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Temporal Patterns and Interrelationships of Reported Mortality Rates of Nine Different Types of Cancer from Five Selected West African Countries

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ABSTRACT: Cancer mortality remains a major public health concern in West Africa and has sent many to untimely deaths globally in the 21st century. The objective of this paper was to investigate the temporal patterns and interrelationships of reported mortality rates of nine different types of cancer from five selected West African countries using appropriate standard procedures by acquiring data from Kaggle.com covering the period of 1990 – 2019. The results show that gallbladder cancer mean mortality rates ranged between 0.48 (Nigeria) and 0.89 (Cote d'Ivoire), kidney cancer from 0.24 (Nigeria) to 0.53 (Ghana), cancer of the bladder ranged between 0.29 (Nigeria) and 1.24 (Senegal) and cancer of the brain and central nervous system between 0.98 (Nigeria) and 1.98 (Ghana), Oesophageal from 0.60 (Cote d'Ivoire) to 1.52 (Liberia and Senegal), cancer of the liver from 5.68 (Cote d'Ivoire) to 10.68 (Liberia), colon and rectum from 2.11 (Cote d'Ivoire) to 2.91 (Senegal), stomach from 1.55 (Nigeria) to 5.60 (Senegal) and TBL from 1.78 (Nigeria) to 3.96 (Senegal). The results show that while four of the cancer variants' mortality rates studied decreased with time, five of them were on the increase over the study period. The study also found a significantly positive and strong (weak) linear relationship between the various cancer-variant mortality rates for the five countries ($p < 0.05$). It is therefore, concluded that cancer-variant mortality rates in West African countries, as low-income countries, are still moderate and that efforts and interventions need to be implemented to reverse the rise observed in certain variants while improving policies to keep those declining on the drop.

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Cancer has emerged as one of the leading non-communicable causes of death globally, with almost 20 million new cases and 9.7 million deaths in 2022. Africa accounts for a relatively small share of global incidence but a disproportionately high share of mortality, reflecting late diagnosis, limited access to treatment and weak cancer surveillance systems (Bray *et al.*, 2024; Sung *et al.*, 2021). It has been reported as the leading cause of death globally and

amongst the top three drivers of the increase in deaths, accounting for an estimated 37% of all deaths in Sub-Saharan African (SSA) (Mutebi, 2023; WHO, 2022). Within Africa, the burden of cancer is projected to rise faster than in any other world region, with nearly 2.1 million new cases and 1.4 million deaths anticipated annually by 2040 if current trends persist (Sharma *et al.*, 2022; Omotoso *et al.*, 2023). West Africa contributes substantially to this growing

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burden, yet available mortality estimates for the subregion are often derived from sparse registry data and modelling assumptions rather than robust longitudinal observations (Ferlay *et al.*, 2024; Omotoso *et al.*, 2023; Sung *et al.*, 2021). Cancer, according to the National Cancer Institute (2021), is an disease in which “some of the body’s cells grow uncontrollably and spread to other parts of the body”. The WHO identified lung, prostate, colorectal, stomach and liver cancer as the most common in men, and breast, colorectal, lung, cervical and thyroid cancer as the most common among women (WHO, 2022). Researchers have noted that “cancer fatalism” makes many cancer patients believe that the diagnosis is a sure death sentence and that treatment is futile, which has led to many deaths from different cancer infections even when care and treatment have improved (Mutebi, 2023; Duru & Topatan, 2023; Salisu *et al.*, 2022; Powe and Finnie, 2003). Fatalism was defined by Keller *et al.* (2021) as an “emotional state of gloom, hopelessness, and helplessness concerning cancer outcomes. Fatalism is driven by cultural and social beliefs and has raised the rates of death from cancer in Africa, coupled with low health access, out-of-pocket treatment and general poverty (Alberto *et al.*, 2023; Kim and Lwin, 2021). Hence, careful trend and correlation analysis of cancer mortality, which is aggregated by cancer variants (e.g., cervical, prostate, breast, liver and colorectal cancers), is essential for understanding changing patterns over time and informing evidence-based policy in selected West African countries.

Trend analysis is a central tool in descriptive cancer epidemiology aimed to characterise how disease indicators such as incidence or mortality rates evolve, quantify the pace of change and identify periods of acceleration, plateau or decline. Approaches range from simple average annual percent change (AAPC) based on log-linear regression through more flexible joinpoint regression, which allows the slope of the trend to change at data-driven time points, which has been widely applied to cancer mortality series to detect statistically significant changes in trend and to compare trajectories across populations, cancer types or demographic groups (Ebrahimi *et al.*, 2025; Roura *et al.*, 2023; Gillis and Edwards, 2019; Yu *et al.*, 2018; Kim *et al.*, 2000). In more recent times, time series models like ARIMA/ ARIMAX have been used alongside joinpoint methods to project future cancer incidence and mortality, highlighting their value for planning and evaluating prevention and control strategies (Acquah *et al.*, 2024; Li *et al.*, 2022). Applying these trend analytic tools to cancer mortality data in West Africa can uncover whether particular cancer variants are rising, stagnating or

declining, and whether patterns differ by country or over calendar periods in which major health policy changes occurred. While trend analysis focuses on the temporal dynamics of individual series, correlation analysis examines how two or more variables move together. In cancer epidemiology, correlation techniques are routinely used to explore associations between mortality rates of different cancer types, or between cancer outcomes and potential determinants such as socioeconomic indicators, health-system capacity and behavioural risk factors (Abdullah *et al.*, 2025; Lo Sasso *et al.*, 2025; Pandey *et al.*, 2024). Pearson’s product-moment correlation coefficient remains the most common measure for assessing the strength and direction of linear relationships between continuous variables under approximate normality assumptions. The Spearman’s rank correlation, on the other hand, provides a non-parametric alternative that captures monotonic but not necessarily linear associations and is robust to outliers and non-normal distributions (Bocianowski *et al.*, 2024; Chaudhary *et al.*, 2022; Rovetta, 2020). Selecting and correctly interpreting these correlation measures is crucial, especially in ecological or country-level analysis, where inferences are based on aggregated rates rather than individual-level data and are therefore vulnerable to ecological fallacy. Correlation analysis, when used carefully, can complement trend analysis by revealing whether mortality patterns for specific cancer variants co-evolve across time or across countries, and how they align with contextual indicators like screening coverage or treatment availability.

