

DIPLOMA THESIS

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**Investigation of the relationship between Economic Growth and
Influenza vaccination coverage of the Elderly:
A comprehensive exploration of influencing factors and outcomes.**

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TABLE OF CONTENTS

TABLE OF CONTENTS	3
INTRODUCTION	5
Influenza Virus:	5
Vaccination as a prevention strategy:	5
Economic growth and influenza vaccination:	6
Factors that could influence influenza vaccination coverage and potential health outcomes: ...	7
OBJECTIVES	9
METHODS	10
STUDY DESIGN	10
STUDY SAMPLE	10
DATA COLLECTION	10
DATA ANALYSIS	11
RESULT SECTION	12
Summary of Descriptive Statistics	12
RESULT SECTION 2: Correlation analysis	23
Table 1 Summary Table of the association of influenza vaccination coverage among the elderly with various health outcomes.	25
Association of influenza vaccination of the elderly with various health outcomes:	26
Table 2 Summary Table of the association of influenza vaccination coverage among the elderly with various health outcomes.	27
Table 3 Summary Table of the association of influenza vaccination coverage among the elderly with age-standardized death rates	31
Table 4 Summary Table of the association of influenza vaccination coverage among the elderly with other vaccines	33
DISCUSSION	34
CONCLUSION	37
LIMITATIONS	39
ACKNOWLEDGEMENT	39
DEDICATION	39
BIBLIOGRAPHY	40

ABSTRACT:

INTRODUCTION: Influenza is a significant global health concern, accounting for about 290,000 to 650,000 deaths annually, worldwide. It is a highly communicable respiratory disease, that poses an increased risk of severity to elderly individuals. Over time, influenza vaccination has proven to be an effective strategy for preventing the Influenza virus and other complications, however, the rate of influenza vaccination varies across countries and regions. A recent study found that the influenza vaccination coverage among elderlies in high-income countries was significantly higher than that in low-income countries, indicating the contribution of the economic status of a country to the extent to which the elderly.

METHODS: To investigate the association between the Gross Domestic Product (GDP) and the influenza vaccination coverage of the elderly, considering the relationship of other contributing factors.

Secondary data from publicly available sources was used in this study. Data on Gross Domestic Product (GDP) was collected from the World Bank Open database. The data on influenza vaccination coverage of the elderly was obtained from the European Health for All database. Data analysis was conducted using STATA statistical software Version 13. A Spearman Rank Correlation was performed to identify the relationship between the GDP and influenza vaccination coverage of the elderly.

RESULTS: The study sample comprised the influenza vaccination coverage of the elderly and the GDP of 56 countries, from 2008 to 2018. The median value of the influenza vaccination coverage of the elderly was 38.40% (IQR 13.70% – 56.90%), this suggests that the distribution of influenza vaccination coverage is quite variable among the elderly population, with the middle 50% ranging from 13.70%. Of the 56 countries analyzed, GDP had a median value of 75,000,000,000\$ (IQR 18,000,000,000 – 390,000,000, 00), indicating a wide range having that 50% of the GDP among the 56 countries, falls within the aforementioned range. A very significant positive association was found between the Gross Domestic Product and the influenza vaccination coverage of the elderly ($p\text{-value} \leq 0.001$, correlation coefficient (ρ) = 0.577).

CONCLUSION: There was a significant association between the influenza vaccination coverage of the elderly and the Gross Domestic Product, indicating that the coverage of the influenza vaccination of the elderly will increase if there is an increase in GDP. Hence, we recommend countries engage in economic development to increase influenza vaccine coverage among elderlies.

INTRODUCTION

Influenza Virus:

Influenza, also known as the flu, is a highly contagious respiratory infection caused by Influenza viruses (Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases (NCIRD), 2022). Since the outbreak of the influenza virus in the early 1900s, it has remained a persistent threat to global health, causing significant morbidity and mortality annually. Influenza A (H1N1 and H3N2 subtype) and Influenza type B are responsible for influenza infections in humans. These viruses can mutate rapidly, evolving into more lethal strains, evading the host community, and leading to the manifestation of a variety of symptoms. According to health experts, the influenza virus poses an increased severity and risk of complication to the elderly (individuals 65 years and above) amongst other populations. It is spread mainly through viral droplets in the air, attacking the upper and lower respiratory tract and causing inflammation of the upper respiratory tree and trachea, accompanied by symptoms like cough, sour throat, fever, and in severe stages acute respiratory distress syndrome (ARDS) (Boktor SW, 2023). The World Health Organization (WHO) estimates the incidence of the dreaded influenza virus to be about a billion cases annually, with death tolls reaching 650,000 deaths, per year (WHO,2023).

Vaccination as a prevention strategy:

Prevention is key to ensuring global health and is an important tool in the fight against influenza. Health promotion and disease prevention is defined as a proactive approach to maintaining good health and well-being by taking steps to avoid illness, disease, and injury. The stages of prevention are classified into primary, secondary, and tertiary prevention stages based on the stage of the disease and the effectiveness of intervention. Primary prevention refers to prevent the diseases before they occur by implementing interventions such as vaccination and health education, secondary prevention aims at detecting and treating a disease early before it results in any significant symptom or complication while tertiary prevention is aimed at restoring health and the provision of rehabilitation (Abdulraheem,2023). Primary prevention of influenza includes annual seasonal influenza vaccination, adopting healthy lifestyle practices like respiratory hygiene, and avoiding contact with sick persons, while secondary prevention includes rapid diagnostic tests and tertiary prevention includes respiratory rehabilitation, cardiac rehabilitation (WHO EMRO,2024).

The development of the influenza vaccine has been lauded as one of the greatest achievements of public health (Okuhara,2022) . In a recent study co-authored by the Centre for Disease control (CDC), it was found that Influenza vaccines offer substantial levels of

protection against serious illness as well as increased protection against infection and minor illnesses, including those brought on by the most severe acute respiratory distress syndrome (Nathaniel M Lewis, n.d.). The importance of vaccines cannot be neglected as they constitute great benefits to individuals and the public. The administration of vaccines helps to stimulate the immune system of the body, increasing the production of antibodies and strengthening the immune response of the body to diseases. The definite benefits of vaccines, particularly the influenza vaccine, make it a very relevant pivotal tool in the fight against influenza in the global population, especially the high-risk groups, the elderly, and children. One study confirms that the uptake of the influenza vaccine in elderlies is correlated with the rate of all-cause mortality in elderlies, specifically highlighting that uptake of the influenza vaccine was most likely able to significantly reduce death from all-cause in the population aged 65 and above but its effectiveness could be negligible without adequate vaccine coverage (Lapi F, 2022). Another systematic review published in 2023 on “influenza vaccine effectiveness against laboratory-confirmed influenza among older adults in aged care facilities” concludes the influenza vaccine remained a very relevant measure to preventing the Influenza virus and its complications among older adults in aged care facilities, not undermining the influence of other preventive measures (Moa A, 2023 Dec 15). However, significant differences were still observed, regarding the vaccination rate between low, middle, and high-income countries, reflecting disparities in access, awareness, and socioeconomic factors.

Economic growth and influenza vaccination:

Economic development, usually measured as the Gross Domestic Product (GDP) per capita of a country has been observed to suggestively have a strong association with the rate of influenza vaccination in the elderly population. The GDP per capita stands as the cornerstone metric, widely accepted to measure a country’s economic status. GDP is the standard measure of the value added created through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production or the total amount spent on final goods and services (less imports) (OECD). A meta-analytic study of 522 studies from 68 countries/regions conducted, revealed that the overall global influenza vaccination rate was poor, especially in the priority groups, that is children and the elderly, but the rates still differed between middle-income countries and high-income countries, as high-income countries still had a supposedly higher vaccination rate compared to middle-income countries, suggestive of the sheer importance of the economic status of a country as regards the vaccine coverage (Chen C, 2022).

Factors that could influence influenza vaccination coverage and potential health outcomes:

The potential loss of human lives annually from influenza remains a substantial burden on public health, especially in high-risk groups (Marchi S, 2023 Aug). By 2030, about 1 in every 6 people globally will be aged 60 or above, and with the increasing proportion of the aging population, concerns about the factors that could influence the rate of influenza vaccine coverage become more profound (WHO, Ageing and Health, 2023). The World Health Assembly in 2003 adopted resolution, urging countries to increase the rate of influenza vaccination among the High-risk group to about 75% by 2010, due to the increasing mortality and surging incidence rate of the influenza virus (WHO, managing seasonal vaccination policies and coverage in the European Region,2023). Furthermore, in 2005, this goal was reaffirmed by the WHO. A 75% coverage rate of influenza vaccine would be a substantial level of progress in the fight against the influenza virus, a study conducted in 2014 concluded that by achieving the 75% vaccination coverage, about 1.6 to 1.7 million cases, 9,800 to 14,300 deaths and about 678,500 to 767,800 physician visits, will be averted, (Preaud E, 2014 Aug 7.). Even in the light of the benefits of reaching this targeted coverage recommended, influenza vaccination coverage of the elderly has remained generally low, regardless of the economic status of countries, globally. In an article published by the WHO on “managing seasonal vaccination policies and coverage in the European region, it was stated that only the Netherlands had ever reached the target of 75% coverage mark of the high-risk group (WHO, managing seasonal vaccination policies and coverage in the European Region,2023). This is then suggestive of a complex interplay of several factors with the influenza vaccination coverage rate among the elderly beyond the economic status of countries.

Among several factors, educational intervention might influence the influenza vaccination rate among the elderly. Health education is any combination of learning experiences that could facilitate voluntary actions conducive to health. Education is a very important intervention in trying to improve vaccine uptake and, consequently, coverage, as higher education is associated with more vaccine uptake (Huth K, 2015). A cross-sectional survey conducted by Cohen et al in New York Heights concluded that more educated adults had higher tendencies to get vaccinated (Cohen,2010). Another study conducted in Serbia detected the importance of education to influenza vaccine uptake among older people as the results of the study indicated that the health sector requires a well-coordinated health campaign to enhance flu vaccine uptake and therefore secure higher vaccination coverage among the elderly (Gazibara T, 2019). The facilitation of a better knowledge base about the flu vaccine might be a good influencing factor.

