires a robust and well-coordinated approach. Logistic regression has become the preferred statistical method for analyzing categorical dependent variables in studies related to MTCT of HIV. This method is particularly useful when dealing with dichotomous outcomes, such as the presence or absence of HIV transmission, allowing for more accurate and reliable estimates (Allison, 1999). Through improved understanding and targeted interventions, the goal of eliminating pediatric HIV and achieving HIV-free survival for children in Nigeria can become a reality.

Statement of the Problem

HIV/AIDS has emerged as a leading cause of death among women in several African settings, significantly impacting maternal health outcomes. Pregnant women living with HIV are at an increased risk of both intrapartum and postpartum complications, with studies indicating that they are more susceptible to postpartum infections compared to their HIV-negative counterparts. This heightened risk persists irrespective of the mode of delivery, whether vaginal or cesarean (Black et al., 2016).

In several southern African countries, maternal mortality attributed to opportunistic infections related to HIV/AIDS is a major concern. For instance, a comprehensive study examining 50 years of maternal deaths in South Africa highlighted a recent surge in maternal mortality primarily due to HIV/AIDS-related infections, rather than pregnancy-related complications. This study revealed that HIV/AIDS accounted for approximately 18% of maternal deaths, making it the leading cause of maternal mortality in the region (Pattinson, 2014).

Similarly, in Zambia, the maternal mortality ratio at the Lusaka University Teaching Hospital increased dramatically from 160 per 100,000 live births in 1974 to 921 per 100,000 live births in 1997. This increase was paralleled by a shift in the causes of maternal deaths, with a decline in deaths due to direct obstetric causes (from 94% to 42%) and a corresponding rise in deaths due to opportunistic infections associated with HIV (from 6% to 57%) (Ahmed et al., 1999). Beyond infection-related risks, HIV exacerbates other health challenges, such as malnutrition, particularly in women living in impoverished areas (UNICEF, 2015).

Mother-to-Child Transmission (MTCT) of HIV remains a significant contributor to new HIV infections, and the coverage of Prevention of Mother-to-Child Transmission (PMTCT) services in Nigeria is alarmingly low. Despite the National Strategic Plan (NSP) aiming for 80% universal coverage and the virtual elimination of MTCT by 2021, this goal remains distant due to inadequate access to PMTCT services (NACA, 2019). Addressing the complex public health challenge posed by HIV, particularly in the context of maternal and child health, requires a thorough examination of the factors

Methodology

Data Source

The data for this research was sourced from the Nigeria Demographic and Health Survey (NDHS) 2018, which is a comprehensive national survey conducted under the Demographic and Health Surveys (DHS) Program, a program designed and implemented by the World Health Organization (WHO) in collaboration with national health agencies (NPC & ICF, 2019). The NDHS provides detailed information on population, health, and nutrition, and is a primary source of data for assessing various health-related outcomes in Nigeria.

Data Collection

The NDHS 2018 employed a two-stage sampling technique. In the first stage, 1,400 clusters were selected using systematic sampling with probability proportional to size (PPS), while in the second stage, a systematic selection of 41,821 households was conducted (NPC & ICF, 2019). From these households, a sample of 15,284 women aged 15-49 years was successfully interviewed, which forms the basis of the dataset used in this study.

The variables considered in this study include the use of condoms, incidence of HIV, educational status, occupation, means of transportation, employment status, literacy, income status, and limiting sexual intercourse to one uninfected partner. However, this analysis focuses on a subset of these variables: literacy, use of condoms, and limiting sexual intercourse to one uninfected partner. The survey sample is nationally representative and covers both urban and rural areas across Nigeria's six geopolitical zones (NPC & ICF, 2019). The survey's sampling methodology ensures that the data are robust and adequately weighted to reflect the population of women aged 15-49 years.

Method of Data Analysis

The analysis in this study employs inferential statistics, specifically utilizing logistic regression to examine the relationship between the independent variables (literacy, condom use, and limiting sexual intercourse to one uninfected partner) and the dependent variable

(HIV status). The statistical software E-Views 12 Student Lite was used to perform the analysis.