The cancer landscape in West Africa is shaped by a complex interplay of infectious and non-infectious risk factors, demographic transitions and constrained health systems. Mapping studies and regional reviews show that breast, cervical, prostate and liver cancers, alongside rapidly increasing colorectal and other gastrointestinal malignancies, account for a substantial share of cancer mortality in the subregion (Omotoso *et al.*, 2023; Sharma *et al.*, 2022; Ayandipo *et al.*, 2020). GLOBOCAN-based estimates indicate that West African countries, as low-income countries, collectively face high mortality-to-incidence ratios, suggesting that case fatality is much higher than in high-income settings caused by structural challenges like late presentation, limited diagnostic and radiotherapy capacity, high out-of-pocket expenditures for healthcare and weak cancer registries, which further aggravate mortality outcomes (Omotoso *et al.*, 2023; Ayandipo *et al.*, 2020). Despite these, published quantitative analyses that track long-term mortality trends across multiple cancer variants and countries in West Africa, and that

formally investigate the correlation structure among these mortality series, remain relatively scarce. Existing African and sub-Saharan African cancer studies have begun to quantify incidence and mortality and to model future burdens. For instance, Sharma *et al.* (2022) analysed GLOBOCAN 2020 data for 34 African countries and projected steep increases in both incidence and deaths by 2040, underscoring geographic disparities across the continent. Acquah *et al.* (2024) recently used GLOBOCAN 2020 age-standardised estimates to model cancer incidence and mortality parameters, demonstrating the feasibility of applying advanced statistical techniques to global and regional datasets. Other studies have examined health-system gaps in Ghana, Nigeria and Senegal and more broadly the inequalities in cancer care in sub-Saharan Africa, emphasising deficiencies in registries, treatment infrastructure and financing (Omotoso *et al.*, 2023; Ayandipo *et al.*, 2020). Nonetheless, most of these contributions either focus on incidence, on a single cancer site or on broad descriptive summaries rather than vigorous multi-country trend and correlation analysis of cause-specific mortality rates. A systematic trend and correlation analysis of mortality rates for key cancer variants in selected West African countries can therefore fill an important evidence gap. First, long-term trend estimation can reveal whether the mortality burden is shifting from infection-related cancers, such as cervical and liver cancers, towards those more strongly linked with lifestyle and ageing, such as breast, colorectal and prostate cancers, and whether these shifts differ across countries with varying levels of urbanisation, health expenditure and screening programs. Second, correlation analysis between mortality rates for different cancer variants can shed light on shared or competing risk factor profiles, health-system constraints and possible synergies in prevention and control strategies. For instance, a strong positive correlation between breast and cervical cancer mortality rates over time might reflect common weaknesses in female cancer screening and treatment services, while divergent patterns between liver and colorectal cancers might suggest differing impacts of hepatitis control versus dietary and obesity-related risks. This study aims to identify the trends of the proportion of deaths from cancer variants in selected West African countries that share a common demographic characteristics and dip into the Atlantic Ocean and estimate the relationships among them. The specific objectives included obtaining the trends of cancer-variants mortality rates (CVMR) for the countries under study over a defined historical period, and measuring the correlation coefficients of the cancer-variants mortality rates. Hence, the

objective of this paper is to investigate the temporal patterns and interrelationships of reported mortality rates of nine different types of cancer from five selected West African countries.

MATERIALS AND METHOD

Study Design: This study adopts a quantitative, retrospective, longitudinal research design, focusing on country-level mortality trends for major cancer variants in selected West African countries over a temporal window of 30 years. The longitudinal approach enables the tracking of temporal changes in mortality rates, while the ecological framework allows assessment of inter-country and inter-cancer relationships using aggregated national data rather than individual patients' records. This design is widely recommended for population-level cancer surveillance and trend modelling (Sung *et al.*, 2021; Bray *et al.*, 2024).

Data: The data used for the study were mortality proportions from 1990 – 2019 for 9 different cancer types (Bladder, Kidney, Stomach, Esophageal, Tracheal, bronchus and lung (TBL), Colon and rectum, Gallbladder and biliary tract, Liver, and Brain and central nervous system) collected from 5 west African countries (Cote d'Ivoire, Ghana, Liberia, Nigeria and Senegal) who had their foot in the Atlantic Ocean (Akarawak & Ikegwu, 2025). These cancers collectively account for the largest share of cancer mortality in West Africa (Sharma *et al.*, 2022).

Source: The age-standardised mortality data for these countries were obtained from Kaggle, at Kaggle.com. The response variables are the age-standardised mortality rates (ASMRs) per 100,000 population for each cancer variant and each country, stratified annually. The measures derived were annual mortality rates, with the trends computed and the Pearson product-moment correlation coefficients. The age-standardised mortality rates ensure comparability across countries and years.

Data Analysis Techniques: The data were summarised descriptively using means, medians, and standard deviations of the cancer variants' mortality rates. The time series plots were derived for each cancer variant and country. These outputs provide preliminary insights into mortality distributions and variability. Pearson product-moment correlation coefficients (r) were used to assess the linear associations between mortality rates of different cancer variants across the board and within each country. The correlation coefficient is computed as:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (1)$$

Where x and y are the two variables that are correlated and r is the correlation coefficient which range between ± 1.0 .

Software: Data analysis was conducted using MS Excel and the Statistical Package for the Social Sciences (SPSS 27.0). Statistical significance was determined at 5% level of significance, and correlation strength and direction were interpreted using established benchmarks (Rovetta, 2020). The study used secondary, aggregated, non-identifiable population-level data. Therefore, no ethical clearance for human subjects was required, and data sources are publicly accessible and compliant with international data governance standards.

RESULTS AND DISCUSSION

The results obtained from the data analyses are displayed in this section using graphs and tables. The interpretations and discussions were presented before each table and graph in line with best practices. Table 1 shows the mean mortality rates for cancer variants country-wise and overall. It reveals that for all the countries, gallbladder, BT has a mean mortality rate of 0.69 (sd = 0.15) per 100,000 persons overall, 0.89 (sd = 0.02) per 100,000 persons in Cote d'Ivoire, 0.58 (sd = 0.02) in Ghana, 0.74 (sd = 0.02) in Liberia, 0.48 (sd = 0.08) in Nigeria and 0.79 (sd = 0.01) in Senegal. Hence, mortality rates from GBT were highest in Cote d'Ivoire and least in Nigeria, while they varied most in Nigeria and least in Senegal.

Also, cancer of the kidney has a mean mortality rate of 0.43 (sd = 0.11) per 100,000 persons overall, 0.42 (sd = 0.03) in Cote d'Ivoire, 0.53 (sd = 0.02) in Ghana, 0.45 (sd = 0.03) in Liberia, Nigeria (0.24, sd = 0.01) and Senegal (0.52, sd = 0.03). This implies that mortality from cancer of the kidney was highest in Ghana and least in Nigeria, but more varied over the years in Cote d'Ivoire and least varied in Nigeria also. The table also show that cancer of the bladder has a mean mortality rate of 0.92 (sd = 0.33) per 100,000 persons overall, 1.00 (sd = 0.07) in Cote d'Ivoire, 0.99 (sd = 0.09) in Ghana, 0.99 (sd = 0.09) in Liberia, Nigeria (0.29, sd = 0.02) and Senegal (1.24, sd = 0.08). Hence, Senegal has the highest mortality from cancer of the bladder, and the least was in Nigeria, while it is more varied over the years in Ghana and least varied in Nigeria also.