Furthermore, the health sector consists of businesses that provide medical services, manufacture medical equipment or drugs, provide medical insurance, or otherwise facilitate the provision of healthcare to patients. It is one of the most important economic sectors of a country, as it not only provides economic benefits but ensures conditions in which people (the general population) can be healthy through the provision of medical services and, the institution of health laws and policies. The total health expenditure as a percentage of the GDP is the total amount of financial resources spent on health care in a country, within a specific period as part of the GDP (WHO, Health expenditure,2023). The total health expenditure constitutes an integral part of the healthcare system development and might influence the rate of influenza vaccine coverage but data regarding this indicator of this association is insufficient. Zunino et al conducted a study to assess the relationship between healthcare spending and vaccination in low-income countries, and the result of the study suggested an increase in healthcare expenditure would make a profound impact on vaccination coverage in low-income, however, not much impact was observed in high-income countries (Zunino, 2020). The healthcare expenditure might be a potential contributor to the influenza vaccination coverage among the elderly.

The rate of unemployment might also be associated with the Influenza vaccination coverage rate among the elderly. According to the Corporate Finance Institute, Unemployment is a term used to describe a status where individuals who are employable and actively seeking a job are unable to find a job. Unemployment is an integral contributor to the health of the economy of a country (CFI,2023). In a study conducted in Canada, the relationship between the unemployment rate and influenza vaccination coverage rate was found to be negative. Indicating that an increase in the number of unemployed Canadians could slow the rate of influenza vaccination, significantly (Reisman et al, 2015). Another study conducted in America detected that high-state unemployment increased the likelihood of the widespread influenza virus (Cornwell B. 2012). Unemployment constitutes a wide range of impacts, which may include the influenza vaccination rate. More on factors that could suggestively influence the rate coverage of the influenza vaccine among the elderly, the density of nurses, which is the number of nurses (health practitioners) in a defined settlement could be a potential influencer of the vaccination coverage among the elderly. An econometric analysis conducted cross-country detected that the number of nurses in a settlement could significantly influence the availability and consequently the coverage rate of vaccines positively meaning more nurses could mean more vaccination (Anand S, 2007). The disability-adjusted life expectancy could also be an influencing factor in the rate at which influenza vaccination occurs in the elderly population. Disability-adjusted life expectancy measures the years of life lost due to both fatal

and non-fatal disease burdens (GBD Collaborators, 2017). Furthermore, the impact of influenza seems to be modest, but it is not. The influenza vaccination suggestively influences a broad spectrum of factors like estimated life expectancy at birth, number of days spent in the hospital, Hospital resource utilization, mortality rate, and many more integral aspects of society's life, particularly of people aged 65 or above. Hence, what indicators and how they influence the influenza vaccine coverage rate among the elderly becomes an integral question to answer.

OBJECTIVES

The main aim of the present study was to investigate the relationship between the economic growth of a country and its effect on the influenza vaccination coverage of the elderly, the population aged 65 or above.

As a secondary aim, we planned to investigate several factors that could contribute to the influenza vaccination coverage of the elderly, the population aged 65 or above, and the outcome of this complex interplay as well.

METHODS

STUDY DESIGN

This study is a longitudinal correlation-ecological study that was performed utilizing data from publicly available online sources. The indicators collected are those relevant to the elderly population, i.e. the population aged 65 and above.

STUDY SAMPLE

The targeted population was the elderly, that is, the population aged 65 years or above. There was no categorization into gender groups, as only the total number of the population including males and females was considered for the study.

DATA COLLECTION

Data were collected from 2008 – 2018 for 56 countries relevant to the research question were gathered from publicly available sources online. Data regarding Gross Domestic Product per capita was gathered from the World Bank open Database, an open-access database that collects data regarding economic indicators of about 189 countries, nations, and sub-nations (The World Bank, GDP). Furthermore, the data of other indicators were collected from the Health for All Database (HFA), which is a database that allows access to the regional, national, and sub-national core health statistics which include indicators and metadata, which are visualized through interactive online tools. The indicators were downloaded directly from the HFA database, with a specific focus on datasets from 2008 to 2018. The indicators downloaded amongst others included data on the influenza vaccination coverage of the elderly, GDP, total health expenditure as a percentage of the GDP, number of general practitioners per 10,000, age-standardized death from all causes 65+, mortality rate from influenza-related causes 0-64 years, deaths from smoking-related causes, deaths from disease of respiratory system per 100,000, deaths from disease of the circulatory system per 100,000, 65+, deaths from bronchitis/emphysema/asthma all ages estimated life expectancy at birth, estimated infant mortality per 1,000 live births, probability of dying before age 5 per 1,000, Hemophilus influenza type B vaccination coverage, Diphtheria vaccination coverage, Pertussis vaccination coverage, poliomyelitis vaccination coverage, Rubella vaccination coverage, mumps vaccination coverage, measles vaccination coverage, Public expenditure on health, purchasing power parity (USD) per capita, unemployment rate and average inflation rate.

The data was cleaned, and upon cleaning only 45 countries remained. Then all the remaining indicators were formatted and merged into a single dataset suitable for statistical analysis.

DATA ANALYSIS

Data were analyzed using Stata version 13 software. The data of the different countries and different indicators were matched using Microsoft Excel. Following simple descriptive statistics, Spearman rank correlation was executed, where correlation coefficients were evaluated with their corresponding p-values. The p-values obtained from the statistics tests were considered as significant if the p-value from the given procedure was smaller than 5%.

RESULT SECTION

The section consists of two parts; the first is a summary of the descriptive statistics performed and the second section presents results of the correlational analyses performed.

Summary of Descriptive Statistics

Fig.1 and Fig 2 below presents the median influenza vaccination coverage of the elderly between 2008-2018 as compared to the influenza vaccination coverage recommendation by the World Health Organization (WHO) in the 45 selected countries. A median vaccination coverage of 38.40% (95% CI 13.7% - 25.9%) was observed, which was low compared to the 75% coverage recommended by WHO. The Netherlands in 2008 had the highest percentage of vaccination coverage 82.50% while the lowest was recorded in 2015 in Kyrgyzstan with only about 0.20% of the elderly population receiving the vaccination. However, The average vaccination coverage was 37.05% across the selected countries.

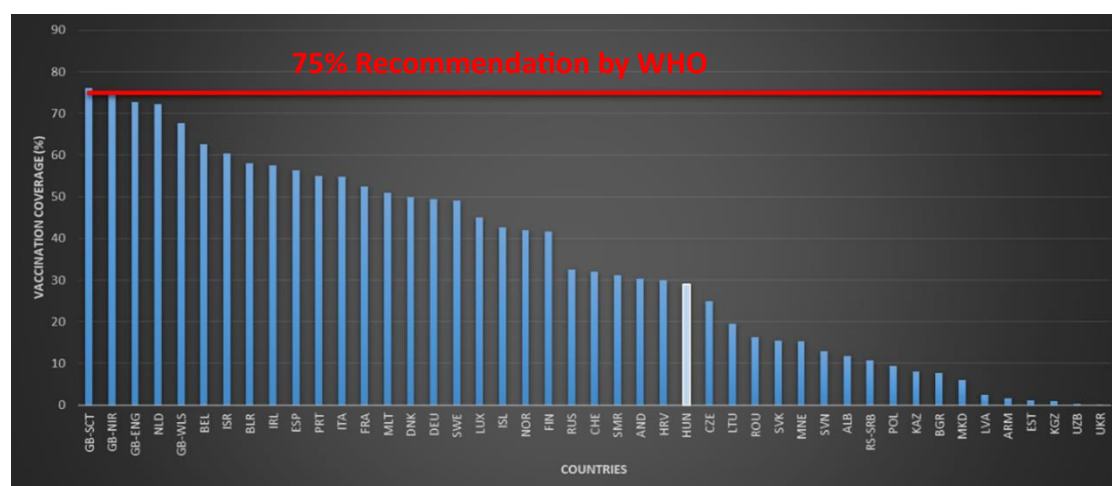


Figure 1. Median distribution of influenza vaccination coverage among the elderly between 2008 and 2018 against the WHO vaccine coverage recommendation across 45 countries

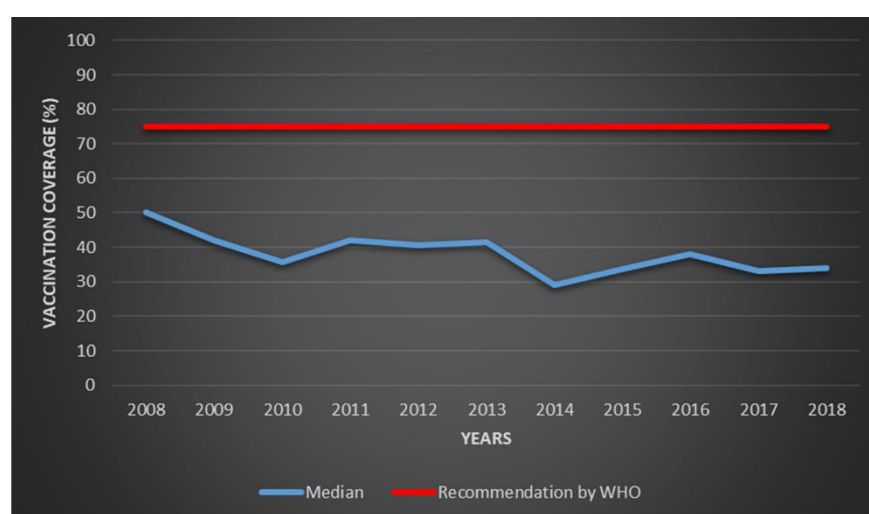


Figure 2. Median distribution of influenza vaccination coverage among the elderly between 2008 and 2018 against the WHO vaccine coverage recommendation

The Gross Domestic Product (GDP) across the 45 selected countries was an average of 385,000,000,000. The minimum GDP reported through the 45 countries was 1,420,000,000\$ and the maximum was 397,000,000,000,000\$ between 2008 and 2018. The median value of the GDP was 75,200,000,000\$, indicating that 50% of the observations fell below this value. An illustration is shown in figure (3) below.

