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RIPPLES OF INFECTION: UNRAVELING THE EFFECT OF WATERBORNE DISEASES ON HEALTH OUTCOME IN DELTA STATE, NIGERIA

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ABSTRACT

This study investigates the ripples of infection: unraveling the effect of waterborne diseases on health outcome in Delta state, Nigeria. The Cost of Illness Theory serves as the theoretical framework for this study. Data for the research were primarily gathered through questionnaires administered to 345 respondents. Logistic regression models analyzed using Statistical Package for Social Science (SPSS) v23 were employed to test the relationship between the predictors: namely Cholera (CHR), Typhoid (TYR), Hepatitis A (HAR), and Amoebiasis (AMR), and the dependent variable: life expectancy (LEX). The findings revealed a statistically significant and negative relationship between Cholera Rate (CHR), Typhoid Rate (TYR), Hepatitis A Rate (HAR), Amoebiasis Rate (AMR) and life expectancy (LEX) in Delta State. This research concludes that water-borne diseases have a profound effect on health outcomes in Delta state. Consequently, it is recommended that vaccination programs be integrated into routine immunization strategies. Moreover, Delta State should prioritize sanitation improvements and access to clean water sources. Investments in proper sewage disposal and the provision of safe drinking water, particularly in underserved areas, are essential. These improvements will not only reduce the economic burden but also enhance public health and well-being.

Keyword: Water-Borne Diseases, Cholera, Typhoid, Hepatitis A, Amoebiasis and Life expectancy.

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1.1 INTRODUCTION

Water cover more than 71% of the surface of the Earth, and that is the reason for it being called 'The Blue Planet', USGS, (2021). It is an irreplaceable and indispensable natural resource, vital for economic development and human well-being. The significance of water to human and other biological systems cannot be over emphasized, and there are numerous scientific and economic facts that, water shortage or its pollution can cause severe decrease in life expectancy. Julien and Griffith (2010). The quality of drinking water is a powerful environmental determinant of health. Gbenga & Seun (2014). Consumption of quality water serves as a pillar for preventing water-borne diseases such as cholera (WHO, 2011), thus, the provision of safe water is of great concern in most developing countries (Pritchard, Mkandawire, & O'Neill, 2008). Confirmed that, with adequate supplies of safe drinking water, the incidence of illnesses and death, in regard to water borne disease could drop by as much as 75%, which is a major consequence of lack of safe drinking water, this has stimulated a larger proportion of persons, to resort to the use of potentially harmful sources of water. The implication of this is that people are exposed to cycles of innumerable water borne diseases such as cholera, typhoid, hepatitis A, etc. UNICEF, (2010).

The World Health Organization (2005) estimated that globally, about 1.8 million people die from water borne diseases annually, many of which have been linked to diseases acquired from the consumption of contaminated waters and seafood. Persons with compromised immune systems, such as those with AIDS, are especially vulnerable to waterborne infections such as cholera, including those infections that are self-limiting and typically not threatening to healthy individuals. Kgalushi, Smite, and Eales (2008)

UNICEF, (2010b) reports that 884 million people in the world use unimproved or contaminated drinking water source, and estimates that in 2015, 672 million people will still use an unimproved or unsafe drinking water source. In another report, UNDESA (2019) put the worldwide estimate for people without access to safe water at nearly 900 million. According to WHO/UNICEF (2022), Over 80 percent of people with unimproved or unsafe drinking water live in rural areas, about 2.6 billion, almost half the population of the developing world, do not have access to adequate safe drinking water, which has resulted to water borne diseases.

Water borne disease remains one of the major causes of reduction in life expectancy worldwide, with an estimated 2–3 million cases and 100 000 deaths each year, this is majorly caused by Some strains of toxigenic Vibrio cholerae, typhoid, etc which can result in explosive outbreaks when introduced into immunologically naive populations with poor sanitary infrastructure, as was evident in the devastating 2010 water-borne disease epidemic in Haiti after the earthquake disaster Barzilay, Schaad, and Magloire (2013). Ali, Lopez, and You (2012).

Water borne disease is one of the main causes of diarrhea. In 1997, a total of 118349 Water borne disease cases and 5853 deaths were reported to WHO by countries of the African Region. World Health Organization (1998). By the end of 2005, the number of Water borne disease cases notified from the Region had increased to 125018 (94.8% of the total 131943 Water borne disease cases reported globally). However, the number of Water borne disease - related deaths reported from the Region had decreased to 2230 (98.2% of the 2272 Water borne disease deaths reported globally) According to World Health Organization (2006), "Globally, the actual number of Water borne disease cases is known to be much higher; the discrepancy is the result of underreporting and other limitations of surveillance systems, such as inconsistency in case definition and lack of a standard vocabulary. The underreporting

could be due to fear, among the notifying countries, of the potential negative impact on their tourism industry and export of commodities.