In addition, cancer of the brain and CNS has a mean mortality rate of 1.25 (sd = 0.40) per 100,000 persons overall, 0.99 (sd = 0.05) in Cote d'Ivoire, 1.98 (sd =

0.13) in Ghana, 1.17 (sd = 0.09) in Liberia, Nigeria (0.98, sd = 0.07) and Senegal (1.32, sd = 0.17). This implies that mortality from cancer of the brain and CNS were highest in Ghana and least in Nigeria, while the variation over the years was highest in Cote d'Ivoire and least in Nigeria also. The table further reveals that for all the countries, cancer of the Esophageal has a mean mortality rate of 1.12 (sd = 0.42) per 100,000 persons overall, 0.60 (sd = 0.03) per 100,000 persons in Cote d'Ivoire, 1.12 (sd = 0.16) in Ghana, 1.52 (sd = 0.30) in Liberia, 0.86 (sd = 0.09) in Nigeria and 1.52 (sd = 0.32) in Senegal. Hence, mortality rates from cancer of the esophageal were highest in Liberia and Senegal and lowest in Cote d'Ivoire, while they varied most in Ghana and least in Cote d'Ivoire. Similarly, it shows that for all the countries, cancer of the liver has a mean mortality rate of 8.82 (sd = 2.00) per 100,000 persons overall, 5.68 (sd = 0.16) per 100,000 persons in Cote d'Ivoire, 8.13 (sd = 0.43) in Ghana, 10.68 (sd = 1.30) in Liberia, 9.92 (sd = 1.44) in Nigeria and 9.71 (sd = 0.55) in Senegal. Therefore, mortality rates from cancer of the liver were highest in Liberia and lowest in Cote d'Ivoire, while they varied most in Nigeria and least in Cote d'Ivoire. Furthermore, it reveals that for all the countries, cancer of the colon and rectum has a mean mortality rate of 2.49 (sd = 0.36) per 100,000 persons overall, 2.11 (sd = 0.07) per 100,000 persons in Cote d'Ivoire, 2.40 (sd = 0.31) in Ghana, 2.66 (sd = 0.24) in Liberia, 2.39 (sd = 0.19) in Nigeria and 2.91 (sd = 0.28) in Senegal. This implies that mortality rates from cancer of the colon and rectum were highest in Senegal and least in Cote d'Ivoire, while they varied most in Ghana and least in Cote d'Ivoire. Likewise, it shows that for all the countries, cancer of stomach has a mean mortality rate of 3.76 (sd = 1.46) per 100,000 persons overall, 2.96 (sd = 0.15) per 100,000 persons in Cote d'Ivoire, 3.70 (sd = 0.17) in Ghana, 4.98 (sd = 0.19) in Liberia, 1.55 (sd = 0.29) in Nigeria and 5.60 (sd = 0.28) in Senegal. Hence, mortality rates from cancer of the stomach were highest in Senegal and least in Nigeria, while they varied most in Nigeria and least in Côte d'Ivoire. Lastly, it reveals that for all the countries, cancer of the TBL has a mean mortality rate of 2.65 (sd = 0.78) per 100,000 persons overall, 2.86 (sd = 0.17) per 100,000 persons in Cote d'Ivoire, 2.47 (sd = 0.19) in Ghana, 2.16 (sd = 0.26) in Liberia, 1.78 (sd = 0.18) in Nigeria and 3.96 (sd = 0.33) in Senegal. Therefore, mortality rates from TBL were highest in Senegal and least in Nigeria, while they varied most in Senegal, Nigeria and least in Cote d'Ivoire. The study found that mean mortality rates from gallbladder and biliary tracts (GBT) were highest in Cote d'Ivoire and least in Nigeria, while the mean mortality rates ranged between 0.48 and 0.89 per

100,000 persons. Also, the mean mortality rates of the cancer of the kidney were highest in Ghana and lowest in Nigeria, ranging from 0.24 to 0.53. Cancer of the bladder has its highest mean mortality rate in Senegal and least in Nigeria, with the mean ranging from 0.29 to 1.24 per 100,000 persons. In addition, cancer of the brain and central nervous system ranged between 0.98 and 1.32 per 100,000 persons, with the highest mean in Senegal and the lowest mean in Nigeria. Also, the mean mortality rates of the cancer of the esophageal ranged between 0.60 and 1.52 per 100,000 persons, with the highest in Liberia and Nigeria and the least in Cote d'Ivoire. In the same vein, the mean mortality rate from cancer of the liver ranged between 5.68 and 10.68 per 100,000 persons, with the highest mean at Liberia and the least at Cote d'Ivoire. Furthermore, the mean mortality rates of the colon and rectum cancer were highest in Senegal and least in Cote d'Ivoire and ranged from 2.11 to 2.91 per 100,000 persons. Likewise, the mean mortality rates of cancer of the stomach ranged from 1.55 to 5.60 per 100,000 persons, with the highest in Senegal and the least in Nigeria. Lastly, the mean mortality rates from TBL ranged from 1.78 to 3.96 per 100,000 persons, with the highest in Senegal and the least in Nigeria. These results were in tandem with the mean mortality rates reported by (Bray et al., 2024; Sharma

et al., 2022; Hamdi et al., 2021), while others were different from the global means. The mortality rate of bladder cancer in West African countries, for instance, was found to be lower than the African average of over 8 per 100,000 and about 3.5 per 100,000 in northern Africa (Pizzato et al., 2024; Morgan et al., 2022; Adeloye et al., 2019). Figure. 1 shows the matrix of the scatterplot of the cancer variants' mortality rates for all selected West African countries. It reveals that while some of the cancer variants are highly correlated with almost linear relationships, others show low association or non-linearity.

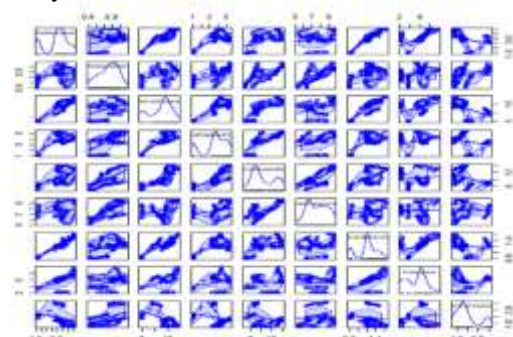


Fig 1: The scatterplot matrix of the cancer variants' mortality rates in five West African countries

Table 1: Descriptive Statistics [mean (std. deviation)] of the mortality rates of different cancer types from the selected West African countries (n = 30).