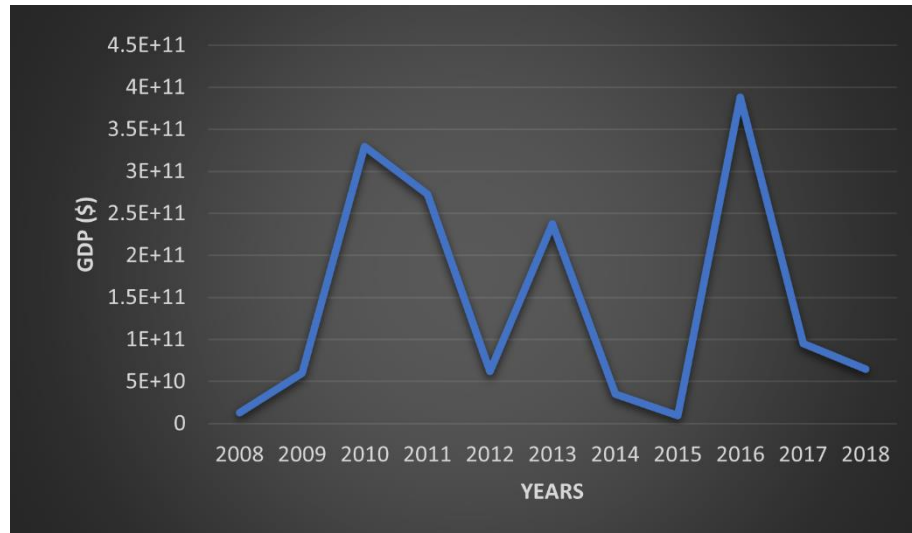


Figure 3. Median distribution of GDP (\$) between 2008 and 2018

As shown in figure 4 below, the health expenditure as a percentage of the GDP reflects that the financial commitment to health care spending as a proportion of total economic output in the 45 selected countries was an average of 7.38% (95% CI 7.14% - 7.63%), between 2008 and 2018. The lowest observed percentage expenditure was 2.1% and the highest financial outlay was 12.4%, during the sample period. The median value was 7.37 %, which indicates half of the period had a health expenditure lower than 7.37% and the other half had a health expenditure allocated as part of the GDP, that was above 7.37%.

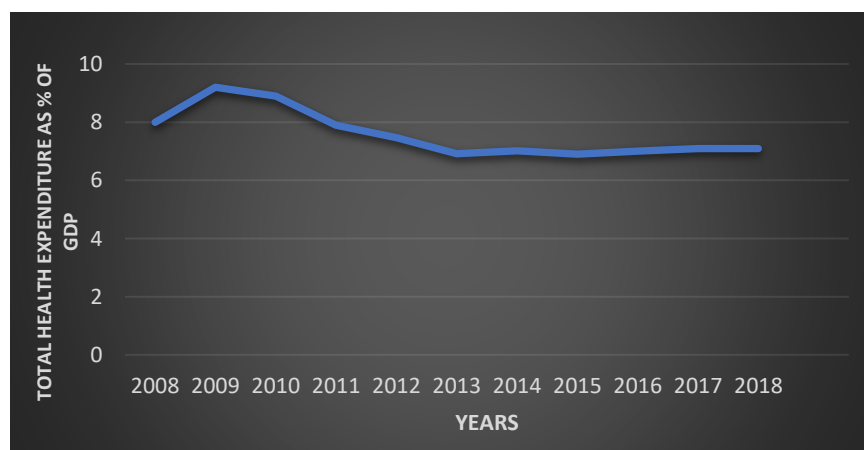


Figure 4. Median distribution of Total Health expenditure as % of GDP between 2008 and 2018

Public expenditure on health, purchasing power parity (USD) per capita, which is the amount of money a government spends on health care per person, adjusted for differences in the cost of living across countries, was estimated to be an average of 1757.80\$, for the 45 selected countries between 2008 and 2018. The analysis revealed a median value of 1315.03\$, indicating that a significant portion of the expenditure fell below 1315.03\$.

As shown in figure 6 the rate of unemployment within the 45 selected countries was a mean value of 9.27% (95% CI 8.70% - 9.84%), with the least percentage of the labor force population actively seeking but do not have a job being about 0.30% and the highest reporting a value of 33.80% between 2008 and 2018. The summary statistics reveal a median value of 7.40%.

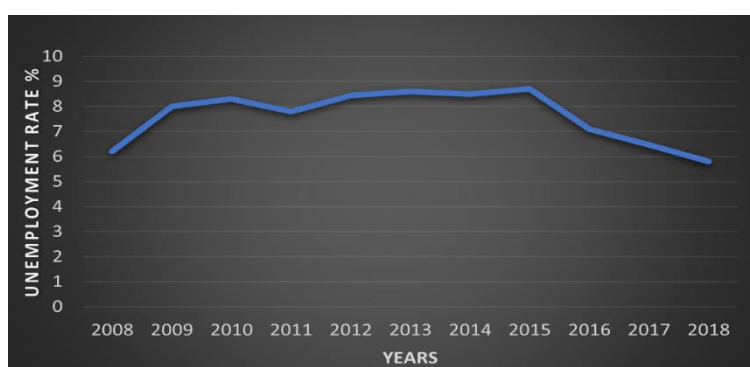


Figure 6. Median distribution of unemployment rate between 2008 and 2018

As regards the annual average inflation rate it was determined that there was an average of 2.36% (CI 2.08%- 2.64%) change in price of goods and services between 2008 and 2018, in the 45 selected countries, with the maximum change being 16.5% and the minimum change being -4.5%. A median value of 1.7% was observed indicating half of the rate of price change of goods and services was below 1.7%, while the other half was above. An illustration is shown in figure 7 below.

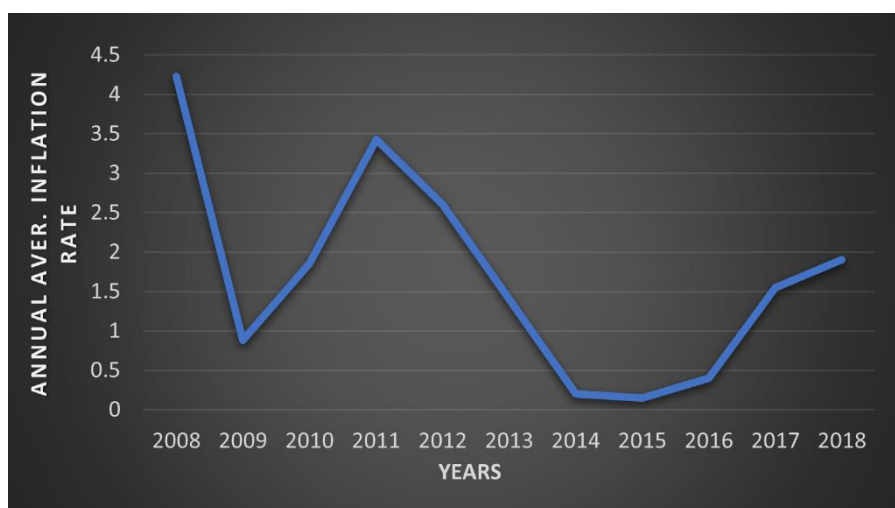


Figure 7. Median distribution of annual average inflation between 2008 and 2018

The estimated life expectancy at birth across 45 selected countries presents an average of 77.12 years (95% CI 76.22 - 78.02). The maximum number of years of life expected at birth was an estimated 83.07 years and the minimum was 67.31yrs, in the 45 selected countries between 2008 and 2018. The median value of 77.70 indicated that half of the population's life expectancy was below 77.70 years, and the other half was above 77.70 years at birth.

As shown in figure 8 below, the number of general practitioners per 10,000 in the 45 selected countries was estimated to be an average of 6.00 persons (95% CI 5.82 - 6.49), with the greatest number of GPs per 10,000 being 24.00 and the least number being about 0.24. Moreover, the number of nurses per 100,000 was an average of 793.25 persons (95% CI 748.64 - 837.86), with a maximum number of 1999.00 nurses per every 100,000. The analysis revealed a median value of 648.00 people.

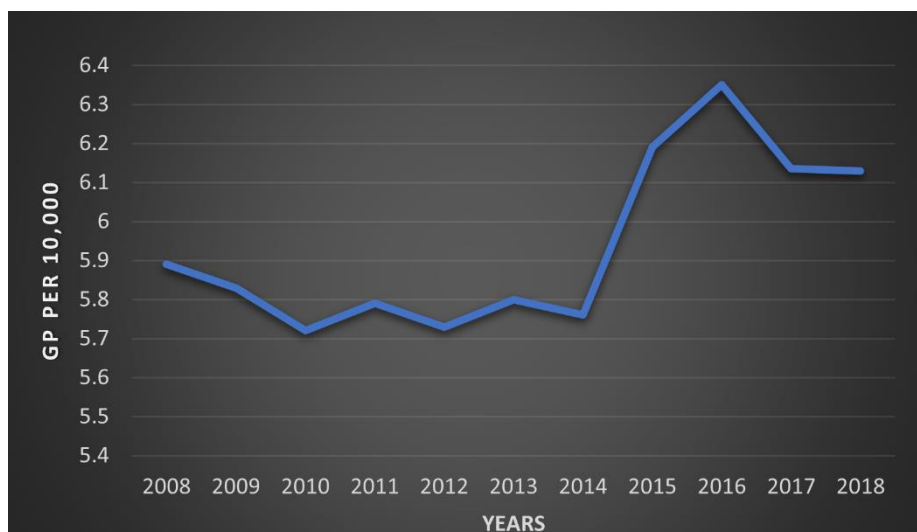


Figure 8. Median distribution of GP per 10,000 between 2008 and 2018

Regarding the Disability life expectancy (DALE), the analysis revealed a mean value of 76.45 years (CI 75.99 - 76.92), with the highest DALE being 83.36 years and the least being 64.53 years and a median value of 76.85, half the DALE are below 76.85 and half are above. Figure 9 below illustrates the finding.

The rate of death from Influenza virus infection in individuals per 100,000 of the 0-64 years population was an average of 0.17 deaths (95% CI 0.14 - 0.19). The minimum rate was 0 and the maximum rate was 2.4. median value of 0.7 was observed, meaning between 2010 and 2018 half of the death rates from influenza in the population aged 65 and above was lower than 0.7 and the other half was higher than 0.7, across the 45 selected countries.

