The Impact of Beta-Lactam Antibiotics on Bacterial Infection Prevalence and Socioeconomic Determinants in Middle-Aged Adults Across Three West African Countries

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ABSTRACT

This research is to ascertain the impact of Beta-lactam classes of antibiotics on the prevalence of bacterial infections, and the socioeconomic determinants influencing their usage in the middle-aged adults within (35-50) years, across diverse populations of some West African countries. The investigation provides insights into how antibiotics use varies by socioeconomics factors such as access to healthcare, education, income level and its later effect on health outcomes. This study utilizes the mix of quantitative analysis via survey questionnaire and qualitative analysis through interviews and focus group of patients. It was used to collect data from 3300 middle-aged adults across three West African countries to understand the prevalence of bacterial infections, and socioeconomic factors influencing the usage of the aforementioned classes of antibiotics. This mixed-methods approach was employed, combining quantitative analysis (descriptive, regression, and multivariate analysis using Real Statistics v2 in Excel) with qualitative thematic analysis of interviews and focus group data using taguette software. Triangulation was also used to validate findings and provide a comprehensive understanding of the research problem. Quantitative data revealed that socioeconomic factors significantly impact antibiotic use, with financial constraints and limited healthcare access correlating with increased self-medication and misuse. Cronbach's Alpha indicated high internal consistency across survey responses. Thematic analysis identified key themes, including cost as a barrier to healthcare, the role of policies in antibiotic use, and awareness of antibiotic risks. Participants expressed concerns about antibiotic resistance and the quality of available medications, highlighting the growing issue of ineffective drugs. The study emphasizes the need for health policy reforms, drug regulation, and interventions that integrate education with economic support to promote responsible antibiotic use. Future research should focus on long-term trends in antibiotic resistance, the role of pharmacies, and interventions targeting both system-level and behavioral factors.

Keywords: Beta-lactam Antibiotics, Antibiotic Resistance, Health Outcomes, Socioeconomic Determinants, Middle-aged Adults.

INTRODUCTION

The issues concerning the intricate rise of antibiotic resistance is a concern. Antibiotic like Beta-lactam have for decades, been proven good in the fight against bacterial infection. However, the pattern of the use of antibiotics and its effectiveness varies across different population in a view of socioeconomics factors contributing to it.

This research addresses the impact of Beta-lactam antibiotics on the prevalence of bacterial infections and the socioeconomic determinants influencing their usage in the middle-aged adults (35-50 years) across diverse populations of West African countries Ghana, Liberia, and Nigeria. It delves into the relationship between the clinical capacity of Beta-lactam antibiotic, the prevalence of bacterial infections, and socio-economic determinants influences on the use of antibiotics, in different populations and its health outcomes.

Beta-lactam Antibiotics and its Clinical Impacts
Clinical indications have shown that Beta-lactam antibiotics being a major class of drug are the most prescribed. Some of the classes of drugs under this classification including penicilins, cephalosporins, carbapenems, and monobactams. Among them the most available and commonly used class is penicillins. (Pandey & Cascella, 2023) These classes of antibiotics use the mechanism of inhibiting the biosynthesis of bacterial cell wall, which consequently results to cell lysis and even death. Particularly, penicillin being one the class of this major class of antibiotics, works by targeting the penicillin-binding proteins (PBPs) in bacteria. These actions of PBPs which is the enzymes involved in bringing about the synthesis of bacterial cell wall leads to its death. (Zeng & Lin, 2023) Irrespective of being effective, the rise of Beta-lactamase enzymes which are produce by bacteria that can alter the structure of Beta-lactam drug from binding to PBPs making the antibiotic inactivate, poses a significant challenge to their continued use. (Werth, 2024)

The study is to ascertain the impact of these major class of antibiotics on the prevalence of bacterial infections, especially in the middle age adults, which is a demographic that usually have an increased risk of conditions that may require antibiotic use. This is an age group where antibiotic use and more medical related conditions which one may be more vulnerable to, may be noticed. This is between the youth age and the old age. Hence, the understanding of how the classes of beta-lactam antibiotics is effective in this demographic across diverse populations is essential for better treatment strategies.

Socioeconomic Determinant of Antibiotic Use
Socioeconomic factors play a crucial role in influencing health access, the use of antibiotic, even its availability. Socioeconomic consist of multiple factors, such as education, employment, income, healthcare infrastructure, attitudes of people towards medicine, all have an important role in how antibiotics are prescribed and used. (CDC, 2023) Antibiotics are some times over prescribed in high income area that has easier access to medication and healthcare. Depending on wellness of an area involved antibiotic misuse and income level varies by the nature of the misuse, though antibiotic can be underuse or misuse in the low-income areas and vice versa. (Otaigbe & Elikwu, 2023) (Mallah, Orsini, Figueiras, & Takkouche, 2021)

By focusing this research on ascertaining socioeconomic determinants variation in middle-aged adults, across the three aforementioned west African countries, is to understand the use of beta-lactam antibiotics in different context and how they affect the clinical results. This is to provide deep understanding and insights into the disparities in antibiotic effectiveness and its level of accessibility across these countries.