Cancer Variants	Overall (150)	Cote d'Ivoire	Ghana	Liberia	Nigeria	Senegal
Gallbladder	0.69(0.15)	0.89(0.02)	0.58(0.02)	0.74(0.02)	0.48(0.08)	0.79(0.01)
Kidney	0.43(0.11)	0.42(0.03)	0.53(0.04)	0.45(0.03)	0.24(0.01)	0.52(0.03)
Bladder	0.92(0.33)	1.06(0.04)	1.00(0.07)	0.99(0.09)	0.29(0.02)	1.24(0.08)
Brain and nervous system	1.25(0.40)	0.99(0.05)	1.98(0.13)	1.00(0.09)	0.98(0.07)	1.32(0.17)
Esophageal	1.12(0.42)	0.60(0.03)	1.12(0.16)	1.52(0.30)	0.86(0.09)	1.52(0.32)
Liver	8.82(2.00)	5.68(0.16)	8.13(0.43)	10.68(1.30)	9.92(1.44)	9.71(0.55)
Colon and rectum	2.49(0.36)	2.11(0.07)	2.40(0.31)	2.66(0.24)	2.39(0.19)	2.91(0.28)
Stomach	3.76(1.46)	2.96(0.15)	3.70(0.17)	4.98(0.19)	1.55(0.29)	5.60(0.28)
TBL	2.65(0.78)	2.86(0.17)	2.47(0.19)	2.16(0.26)	1.78(0.18)	3.96(0.33)

TBL - Tracheal, bronchus, and lung

Fig. 2 shows that the estimated marginal means of cancer of the bladder decreased in all five selected West African countries over the years, while cancer of the kidney increased gradually over the periods. Fig. 3 shows that the estimated marginal means of cancer of the stomach decreased sharply till 1999 and then experienced a gradual decrease later till 2019, while oesophageal cancer decreased so slowly till 2000, when it picked up and rose gradually. Tracheal, bronchitis and lung cancer experienced dragging decline till 1990, declined gradually till 2000 and rose from them in all the countries while cancer of the colon and rectum had a dragged increase till 1994, declined gradually up till 2000 and rose from them in all the countries (see Fig. 4). Fig. 5 shows that cancer of the gallbladder and biliary tract declined sharply till 2000 and then went on gradual

decrease in all the countries in West Africa while cancer of the liver increase gradually till 1997 and then declined gradually in all the five countries under study.

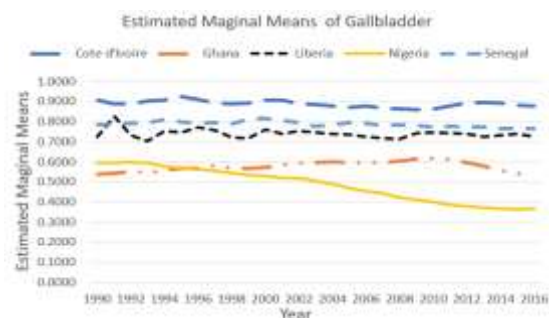


Fig. 2: Estimated mean plot of bladder cancer mortality rates

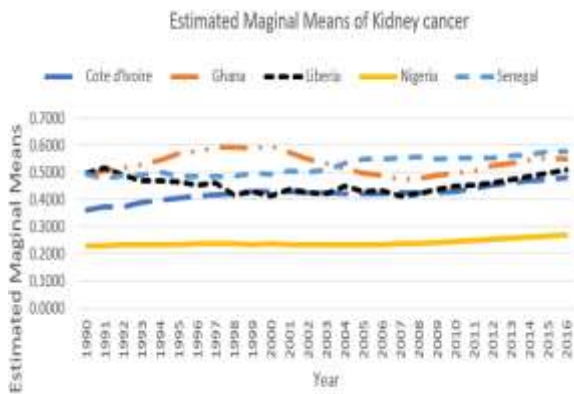


Fig. 3: Estimated mean plot of kidney cancer mortality rates

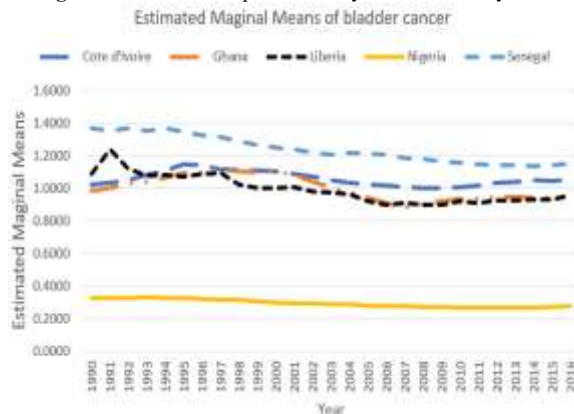


Fig. 4: Estimated mean plot of bladder cancer mortality rates

Lastly, the cancer of the brain and central nervous system maintained a steady rise in all five countries over the years of study (Fig. 6).

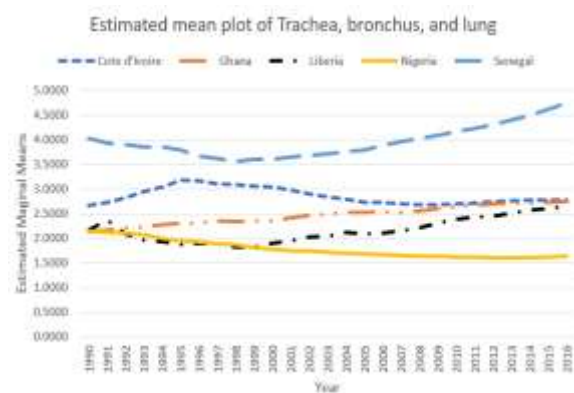


Fig. 5: Estimated mean plot of Trachea, bronchus, and lung cancer mortality rates

The study also found from the trends of the mortality of cancer variants that while Bladder cancer, Stomach cancer, Gallbladder and biliary tract (GBT) cancer and Liver cancer dropped over the studied period, Kidney cancer, Esophageal cancer, Tracheal, Bronchus and Lung cancer, Colon and rectum cancer and Brain and central nervous system cancer all increased over the studied period and agreed with

other studies (Zhang, *et al.*, 2023; Shokouhi *et al.*, 2021). The various countries studied should improve on their policies that brought down the trends of bladder, stomach, GBT and liver cancers, while actions should be expedited to reverse the rise in the other cancer-variants – kidney, oesophageal, TBL, colon and rectum and brain and CNS cancers.

