Describing and Modeling the Burden of Hospitalization of Patients With Neoplasms in Ghana Using Routine Health Data for 2012-2017

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review articles

abstract

PURPOSE The increasing cancer burden calls for reliable data on current and future associated hospitalizations to enable health care resource planning, especially in low- and middle-income countries. We provide nationwide estimates of the current and future burden of hospitalization because of neoplasms in Ghana.

METHODS We conducted secondary data (2012-2017) analysis using nationwide routine administrative in-patient health data from the Ghana Health Service. Multivariable Poisson regression was used to model spatial and temporal hospitalization trends stratified by sex and 5-year age group. In conjunction with official population projections, the model was used to predict future hospitalization up to 2032.

RESULTS Out of 2,915,936 hospitalization records extracted for 6 years, 26,627 (1.0%) were for neoplasms, most of them benign (D10-D36, 15,362; 57.7%) and in female patients (20,159; 76%). In total, 9,463 (35.5%) patients with malignancies were mostly female (5,307; 56.1%), had a median age 50 years (interquartile range, 34-66 years) and a median duration of stay of 4 days (interquartile range, 2-8 days). Poisson regression for the malignant cancers revealed an annual increase in hospitalizations with a relative rate of 1.23 (95% CI, 1.19 to 1.27). The estimated hospitalization rate for malignancies of female patients was 1.5 times higher than that of male patients (relative rate, 1.53; 95% CI, 1.00 to 2.34), adjusted for age. We predicted an increase of 67.5% malignant cancer hospitalizations from the empirical years (2012-2017) into the prediction years (2022-2032) in Ghana.

CONCLUSION In the absence of a national population-based cancer registry, this nationwide study used secondary health services data on hospitalizations as a proxy for neoplasm morbidity burden. Our results can support planning public health resources and building evidence-based advocacy campaigns for neoplasm-prevention efforts.

INTRODUCTION

The burden of noncommunicable diseases (NCDs) continues to show strongly disproportionate growth relative to population size irrespective of global efforts.[1-5] In 2018, the WHO estimated that 71% of the 40.5 million global deaths were due to NCDs, of which 34.4 million (85%) were premature deaths.[5] The majority of these premature deaths are estimated to have occurred in Africa where NCDs are associated with higher mortality than in high-income countries.[2,5,6] The disability burden of NCDs in sub-Saharan Africa from 1990 to 2017 showed a 67.0% increase in disability-adjusted life-years (DALYs),[6,7] from 90.6 million DALYs in 1990 to 151.3 million DALYs in 2017. It is estimated that by 2030, 46% of all deaths in Africa will be attributed to NCDs.[7,8] In Ghana, NCDs accounted for 43% of all deaths in 2016.[8,9] Cancers in particular show increased numbers globally as well in Ghana.[10] In 2020, Ghana recorded 24,009 incident cancer cases with corresponding mortality of more than two thirds (15,802) of the incident cases. Unfortunately, the GLOBOCAN estimates used only data from one of the two cancer registries in Ghana, which could have affected their estimates. Additionally, the reported mortality estimates were based on modeling of the mortality incidence from cancer registry data in neighboring countries.[10] Maintaining a cancer registry with nationwide coverage comes at a high cost to low- and middle-income countries (LMICs). An alternative, already existing data source to gain information on the cancer burden is the routine health care data on hospitalizations.

Because of the increasing burden of NCDs, it is imperative that health services plan and allocate resources accordingly—both toward treatment and prevention measures. However, this requires accurate and reliable estimates of the future burden of the disease. Routine

CONTEXT

Key Objective

A nationwide comprehensive analysis of neoplasm-related hospitalizations in Ghana using routinely collected health data from the District Health Information Management System 2.

Knowledge Generated

Overall, the hospitalization rate for females for any neoplasm was three times as high compared with male patients. The predicted future hospitalizations because of neoplasms is higher in females than in males for neoplasms with uncertain or unknown behaviors category. Hospitalization rates strongly increase with age in the 10 regions of Ghana for different types of neoplasms.

Relevance

Evidence-based advocacy campaigns targeted at the distribution of neoplasms across the different regions of Ghana and the identified sociodemographic risk factors should be initiated.

health service delivery data are increasingly available but have been widely underused for research purposes, especially in LMICs.[11-13] The potential benefits gained from using these routinely collected health data sets for health services include morbidity and mortality estimation specific to geographic regions, planning of resource allocation, and acquisition and distribution of essential medical drugs, beds, and consumables. Administrative health data can also support research, aiding in public health and health care decisions and policy.[11,14,15] The Ghana Statistical Service data on vital statistics and population data, and the Ghana Health Service (GHS) District Health Information Management System 2 (DHIMS-2) database,[10] are two examples of databases that contain nationwide information on vital statistics and patient health records.