The Interplay Between Antibiotic Use and Socioeconomic Factors in Middle-Aged Adults

This research is distinguishing from others in that it combines clinical and socioeconomic analyses in middle-aged adults. Unlike previous research work that typically focus on either the socioeconomic determinants of healthcare which are non-medical agents impacting health (CDC, 2024) or the pharmacological aspect of antibiotics based on deficiency of novel antimicrobial factor (Gajdács & Jamshed, 2024) The effort to reduce antibiotic use only is improbably to solve antibiotic resistance menace (Maugeri, Barchitta, Puglisi, & Agodi, 2023) A more holistic comprehensive approach is used in this study. The interplay between antibiotic use and socioeconomic is particularly pertinent in the context of antibiotic resistance, which is aggravated by both misuse and overuse of antibiotics.

In a socioeconomically underserved community, for instance there may be high prevalence of self-medication and incomplete antibiotic course. In contrast, issues related to antibiotic overuse may be the problem of the wealthier population, as a result of greater access to healthcare services. This study is to present the social status influence on the use of antibiotic, also the associated health outcome with bacterial infection.

Public Health Implications

The result from this study can inform public health strategies targeted to salvage the exact needs of different populations. The understanding of socioeconomic factors that influence the use of antibiotics can help to improve health outcome. Also using appropriate antibiotics when deem necessary will aid in the fight against antibiotic resistance, this strategy will enhance antibiotic use. (CDC, 2024) Policy makers can develop strategies to ensure the good use of beta-lactam antibiotics, thereby reducing the risk of resistance.

This study ultimately aims to contribute to global initiative to fight antibiotic resistance a major public health threat, by offering evidence-based recommendations that will look into socioeconomic conditions of various populations.

This research has the potential to advance one's understanding of beta-lactam antibiotics, the clinical impact and also the things that shape their use like socioeconomic factors. The study will propagate valuable insight to the field of public health, encouraging equitable and effective strategies in handling this issue of antibiotic resistance. The significance of this study is that it can inform public health schemes aimed at bringing down the level of prevalence of bacterial infection, improve antibiotics use, especially in underserved populations, and help to alleviate the global antibiotic resistance.

PROBLEM DESCRIPTION

This research handles the prevalence of bacterial infections, across three different countries and demographic group, especially in middle-age adults, addressing the problem of deficient understanding of how the socioeconomic factors contribute to variations in health outcomes. Filling the gap in the understanding considering the ways factors such as access to health, cultural belief, and education, affect the usage and effectiveness of beta-lactam antibiotics in relation to the prevalence of infections. Most studies out there either focused on the clinical efficacy of antibiotics or explored socioeconomic disparity in health access in more general

sense. Hence, this research is novel because it incorporates these dimensions, looking into not only the direct clinical impact of beta-lactam antibiotics but also how socioeconomic factors drive their use or misuse in middle-aged adults across countries Ghana, Liberia, and Nigeria.

OBJECTIVES AND GOAL OF RESEARCH
1. To delve into the socioeconomic determinants of beta-lactam antibiotic use in middle-aged adults.
2. To look into the relationship between beta-lactam antibiotic use and the bacterial infection prevalence.
3. To find out and analyze the socioeconomic determinants influencing antibiotic use.
4. To give evidence-based insight that can inform an effective public health policies and interventions.
5. To fill the knowledge gap providing analysis of the intersection between antibiotic use and socioeconomic factor

Socioeconomic Determinants and Antibiotic Usage
The good of this research is on its potential to significantly inform public health interventions and strategies, aimed at promoting antibiotic use, handling antibiotics resistance threat, by reducing the prevalence of bacterial infection, particularly in underserved population.

MATERIALS AND METHODS
To make this article duplicability, a concise and clear methodology is employed. The study integrates both qualitative and quantitative dimensions. With careful consideration given to the theoretical framework, which provide insight into the research question and proper participant selection, data collection, analysis, and interpretation. The following are the sequence of materials and methods used:

Study Design
- **Type:** An elaborate mixed-methods cross sectional study.
- **Population:** Middle-aged adults (35-50 years) from three west African countries.
- **Sample Size:** Statistically substantial sample size for each of the country were calculated based on the population demographics from both urban and rural areas, ensuring good representative coverage. The study was focused on sample size of 1000 participants from each of the three countries involved, making it (3000) participant in all. Additionally, 100 patients (those that are currently on beta-lactam antibiotics drug) per country was selected for a qualitative interview.
- **Inclusion criteria:** Adults aged 35-50 years,
    1. People that have live in this various countries Ghana, Liberia, and Nigeria for at least the past 12 months and still living in them.
    2. Patients who have taken beta- lactam antibiotics in the past twelve months.
    3. Those that are willing to provide information and participate in both and either survey or interview processes (qualitative).
- **Exclusion criteria:** Persons that their sickness was unrelated to bacterial infections
    1. Those individuals with chronic conditions.
    2. Those who have not taken beta-lactam antibiotics in the past twelve months.