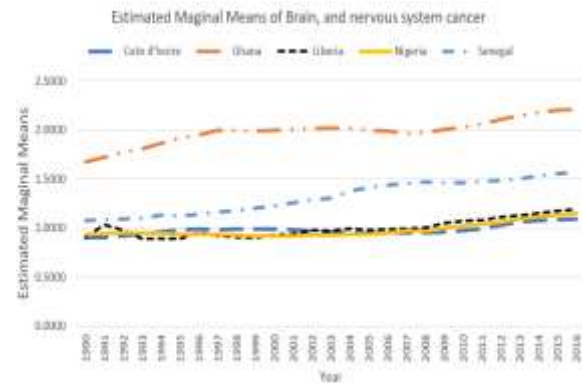


Fig. 6: Estimated mean plot of Brain, and nervous system cancer mortality rates

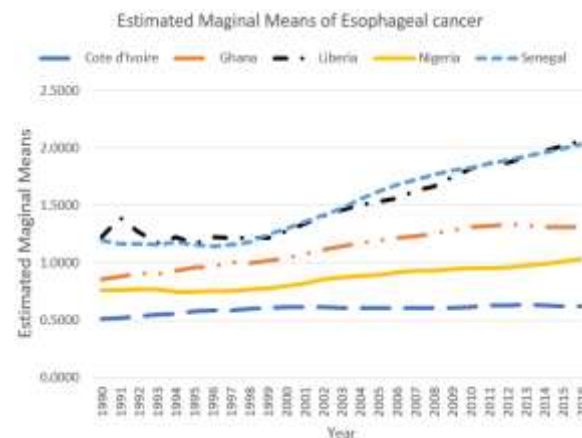


Fig. 7: Estimated mean plot of Esophageal cancer mortality rates

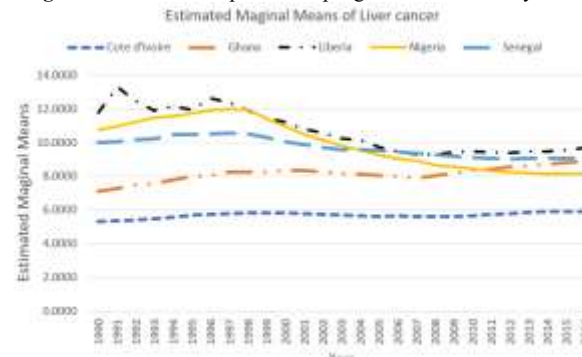


Fig. 8: Estimated mean plot of liver cancer mortality rates

Table 2 shows the correlation coefficients of the various cancer variants' mortality rates in the five selected countries in West Africa. It reveals that cancer of the bladder is significantly and positively

correlated with all the other cancer variants except cancer of the brain and central nervous system, which is negative ($p < 0.05$) and colon and rectum cancer, which, though positive, is not significant ($p > 0.05$).

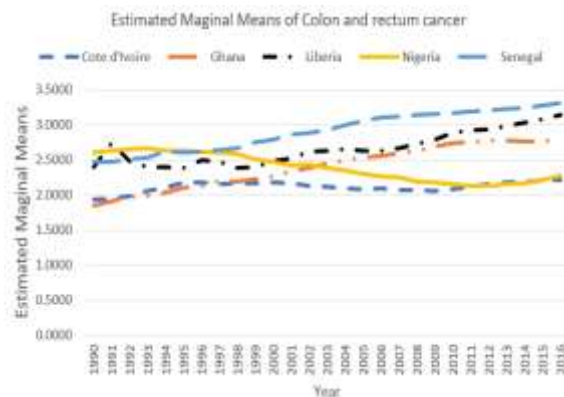


Fig. 9: Estimated mean plot of colon and rectum cancer mortality rates

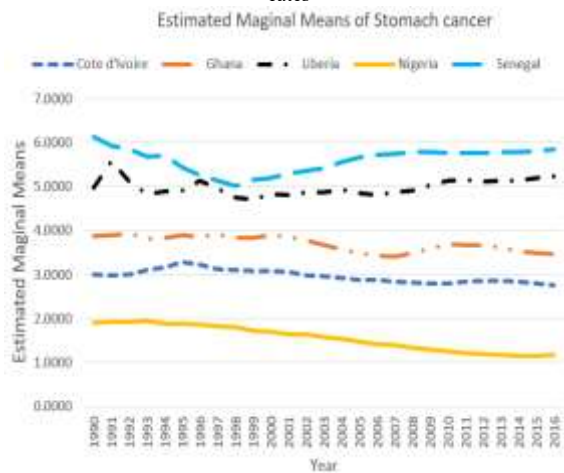


Fig. 10: Estimated mean plot of stomach cancer mortality rates

Also, mortality rates of cancer of the kidney positively and significantly correlated with all other cancer variants' mortality rates ($p < 0.05$), with some strong and others weak. In addition, the mortality rates of cancer of the stomach are significantly and positively correlated with other cancer variants ($p < 0.05$) except cancer of the brain and central nervous system, which is negative ($p < 0.05$), with the majority exhibiting strong relationships. In the same vein, the mortality rates of cancer of the esophageal are significantly and positively correlated with other cancer variants ($p < 0.05$) except cancer of the brain and central nervous system, which is negative ($p < 0.05$). It further reveals that cancer of the colon and rectum is significantly and positively correlated with all the other cancer variants except cancer of the brain and central nervous system, which is negative ($p < 0.05$) and cancer of the liver, which, though it is positive, is not significant ($p > 0.05$). Lastly, it shows

that cancer of the trachea, bronchus, and lung (Akarawak & Ikegwu, 2025)g is significantly and positively correlated with cancer of the liver and negatively but not significantly with the brain and central nervous system ($p > 0.05$), while cancer of the liver is positively and not significantly correlated with the brain and central nervous system ($p > 0.05$).

Lastly, the study found that there is a significant linear correlation among the mortality rates of the different cancer types, with some weak and others strong relationships and some positive, while others were negative. This implies that higher mortality rates in some cancer variants spur higher rates in other variants (Lindström *et al.*, 2023; Park *et al.*, 2022; Ziyuan *et al.*, 2021). This is a call for action as it portends that the existence or prevalence of one cancer variant will predispose the countries and their citizens to other variants.

Table 3 shows the correlation coefficients of the various cancer variants' mortality rates in Côte d'Ivoire. It reveals that the mortality rates of the cancer of the gallbladder and biliary tract is significantly and positively correlated with bladder, stomach and tracheal, bronchus, and lung cancers ($p < 0.05$), significantly and negatively associated with mortality rates of the cancer of the esophageal ($p < 0.05$) and not significantly correlated with the mortality rates of the other cancer variants ($p > 0.05$). Also, mortality rates of cancer of the kidney positively and significantly correlated with all other cancer variants' mortality rates ($p < 0.05$) except cancer of the stomach, with significant and negative correlation ($p < 0.05$) while the correlation with cancer of the bladder and tracheal, bronchus, and lung is negative, weak and not significant ($p > 0.05$). In addition, the mortality rate of cancer of the bladder is only significantly and positively correlated with cancers of the colon and rectum, stomach and trachea, bronchus, and lung ($p < 0.05$), with other variants not significant ($p > 0.05$), with some negative and others positive. In the same vein, the mortality rates of the cancer of the brain and central nervous system are significantly and positively correlated with cancers of the oesophageal, liver and colon and rectum ($p < 0.05$), while not significant with the mortality rates of the cancer of the stomach, and brain and central nervous system ($p > 0.05$). It further reveals that cancer of the esophageal is significantly and positively correlated with the cancers of liver, colon and rectum, and stomach ($p < 0.05$), while it is negative and not significantly associated with the mortality rates of the brain and central nervous system ($p > 0.05$). Likewise, it shows that the mortality rates of the cancer of the liver are

significantly and positively correlated with the mortality rates of the cancers of the colon and rectum ($p < 0.05$) but not significantly associated with the mortality rates of the cancer of the stomach and TBL ($p > 0.05$). Lastly, it shows that cancer of the colon and rectum is significantly and positively correlated

with cancer of the trachea, bronchus, and lung and not significantly associated with cancer of the stomach ($p > 0.05$), while cancer of the trachea, bronchus, and lung is positively and significantly correlated with stomach ($p < 0.05$).