In 2007, various countries around the world notified 178677 cases of Water borne disease and 4033 Water borne disease deaths to the World Health Organization (WHO). About 62% of those cases and 56.7% of deaths were reported from the WHO African Region alone. To date, no study has been undertaken in the Region to estimate the economic burden of cholera for use in advocacy for its prevention and control. The objective of this study was to estimate the direct and indirect cost of Water borne disease in the WHO African Region.

Water borne disease contributes significantly to ill-health in the tropics. Improved health contributes to increase in life expectancy, economic growth in various ways: it reduces production losses caused by workers' illness, it increases the enrolment of children in schools and makes them better in learning and it makes alternative use of resources that would otherwise have to be spent on treatment (World Bank, 2013). Some of the benefits derived from healthier workers are increased productivity, greater better paying job opportunities and longer working lives (Sauerborn, Adams, & Hien, 2016). Health status is mostly used to explain wage rate, productivity, school performance, fertility and the demand for medical care (Rout & Nayak, 2017). As will be applicable to this study, Sauerborn, Adams, and Hien (2016) differentiated financial cost of illness (direct cost) from time cost of illness (indirect cost). The financial cost includes expenditure on drugs, fees, transport to treatment site, lodging and food for accompanying household member(s). The time cost represents the sum of the opportunity costs of wages forgone by the sick individuals due to illnesses and opportunity cost of carers' time spent on treating or attending to the sick person or accompanying them for treatment (Sauerborn, Adams, & Hien, 2016).

In Nigeria today research indicates that, majority of the common fresh water sources are polluted, resulting to serious outbreak of water-borne diseases. where an estimated 70% of water at the point of consumption is contaminated. UNDESA (2019). The U.N. agency said, this contamination is why Nigeria has the world's highest number of deaths from waterborne diseases among children under five years old. As a result, UNICEF says 117,000 children die in Nigeria each year due to water-related illnesses - the highest number of any nation. UNICEF (2022).

In Delta State, Nigeria, a vast majority of people living along the course of water bodies still source and drink from rivers, streams and other water bodies irrespective of the state of these water bodies without any form of treatment. DID (2008).

The water problem in Delta State has reached crisis point, no day passes without stories or news about cases of water borne diseases caused by chronic shortage of safe water, this making the rounds, about 75 percent of the residents do not have daily access to clean and safe water, meeting their daily water needs, getting clean drinkable water for the average family in the city is a difficult task. Safe water is expensive and almost unaffordable for many. DID (2008)

Findings by Department for International Development (DID) reveal that for an average family of 4 in Delta State, a sizeable portion of their income is utilized to meet water requirements. A conservative estimate shows that such family would require between half to full bag of water daily. At ₦ 250 per bag, approximately ₦900 to ₦1800 is expended per week on drinking water. For their domestic water needs such as washing and cooking, the services of the Mai Ruwa (water seller) to supply them an average of five to ten (25-litre)

jerry-cans of water at N100 per jerry-can daily, approximately ₦500 to ₦1000 for domestic water usage. DID, (2008).

The prevalence of water borne diseases in Delta State does not come as a surprise. This can explain why the high rate of outbreak of water-borne diseases. In the state, and nationwide, more than half of Nigeria's population has no access to clean water and more than two thirds has no access to sanitation, according to official statistics. Unfortunately, millions of Nigerians are yet to have access to safe water. UNICEF (2010a)

The greatest challenge facing the Delta State is non availability of physical infrastructure to harness rainfall and ground water effectively. Today, there are huge variations in rainfall between north and south Nigeria, making it more important to better plan and manage water resources to minimize the impact of floods and drought. Unfortunately, these factors force children and adults to use unsafe water, which exposes them to potentially deadly water related diseases like cholera and amoebiasis. UNICEF, (2022).

From the remotest part of Delta State to the farthest communities in Maiduguri, the story is the same, there is no safe water anywhere. It is against this background that this study is out to uncover the ripples of infection: unraveling the effect of waterborne diseases on health outcome in Delta state, Nigeria.

However, this study intends to fill the gap in the literature by empirically analyzing the effect of water borne disease, with special emphasis on cholera, and its effect on life expectancy in Delta State. The objectives of the study are therefore: (1) Evaluate the effect of Cholera on life expectancy in Delta State. (2) Examine the effect of Typhoid on life expectancy in Delta State, (3) Determine the effect of Hepatitis A on life expectancy in Delta State. (4) Examine the effect of Amoebiasis on life expectancy in Delta State. The rest of the study is presented as follows: section 2 presents the literature review involving the theoretical underpinning of the study and the review of empirical studies. Section 3 focuses on material and methods which captures the data and model specifications. Section 4 analyses the data and divulges the findings, while sections 5 conclude the paper and highlights the recommendations.

2.0 REVIEW OF RELATED LITERATURE

2.1 Conceptual Framework

2.1.1 Water-Borne Diseases

Waterborne diseases are a disparity in water quality, that has led to the contamination of water sources due to oil spillage, sewage and wastewater discharge, erosion and groundwater contamination and sedimentation etc. this compromises the quality of drinking water, resulting in the proliferation of disease-causing pathogens. Cholera, typhoid, hepatitis A, and amoebiasis are among the most common waterborne diseases in affected areas, and their impact on the local population's health cannot be underestimated. Centre for Diseases Control, (CDC) (2022).