Data Collection
Section A Quantitative Data: Survey Questionnaire:
Survey Questionnaire Structure:
The survey is incorporated into six sections namely demographic information, health and antibiotic usage, social-economics determinant of antibiotic use, health outcomes, socio-economic impact and additional comments.

Nature of Questions:
The survey questionnaire consists of both close-ended question, Likert scale, multiple-choice questions and open-ended question.

Survey Questionnaire Validation Process:
In other to ascertain that the survey structure is reliable and to make sure that the questions were understood, and culturally appropriate, it was tested on small groups in each country. As a result of the feedback gotten, the survey was adjusted to improve its effectiveness before mass produced.

Section B Qualitative Data:
Administration:
An in person interviews on a focus group of patients were conducted to understand their experiences with beta-lactam antibiotics, their financial challenges, access to healthcare, and thoughts on antibiotics resistance. With permission every word was written down verbatim as spoken. This is for clarity in analysis. The interview continues until data saturation which infers that enough data has been gathered to cover all the provided question.

Ethical Consideration
Participants were provided with comprehensive information about the research objectives. In each country the series of numbers in 001, 002 ... format was used in place of real name of the participant. All data collected were anonymized stored securely for use and was not available to those not involve in the research.

Data Analysis
Quantitative Analysis:
Descriptive statistics was used to present the summarized demographic information, infection rates and antibiotic patterns.

Inferential Statistics:
Regression analysis was used to delve into the relationship between beta-lactam antibiotics use pattern and bacterial infection prevalence aligning for socio-economics factors.

Multivariate analysis was used to determine the effects of multiple socio-economic determinants on antibiotic use and health outcomes.

Type of software used: Statistical analysis was carried out using Real Statistics software v2, ensuring reproducibility through detailed procedures.

Qualitative Analysis
Thematic Analysis was carried out on focus group and interview data to identify the main themes related to socio-economic determinants of antibiotic use. Taguette software was used to ensure transparency and accurate interpretation of the theme.

Triangulation: The combined analysis of both quantitative and qualitative data analyses was carried out to validate findings and provide a comprehensive understanding of the research problem.

THEORETICAL FRAMEWORK

This research theoretical framework is rooted in the social determinants of health (SDH) model. This model based health outcome as influenced by conditions like where people was born, age. grow, live and work. It also emphasizes health inequalities as being caused by socioeconomic factors such as unequal distribution of power, education, income, goods and services. (Marmot, 2008) Its present access to healthcare as very important determinant of health, which include the use of antibiotics drugs. In the context of this research SDH model is employed to explore how the use and effectiveness of beta-lactam antibiotics among middle-aged adults across different countries are being influenced by socioeconomic disparities

Another model used for this research is the Behavioral Model of health service use, which postulate that the utilization of health service can be ascertain as through the type of individual behavior. It assessed show the impact of environmental, individual, and healthcare system components influence health service utilization. (Andersen & Newman , 2005) This model describes disparities in antibiotic usage by considering the interaction between individual, healthcare access and health system characteristics. For more understanding, it explains variations in antibiotic usage, by the individual level of knowledge, beliefs, attitude, the contextual factors such as cultural norms, health access and health system characteristics in making antibiotics available for use.

EXISTING LITERACTURE

Antibiotic Use and Resistance
A lot of literatures widely present the global menace of antibiotic resistance, which is directing to the misuse and overuse of antibiotic as one of the causes of this challenge. (FDA, 2019) Many studies have shown that beta-lactam antibiotics which include class of cephalosporin's and penicillin's which are one of the most used antibiotics, (Power, n.d.)(Felman , 2024) are often facing resistance as a result of inappropriate use. This issue of wrong use will lead to development of beta-lactamases enzyme with extended spectrum beta-lactamases (ESBLs), which is capable of breaking beta-lactam antibiotic ring making this classes such as cephalosporin's and penicillin's ineffective. (Hooper, 2024)(Castanheira, Patricia, & Patricia, 2021)

Socioeconomic Determinants of Health
Considering the framework SDH that was used in this study which is based health result as influenced by several factors, if not handle well leads to health disparity, including those related to infectious diseases. Other people's work has indicated that socioeconomic status (SES) is a powerful indicator of health outcome, even health access. American psychological

association has defined SES as social status of people evaluate through the crisscrossing of occupation, income, and education. It established that there is connection with healthcare quality and health accessibility. (Caballo, Dey, Prabhu, Seal, & Chu, 2021) Also high level of SES factors availability is linked to better health. It is obvious that the SES of higher income countries are better than those from the lower income countries. (Sabsay, 2022)