Table 2: Correlation coefficients of cancer mortality rates for different cancer variants in some West African Countries

	Bladder	Kidney	Stomach	Esophageal	TBL	Colon and rectum	GBT	Liver	Brain and CNS
Bladder	1								
Kidney	.311** (<0.001)	1							
Stomach	.905** (<0.001)	.378** (<0.001)	1						
Esophageal	.736** (<0.001)	.571** (<0.001)	.865** (<0.001)	1					
TBL	.578** (<0.001)	.616** (<0.001)	.825** (<0.001)	.786** (<0.001)	1				
Colon and rectum	.112 (0.174)	.692** (<0.001)	.301** (<0.001)	.307** (<0.001)	.715** (<0.001)	1			
GBT	.963** (<0.001)	.415** (<0.001)	.864** (<0.001)	.682** (<0.001)	.590** (<0.001)	.239** (0.003)	1		
Liver	.520** (<0.001)	.341** (<0.001)	.370** (<0.001)	.301** (<0.001)	.111 (0.177)	.099 (0.229)	.564** (<0.001)	1	
Brain and CNS	-.303** (<0.001)	.409** (<0.001)	-.505** (<0.001)	-.239** (<0.001)	-.382** (<0.001)	.073 (0.374)	-.159 (0.052)	.162* (0.048)	1

Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). NB: GBT - Gallbladder and biliary tract; CNS - Central Nervous System; TBL - Tracheal, bronchus, and lung.

Lastly, the study found that there is a significant linear correlation among the mortality rates of the different cancer types, with some weak and others strong relationships and some positive, while others were negative. This implies that higher mortality rates in some cancer variants spur higher rates in

other variants (Lindström et al., 2023; Park et al., 2022; Ziyuan et al., 2021). This is a call for action as it portends that the existence or prevalence of one cancer variant will predispose the countries and their citizens to other variants.

Table 3: Correlation coefficients of cancer mortality rates for different cancer variants in Cote d'Ivoire

	GBT	Kidney	Bladder	Brain and CNS	Esophageal	Liver	Colon rectum	and Stomach	TBL
GBT	1								
Kidney	-.316 (0.109)	1							
Bladder	.800** (<0.001)	-.141 (0.483)	1						
Brain and CNS	.008 (0.969)	.906** (<0.001)	.130 (0.518)	1					
Esophageal	-.382* (0.049)	.910** (<0.001)	-.160 (0.426)	.695** (<0.001)	1				
Liver	-.018 (0.931)	.905** (<0.001)	.254 (0.202)	.884** (<0.001)	.863** (<0.001)	1			
Colon and rectum	.195 (0.330)	.790** (<0.001)	.476* (0.012)	.830** (<0.001)	.757** (<0.001)	.958** (<0.001)	1		
Stomach	.836** (<0.001)	-.544** (0.003)	.892** (<0.001)	-.303 (0.125)	.479* (0.012)	-.168 (0.402)	.077 (0.703)	1	
TBL	.733** (<0.001)	-.152 (0.449)	.984** (<0.001)	0.066 (0.742)	-.107 (0.596)	.254 (0.202)	.476* (0.012)	.896** (<0.001)	1

Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). NB: GBT - Gallbladder and biliary tract; CNS - Central Nervous System; TBL - Tracheal, bronchus, and lung.

Table 4 shows the correlation coefficients of the various cancer variants' mortality rates in Ghana. It reveals that the mortality rates of the cancer of the gallbladder and biliary tract is significantly and positively correlated with the mortality rates of the cancers of the esophageal, colon and rectum, and of the tracheal, bronchus, and lung ($p < 0.05$), but not significantly associated with mortality rates of the other cancer variants ($p > 0.05$) with some negative and others positive. Also, mortality rates of cancer of the kidney are positively and significantly correlated with cancer of the bladder mortality rates ($p < 0.05$)

and negatively and significantly associated with the mortality rates of cancer of the stomach ($p < 0.05$) while the correlation with the mortality rates of other cancer variants are not significant ($p > 0.05$) though some are positive and others negative. In addition, the mortality rates cancer of the bladder is only significantly and positively correlated with cancers of the stomach ($p < 0.05$), significantly but negatively correlated with cancers of the esophageal and colon and rectum, and of the tracheal, bronchus, and lung ($p < 0.05$) and with other variants is not significant ($p > 0.05$) with some negative and other positive. In the

same vein the mortality rates of the cancer of the brain and central nervous system is significantly and positively correlated with cancers of the esophageal, liver, colon and rectum and of the of the tracheal, bronchus, and lung ($p < 0.05$) while significantly and negatively correlated with the mortality rates of the cancer of the stomach ($p < 0.05$). It further reveals that cancer of the esophageal is significantly and positively correlated with the cancers of the liver, colon and rectum, trachea, bronchus, and lung ($p < 0.05$), while it is negative and significantly associated with the mortality rates of the stomach ($p < 0.05$). Likewise, it shows that the mortality rates of the cancer of the liver are significantly and positively correlated with the mortality rates of the cancers of the colon and rectum, and TBL ($p < 0.05$), but negatively and significantly associated with the mortality rates of the cancer of the stomach ($p < 0.05$). Lastly, it shows that the mortality rates of the

cancer of the colon and rectum is significantly and positively correlated with mortality rates of the cancer of the tracheal, bronchus, and lung ($p < 0.05$) and negatively and significantly associated with cancer of the stomach ($p < 0.05$) while cancer of the Tracheal, bronchus, and lung is negatively and significantly correlated with the mortality rates of the cancer of the stomach ($p < 0.05$). Lastly, the study found that there is a significant linear correlation among the mortality rates of the different cancer types, with some weak and others strong relationships and some positive, while others were negative. This implies that higher mortality rates in some cancer variants spur higher rates in other variants (Lindström et al., 2023; Park et al., 2022; Ziyuan et al., 2021). This is a call for action as it portends that the existence or prevalence of one cancer variant will predispose the countries and their citizens to other variants.