In another definition by World Health Organization (WHO) (2011), waterborne diseases are infections that are transmitted through drinking water that is contaminated with human or animal excreta. These diseases are caused by pathogenic microorganisms such as bacteria, viruses, and parasites that can thrive in untreated or poorly treated water sources. The following are the types of water diseases.

i. **Cholera:** According Piarroux (2011), Cholera is caused by the bacterium Vibrio cholerae and can lead to severe diarrhoea and dehydration. The disease spreads rapidly in areas with

poor sanitation and inadequate access to clean water. The cholera outbreak in Haiti in 2010, following a devastating earthquake, highlighted the devastating consequences of waterborne diseases when healthcare infrastructure is compromised. Cholera spreads in areas with inadequate sanitation and poor hygiene practices. The primary mode of transmission is through contaminated Water, Cholera bacteria can thrive in water contaminated with fecal matter or sewage that contains the bacterium. Drinking or using this contaminated water for cooking or cleaning can lead to infection. Cholera remains a significant public health concern in many parts of the world, particularly in regions with inadequate access to clean water and sanitation facilities. Outbreaks can occur due to natural disasters, conflicts, and other factors that disrupt water and sanitation infrastructure.

In summary, cholera's impact on life expectancy is closely tied to the availability of clean water, sanitation facilities, healthcare services, and health education. Efforts to prevent and control cholera outbreaks can contribute to improving the overall health of populations and extending life expectancy, especially in Delta state where is prone to waterborne diseases.

ii. **Typhoid Fever:** According Crump (2004). Typhoid Fever: Caused by the bacterium Salmonella Typhi, typhoid fever leads to high fever, abdominal pain, and can be fatal if not treated promptly. In regions with inadequate water treatment and sanitation, like parts of South Asia, typhoid remains a significant health burden. The disease is primarily transmitted through the consumption of contaminated water, where there is inadequate sanitation and hygiene practices. The Consuming of contaminated water or consuming food prepared with contaminated water can lead to infection.

The symptoms of typhoid fever can vary in severity. They typically appear 6 to 30 days after exposure, which includes, High fever, often gradually increasing, Weakness and fatigue, Abdominal pain and discomfort, Headache, Loss of appetite, Constipation or diarrhea, Rose-coloured spots on the chest and abdomen, Enlarged spleen and liver and Delirium or confusion (in severe cases)

In summary, typhoid fever's impact on life expectancy is closely linked to the availability of clean water, sanitation facilities, healthcare services, and health education. Efforts to prevent and control typhoid fever through vaccination, improved water and sanitation infrastructure, and healthcare access can contribute to healthier populations and extended life expectancy, particularly in Delta State where the disease is prevalent

iii. **Hepatitis A:** According to Salvatore (2006). Hepatitis A is a viral infection that primarily affects the liver. It is caused by the hepatitis A virus (HAV). This virus is typically transmitted through the consumption of water contaminated with fecal matter containing the virus, this virus spread in areas with poor sanitation and hygiene practices. If water sources are contaminated with sewage or human waste containing the virus, the water can become a source of infection. Drinking, cooking, or washing food with this contaminated water can lead to infection. Symptoms of hepatitis A can range from mild to severe and usually appear around 2 to 6 weeks after exposure. They can include. Fatigue, Nausea and vomiting, Abdominal pain or discomfort, Loss of appetite, Jaundice (yellowing of the skin and eyes), Dark urine, Pale stools and Low-grade fever.

Hepatitis A is a common parasitic infection worldwide, and outbreaks can occur in settings with compromised water and sanitation infrastructure. It is often associated with recreational water activities and travel to areas with poor hygiene practices.

In summary, while hepatitis A is generally not as severe as other forms of hepatitis A, its impact on life expectancy is related to the availability of vaccination, clean water, sanitation

facilities, proper hygiene practices, and timely medical care. Efforts to prevent and control hepatitis A, can lead to healthier populations and extended life expectancy, particularly in Delta state where there is inadequate safe water supply.

iv. **Amoebiasis:** According Mac-Kenzie (2004). Amoebiasis also known as amoebic dysentery, is an infection caused by the parasite. It primarily affects the intestines and can lead to a range of gastrointestinal symptoms. Amoebiasis is transmitted through the ingestion of water contaminated with cysts (the dormant form) of the Entamoeba histolytica parasite. The primary modes of transmission include: Drinking water or consuming food that has been contaminated with fecal matter containing the parasite's cysts can lead to infection, especially in areas with inadequate hygiene practices, direct contact with contaminated surfaces, hands, or objects that carry the parasite can lead to transmission. Amoebiasis can vary in severity, and some individuals might not show symptoms. When symptoms do occur, they can include: Diarrhea, often with blood and mucus, Abdominal pain and cramping, Fatigue, Weight loss, Nausea and vomiting and Fever (less common). Safe Water and Sanitation: Improving access to clean and safe drinking water and proper sanitation facilities is crucial to preventing the transmission of amoebiasis. These measures can help reduce the risk of infection and contribute to improved health outcomes, indirectly impacting life expectancy.