Logistic Regression Model Assumptions

Logistic regression is appropriate for analyzing binary outcomes and does not require several of the key assumptions of linear regression models, such as linearity of the relationship between independent and dependent variables, normality of residuals, and homoscedasticity (Allison, 1999). However, it does require that the outcome variable is binary, that observations are independent, that there is no significant multicollinearity among independent variables, that independent variables are linearly related to the log odds, and that the sample size is sufficiently large to ensure reliable estimates (Long & Freese, 2001).

Logistic Regression Model

Logistic regression is a statistical method used to model a binary outcome variable based on one or more predictor variables. The logistic model estimates the probability that a given outcome occurs (e.g., HIV-positive status) as a function of the predictor variables (Usman, 2019). The logistic regression model is expressed as:

$$\log it(p) = b_o + b_1 X_1 + b_2 X_2 + b_3 X_3 + ... + b_k X_k$$

where p is the probability of the outcome of interest, α is the constant term, βi are the coefficients, and Xi are the independent variables.

Rather than minimizing the sum of squared errors as in ordinary least squares (OLS) regression, logistic regression maximizes the likelihood of observing the sample values (Long & Freese, 2001). The exponential of the logistic regression coefficients represents the odds ratio, which indicates the relative change in the odds of the outcome for a one-unit increase in the independent variable (Usman, 2019).

ROC Curve Analysis

The Receiver Operating Characteristic (ROC) curve is used to evaluate the performance of the logistic regression model. The Area Under the Curve (AUC) quantifies the model's ability to distinguish between positive and negative cases. An AUC of 0.5 indicates no discrimination (equivalent to random guessing), while an AUC of 1.0 indicates perfect discrimination (Hosmer & Lemeshow, 2013).

Wald Test

The Wald test is applied to assess the significance of individual coefficients in the logistic regression model. It calculates a Z-statistic, which is squared to yield a chi-square statistic. However, it is important to note that the Wald test can be unreliable, particularly for models with large coefficients or small sample sizes, where the likelihood-ratio test may be more appropriate (Menard, 1995; Agresti, 1996)

Likelihood-Ratio Test

The likelihood-ratio test compares the fit of the logistic regression model with a simpler model to determine whether the inclusion of additional predictors significantly improves model fit.

The test statistic follows a chi-square distribution, and a significant result suggests that the more complex model provides a better fit (Long & Freese, 2001).

Hosmer-Lemeshow Goodness of Fit Test

The Hosmer-Lemeshow test evaluates the goodness of fit of the logistic regression model by comparing observed and expected frequencies in subgroups of the data. A non-significant chi-square value ($p > 0.05$) indicates a good fit between the model and the data (Hosmer & Lemeshow, 1989 & 2013).

Theoretical Review

Logistic regression has been extensively applied in various research fields, particularly in studies where the dependent variable is binary or categorical. This statistical technique is especially useful for modeling the probability of a particular outcome based on one or more predictor variables.

Logistic Regression in Educational Research: Osibanjo et al. (2015) applied logistic regression to analyze factors influencing the transition from foundation programs to degree programs at the University of Lagos. Their study highlighted the dichotomous nature of the admission process (i.e., whether a student is recommended for admission or not) and employed logistic regression to model this binary outcome. The study demonstrated that factors such as the type of secondary school attended, the mode of school fee payment at first registration, sponsorship, and first-semester grade point average significantly influenced the likelihood of gaining admission. The model's fitness was validated using the Hosmer-Lemeshow test and other supplementary indices, confirming the utility of logistic regression in predicting future admissions.

Logistic Regression in Political Science: Fernandes and Filho (2020) provide an intuitive introduction to logistic regression, emphasizing its appropriateness for handling binary categorical dependent variables. Their study examined the impact of corruption scandals on the re-election chances of candidates in the Brazilian Chamber of Deputies, using logistic regression to model this relationship. They highlighted the importance of correctly interpreting odds ratios and provided replication materials to facilitate the use of logistic regression in research, thereby encouraging its adoption in political science and related fields.

Common Pitfalls in Logistic Regression Interpretation: Niu (2018) conducted a comprehensive review of the application of logistic regression in educational research, identifying several common practices and pitfalls. The review revealed that while most studies report statistical significance and the direction of predictor effects, many fail to interpret the magnitude of relationships in terms of probabilities. Furthermore, the odds ratio is frequently misinterpreted as a relative risk, leading to exaggerated conclusions. Niu recommends that researchers report marginal effects and predicted probabilities more frequently to fully utilize the information provided by logistic regression.