Cross Country Comparisons

Relative researches across diverse countries have shown notable variation in antibiotic use, steered by regulatory environments, health systems and cultural attitudes. Nations with strict antibiotic prescription polces and high level of implementation is likely to have lower rate of antibiotic resistance contrast to those with less regulation. (WHO, 2021) Also cultural beliefs and inadequate understanding about illness and treatment has influence on how antibiotic may be perceived or used across population (Mcleod, 2023)

Middle Aged Adult and Health Outcome

While diverse literature on antibiotic use aims on children, and older adult, middle aged adults represent a unique demographic that are less regularly studied. This is the age bracket that stabilizes a lot of responsibilities, including business and family, that may indirectly impact their healthcare seeking behavior. Numerous literatures out there focused on old adult, increase of chronic, cognitive health and degenerative diseases and it likes. (NIA, 2024)(Maresova, et al., 2019)

Impact of Beta-Lactam Antibiotic

Beta-lactam antibiotics are broadly prescribed against various bacterial infections. (Mondemé, Carnoy, Sirard, & Faveeuw, 2023) The effectiveness and appropriate use of this brand of antibiotics can be influenced by socioeconomic factors, individual health behaviors, and broader demographic, economic, and governance. (Maugeri, Barchitta, Puglisi, & Agodi, 2023) This research work aims to contribute to the existing literature by delving into the impact of beta-lactam antibiotics on health outcome within the setting of socioeconomic determinants. This is by providing understanding into the complex association between antibiotic use, health outcome in the middle age adult and socioeconomic elements.

This research is grounded on the existing literatures gearing on the intersection of antibiotic utilization, antibiotic resistance, socioeconomic determinants and health outcomes, in particular, middle-aged adults in diverse countries. While several literatures have looked into these factors individually, this study combine them to give thorough insight on their impact on health in different populations that used beta-lactam antibiotics.

The use of theoretical frameworks SDH and the Behavior mode of health services use, supply a strong base for analyzing multiplex aforementioned intersections, filling a research gap in the literature. This research work is offering a novelty insight on the ongoing discourse on public health and antibiotic resistance, focusing on bring new understanding in how socioeconomic disparities influence health behaviors and outcomes, specifically in middle-age adults, which is underexplored demographic in this context.

RESULTS AND DISCUSSION

This research work integrates the qualitative and quantitative outcomes, including descriptive and inferential statistics, thematic analysis and triangulation to provide a comprehensive finding. Emphasis is geared towards the drivers of antibiotics use and misuse, healthcare access, socioeconomics factors, and participants' awareness of antibiotic risks. Furthermore, Cronbach's Alpha was used to confirm the reliability of the set of survey, ensuring that the collected items is consistently measured the same characteristics for a statistically sound finding. These findings are contextualized within the research questions and objectives to demonstrate how they address the core issues in the study across the countries Ghana, Liberia and Nigeria. Below are the Cronbach's Alpha results:

Reliability and Internal Consistency (Cronbach's Alpha)

Table 1.

Survey Section	Cronbach's Alpha	Interpretation
Ghana data set	0.902037	High reliability
Liberia data set	0.863868	High reliability
Nigeria data set	0.874496	High reliability

Quantitative Results
Descriptive Statistics:

These aspects summarize participants' demographic information, antibiotic use patterns, self-medication with antibiotics, infection prevalence and Completed Prescribed Antibiotics across Ghana, Liberia and Nigeria. It is shown in the table 1 below:

Table of Descriptive Statistics (Demographics and antibiotics use patterns)

Table 2.

Variable	Ghana (%)	Liberia (%)	Nigeria (%)	Overall (%)
Sample Size (n)	78	72	90	240
Mean Age	41.85	36	42.56	40.14
Gender (Male)	67.95	61.11	57.78	62.28
Financial Constraints (Income Level)	24.36	50	10	28.12
Antibiotics Self-Medication	46.15	58.33	60	54.83
Infection Prevalence	65.38	66.67	76.67	69.57
Completed Prescribed Antibiotics (antibiotic completion course)	1.27	1.39	14.44	5.7
Healthcare Access	1.59	1.58	1.54	1.57

From the Table 2 Considering the mean variations participants from Nigeria is the oldest with an age mean of 42.56 years, slightly older than the Ghanaian 41.85 years and Liberia with the average of 36years. This suggest that age related variations could have influence on both healthcare access and self-medication behaviors.

While across these three countries men represent the majority, with the highest percentage in Ghana 67.95% and the lowest in Nigeria 57.78%. The study show that men often engage in more self-medication practices, may be due to their reluctance to seek medical help. When considering financial constraints and healthcare access, financial constraints were mostly reported in Liberia 50% and least in Nigeria 10%. This financial hardship correlates with restricted healthcare access and increased self-medication. Also, in Liberia, high financial constraints align with the 58.33% self-medication rate, indicating cost pressure may be the root cause of the behavior.