In summary, amoebiasis's impact on life expectancy is closely linked to factors such as access to clean water, sanitation facilities, hygiene practices, timely medical care, and awareness of the disease's potential complications. Efforts to prevent and control amoebiasis can lead to healthier populations and extended life expectancy, particularly in Delta state w where there is inadequate safe water supply and limited access to healthcare resources.

2.1.2 Health:

Health is a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity, which is promoted by encouraging healthful activities, such as regular physical exercise and adequate sleep, and by reducing or avoiding unhealthful activities or situations, such as smoking or excessive stress. Some factors affecting health are due to individual choices, such as whether to engage in a high-risk behaviour, while others are due to structural causes, such as whether the society is arranged in a way that makes it easier or harder for people to get necessary healthcare services. Still, other factors are beyond both individual and group choices, such as genetic disorders. World Health Organization (2006).

2.1.3 Health Outcomes:

Health outcome, is a change in the health status of an individual, group, or population which is attributable to a planned intervention or series of interventions, regardless of whether such an intervention was intended to change health status. Centre for Diseases Control, (CDC) (2022).

Health outcome simply refers to population health status or condition within a given period of time. It is usually measured by health status indicators or indices. Though there seem to be no consensus on how to quantitatively measure health outcome, different scholars on population health have adopted various indices as proxies for measuring health outcome. Some of these indices include self-rated health, infant mortality rate, population mortality rate, life expectancy, average age at death, child nutritional status, diseases burden and maternal mortality (Orji & Okechukwu, 2015).

The indicators of health status, specifically life expectancy is relevant to this research because as stated above. This research adopts health outcomes: as a measurement of health, specifically as health outcome indicators such as life expectancy, Health status could thus, be regarded as health outcome, or output.

Life Expectancy: Life expectancy is the most common indicator of health conditions in a country. Life expectancy is the expected number of years of life remaining at a given age. It is the average life a person is expected to live. Stibitch (2007) explained that life expectancy (LE) is the expected number of years of life remaining at a given age. This means that life expectancy could be at birth, at age 65, or 80. Life expectancy at birth according Kalu (2006) is the average lifespan of a new-born and is an indicator of the overall health of a country, despite the fact that maximum lifespan potential is fixed, life expectation at birth is not fixed and it varies from one country to another. Life expectancy at birth is the average number of years to be lived by a group of people born in the same year if mortality at each age remains constant in the future.

2.2. Theoretical framework

2.2.1 Cost of Illness Theory

The study is hinged onthe Cost of Illness Theory of water borne diseases on health outcomes which was propounded by Anderson in 1927. The theory is an economic framework that focuses on quantifying the economic burden of illness on individuals, families, healthcare systems, and society as a whole. It seeks to understand and measure the various costs associated with illness, including both direct and indirect costs.The Cost of Illness Theory provides insights into how illnesses, including waterborne diseases, and how it can affect life expectancy. By examining the economic consequences of waterborne diseases, this theory helps to understand the broader implications of health issues on individuals' well-being, healthcare systems, and society's overall health status.Waterborne diseases, such as cholera, and amoebiasis can impose significant economic costs on affected individuals, families, and communities. These costs can have implications for both short-term well-being and long-term life expectancy.Understanding the economic costs of waterborne diseases sheds light on the importance of prevention and control measures. Investments in safe water and sanitation infrastructure, health education, and early intervention can mitigate the economic burden associated with these diseases, and increase life expectancy.

2.3 Empirical Review

Iiori, Karo and Joshua (2016) examined the effect of water borne diseases in exacerbating Under-five Mortality Rates in Hawassa city, Ethiopia. The study was aimed at examining the effect of water borne diseases in exacerbating Under-five Mortality Rates in Hawassa city, Ethiopia. the Data for the study were gathered from a sample of 204 affect patients records in Hawassa university teaching hospital. The study employs recent Cronbach approach developed within the framework of logistic regression models and mincerian equation for the analysis of the study. This was made possible by examining Typhoid Rate, Escherichia Coli Rate, Cholera Rate, and Salmonella Rate as the independent variables, determining their effects on Under-five Mortality Rates, using descriptive survey research design, sourcing data through questionnaires and one on one interview. Findings of the study revealed that, water borne diseases plays a crucial effect in exacerbating health outcome such as Under-five Mortality rates in the rural area through consumption of contaminated water, more than the urban areas where there is proper water supply. The study concluded that poor supply of clean water is the main caused of water borne diseases, and the increase in Under-five

Mortality Rates in Hawassa city, Ethiopia. The study therefore recommended that, government should put in place standard water supply and infrastructures especially in rural areas where there is a high rate of Under-five Mortality Rates.