Logistic Regression in Financial and Corporate Studies: Sakinc (2013) applied logistic regression to investigate the factors influencing gender diversity on the boards of directors of firms listed on the Istanbul Stock Exchange. The study identified that variables such as board

size and education level positively impacted gender diversity, while foreign ownership and free float rate had negative effects. The use of logistic regression in this context underscores its utility in analyzing the probability of categorical outcomes in corporate governance research.

Logistic Regression in Public Health: In the field of public health, logistic regression has been applied to various studies related to HIV prevention and maternal health. Amoran et al. (2012) used logistic regression to compare the utilization of Prevention of Mother-to-Child Transmission (PMTCT) services between teenage and older pregnant women in Western Nigeria. The study found that teenage pregnant women, who were more vulnerable to HIV/AIDS, utilized PMTCT services less frequently than older women, highlighting the need for targeted interventions.

Similarly, Liu et al. (2017) explored factors influencing the risk of mother-to-child transmission (MTCT) of HIV, identifying high maternal viral load and low CD4+ T cell count as significant predictors of transmission. Their study emphasized the importance of logistic regression in identifying key risk factors and informing public health strategies.

Conclusion: Logistic regression is a powerful and versatile tool that has been effectively applied across various research domains. However, its proper application and interpretation require careful consideration of the underlying assumptions and potential pitfalls. Researchers are encouraged to report marginal effects and predicted probabilities to provide a more nuanced understanding of the relationships being studied.

Summary, Conclusion. Recommendation and Suggestion for further Research

Summary

This study employed logistic regression analysis, alongside the Wald test and Goodness-of-Fit tests, to investigate factors enhancing the prevention of mother-to-child transmission (PMTCT) of HIV in Nigeria. Assumptions of logistic regression, including appropriate outcome structure, independence of observations, absence of multicollinearity, linearity of independent variables and log odds, and large sample size, were verified and found valid. The logistic regression analysis indicated a significant relationship between the examined factors and PMTCT efficacy. The model's robustness was supported by the ROC curve and the Pearson and Hosmer-Lemeshow goodness-of-fit tests, confirming its suitability for the data.

Conclusion

The study concludes that there is a significant relationship between the identified factors and the effectiveness of PMTCT of HIV in Nigeria. The factors considered in this research are effective in enhancing the prevention of HIV transmission from mothers to their children, thereby highlighting their importance in public health strategies.

Recommendations

1. **Intensify Campaigns:** Government and NGOs should enhance campaigns to reduce mother-to-child transmission of HIV. This should include education about prevention strategies and early intervention (NACA, 2019).

2. **Promote Girl Child Education:** Educating girls is essential for equipping them with knowledge to prevent HIV transmission in their homes (Sampson, 2018).
3. **Target Rural Communities:** Focus additional PMTCT efforts on women in rural areas where access to healthcare and educational resources is limited (Amoran et al., 2012).
4. **Increase Awareness:** Intensify awareness campaigns about HIV dangers and prioritize effective distribution of treated mosquito nets (Yu et al., 2020).
5. **Explore Other Statistical Models:** Future research should use various statistical models and tools beyond logistic regression to gain further insights into PMTCT (Antônio Alves Tôrres Fernandes & Dalson Britto Figueiredo Filho, 2020).

Suggestions for Further Research

1. **Alternative Statistical Models:** Investigate other statistical models, such as Poisson regression or machine learning techniques, to analyze HIV-related data and compare their effectiveness with logistic regression (Niu, 2018).
2. **Expanding Scope:** Include additional factors like socio-economic status, cultural beliefs, and healthcare access to provide a more comprehensive understanding of PMTCT factors (Ezeanolue et al., 2013).
3. **Longitudinal Studies:** Conduct longitudinal studies to assess the long-term impact of PMTCT interventions and strategies (Ilker Sakinc, 2013).
4. **Cross-Country Comparisons:** Compare PMTCT strategies and outcomes across different regions or countries to identify best practices and improvement areas (Juliet Iwelunmor et al., 2014).

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