Table 4: Correlation coefficients of cancer mortality rates for different cancer variants in Ghana

	GBT	Kidney	Bladder	Brain and CNS	Esophageal	Liver	Colon and rectum	Stomach	TBL
GBT	1								
Kidney	-.371 (0.057)	1							
Bladder	-.340 (0.083)	.850** (<0.001)	1						
Brain and CNS	.241 (0.226)	.206 (0.302)	-.330 (0.124)	1					
Esophageal	.498** (0.008)	-.341 (0.081)	-.740** (<0.001)	.837** (<0.001)	1				
Liver	.193 (0.335)	.345 (0.078)	-.158 (0.431)	.981** (<0.001)	.759** (<0.001)	1			
Colon and rectum	.491** (0.009)	-.286 (0.148)	-.701* (<0.001)	.867** (<0.001)	.998** (<0.001)	.795** (<0.001)	1		
Stomach	-.320 (0.104)	-.553** (0.003)	.850** (<0.001)	-.595** (<0.001)	-.816** (<0.001)	-.441* (0.021)	-.805** (<0.001)	1	
TBL	.402* (0.038)	-.229 (0.250)	-.669** (<0.001)	.899** (<0.001)	.987** (<0.001)	.832** (<0.001)	.991** (<0.001)	-.788** (<0.001)	1

Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). NB: GBT - Gallbladder and biliary tract; CNS - Central Nervous System; TBL - Tracheal, bronchus, and lung.

Table 5 shows the correlation coefficients of the various cancer variants' mortality rates in Liberia. It reveals that the mortality rates of the cancer of the gallbladder and biliary tract are significantly and positively correlated with the mortality rates of the cancers of the bladder, liver, and stomach ($p < 0.05$), but not significantly associated with mortality rates of the other cancer variants ($p > 0.05$), with some negative and others positive. Also, mortality rates of cancer of the kidney are positively correlated with all the cancer variants, but are only significant with the mortality rates of the cancers of the bladder, brain and central nervous system, stomach and tracheal and biliary tracts ($p < 0.05$). In addition, the mortality rates cancer of the bladder is only significantly and positively correlated with the mortality rates of the cancers of the liver ($p < 0.05$), significantly but negatively correlated with cancers of the brain and central nervous system, esophageal, colon and rectum, and of the tracheal, bronchus, and lung ($p < 0.05$) and with other variants is not significant ($p > 0.05$). In the same vein, the mortality rates of the cancer of the brain and central nervous system are significantly and positively correlated with cancers of

the oesophageal, colon and rectum, stomach and of the tracheal, bronchus, and lung ($p < 0.05$), while significantly and negatively correlated with the mortality rates of the cancer of the liver ($p < 0.05$). It further reveals that cancer of the esophageal is significantly and positively correlated with the cancers of colon and rectum, liver and trachea, bronchus, and lung ($p < 0.05$), while it is negative and significantly associated with the mortality rates of the liver ($p < 0.05$). Likewise, it shows that the mortality rates of the cancer of the liver are significantly and negatively correlated with the mortality rates of the cancers of the colon and rectum, and TBL ($p < 0.05$), but positively and not significantly associated with the mortality rates of the cancer of the stomach ($p > 0.05$). Lastly, it shows that the mortality rates of the cancer of the colon and rectum is significantly and positively correlated with mortality rates of the cancer of the stomach and, tracheal, bronchus, and lung ($p < 0.05$) while cancer of the Tracheal, bronchus, and lung is negatively and significantly correlated with the mortality rates of the cancer of the stomach ($p < 0.05$). Lastly, the study found that there is a significant linear correlation

among the mortality rates of the different cancer types, with some weak and others strong relationships and some positive, while others were negative. This implies that higher mortality rates in some cancer variants spur higher rates in other

variants (Lindström et al., 2023; Park et al., 2022; Ziyuan et al., 2021). This is a call for action as it portends that the existence or prevalence of one cancer variant will predispose the countries and their citizens to other variants.

Table 5: Correlation coefficients of cancer mortality rates for different cancer variants in Liberia

	GBT	Kidney	Bladder	Brain and CNS	Esophageal	Liver	Colon and rectum	Stomach	TBL
GBT	1								
Kidney	.249 (0.211)	1							
Bladder	.541** (<0.001)	.445* (0.020)	1						
Brain and CNS	-.004 (0.983)	.406* (0.036)	-.507** (<0.001)	1					
Esophageal	-.172 (0.391)	.226 (0.257)	-.706** (<0.001)	.958** (<0.001)	1				
Liver	.461* (0.015)	.261 (0.188)	.963** (<0.001)	-.656** (<0.001)	-.829** (<0.001)	1			
Colon and rectum	-.015 (0.942)	.343 (0.080)	-.568** (0.002)	.990** (<0.001)	.978** (<0.001)	-.716** (<0.001)	1		
Stomach	.563** (<0.001)	.749** (<0.001)	.238 (0.238)	.655** (<0.001)	.477* (0.012)	.036(0.858)	.615** (0.001)	1	
TBL	-.013 (0.949)	.540** (0.004)	-.415* (0.031)	.951** (<0.001)	.921** (<0.001)	-.605** (0.001)	.948** (<0.001)	.720** (<0.001)	1

Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). NB: GBT - Gallbladder and biliary tract; CNS - Central Nervous System; TBL - Tracheal, bronchus, and lung.

Table 6 shows the correlation coefficients of the various cancer variants' mortality rates in Nigeria. It reveals that the mortality rates of the cancer of the gallbladder and biliary tract is significantly and positively correlated with the mortality rates of the cancers of the bladder, liver, colon and rectum, stomach and TBL ($p < 0.05$), but significantly and negatively associated with mortality rates of the cancers kidney, brain and central nervous system, and esophageal ($p < 0.05$). Also, mortality rates of cancer of the kidney are positively correlated with all the cancer variants, but are only significant with the mortality rates of the cancers of the bladder, brain and central nervous system, stomach and tracheal and biliary tracts ($p < 0.05$). In addition, the mortality rates cancer of the bladder is significantly and positively correlated with the mortality rates of the cancers of the liver, colon and rectum, stomach and of the tracheal, bronchus, and lung ($p < 0.05$) while it is negatively and significantly correlated with cancers of the brain and central nervous system, and esophageal ($p < 0.05$).

In the same vein, the mortality rates of the cancer of the brain and central nervous system is significantly and positively correlated with cancers of the esophageal only ($p < 0.05$) while significantly and negatively correlated with the mortality rates of the cancer of the liver, colon and rectum, stomach and of the tracheal, bronchus, and lung ($p < 0.05$).