3.1 MATERIALS AND METHODS

The study adopted Quantitative research design which was used to evaluate the effect of cholera on life expectancy in Delta state. The study used the descriptive (survey) research design which was used, given that the research contains two variables viz: water-borne diseases (independent) and Life expectancy, (dependent variables)The study used Questionnaire, by distribution via the various federal, state and primary healthcare centers. The population of this study cover all the staff of the selected public, tertiary, secondary and primary healthcare centers within Delta State. The State is made up of three zones, Delta South, Delta North and Delta Central. For easy coverage, three public healthcare centers were selected in each local zone for the study. The study also adopts the purposive/judgmental sampling technique, using Taro Yamane (1967) to determine the sample size which was six thousand and thirty-nine (6,039) from the earmarked population, given a total sample of three hundred and seventy-five (375) for the study.

3.5 Model specification

The study adapts the logistic model proposed by work of Liori, Karo & Joshua (2016) who investigated on the effect cholera and typhoid on maternal mortality rate in Nigeria. Since the dependent variable (health outcome) takes values of either zero (0) or (1), it is assumed that the error term follows a logistic distribution, regression estimates by the logit model. Specifically, the model takes the implicit form as follows:

$$Y=(p/l-p) = \beta o_X + \beta_{1X} 1_i + \beta_{2X} 2_i + \beta_{3X} 3_i + \text{---} + \beta_{kX} k_i + \varepsilon_t \quad - \quad - \quad (3.1)$$

Where X_1- - - - X_k were the predictor variables- type of residence (rural or urban), educational

Level of the household head, region, size of household, age of household head, sex of household, head, respectively; and p denoted the probability that a person has been faced with maternal mortality case. |Including variables of interest, the first model is specified as:

Model 1

$$LEX = f (CHR, TYR, HAR, AMR) \quad - \quad - \quad - \quad - \quad - \quad (3.2)$$

Where:

CHR = Cholera Rate;

TYR = Typhoid Rate;

HAR = Hepatitis A Rate;

AMR = Amoebiasis Rate;

LEX = Life Expectancy;

This study however modified the equation (3.2) to suit this work. Hence the following functional equations for model 2

Model 2

$LEX = \beta o + \beta_1 CHR + \beta_2 TYR + \beta_3 HAR + \beta_4 AMR + \varepsilon_t$ - - (3.3)

Where;

β_o= Constant

$\beta_1 - \beta_4$ = are the parameters of the model

ε_t. is the random disturbance term which is serially independent and assumed to be Constant.

4.0 Data Analysis and Discussions

it was observed that out of the 375 questionnaires distributed, 18 were not returned, and 12 were not properly filled; thus, making the properly filled questionnaire to be 345, which was returned. The 345 properly filled questionnaires were thus used for the analysis. This shows that 87.76 percent of the administered questionnaire were used for the analysis in this study.

4.1.1.1 Model Equation 1 Resultson effect Water-Borne Diseases on Health Outcome (WBD-HOC)

$LEX = \beta o + \beta_1 CHR + \beta_2 TYR + \beta_3 HAR + \beta_4 AMR + \varepsilon_t$ - - (3.6)

Variable	B	S.E.	Wald	Df	Sig.	Exp(B)
TYR	-5.601	.856	43.164	1	.000	.013
CHR	-4.601	.800	33.059	1	.000	.010
HAR	-3.467	.819	17.938	1	.000	.031
AMR	-2.486	1.095	5.155	1	.023	.083
Constant	17.039	2.434	49.007	1	.000	25108361.639
Hosmer-Lemeshow	1.000					
Nagelkereke R Square	.712					
Cox & Snell R Square	.491					
-2 Log likelihood	170.842					

Source: SPSS Computations (2023)

The logistic regression model reveals compelling insights into the relationship between various disease rates and life expectancy. The analysis demonstrates that higher rates of Typhoid, Cholera, Hepatitis A, and Amoebiasis are linked to a significant decline in the odds of achieving a longer life. (See Appendix I).Particularly, the alarming odds ratios associated with these diseases underscore the critical impact they have on life expectancy. Typhoid and Cholera, with odds ratios of 0.013 and 0.010 respectively, exhibit a substantial reduction in the likelihood of higher life expectancy for every unit increase in their rates. Hepatitis A follows closely with an odds ratio of 0.031, emphasizing the importance of controlling this disease for improved longevity. Additionally, Amoebiasis, though to a slightly lesser extent, also demonstrate detrimental effects on life expectancy, emphasizing the need for comprehensive public health interventions to mitigate the impact of these diseases on population health. The odds ratios (Exp(B)) further illustrate that a higher disease rate substantially reduces the odds of life expectancy, underscoring the critical need for effective disease prevention and control measures to improve life expectancy.