In terms of self-medication, the significant concern, particularly in Nigeria 60%, suggesting more participants favoring non-prescribed antibiotic use. Ghana has the lowest rate of self-medication which is 46.15%, though is still moderately high. The overall self-medication rate is 54.83%, showing the need for better regulation of antibiotic use. Considering this trend, it raises the concern about antimicrobial resistance, hence improper use of antibiotics strengthens the resistance. Considering Infection prevalence being high across all represented countries, with Nigeria showing the highest rate at 76.67%. Close monitoring show that high infection rates correlate with antibiotic use, as seen in Nigeria's highest antibiotic use rate at 0.77 mean. This could also lead to misuse and overuse of antibiotics.

Looking into the low overall antibiotic completion rate of prescribed course of antibiotic which is 5.70%, it's alarming. Nigerian participants indicate slightly better adherence at 14.44%, which is still a public health issue considering the figure. This issue can pose significant health risk, because inadequate completion of antibiotics course contributes to the emergency of antibiotic resistant bacteria. The healthcare access score of Liberia is 1.58. This suggest that factors other than finances such as awareness and health literacy may influence healthcare seeking behavior.

Considering this key qualitative theme identified through thematic analysis.

High evidence of Self-Medication across all countries was reported frequently, particular in the Liberia and Nigeria, where healthcare access was limited. The antibiotics (beta-lactams) use patterns show significant misuse reports (like, misuse or incomplete course). While large proportion of participants cited financial challenges, leading to avoidance of hospital visits or laboratory test. With some saying things like "I don't have money to throw to the lab People, I buy antibiotics when I feel I need them".

Regression Analysis:
A logistic Regression model was used to predict the likeliness of positive overall health status based on several factors, which include antibiotic use and healthcare access. The result gotten is presented in Table 3. Focusing on the intercept interpretations across Ghana, Liberia and Nigeria. The intercepts were negative and statistically significant in all the countries involved, pointing that in the absence of improved health access and health status, the tendency of achieving successful outcomes like appropriate antibiotic use or better health is low. This suggests that sociodemographic characteristics only are not sufficient predictor of positive health behavior, indicating that external factors like overall health and healthcare access status are also important. Below are more explanations.

Table 3.

Independent Variables	Ghana (Beta Coefficient)	p-value	Significance	Liberia (Beta Coefficient)	p-value	Significance	Nigeria (Beta Coefficient)	p-value	Significance
Intercept	-2.31	0.007	Significant	-4.74	0.001	Significant	-4.85	0.001	Significant
Overall Health Status	2.99	< 0.001	Significant	1.53	0.011	Significant	4.69	< 0.001	Significant
Healthcare Access	-1.53	0.028	Significant	1.35	0.024	Significant	-1.86	0.02	Significant

Healthcare Access as a Predictor:
Ghana with (Beta = -1.53, p = 0.028) and Nigeria (Beta = -1.86, p = 0.020) is an indication of a negative impact, possibly due to over-prescription or low-quality care while in Liberia (Beta = 1.35, p = 0.024) exhibits a positive relationship, reflecting effective service use. Suggesting access health interventions yielding beneficial outcomes.

Overall Health Status as a Predictor:
There is a strong positive effect (Beta = 2.99, p < 0.001) in Ghana, leading to 20 times increase in positive outcomes. Showing that people in their better health status are likely not to adhere to appropriate use of antibiotic. The positive impact (Beta = 1.53, p = 0.011) in Liberia, increasing outcomes by 4.6 times, but with moderating country's factors. Comparing the smaller coefficient to that of Ghana suggests that factors like access to healthcare, financial constraints might moderate the impact. Nigeria has extremely strong impact (Beta = 4.69, p < 0.001), boosting outcomes by 109 times. This may have something to do with health awareness or access to better facilities, amplifying the effect of good health on behavior.

Model Performance Metrics (ROC Analysis for The Three Countries):
Ghana model: AUC = 0.92, Accuracy = 83%, indicating excellent predictive power. Liberia model: AUC = 0.90, Accuracy = 79%, good performance but slightly lower predictive strength than Ghana. While Nigeria model: AUC = 0.98, Accuracy = 90%, showcasing near-perfect classification ability. The table 4 below is the expression.

Table 4.

Countries	AUC	Interpretation	Accuracy
Ghana	0.916	Excellent performance	0.83
Liberia	0.9	Excellent performance	0.79
Nigeria	0.981	Outstanding performance (near-perfect)	0.9

### *Comparative Findings (Comparative ROC Curve Analysis Across Three Countries):*
Ghana vs. Liberia, both models show excellent performance, though Liberia has slightly lower accuracy, indicating more complex factors influencing outcomes. Nigerian's superior performance seen in highest AUC (0.98), reflecting better predictability and perhaps higher health awareness or service quality. The table 4 below is comparative ROC Curve Analysis.