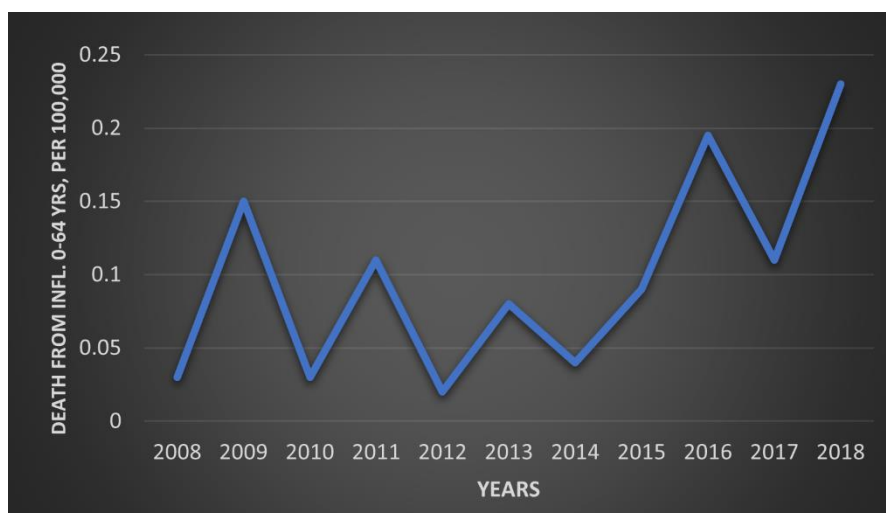


Figure 11. Median distribution of death from influenza per 100,000 0-64years between 2008 and 2018

More so, the standard death rate from respiratory diseases in all ages was reported to be an average of 42.37 deaths (95% CI 40.65 - 44.08) per 100,000 between 2008 and 2018. The Highest rate of deaths from respiratory diseases was 157.48 and the lowest was 9.67 deaths, in the sample period. The median value of 39.34 indicates that half the rates at which respiratory deaths occurred in the general population regardless of age, was higher the 39.34 deaths and the other half was lower than 39.34 deaths, in the 45 selected countries.

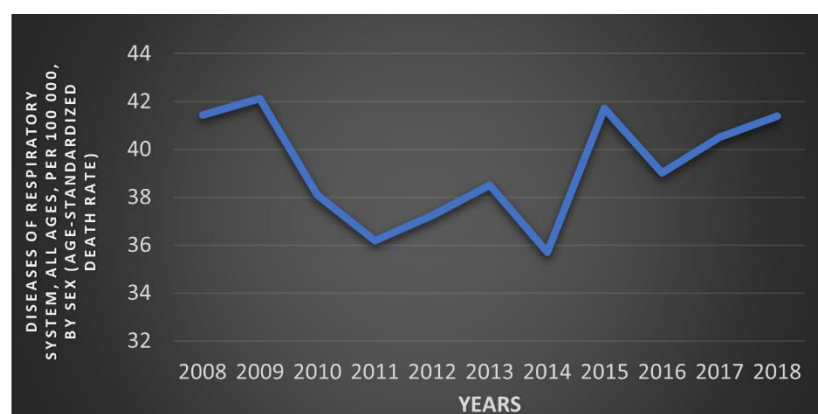


Figure 12. Median distribution of death disease of resp. system per 100,000, all ages between 2008 and 2018

The mean for the selected smoking-related causes of death per 100,000 by sex across the selected countries was an average of 252.45 deaths (95% CI 238.3454 - 266.5496), with the maximum rate of death being 776.51 and a minimum of 92.59, between 2008 and 2018. The analysis revealed a median value of 191.89 deaths.

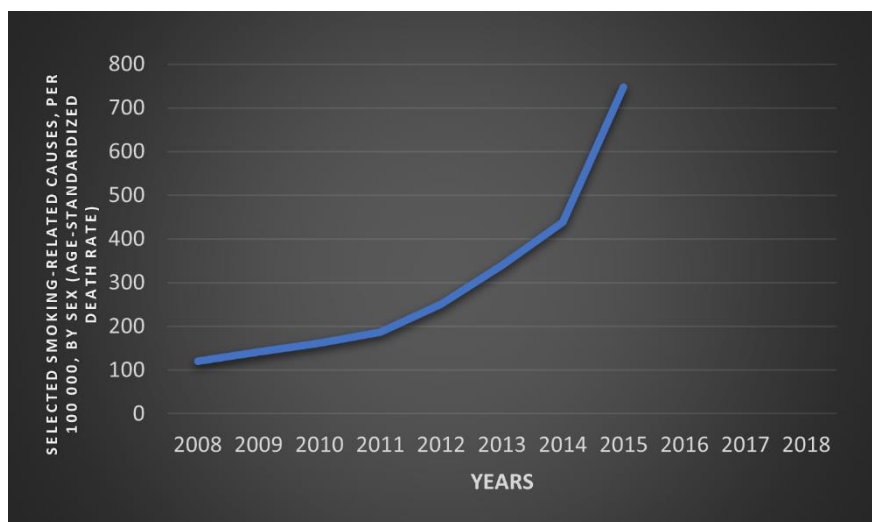


Figure 13. Median distribution of death from selected smoking-related causes per 100,000 between 2008 and 2018

Across the 45 analyzed countries between 2008 and 2018, the rate of deaths from the disease of circulatory among the population aged 65 or above was estimated to be an average of 2285.24 deaths per 100,000 (95% CI 2165.62 - 2404.86). The maximum death rate was 5313.32 deaths, and the minimum was 697.73 deaths. Half of the population's death rate was above 1803.13 deaths and the other half fell below. An illustration is shown in the figure (14) below.

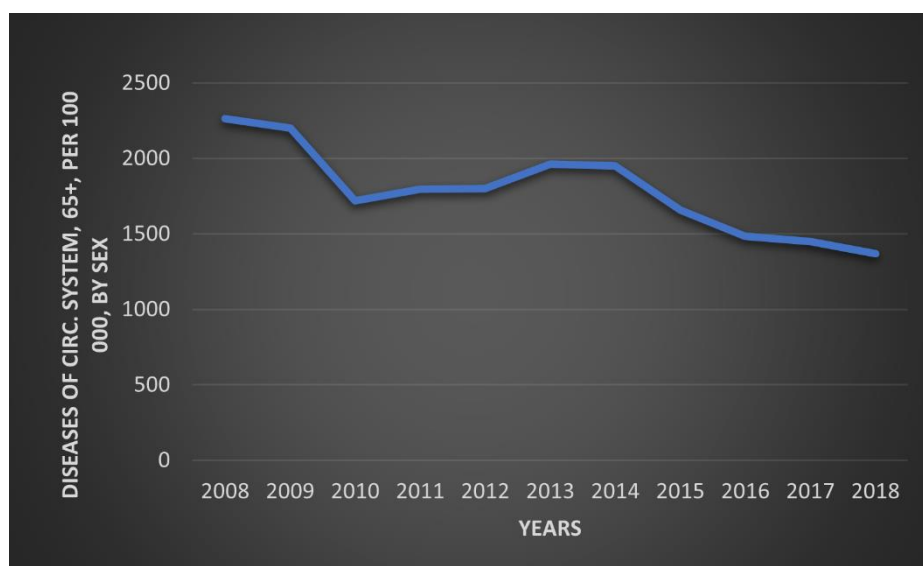


Figure 14. Median distribution of death from disease of circ. System. 65+ per 100,000 between 2008 and 2018

Furthermore, the mean deaths from bronchitis/emphysema/asthma in all ages per 100,000 by sex was 3.72 deaths (95% CI 3.41 - 4.02), where the highest rate of death was 21.09 deaths, and the lowest was 0, between 2008 and 2018. The median value was 3.06.

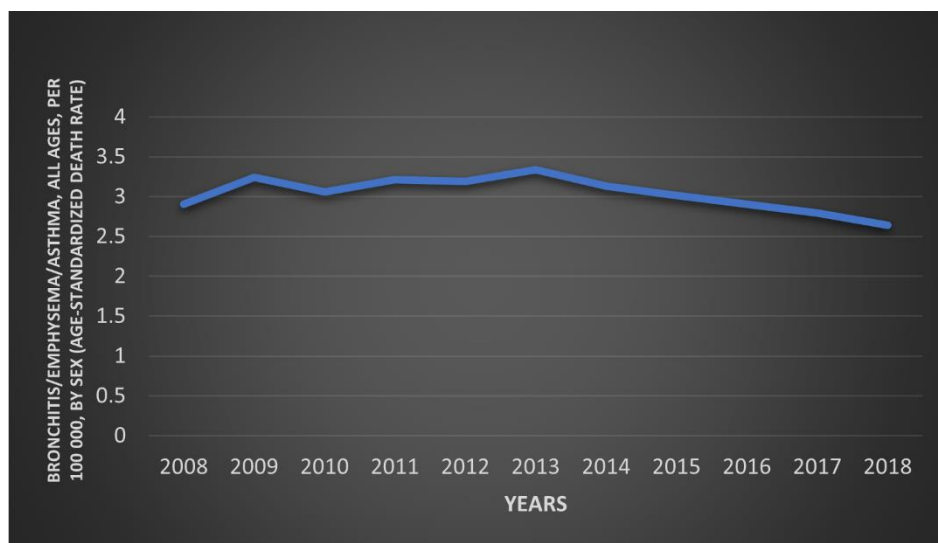


Figure 15. Median distribution of death from Bronchitis/emphysema/asthma per 100,000 between 2008 and 2018

The rate of death resulting from all causes in the population aged 65 or above across the selected 45 countries, was an average of 4449.55 deaths per 100,000(95% CI 4342.49 - 4556.60), with the highest rate of death being 7188.04 deaths and the lowest, 2795.6 deaths, between 2008 and 2018. Furthermore, a significant proportion of the deaths were estimated to be below 4150.76 deaths and half are above.

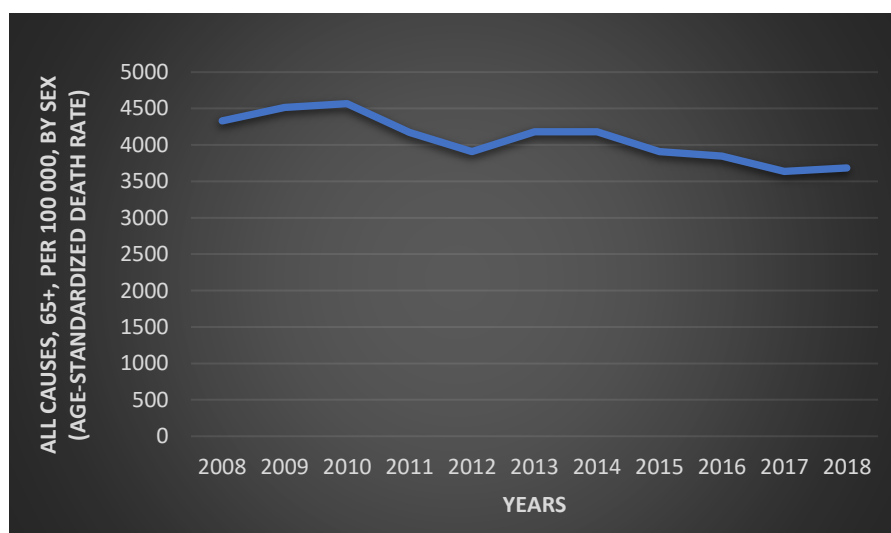


Figure 16. Median distribution SDR all causes 65+ between 2008 and 2018

Descriptive statistics of other vaccines

The percentage of infants vaccinated against invasive disease due to *Hemophilus influenza* type B was an average of 90.11% (95% CI 88.099 - 92.12), with the highest number of vaccinated children being 99%, the median value was 96.5 %. (Figure 17.)