The logistic regression model's strong goodness-of-fit, as indicated by the Hosmer-Lemeshow test (p-value 1.000), highlights the model's appropriateness in capturing the relationships within the data. The high Nagelkereke and Cox & Snell R-squared values (0.712 and 0.491 respectively) suggest that a substantial proportion of the variability in life

expectancy can be explained by the disease rates considered in the model. This underscores the importance of these disease rates as significant predictors of life expectancy. Overall, the findings stress the urgent need for effective public health strategies to mitigate and manage Typhoid, Cholera, Hepatitis A, and Amoebiasis to ultimately improve life expectancy and enhance the overall well-being of the population.

4.1.2 Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.913	.812	6

Source: SPSS Computations (2023)

The reliability results above offer crucial insights into the internal consistency and robustness of the logistic regression model used to predict life expectancy based on disease rates. Cronbach's Alpha yielded a high value of 0.913. This indicates a strong and consistent relationship among the disease rate variables (Typhoid, Cholera, Hepatitis A, and Amoebiasis) in their contribution to predicting life expectancy. Essentially, the disease rate variables are effectively measuring the same underlying construct, enhancing the reliability of the model's predictions. Moreover, Cronbach's Alpha based on standardized items, standing at 0.812, reaffirms this consistency even when considering standardized versions of the variables. The model's reliability remains robust, bolstering the confidence in its predictive capacity concerning life expectancy.

In practical terms, these reliability measures imply that the logistic regression model is a dependable tool for forecasting life expectancy based on the specified disease rate variables. Policymakers and public health practitioners can rely on this model's consistent performance, making informed decisions and designing interventions to mitigate the adverse impact of diseases like Typhoid, Cholera, Hepatitis A, and Amoebiasis on life expectancy. The high Cronbach's Alpha value signifies a high level of internal agreement among the variables, suggesting that improvements in controlling or managing these diseases can potentially lead to enhanced life expectancy. This insight is invaluable for crafting targeted strategies that prioritize disease prevention and control efforts, ultimately promoting healthier and longer lives within the population.

4.3 Testing of Hypothesis Results

4.3.1 Test of hypothesis One

H01: Cholera Rate (CHR) has no significant effect on life expectancy (LEX) in Delta State.

The logistic regression results for CHR include a significant p-value (Sig.) of 0.000, and the coefficient for CHR is -4.601. Based on these results, we reject the null hypothesis for CHR. There is strong evidence to suggest that Cholera Rate (CHR) does have a significant effect on Life Expectancy (LEX) in Delta State. Additionally, the Hosmer-Lemeshow statistic (1.000) suggests that the model fits the data well. Therefore, we reject the null hypothesis for CHR.

4.3.2 Test of hypothesis Two

H02: Typhoid Rate (TYR) has no significant effect on life expectancy (LEX) in Delta State

The logistic regression results for TYR include a significant p-value (Sig.) of 0.000, and the coefficient for TYR is -5.601. Based on these results, we reject the null hypothesis for TYR. There is strong evidence to suggest that Typhoid Rate (TYR) does have a significant effect on Life Expectancy (LEX) in Delta State. Additionally, the Hosmer-Lemeshow statistic (1.000) suggests that the model fits the data well. Therefore, we reject the null hypothesis for TYR.

4.3.3 Test of hypothesis Three

H03: Hepatitis A Rate (HAR) has no significant effect on life expectancy (LEX) in Delta State

The logistic regression results for HAR include a significant p-value (Sig.) of 0.023, and the coefficient for HAR is -3.467. Based on these results, we reject the null hypothesis for HAR. There is strong evidence to suggest that Hepatitis A Rate (HAR) does have a significant effect on Life Expectancy (LEX) in Delta State. Additionally, the Hosmer-Lemeshow statistic (1.000) suggests that the model fits the data well. Therefore, we reject the null hypothesis for HAR.

4.3.4 Test of hypothesis Four

H04: Amoebiasis Rate (AMR) has no significant effect on life expectancy (LEX) in Delta State

The logistic regression results for AMR include a significant p-value (Sig.) of 0.000, and the coefficient for AMR is -2.434. Based on these results, we reject the null hypothesis for AMR. There is strong evidence to suggest that Amoebiasis Rate (AMR) does have a significant effect on Life Expectancy (LEX) in Delta State. Additionally, the Nagelkerke R Square (0.712) and Cox & Snell R Square (0.491) values suggest that the model explains a substantial amount of variability in LEX. Therefore, we reject the null hypothesis for AMR.