It further reveals that cancer of the esophageal is significantly and negatively correlated with the cancers of the colon and rectum, liver, stomach and trachea, bronchus, and lung ($p < 0.05$). Furthermore,

it shows that cancer of the liver is significantly and positively correlated with the cancers of the colon and rectum, stomach and trachea, bronchus, and lung ($p < 0.05$). Lastly, it shows that the mortality rates of the cancer of the colon and rectum is significantly and positively correlated with mortality rates of the cancer of the stomach and, tracheal, bronchus, and lung ($p < 0.05$) while cancer of the Tracheal, bronchus, and lung is positively and significantly correlated with the mortality rates of the cancer of the stomach ($p < 0.05$). Lastly, the study found that there is a significant linear correlation among the mortality rates of the different cancer types, with some weak and others strong relationships and some positive, while others were negative. This implies that higher mortality rates in some cancer variants spur higher rates in other variants (Lindström et al., 2023; Park et al., 2022; Ziyuan et al., 2021). This is a call for action as it portends that the existence or prevalence of one cancer variant will predispose the countries and their citizens to other variants. Table 7 shows the correlation coefficients of the various cancer variants' mortality rates in Senegal. It reveals that the mortality rates of the cancer of the gallbladder and biliary tract is significantly and positively correlated with the mortality rates of the cancers of the bladder and liver ($p < 0.05$), but significantly and negatively associated with mortality rates of the cancers kidney, brain and central nervous system, esophageal, colon and rectum, stomach and TBL ($p < 0.05$). Also, mortality rates of cancer of the kidney are negatively and significantly correlated with all the cancer variants ($p < 0.05$) except the mortality rates of the cancers of the bladder and liver, which are positive and significant ($p < 0.05$).

Table 6: Correlation coefficients of cancer mortality rates for different cancer variants in Nigeria

	GBT	Kidney	Bladder	Brain and CNS	Esophageal	Liver	Colon and rectum	Stomach	TBL
GBT	1								
Kidney	-.816** (<0.001)	1							
Bladder	.964** (<0.001)	-.650** (<0.001)	1						
Brain and CNS	-.825** (<0.001)	.983** (<0.001)	-.655** (<0.001)	1					
Esophageal	-.971** (<0.001)	.791** (<0.001)	-.941** (<0.001)	.818** (<0.001)	1				
Liver	.942** (<0.001)	-.091** (<0.001)	.933** (<0.001)	-.757** (<0.001)	-.977** (<0.001)	1			
Colon and rectum	.964** (<0.001)	-.645** (<0.001)	.990** (<0.001)	-.671** (<0.001)	-.944** (<0.001)	.958** (<0.001)	1		
Stomach	.997** (<0.001)	-.790** (<0.001)	.976** (<0.001)	-.802** (<0.001)	-.980** (<0.001)	.958** (<0.001)	.975** (<0.001)	1	
TBL	.912** (<0.001)	-.601** (<0.001)	.966** (<0.001)	-.566** (<0.001)	-.871** (<0.001)	.826** (<0.001)	.925** (<0.001)	.920** (<0.001)	1

Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). NB: GBT - Gallbladder and biliary tract; CNS - Central Nervous System; TBL - Tracheal, bronchus, and lung.

Table 7: Correlation coefficients of cancer mortality rates for different cancer variants in Senegal

	GBT	Kidney	Bladder	Brain and CNS	Esophageal	Liver	Colon and rectum	Stomach	TBL
GBT	1								
Kidney	-.720** (<0.001)	1							
Bladder	.629** (<0.001)	-.892** (<0.001)	1						
Brain and CNS	-.690** (<0.001)	.974** (<0.001)	-.976** (<0.001)	1					
Esophageal	-.765** (<0.001)	.979** (<0.001)	-.940** (<0.001)	.983** (<0.001)	1				
Liver	.767** (<0.001)	-.920** (<0.001)	.905** (<0.001)	-.926** (<0.001)	-.962** (<0.001)	1			
Colon and rectum	-.649** (<0.001)	.958** (<0.001)	-.977** (<0.001)	.996** (<0.001)	.974** (<0.001)	-.916** (<0.001)	1		
Stomach	-.596** (<0.001)	.493** (0.003)	-.184 (0.357)	.336 (0.087)	.468* (0.014)	-.572** (0.002)	.286 (0.148)	1	
TBL	-.816** (<0.001)	.787** (<0.001)	-.595** (0.001)	.705** (<0.001)	.807** (<0.001)	-.763** (<0.001)	.671** (<0.001)	.704** (<0.001)	1

Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). NB: GBT - Gallbladder and biliary tract; CNS - Central Nervous System; TBL - Tracheal, bronchus, and lung

In addition, the mortality rates of cancer of the bladder are significantly and negatively correlated with the mortality rates of all other cancer variants ($p < 0.05$) and positively and significantly correlated with cancers of the brain and central nervous system ($p < 0.05$). In the same vein, the mortality rates of the cancer of the brain and central nervous system is significantly and positively correlated with cancers of the esophageal, colon and rectum, and of the TBL ($p < 0.05$) while it is significantly and negatively correlated with the mortality rates of the cancer of the liver ($p < 0.05$) but is not significant correlated with the mortality rate of the cancer of the stomach though positive and weak. It further reveals that cancer of the esophageal is significantly and positively correlated with the cancers of the colon and rectum, stomach, and trachea, bronchus, and lung ($p < 0.05$), while it is significantly and negatively correlated with the mortality rates of the cancer of the liver. Furthermore, it shows that cancer of the liver is significantly and negatively correlated with the cancers of the colon and rectum, stomach, and trachea, bronchus, and lung ($p < 0.05$). Lastly, it shows that the mortality rates of the cancer of the colon and rectum is significantly and positively correlated with mortality rates of the

cancer of the tracheal, bronchus, and lung ($p < 0.05$) but not significantly with the mortality rate of the cancer of the stomach though positive while cancer of the Tracheal, bronchus, and lung is positively and significantly correlated with the mortality rates of the cancer of the stomach ($p < 0.05$). Lastly, the study found that there is a significant linear correlation among the mortality rates of the different cancer types, with some weak and others strong relationships and some positive, while others were negative. This implies that higher mortality rates in some cancer variants spur higher rates in other variants (Lindström et al., 2023; Park et al, 2022; Ziyuan et al., 2021). This is a call for action as it portends that the existence or prevalence of one cancer variant will predispose the countries and their citizens to other variants.

Conclusion: The study concludes that positive correlations for the cancer-variants mortality rates (CVMR) exist in the studied West African countries, implying that efforts should be rallied in dealing with the various cancer-variants simultaneously to safeguard the citizenry. Also, the trend of the cancer variants' mortality rates seems to correlate positively

in the five West African countries as they all move in the same direction, increasing for the cancer variants that experienced an increase and declining for those where a decline was observed. The countries in the subregion should also come together to fashion a common intervention to deal with the mortality rates arising from the various cancer variants, as they all seem to experience the same cancer variants mortality patterns.

DECLARATIONS

Ethical Approval: This study did not involve human participants or animal experimentation and therefore did not require formal ethical approval. All procedures involving data handling and analysis were conducted responsibly and in accordance with standard academic and institutional guidelines.

Disclaimer (Artificial Intelligence): Authors hereby declare that no generative Artificial Intelligence (AI) technologies like Large Language Models and test-to-image generators have been used during writing or editing of this manuscript.

Declaration of Conflict of Interest: The authors declare that no known issue issues of conflict of interest or personal relationships that have influence on the work reported in this paper exist.

Declaration of Data Availability: The data that are used in this research are available upon request from the corresponding author.

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