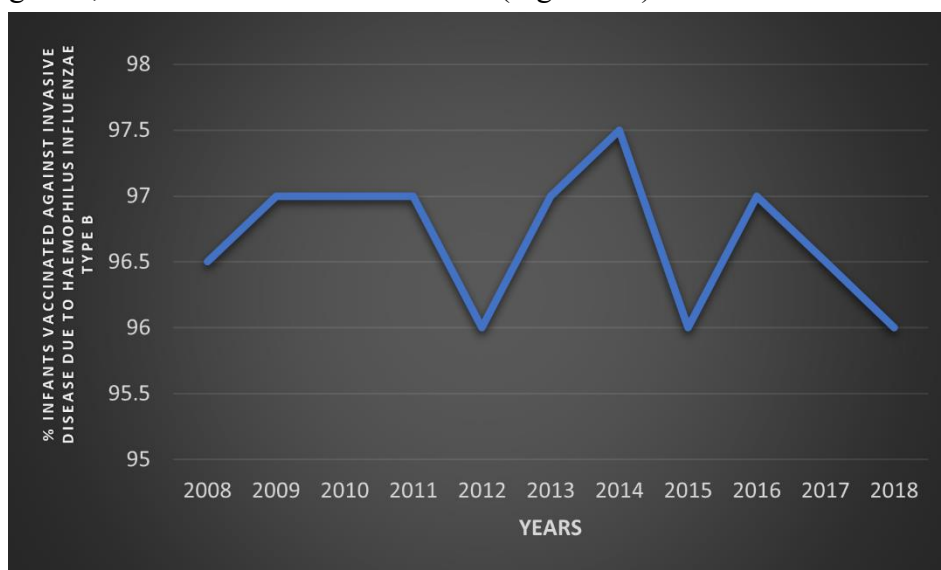


Figure 17. Median distribution % of infants vaccinated against Hem. B between 2008 and 2018

As shown in fig.18 below , across the 45 countries, the percentage of infants vaccinated against diphtheria presented a mean value of 94.29% (95% CI 93.65% - 94.93%). Half of the percentage vaccinated was below the value of 96%, while the other half was above. The maximum number of children vaccinated was 99% while the minimum was 19%.

The percentage of infants vaccinated against tetanus across the 45 countries was an average of 94.29% (95% CI 93.65% - 94.93%), with a maximum value of 99% and a minimum value of 19%. The result presented a median of 96%.(Figure 19)

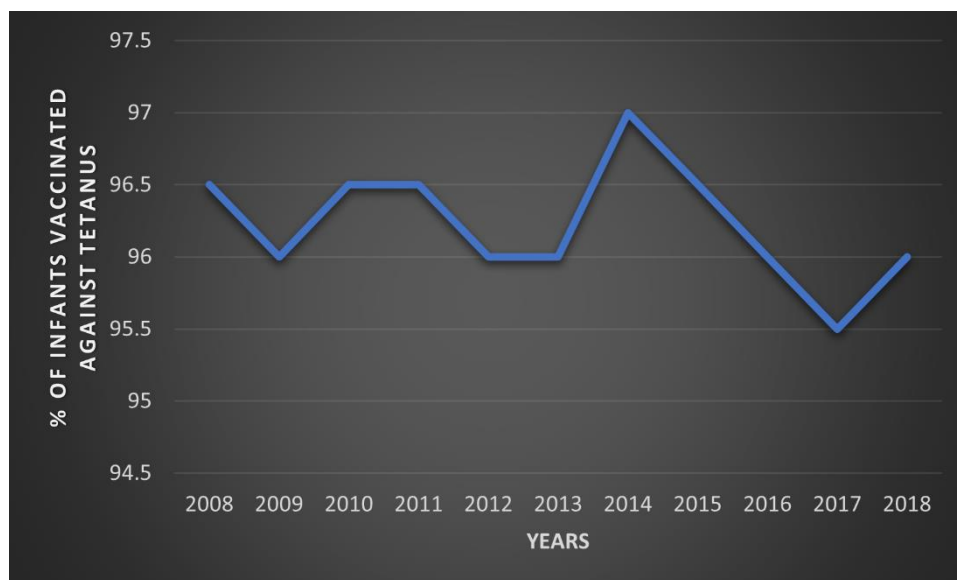


Figure 19. Median distribution % of infants vaccinated against Tetanus between 2008 and 2018

Furthermore, an average of 94.29% (93.65% - 94.93%) of infants were vaccinated against pertussis across the 45 countries with the highest percentage of vaccination being 99% and the lowest, 19%. This had a median value of 96%.

The mean value of the percentage of infants vaccinated against measles across the 45 selected countries was 93.51 % (95% CI 92.91% - 94.09%). The highest percentage of children vaccinated against measles was 99% and the lowest was 42%. The median value was 96%.

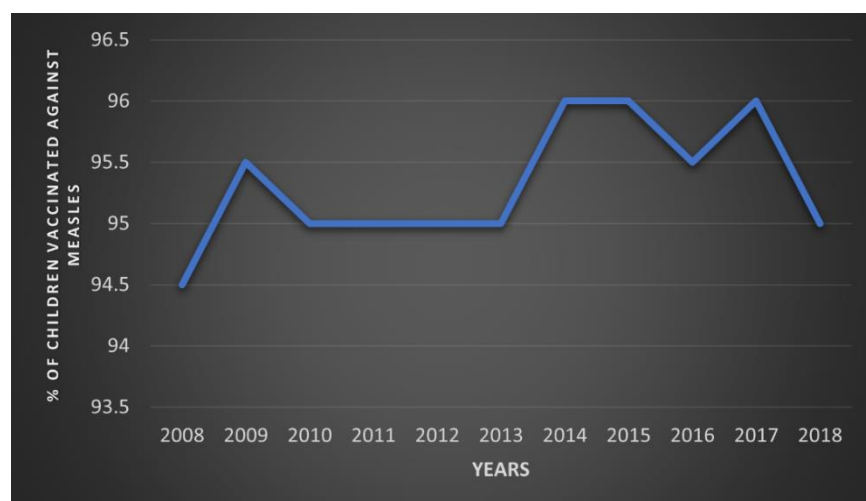


Figure 21. Median distribution % of infants vaccinated against measles between 2008 and 2018

The percentage of infants vaccinated against mumps across the 45 selected countries was an average of 93.74% (95% CI 93.14% - 94.34%). The maximum percentage of children

vaccinated was 99% and the minimum was 42%. The results presented a median value of 96%. (Figure 22)

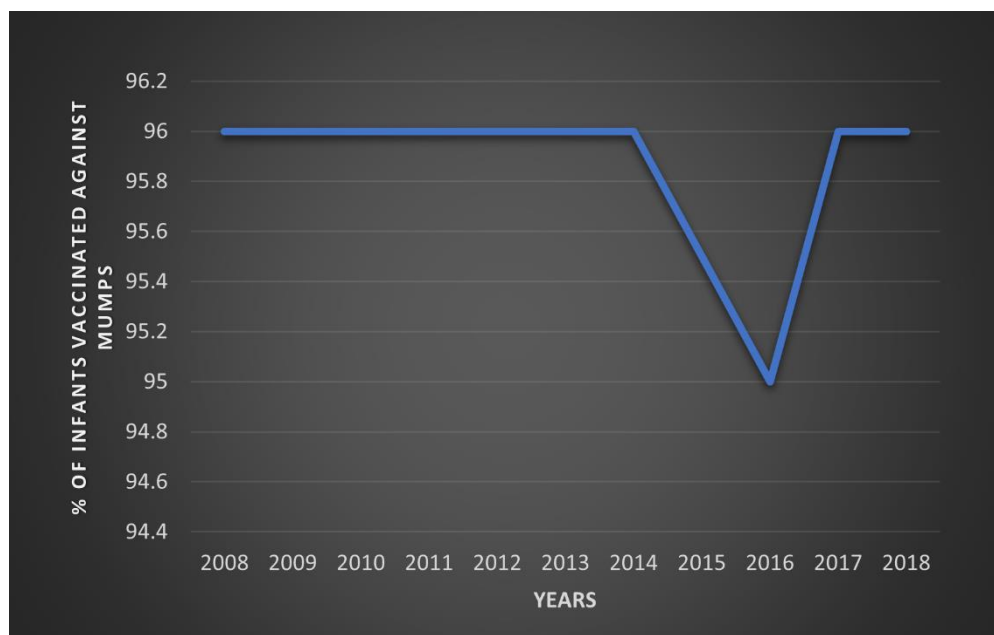


Figure 22. Median distribution % of infants vaccinated against mumps between 2008 and 2018.

An average of 93.65% (95% CI 93.02% - 94.27%) of infants were vaccinated against rubella across the 45 selected countries, between 2008 and 2018, with the highest percentage being 99% and lowest 42%. The mean value was 96%.

Across the 45 countries, the percentage of infants vaccinated against poliomyelitis presented a mean value of 94.43% (95% CI 93.90% - 94.96%). Half of the percentage vaccinated was below the value of 96%, while the other half was above. The maximum number of children vaccinated was 99% while the minimum was 45%.

RESULT SECTION 2: Correlation analysis

Presenting the result of the Spearman rank correlation

Further investigations were made into the relationship between influenza vaccination coverage among the elderly and the GDP, including other variable factors that could contribute to influenza vaccination coverage among the elderly.

Spearman's Rank correlation was used to generate the results of this quantitative correlational analysis. The result of Spearman's Rank correlation presented in this sub-section is aimed at showing the statistical relationship between the influenza vaccination coverage and other variables used in the model of this study as well as the strength of the relationship between these variables.