4.4 Discussion of findings

From the foregoing, findings of this study reveal a significant negative impact of Cholera Rate (CHR) on life expectancy (LEX) in Delta State, signifying that an increase in CHR correlates with decreased life expectancy. This finding, viewed through the lens of the Cost of Illness Theory, highlights several dimensions of the disease's impact. Direct medical costs encompass expenses such as hospitalization, medication, and healthcare personnel, straining both individuals and the healthcare system. Indirect costs emerge from lost productivity due to illness and care-seeking efforts, affecting economic well-being at both individual and societal levels. The intangible costs, comprising emotional distress and psychological suffering for patients and their families, underscore the enduring mental health consequences of Cholera. Additionally, Cholera outbreaks strain healthcare resources, accentuating the need for public health measures and investments in clean water infrastructure to mitigate these societal impacts and enhance overall well-being in Delta State. This findings in tandem with Kelly et al. (2019) which reported a cholera outbreak with 43,996 cases and 836 deaths across 20 states in Nigeria in 2018. It emphasized the need for clean water supply to reduce the spread of cholera. These findings align with the current results for Cholera Rate (CHR-

LEX), which demonstrated a significant negative effect on life expectancy in Delta State. Both studies underscore the importance of clean water in preventing cholera. The findings are also supported by Idowu et al. (2022) which investigated a cholera outbreak in North-East Nigeria and identified non-attendance at social gatherings and a clean water source as protective factors against cholera. These findings align with the importance of clean water supply discussed in response to the Cholera Rate (CHR-LEX) regression results.

The logistic regression analysis highlights that Typhoid Rate (TYR) significantly and negatively affects life expectancy (LEX) in Delta State, with increasing Typhoid Rates correlating with reduced life expectancy. This finding aligns with the Cost of Illness Theory, illustrating several dimensions of the disease's impact. Firstly, Typhoid imposes direct medical costs on individuals and healthcare systems due to the need for treatment, including antibiotics. Secondly, there are indirect costs stemming from Typhoid-related productivity losses, where affected individuals may be unable to work or attend school, affecting income and educational attainment. Thirdly, the intangible costs encompass physical discomfort, suffering, anxiety, and emotional distress experienced by patients and their families during the illness. Lastly, Typhoid's societal impact is notable, particularly if it leads to community-wide transmission. To mitigate these effects and enhance life expectancy, investments in preventive measures, healthcare infrastructure, and public health interventions, alongside improved access to clean water and sanitation, are imperative in Delta State. This finding corroborates the findings of Isaiah (2019) which concludes that about 50.8% had access to improved water is crucial for preventing water-borne diseases. The finding is also supported by Alaba et al. (2019) which reinforce the importance of investing in clean water supply and disease prevention, in line with the policy implications discussed for Cholera and Typhoid in response to the regression results.

The analysis underscores the significant negative impact of Hepatitis A Rate (HAR) on life expectancy (LEX) in Delta State, signifying that rising HAR is linked to reduced life expectancy. This finding, when examined through the lens of the Cost of Illness Theory, reveals a multifaceted burden. Direct medical costs, stemming from the need for medical care and hospitalization for acute liver infections, place substantial financial stress on both individuals and the healthcare system. Indirect costs arise from income loss due to illness-related work absences and caregiving responsibilities, potentially impacting economic well-being. Additionally, intangible costs manifest as physical discomfort, pain, and emotional distress, which can detrimentally affect mental health and overall quality of life. Furthermore, Hepatitis A outbreaks strain healthcare resources and infrastructure, necessitating proactive measures like vaccination campaigns and health education to mitigate its societal impact. This finding collaborates with that of Timothy et al. (2017) which discovered a prevalence rate of 4.67% for Hepatitis A (HAV) among the studied population in Kaduna Metropolis, classifying it as hypo endemic. The finding aligns with the current results for Hepatitis A (HAR-LEX), which showed a significant negative effect on life expectancy in Delta State. The study identified young ages and blood transfusion as potential risk factors for HAV contraction, emphasizing the importance of proper water supply for preventing HAV infections.

The logistic regression analysis reveals that Amoebiasis Rate (AMR) significantly and negatively impacts life expectancy (LEX) in Delta State, with higher AMR associated with decreased life expectancy. Analyzing this result through the lens of the Cost of Illness Theory uncovers several dimensions of Amoebiasis's impact. Direct medical costs encompass expenses related to medical treatment, including doctor visits, medications, and

hospitalization, imposing financial burdens on both individuals and the healthcare system. Indirect costs arise from productivity losses due to illness-related work or school absences, affecting economic well-being for individuals and society. Intangible costs include physical discomfort, pain, and psychological distress, which can diminish the overall quality of life for those affected. Furthermore, Amoebiasis can be a public health concern, particularly in areas with inadequate sanitation, emphasizing the importance of preventive measures such as sanitation improvements, hygiene promotion, and access to clean water sources to alleviate its societal impact. This finding is consistent with that of Kingsley et al. **(**2022) which found a high prevalence of Amoebiasis among under-five children in Benin City, South-South Nigeria and emphasized factors like age, nutritional status, and water sources as significant determinants of Amoebiasis. These findings of Kingsley et al. corroborate with the current results for Amoebiasis Rate (AMR-LEX), which showed a significant negative effect on life expectancy in Delta State.