ROC Curve Insights (Key Sensitivity-Specificity Observations):

Ghana high sensitivity (88%) and specificity (75%), maintaining a good balance between capturing positive outcomes and minimizing false positives while Liberia moderate sensitivity (87%) and specificity (67%), has more false negatives compared to Ghana. Also, Nigeria outstanding sensitivity (92%) but slightly lower specificity (83%), indicating very effective detection of positive outcomes.
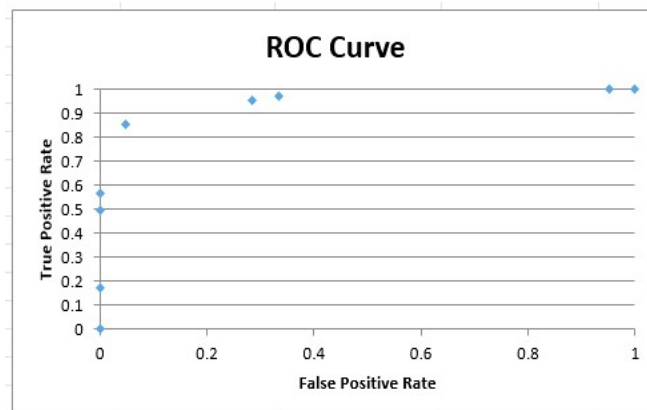
ROC Curve Analysis Summary:
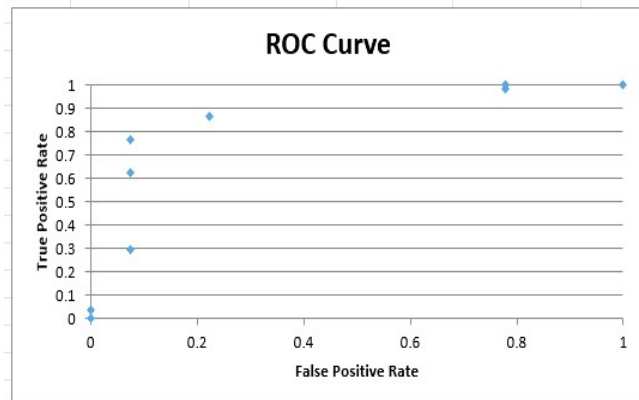
Fig 1: Ghana
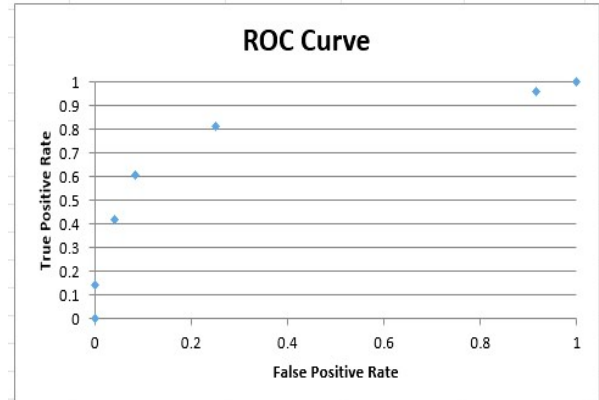
Fig 2 Liberia

Fig 3: Nigeria

The fig 1, 2 and 3 ROC Curve figures above is briefly explained below with a suggested intervention.

- Ghana (1): Steep rise indicates high sensitivity and specificity; slight trade-off in specificity toward the top-right.
- Liberia (2): Gradual rise suggests lower predictive power, with more false positives and negatives than Ghana.
- Nigeria (3): Near-perfect prediction with minimal false positives and negatives.

Interventions:
- Nigeria should focus on health promotion and antibiotic awareness.
- Ghana and Liberia should Improve service delivery to reduce false results.

- Healthcare Access Programs: Ghana should address negative impacts of healthcare access on antibiotic use while Liberia should strengthen healthcare infrastructure for better health outcomes.

Multivariate Analysis:
In other to explore how multiple socioeconomic factors interact to influence antibiotic use and health outcomes multivariate analysis was employed. Below is the model fit and overall performance of regression analysis for Ghana, Liberia, and Nigeria Models.

Table 5

Metrics	Ghana Model	Liberia Model	Nigeria Model
Sample Size	78	72	90
R-Square	0.872	0.553	0.719
Adjusted R-Square	0.859	0.496	0.695
AIC	-177.5	-115.21	-152.84
Significant Predictors	5 out of 7	7 out of 8	5 out of 7
Standard Error	0.305	0.424	0.41
Breusch-Pagan Test (p)	0.145	0.752	0.133
White Test (p)	0.58	0.143	0.301

Multicollinearity and Predictor Significance:
Education Level and Healthcare Access are significant across all models, emphasizing their role in socioeconomics determinant of health.

Antibiotic Use is the most significant predictor in Ghana Model (t = 11.32, p < 0.001) while "infection diagnosis" improves Liberia's Model performance (t = 6.09, p < 0.001).

The multicollinearity is well-managed, hence, all VIF values < 5, ensuring predictors are independent.