Table 1 below, presents the result of the analysis showing the P-value and the correlation coefficient of every pair of variables.

The Spearman's rank correlation indicated that there was a positive correlation between the Gross Domestic Product (GDP) per capita and the Influenza Vaccination coverage rate in the population of the elderly i.e. people aged 65 and above, with a correlation strength of 0.577, which implied a strong relationship. This was a statistically significant association (p-value <0.001). This therefore means that more elderly population will likely get vaccinated as the Gross domestic product increases.

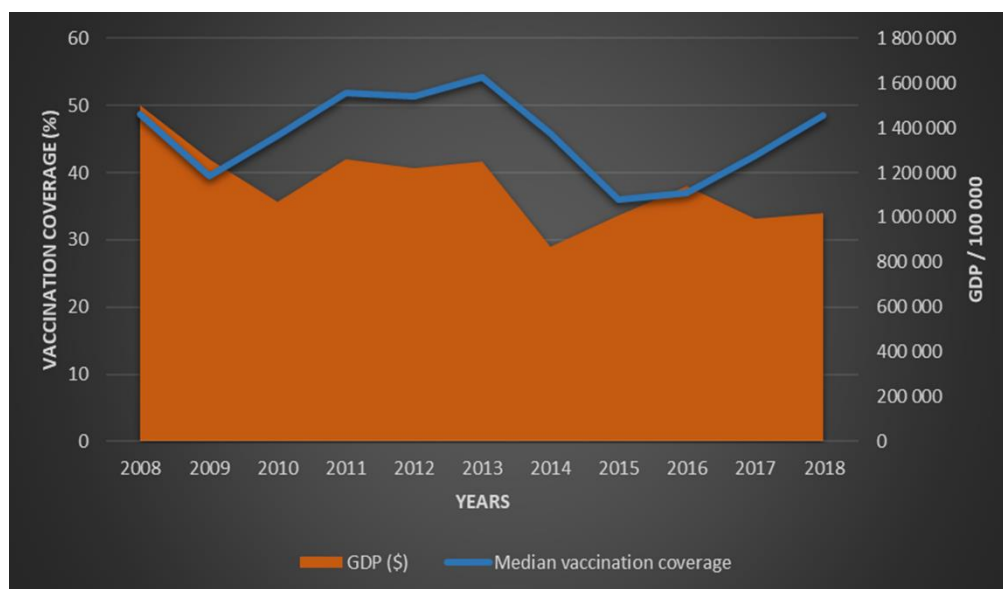


Figure 25. Graph illustrating the association between GDP and Median vaccination coverage between 2008 and 2018.

The Spearman's rank correlation indicated that total health expenditure as a percentage of the Gross Domestic Product was positively correlated with the influenza vaccination coverage rate of the elderly. This was a significant correlation (P-value <0.001) and the correlation coefficient observed between these variables implied a strong relationship, with a Rho value of 0.566. Therefore, as health expenditure as a percentage of GDP increases, the rate of Influenza vaccination in the population aged 65 and above consequently increases.

The Spearman's rank correlation indicated that the public expenditure on health, purchasing power parity (\$) per capita was positively correlated with the rate of influenza vaccination coverage among the elderly. The correlation coefficient of 0.724 implied a strong correlation, furthermore, this was a statistically significant association (P-value <0.001). This means that the rate at which the elderly population is vaccinated will increase as the public expenditure on health, purchasing power parity (\$) per capita increases.

The Spearman's rank correlation indicated that the number of nurses (Physical persons) per 100,000 was positively correlated with influenza vaccination coverage among the elderly. This was a statistically significant relationship (P-value= 0.032), with a correlation coefficient of 0.519, implying that the more nurses (physical persons) there are, the higher the rate of influenza vaccination coverage among the elderly.

Furthermore, Spearman's rank correlation indicated that there was a positive correlation between General practitioners per 10,000 and the influenza vaccination coverage among the elderly. The correlation coefficient was 0.362, implying a weak correlation strength, however, this was a statistically significant correlation (P-value <0.001). This means that, as the number of General practitioners increases the rate of influenza vaccination coverage will increase.

The Spearman's rank correlation indicated that the annual average inflation rate was negatively correlated with the rate of influenza vaccination coverage among the elderly, with a correlation coefficient of -0.188, implying a weak correlation, however, this was a statistically significant correlation (P-value= 0.002). Therefore, if the average rate of inflation decreases, the rate of influenza vaccination coverage among the elderly will increase.

The Spearman's rank correlation presented a negative correlation between the unemployment rate and the rate of influenza vaccination coverage among the elderly. The correlation coefficient was -0.112, indicative of a weak correlation, however, this was a statistically significant correlation (P-value=0.049). This implies that the lower the rate of unemployment, the higher the rate of influenza vaccination coverage among the elderly.

Table 1 Summary Table of the association of influenza vaccination coverage among the elderly with various health outcomes.

Indicators	Correlation coefficient (Rho)	P-value
Gross Domestic Product (GDP) per capita	0.577	<0.001*
Total health expenditure as % of the GDP	0.566	<0.001*
Public expenditure on health, purchasing power parity (\$) per capita	0.724	<0.001*
Number of nurses (Physical persons) per 100,000	0.519	0.032*
General practitioners per 10,000	0.362	<0.001*
Annual average inflation rate	-0.188	0.002*
Unemployment rate	-0.112	0.049*

Significant association = *p-value <0.05

Association of influenza vaccination of the elderly with various health outcomes:

The Spearman's rank correlation indicated that the influenza vaccination coverage among the elderly was negatively correlated with the probability of dying before age 5. This was a statistically significant correlation (P-value <0.001), with a strong correlation coefficient of 0.516. This implies that the higher the rate of influenza vaccination in the elderly, the lesser the probability of death occurring before the age of 5. Hence, the alternative hypothesis was accepted, and the null hypothesis was rejected.

The Spearman's rank correlation indicated a negative between the coverage of influenza vaccination among the elderly and the estimated infant mortality per 1,000 live births. This was a significant correlation (P-value <0.001), with a strong correlation coefficient of -0.502. This means that the infant mortality per 1,000 live births will decrease if the rate of influenza vaccination coverage among the elderly increases.

The Spearman's rank correlation indicated a very strong positive correlation between the influenza vaccination coverage among the elderly and the estimated life expectancy at birth, with a P-value of <0.001 and a correlation coefficient of 0.730. This means that the estimated life expectancy at birth will increase if the Influenza vaccination rate among the elderly increases.

The Spearman's rank correlation indicated that there was a negative correlation between the influenza vaccination coverage among the elderly and the average length of stay, in all hospitals. The correlation coefficient was -0.180, which implies a weak correlation, however, this was a statistically significant association (P-value <0.001). This means that the average length of stay, in all hospitals will decrease the Influenza vaccination rate among the elderly increases.

The Spearman's rank correlation indicated that the influenza vaccination coverage among the elderly was positively correlated with the Disability-adjusted life expectancy (DALE), with a strong correlation coefficient of 0.708. This is a statistically significant relationship (P-value <0.001). This implies that the DALE will increase as the rate of influenza vaccination coverage among the elderly increases.

Table 2 Summary Table of the association of influenza vaccination coverage among the elderly with various health outcomes.

Indicators (Health outcomes)	Correlation coefficient (Rho)	P-value
Probability of dying before age 5	0.516	<0.001*
Estimated infant mortality per 1,000 live births	-0.502	<0.001*
Estimated life expectancy at birth	0.730	<0.001*
Average length of stay, in all hospitals	-0.180	<0.001*
DALE	0.708	<0.001*
Significant association = *p-value <0.05		

Association of influenza vaccination coverage among the elderly with age-standardized death rates:

Spearman's rank correlation indicated a negative correlation between the influenza coverage vaccination among the elderly and the age-standardized death rate of people aged 65 or above from all causes per 100,000. This is a statistically significant correlation (p-value <0.001), with a strong correlation coefficient of -0.697. This indicates that the standard death rate of people aged 65 or above from all causes per 100,000. will decrease if the rate of vaccination among the population aged 65 or above increases.

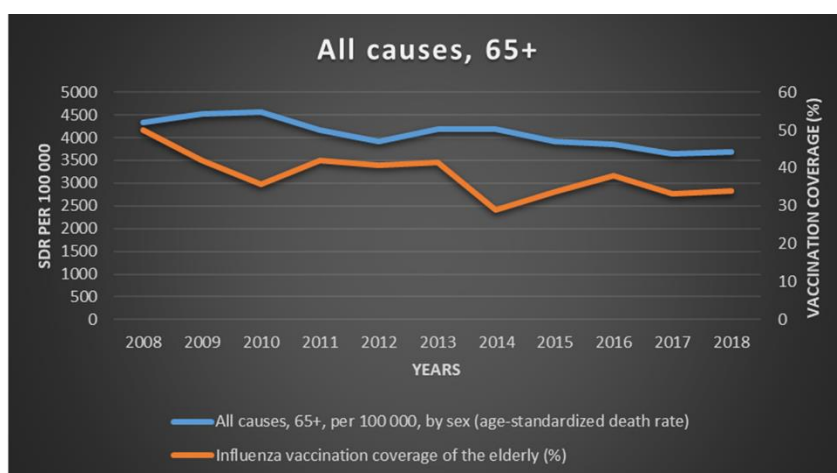
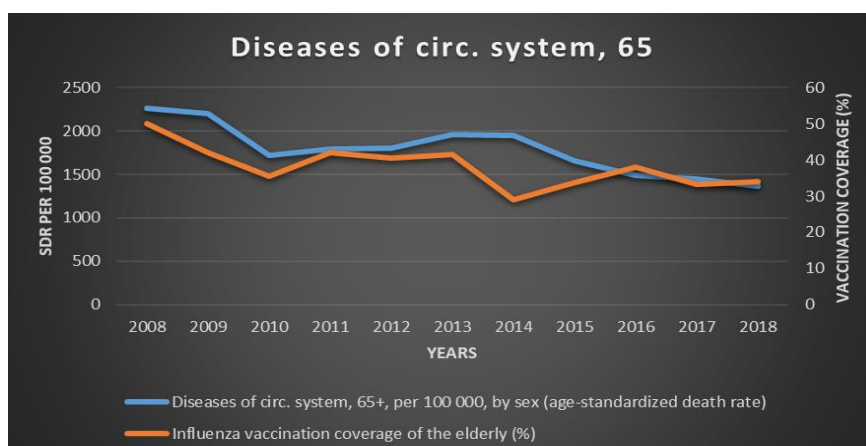


Figure 26. Graph illustrating the association between SDR from all-causes and Influenza vaccination among the elderly

Also, the coverage of influenza vaccination among the elderly was observed to be negatively correlated with the age-standardized death rate from diseases of the circulatory system in the population aged 65 or above per 100,000. The correlation coefficient indicated a very strong correlation ($Rho = -0.756$), more so, this was a statistically significant correlation (P-value <0.001). This means that an increase in the rate of the coverage of the influenza vaccine among the elderly will likely reduce the age-standardized death rate from diseases of the circulatory system in the population aged 65 or above per 100,000. Shown in figure 27 below.