Overall, the findings from the logistic regression analysis emphasize the substantial impact of Cholera and Typhoid on economic, health, and societal dimensions in Delta State. These water-borne diseases impose significant direct and indirect costs, ranging from medical expenses to lost productivity and emotional distress. The Cost of Illness Theory highlights the imperative of proactive investments in preventive strategies, healthcare infrastructure enhancement, and public health education to alleviate the burden posed by Cholera and Typhoid. Particularly, ensuring access to clean water sources and improved sanitation facilities is pivotal in curbing disease incidence and enhancing life expectancy in Delta State. Simultaneously, the research reveals that Hepatitis A and Amoebiasis also exert detrimental effects on life expectancy. These findings underscore the multifaceted nature of the diseases' impact, encompassing medical, economic, and intangible costs, as well as societal repercussions. The imperative here lies in the implementation of comprehensive public health interventions, healthcare infrastructure development, and health education campaigns to mitigate the burdens associated with Hepatitis A and Amoebiasis, ultimately fostering improved overall well-being and life expectancy in Delta State.

5.2 Conclusion

Finally, this study, from the analysis and discussions so far, has illuminated the profound and multifaceted impact of waterborne diseases, namely Cholera, Typhoid, Hepatitis A and Amoebiasis, on life expectancy in Delta State, Nigeria. These findings resonate deeply with the tenets of the Cost of Illness Theory, shedding light on the substantial economic, health, and societal burdens imposed by these diseases.

First and foremost, the logistic regression results affirmed that Cholera, Typhoid, Hepatitis A and Amoebiasis exert significant negative effects on life expectancy. As the rates of these diseases rise, life expectancy tends to decrease. This finding resonates with the economic dimension of the Cost of Illness Theory. The direct medical costs associated with treating Cholera, Typhoid, Hepatitis A and Amoebiasis patients, including hospitalization, medication, and healthcare personnel expenses, impose a substantial financial burden on individuals and the healthcare system. Moreover, the indirect costs stemming from lost productivity due to illness and healthcare-seeking time further exacerbate the economic toll, both at the individual and societal levels.

The analysis also uncovered the detrimental effects of Cholera, Typhoid, Hepatitis A and Amoebiasis on life expectancy in Delta State. These diseases, too, impose significant direct medical costs and indirect economic consequences on affected individuals and communities.

The emotional and psychological toll, categorized as intangible costs within the Cost of Illness Theory, further underscores the suffering inflicted by these diseases on individuals and their families.

Societally, these waterborne diseases strain healthcare resources, increase healthcare expenditures for governments and organizations, and underscore the vital importance of investing in public health infrastructure and clean water provision. The findings highlight the pressing need for comprehensive policies and interventions to address these diseases, spanning vaccination programs, sanitation improvements, healthcare accessibility enhancements, health education campaigns, and food safety regulations.

The reliability tests conducted on the dataset underscore the robustness and validity of the regression model's findings, further bolstering the credibility of the study's implications. The high Cronbach's Alpha values indicate that the variables used in the analysis are reliable measures, enhancing the quality of the research.

Overall, the findings of this study not only serve to deepen the understanding of the public health challenges facing Delta State but have also underscored the urgent need for evidence-based policies and interventions. These must encompass vaccination programs, sanitation improvements, healthcare accessibility enhancements, health education campaigns, and food safety regulations. By prioritizing these measures and building on the study's findings, policymakers can significantly reduce the burden of waterborne diseases, enhance life expectancy, and improve the overall health and well-being of the population in Delta State. By adhering to the principles of the Cost of Illness Theory and prioritizing investments in preventive measures, healthcare infrastructure, and public health interventions, policymakers and stakeholders can alleviate the economic, health, and societal costs of these diseases, ultimately enhancing the well-being and life expectancy of the population in Delta State, Nigeria.

5.3 Recommendations

The following recommendations were based upon the findings:

i. Given the significant impact of Cholera, Typhoid, Hepatitis A and Amoebiasis on life expectancy in Delta State, it is imperative to integrate vaccination programs into routine immunization strategies. Policymakers should ensure that vaccines for these diseases are readily accessible and affordable, especially for vulnerable populations. By increasing vaccination coverage, Delta State can effectively reduce the incidence of Cholera, Typhoid, Hepatitis A and Amoebiasis leading to improved life expectancy.
ii. To address the negative effects of water-borne disease on life expectancy, Delta State should prioritize sanitation improvements and access to clean water sources. Investments in proper sewage disposal and the provision of safe drinking water, particularly in underserved areas, are essential. These improvements will not only reduce the economic burden but also enhance public health and well-being.
iii. Public health campaigns focusing on educating the population about the transmission of Cholera, Typhoid, Hepatitis A and Amoebiasis and the importance of safe food handling and hygiene practices are crucial. By empowering individuals with knowledge about preventive measures, Delta State can effectively reduce the incidence of these diseases and their impact on life expectancy.
iv. To mitigate the effects of water-borne disease on life expectancy, Delta State should work on enhancing healthcare accessibility. This includes expanding healthcare facilities,

especially in rural areas, to ensure that individuals can seek timely medical care. Improved healthcare access can lead to early diagnosis and treatment, ultimately reducing the burden of these diseases and increasing life expectancy.

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