Model Reliability and Residual Diagnostics:
- Ghana Model: Residuals show minimal non-linearity and heteroscedasticity, with no influential points (all studentized residuals within ±3).
- Liberia Model: Displays mild non-linearity and some clustering of residuals, suggesting potential influential points.
- Nigeria Model: Residuals are well-scattered, with no heteroscedasticity or severe outliers (Breusch-Pagan p = 0.133). Below are the images of residuals plot and studentized residuals plot in the various countries' multiple regression analysis.
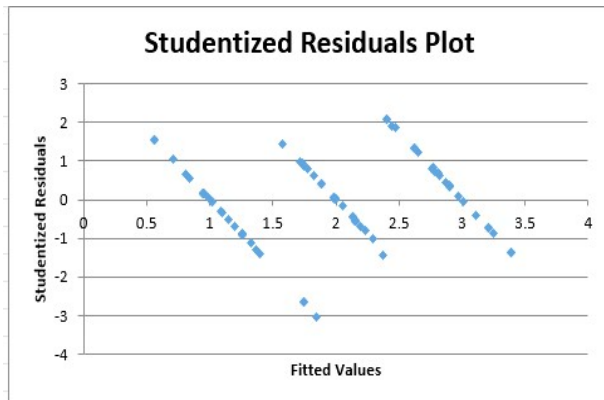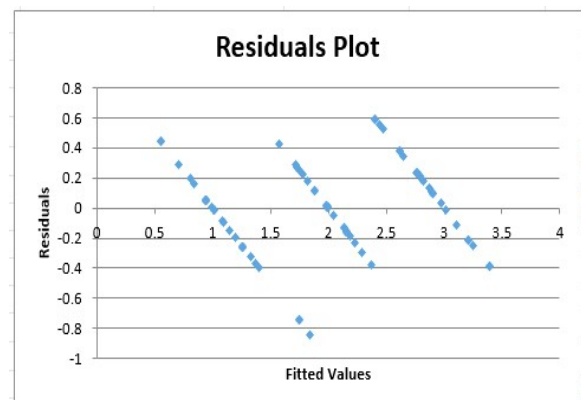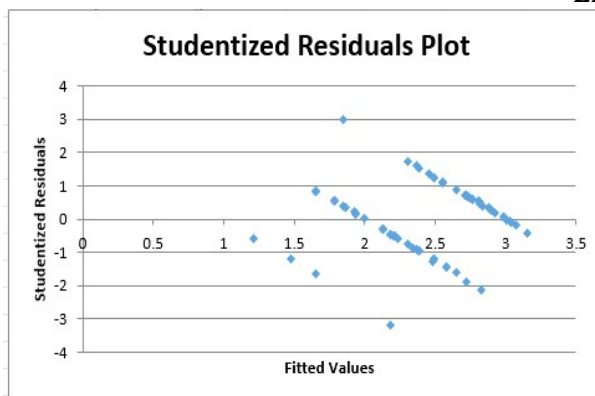
Ghana

Fig 4a

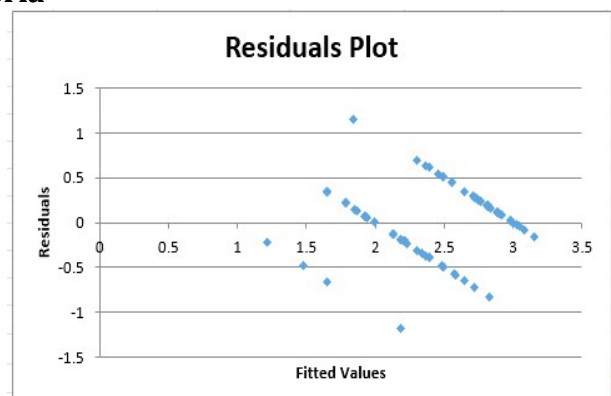**Fig 4b**

Liberia
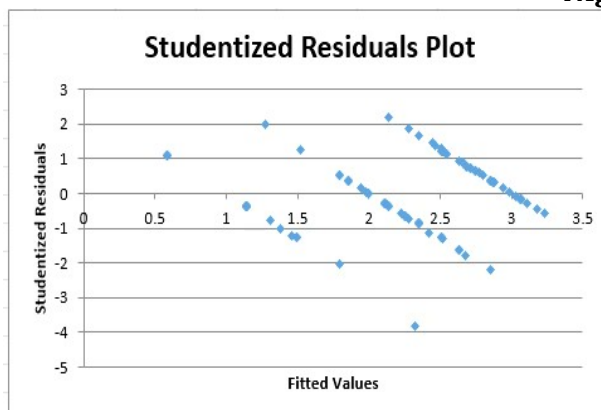

Fig 5a
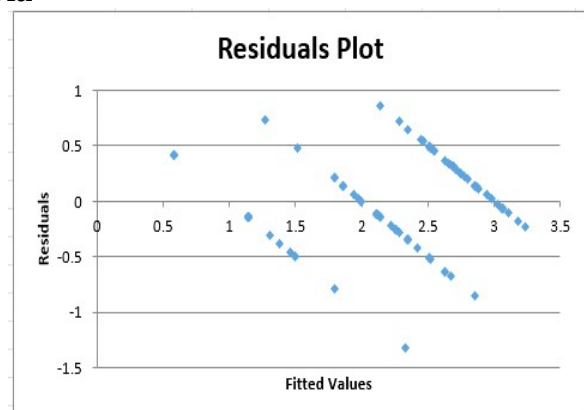

Fig 5b

Nigeria

Fig 6a

Fig 6b

Comparison of Models:

- Ghana Model offers the highest predictive power and reliability, making it the most effective model.
- Liberia Model adds depth with behavioral predictors but introduces variability and influential points.