An indirect negative correlation was observed between the influenza vaccination coverage among the elderly and the age-standardized death rate from influenza, 0-64, per 100,000 population. Although, with a correlation coefficient ($Rho = -0.167$), this was statistically significant. This implies that the age-standardized death rate from influenza, 0-64, per 100,000 will decrease if the rate of influenza vaccination coverage among the elderly increases, however, this was an indirect correlation.

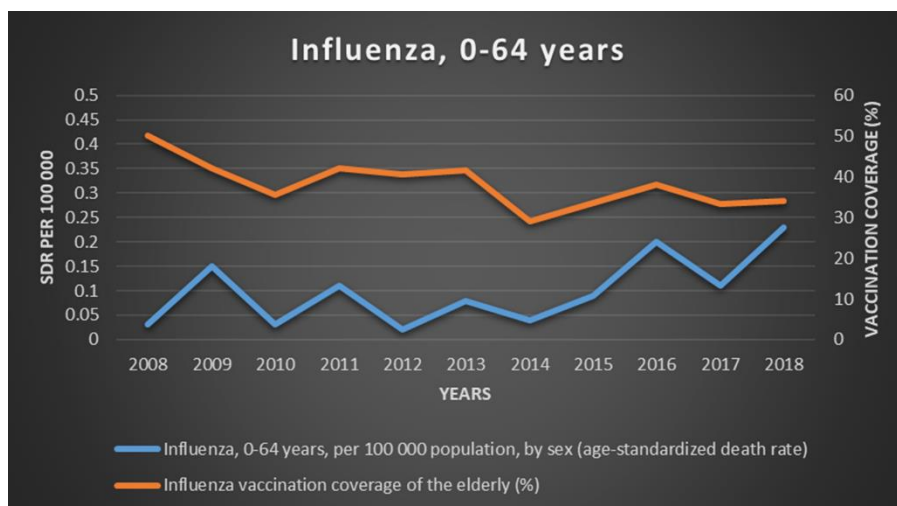


Figure 28. Graph illustrating the association between deaths from influenza-related causes and Median influenza vaccination among the elderly coverage between 2008 and 2018.

Influenza vaccination coverage of the elderly was observed to be negatively correlated with age-standardized deaths from selected smoking-related causes. This was a very strong correlation ($Rho = -0.756$), more so, it was statistically significant (P -value 0.001). This indicates that there will be more likely a decrease in age-standardized deaths from selected smoking-related causes if the Influenza vaccination coverage of the elderly increases.

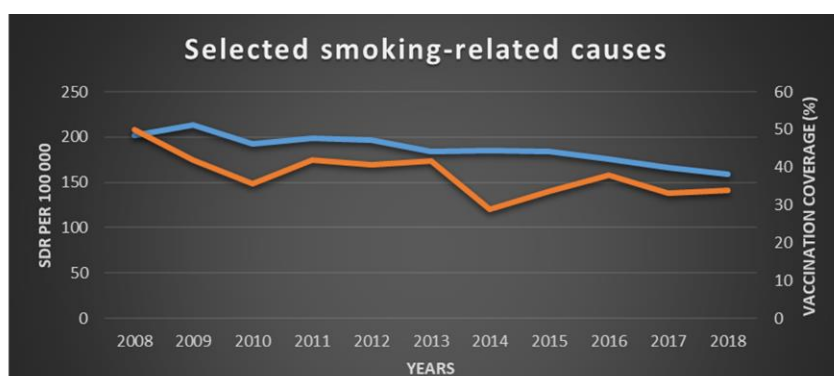


Figure 29. Graph illustrating the association between deaths from selected smoking-related causes and Median influenza vaccination among the elderly coverage between 2008 and 2018.

There was a negative correlation observed between the influenza vaccination coverage of the elderly and the Standard death rate from bronchitis/emphysema/asthma per 100,000. There was a weak correlation between the variables, with a Rho value of -0.52, However, this was a statistically significant relationship ($p\text{-value} < 0.001$). This means that the deaths from bronchitis/emphysema/asthma per 100,000 in all ages will decrease if the influenza vaccination coverage of the elderly increases.

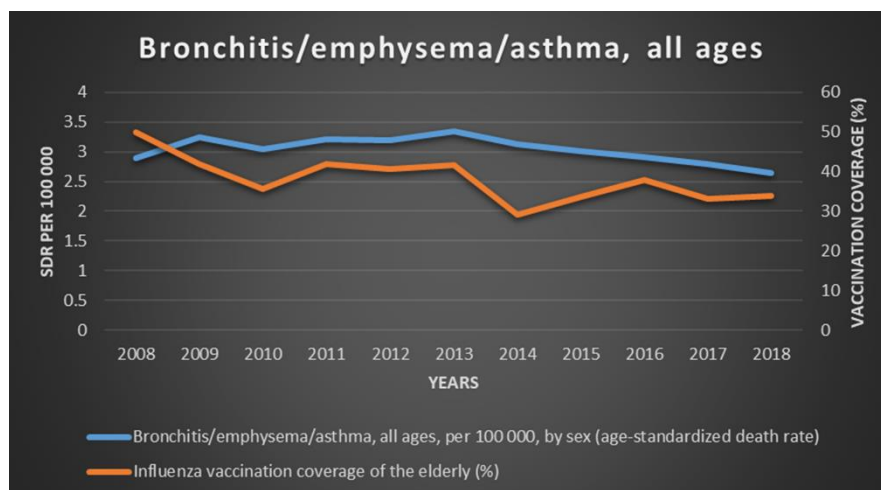


Figure 30. Graph illustrating the association between deaths from bronchitis/emphysema/asthma and Median influenza vaccination among the elderly coverage between 2008 and 2018.

An indirect positive association was observed between the influenza vaccination coverage of the elderly and the age-standardized death rate from diseases of the respiratory system in the population aged 65 or above per 100,000. Although this was a weak correlation ($Rho=0.384$), it was a statistically significant correlation. This means that the higher the vaccination coverage becomes, the lesser the age-standardized death rate from diseases of the respiratory system. Fig.31 below illustrates the association observed.

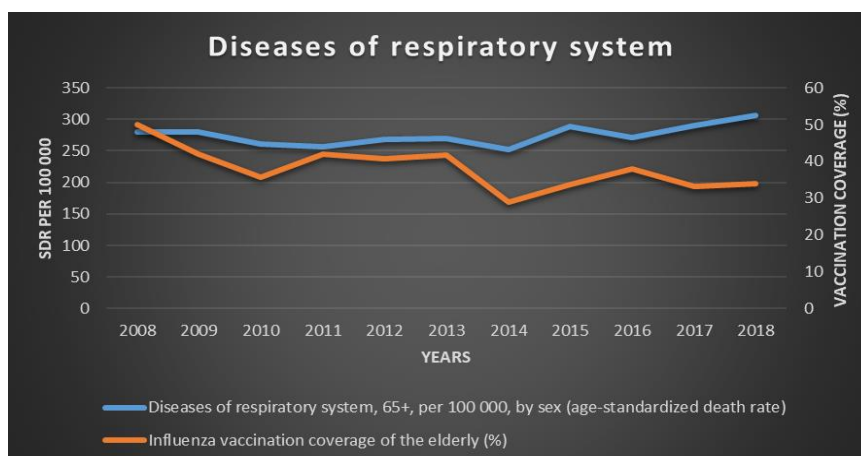


Table 3 Summary Table of the association of influenza vaccination coverage among the elderly with age-standardized death rates

Indicators	Correlation coefficient (Rho)	P-value
Deaths from all-cause 65+ per 100,000	-0.697	<0.001*
Deaths from diseases of circulatory system, 65 per 100,000	-0.756	<0.001*
Deaths from influenza - related cause. 0-64 years	-0.167	<0.001*
Deaths from selected smoking related causes	-0.756	<0.001*
Deaths from Bronchitis/emphysema/asthma per 100,00	-0.52	<0.001*
Deaths from disease of respiratory system per 100,000	0.384	<0.001*
Significant association = *p-value <0.05		

Association of influenza vaccination coverage among the elderly with other vaccines:

Investigating the association of influenza coverage among the elderly with other vaccines, it was determined that the Hemophilus influenza type B vaccine, was positively correlated with influenza vaccination coverage among the elderly, and this was statistically significant, having a correlation coefficient of $Rho=0.119$ and $P\text{-value}=0.034$. This means that an increase in influenza vaccination coverage among the elderly will increase the rate of coverage of the Hemophilus influenza type B vaccine.

The influenza vaccination coverage among the elderly was observed to have a statistically significant positive association with the diphtheria vaccine, indicating that an increase in the influenza vaccination coverage will increase the rate of the coverage of the diphtheria vaccine (with a correlation coefficient of $Rho=0.151$ and $P\text{-value}=0.006$).

Also, a statistically significant positive association was detected between the influenza vaccination coverage among the elderly and the rate of coverage of the tetanus vaccine coverage, indicating that an increase in the influenza vaccination coverage will increase the rate of the coverage of the tetanus vaccine. The correlation coefficient (Rho) was $=0.151$, with a $P\text{-value}=0.006$.

Furthermore, a statistically significant positive association was detected between the influenza vaccination coverage among the elderly and the rate of coverage of the pertussis vaccine, implying that an increase in the influenza vaccination coverage will increase the rate of the coverage of the pertussis vaccine having a correlation coefficient $Rho=0.151$ and $P\text{-value}=0.006$. More so, influenza vaccination among the elderly was observed to have been positively correlated with the poliomyelitis vaccine, The correlation coefficient (Rho) was $=0.176$ and $P\text{-value}=0.001$.

However, a negative association was detected between the influenza vaccination coverage among the elderly and the rate of coverage of the rubella vaccine, but this was not statistically significant with a correlation coefficient $Rho=-0.026$, $P\text{-value}=0.655$. Implying that an increase in influenza vaccination coverage among the elderly will not affect the rate of coverage of the rubella vaccine. Also, the rate coverage of the mumps vaccine showed no statistically significant correlation with the influenza vaccination coverage among the elderly, although it was negatively associated ($Rho=-0.020$, $P\text{-value}=0.724$).

Table 4 Summary Table of the association of influenza vaccination coverage among the elderly with other vaccines

Indicators (% of infants vaccinated against)	Correlation coefficient (Rho)	P-value
Rubella	-0.026	0.655
Mumps	-0.020	0.724
Measles	0.004	0.945
Hemophilus influenza type B	0.119	0.034*
Diphtheria	0.151	0.006*
Tetanus	0.151	0.006*
Pertussis	0.151	0.006*
Poliomyelitis	0.176	0.001*
Significant association = *p-value <0.05		

DISCUSSION

The main aim of our research was to investigate the relationship between the economic growth of a country and its effect on the influenza vaccination coverage of the elderly, the population aged 65 or above. The economic growth being the Gross Domestic Product (GDP) per capita. Our findings revealed that the economic growth (GDP) of countries was significantly associated with the percentage of the elderly who have received influenza vaccine. This association was noted to be significantly positive, which suggests that the GDP per capita may potentially contribute to an increased percentage of vaccination among the elderly. Contrary to our findings, a study by Zunino et al, 2020 on the association between health spending and vaccination coverage in low-income countries found no significant association between GDP and vaccination coverage rate (Zunino,2020). On the other hand, Similar to the outcome of our study, A meta-analysis conducted by Chen et al,2022 involving 522 studies from 68 countries/regions, reported that influenza vaccination rates were significantly higher in high-income countries/regions than those in middle-income countries/regions. Also, Bhan and Sinha in a study conducted in India in 2019, highlighted the gross underuse of the influenza vaccine in low and middle-income countries, especially in India, which may be due to various barriers like belief, but this varied observably from the use of influenza in high-income countries. More so, a study by Veronese et al, 2023, assessing poverty and influenza/pneumococcal vaccination in older people, detected that the poor sample respondents had a lower vaccination coverage compared to the respondents who were “not poor” (35.56% VS 39.57%).

Conversely, Yang et al, 2014 observed that a higher socioeconomic status including Income level and education was associated with a lower vaccination coverage among adults in Korea, as the result of the study revealed a low vaccination rate of approximately 30% of people with higher income and higher education.

Furthermore, another population-based study in India on influenza vaccination coverage among older adults by Rizvi et al, 2022 detected that sample populations who were better off economically had higher tendencies to get vaccinated with the flu vaccine. Among other factors, this highlighted the importance of the economic stance of an individual and at large, a country to the influenza vaccination coverage.

The second aspect of this research was examining the association between proposed factors that could influence Influenza vaccination coverage among the elderly besides GDP, and the findings revealed that Influenza vaccination coverage among the elderly could be significantly influenced by total health expenditure as a percentage of the GDP, Public

expenditure on health, purchasing power parity (\$) per capita, nurses (Physical persons) per 100,000, general practitioners per 10,000, Annual inflation rate and unemployment rate.

Total health expenditure as a percentage of the GDP and public expenditure on health, purchasing power parity (\$) per capita were influential factors in the percentage coverage of influenza vaccination among the elderly. This study demonstrated that in countries where health expenditure as a percentage of GDP and public expenditure on health, purchasing power parity (\$) per capita was higher, there was an observed higher percentage of influenza vaccination coverage among the elderly. Similar to our findings, a study by Castillo-Zunino et al, on the effect of health spending on vaccination coverage in low-income countries revealed that government Health spending had a significant positive association with vaccination coverage, however, no association was detected between private health expenditures and vaccination coverage. Analogously, in another study consisting of 45 countries measuring country-level predictors of vaccination coverage and inequalities in Gavi-supported countries, it was observed that government spending on health and lower linguistic fractionalization was significantly associated with better DTP vaccination coverage outcomes (Catherine Arsenault, 2017).

It also appears that the number of nurses (Physical persons) per 100,000 and General practitioners per 10,000 was associated with increased influenza vaccination coverage among the elderly. This is indicative that the more nurses and GPs there are in a settlement, the higher the percentage of vaccination coverage. Similar to our findings, Anand et al in a cross-country study found that the denser health workers(nurses) are in a settlement, the higher the vaccination coverage, however, the density of doctors did not show any association with vaccination coverage. Consistent with our findings, Hu et al,2021 in their study “The Association between the Density of Vaccination Workers and Immunization Coverage in Zhejiang Province East China” found that the density of vaccination workers was positively associated with immunization coverage, however, when the effects of full-time and part-time vaccination workers were separated, only the density of full-time vaccination workers was significant. Along the same line, a study conducted by Gai et al, 2015 unraveled that the density of pharmacists was associated with increased influenza vaccination coverage both in Hispanics and non-Hispanic whites, however, there was an observed variation based on different regions and population groups.

The unemployment rate was another influential factor in the influenza vaccination coverage of the elderly. Our study detected that a high unemployment rate adversely contributes to the influenza vaccination coverage of the elderly, decreasing the coverage percentage. Similarly, A paper published by Hu et al,2023 determined a negative association between the unemployment rate and influenza vaccination, shedding light on the decrease in unemployment as the influenza vaccination rate coverage increases and vice versa. Contrary to this finding, Der-Martirosian et al, in their study comparing the use of H1N1 and seasonal influenza vaccination among US veteran and non-veteran adults, highlighted that employment status was not associated with the influenza vaccination and H1N1 use in both veterans and non-veterans.

Furthermore, our study revealed a strong association of influenza vaccination of the elderly with a variety of health outcomes. A strong negative association was found between influenza vaccination(indirect negative association) and age-standardized mortality rates which included deaths from all causes in the population aged 65 or above, deaths from disease of the circulatory system 65+, deaths from influenza-related causes age 0-64 years, deaths from selected smoking-related causes, deaths from bronchitis/emphysema/asthma, all ages, deaths from respiratory deaths 65+(Showed an abnormal indirect positive association), probability of dying before age 5 per 1,000 live births and estimated infant mortality per 1,000 live births. In one of these studies, it was observed that influenza vaccination was associated significantly with a reduction in all-cause mortality, generating its results from a meta-analysis of Randomized Control Trials and observational studies assessing the association of influenza vaccination with mortality and cardiovascular outcomes in patients with cardiovascular disease.

We also observed evidence of the influenza vaccination among the elderly being associated with a decrease in the average length of stay, all hospitals. This finding was consistent with the findings of Thompson et al,2018 in their study “influenza vaccine effectiveness in preventing influenza-associated intensive care admissions and attenuating severe disease among Adults in New Zealand 2012–2015”. The study revealed that the influenza vaccine was significantly associated with shorter length of stay in ICU units. Vaccinated people spent four days fewer than those who were not vaccinated (CDC, 2023). similarly, another study found that the influenza vaccine was associated with about a 2.5-day decrease in the duration of all-cause hospital stays.

Additionally, our study observed a significant association between influenza vaccination coverage among the elderly and with increase in other vaccines like Hemophilus influenza type B vaccine, diphtheria vaccine, tetanus vaccine, pertussis vaccine, and poliomyelitis vaccine underscoring the synergistic effects of comprehensive vaccination. However, Rubella, mumps, and measles vaccination coverage showed no association with influenza vaccination coverage. Studies regarding this finding is grossly lacking.

Overall, our study highlights the variety of factors that influence influenza vaccination coverage of the elderly and emphasizes the importance of addressing socioeconomic, health infrastructure, and public health policy to improve vaccine uptake and enhance health results in aging communities.

CONCLUSION

Relationship between Economic Growth and Influenza vaccination coverage of the elderly:

Our study assessed the relationship between Economic growth, as measured by GDP per capita, and influenza vaccination coverage of the elderly. Based on the findings of our study, there was a positive association between Economic growth, as measured by GDP per capita, and influenza vaccination coverage of the elderly i.e. the population aged 65 or above, revealing that countries who had a better economic stance had variably higher vaccination coverage than those who did not. This finding provides profound insight into the importance of economic factors to the availability, access, and utilization of healthcare provisions, especially for vulnerable populations.

Factors that could influence Influenza vaccination coverage of the elderly:

Beyond GDP, our investigation identified additional factors that could influence influenza vaccination coverage among the elderly. Among these, public health expenditure, purchasing power parity (\$) per capita, Total health expenditure as a percentage of the GDP, Density of nurses and General practitioners, unemployment rate, and average inflation rate were significant contributing factors. These findings underline the multifaceted association of socioeconomic factors with the coverage of influenza vaccine and health outcomes in this vulnerable population.

Influenza vaccination coverage of the elderly and health outcomes:

Importantly, our analysis revealed a crucial association between influenza vaccination among the elderly and positive health outcomes. Particularly highlighting, amongst other results, that increased vaccination coverage of the elderly could significantly reduce the average length of stay in all hospitals, increase estimated life expectancy, and reduce mortality rates. These findings underscore the potential of the influenza vaccine to influence health outcomes, mitigate the severity of illnesses, and improve life quality.

Influenza vaccination coverage of the elderly and the coverage of other vaccines:

Furthermore, our study outlined a robust association between influenza vaccination coverage of the elderly and the coverage of other vaccines. A positive synergistic effect was observed, in that, the increase in influenza vaccination coverage of the elderly contributed to an increased coverage of other vaccines like the Tetanus vaccine, Diphtheria vaccine, Hemophilus influenza

type B vaccine, and Pertussis vaccine. However, the Rubella, mumps, and measles vaccine coverage did not show any association with the influenza vaccination coverage.

In conclusion, the insights gained from this study emphasize the multifaceted approach needed to improve influenza vaccination coverage among the elderly, highlighting the roles of economic factors, socio-economic factors, the relevance of strengthening the health infrastructure, and implementing evidence-based public health interventions.

We recommend that more strategic approaches be given to improving potential contributing factors that can influence influenza vaccination coverage among the elderly, consequently, improving the vaccination coverage.

LIMITATIONS

This investigation, being an ecological study, faced the bias of ecological fallacy.

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Thank you [REDACTED], your supervision, and support were the best any student could ask for.

DEDICATION

To my mum, [REDACTED], thank you for being a constant source of support and inspiration.

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