- Nigeria Model provides a strong balance between predictive fit and reliability, making it a practical alternative.

Main predictors like Education Level, Healthcare Access, and Antibiotic Use consistently influence outcomes. However, the inclusion of "infection diagnosis" in Liberia Model highlights the importance of diagnostic factors in socioeconomics determinant of health.

Qualitative Results and Thematic Analysis
Using Taguette software, the following themes were gotten from interviews and focus groups discussion:

Access to Healthcare and Self-Medication:
Limited healthcare facilities push participants to rely on chemist shops for antibiotics.

Example: "There are chemist shops everywhere in this community; I can buy my drug and take care of myself."

Antibiotic Resistance and Health Risks:
Participants acknowledge antibiotic resistance but report ineffective antibiotics forcing them to switch medications.

Example: "Many antibiotics now are chalk; they don't work anymore." Overuse of antibiotics raises concerns about weakened immunity.

Example: "I am afraid, too much antibiotic can weaken my immune and I will have resistance."

Cost and Financial Constraints:
Financial hardship leads participants, particularly in Liberia and Nigeria, to self-medicate.

Example: "No easy access to healthcare without money encourages me to self-medicate with antibiotics." Lack of government subsidies frustrates participants.

Example: "Government should help subsidize the cost of drugs for us."

Education and Awareness about Antibiotic Use:
Attendees of health seminars and those receiving guidance from doctors show better antibiotic use.

Example: "My doctor guides me on how to use antibiotics to avoid risks."

Some participants educate family members on the dangers of improper antibiotic use.

Example: "I educate my family about the risks associated with antibiotics without prescription."

Healthcare Policies and Government Support:

Ghana has fewer reports of self-medication due to better healthcare policies. In contrast, poor policies in Liberia and Nigeria restrict access to antibiotics.

Example: "I hope if our government will change to better healthcare policies that can affect our access to antibiotics."

Triangulation of Quantitative and Qualitative Results

The merge analysis confirms that, education, financial constraints, healthcare access and policy support are critical to antibiotic use patterns.

- Quantitative Data: logical regression and multivariate analysis show that sociodemographic factors like income and healthcare access predict antibiotic misuse.
- Qualitative Data: Thematic analysis provides contextualizing trends identified in the quantitative results and behavioral insights. That shows that economic hardship, policy gaps, and health education together shape participants' engagement with antibiotics.

DISCUSSION

Addressing Antibiotic Resistance and Medication Quality

Reports of ineffective antibiotics indicate a need for stricter regulation to ensure medication quality. Public health authorities must monitor drug efficacy.

Balancing Emergency Self-Medication and Regulation: Policies should regulate over-the-counter antibiotic sales while ensuring affordable emergency healthcare services to reduce reliance on self-medication.

Education as a Tool for Behavior Change

Education alone is insufficient; it must be coupled with economic support to change behaviors. Campaigns should focus on vulnerable populations with limited healthcare access.

Implications for Healthcare Policy and Access

Subsidies and healthcare reforms are essential in reducing self-medication, particularly in Liberia and Nigeria. Ghana offers a model for improving access and adherence to responsible antibiotic use.

CONCLUSION

The study presents the complex relationship between socioeconomic factors, education, healthcare policies and antibiotic use across Ghana, Liberia, and Nigeria. Policy gaps, limited healthcare access and Financial constraints drive antibiotic misuse. Although education helps promote responsible use, healthcare reforms and economic support are necessary for a lasting impact.

Recommendations

- Educational Campaigns: Targeted campaigns on the risks of antibiotic misuse in vulnerable communities.

- Emergency Healthcare Access: Develop affordable emergency healthcare services to reduce self-medication reliance.
- Monitoring Drug Quality: Implement regular checks to ensure antibiotic efficacy.
- Policy Reform: Governments in Liberia and Nigeria should provide drug subsidies and improve healthcare access.
- Regulation of Drug Sales: Enforce stricter controls on the sale of antibiotics without prescriptions.

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The table 7 below is the list of symbols used.

Table 7

Symbol	Description
ROC	Receive Operation Characteristics (Curve)
AUC	Area Under the Curve
R²	Coefficient of Determination (Explained Variance)
F	F-Statistic (Test of Model Significance)
P	p-value (Probability of Obtaining Test Result as Extreme)
B or Beta	Regression Coefficient (Slope, or Effect Size)
AIC	Akaike Information Criterion

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