Cancer continues to be the second leading cause of NCD morbidity and mortality globally, accounting for 9.6 million (22%) annual deaths with about 6.7 million (70%) of these deaths in LMICs.[16] Cancer is estimated to account for 4,720 (5%) annual deaths in Ghana.[8,9] Several small and non-representative hospital-based studies have indicated that cancer of the breast, prostate, and cervix[10,17-22] are among the leading neoplasms responsible for hospital admissions. However, reliable nationwide data in Ghana are missing such that there is large uncertainty about the future cancer-related morbidity, mortality, and hospitalizations. Similar to previous data sets used for estimating NCD burden,[1,2,10] the DHIMS-2 data set is a promising candidate, but has not yet been applied in detail to the situation in Ghana. Hence, our study aimed to provide reliable nationwide age, sex, and region-specific estimates of the current and future burden of hospitalization because of neoplasms in Ghana.

METHODS

Study Setting and Data Sources

This study was based on data from two sources. First, inpatient data on neoplasms were extracted from the GHS DHIMS-2 database. The DHIMS-2 is based on the District Health Information System 2 developed by the University of Oslo, Norway, which is widely used in LMICs.[23] It covers inpatient data entered by more than 10,000 users from over 300 university/teaching, regional, district, and mission/private hospitals in Ghana.[24] Clinicians or data entry staff are supposed to code patient diagnoses in the DHIMS-2 according to the WHO International Statistical Classification of Diseases and Related Health Problems (International Classification of Diseases, 10th Revision [ICD-10]) classification.[25] However, this is not always the case as some of the diagnoses are captured as free text without ICD-10 codes. The DHIMS-2 is an improvement of DHIMS-1, which lacks the ICD-10 codes and is not user friendly. In Ghana, neoplasm-related diagnoses vary considerably across the different types of hospitals. For instance, benign and malignant excisions are done by medical officers in district hospitals and sent for histopathology in another hospital or laboratory with the capacity to do the test. Although benign tumors are managed in local hospitals, malignant tumors generally are referred to larger and teaching hospitals. In regional hospitals, which serve as the referral points for district hospitals, neoplasms requiring excisions are treated by surgeons, with histopathology and management either done within the hospital or referred to a specialized center. Ghana does not have national cancer registry, and the two population-based registries are either not well defined or limited in scope like in most LMICs.[10,20,26-28] The DHIMS-2 is one of the few nationwide data sources for disease-specific hospitalizations globally. Hence, for our study, 13 variables on hospital admission and discharge including sociodemographic characteristics were extracted by the national data manager with assistance from the principal investigator. Second, the Ghana Statistical Service provided past and future projected counts for the country's population by region, age, and sex.[29]

Study Population

The study participants included patients hospitalized with all types of neoplasms from 446 hospitals between 2012 and 2017 recorded in the DHIMS-2 database. Patients with

missing data on age, sex, or date of admission were excluded as these could be described as missing at random.

Statistical Analysis

All neoplasms were defined by the principal diagnosis for hospitalization according to ICD-10 neoplasm codes (C00-D48). Missing ICD-10 codes captured as free text (approximately 10%) were manually assigned on the basis of the free text, where possible. Hospitalization duration was defined as the difference between the date of admission and discharge plus one. Each episode of hospitalization was treated as a unique record as our data did not distinguish between multiple visits per patient. The sociodemographic characteristics of the patients were stratified by the malignancy category, that is, malignant (C00-C97), benign (D10-D36), and neoplasms of uncertain or unknown behaviors (D37-D47). We modeled the rate of hospitalizations because of neoplasms between 2012 and 2017 using Poisson regression with a robust sandwich estimator to account for overdispersion. Our choice of Poisson regression is to report (empirical) and predict (future) rates of neoplasm hospitalizations as a count data compared with other models.[30,31] Modeling the future hospitalization rates is useful to hospital managers and policymakers for resource allocation. The three malignancy groups (malignant, benign, and neoplasms of uncertain or unknown behaviors) were treated as categorical outcomes in three separate models. Covariates in the model included calendar-year (quantitative, reference year 2012), age (categorized into 5-year age groups with age 25-29 years as the reference group), sex (reference group: male), region (10 categories with the Greater Accra region as the reference group), as well as an interaction term for age and sex. Log population count was used as the offset. This model was used to predict the future (2022 through 2032) hospitalization counts for three broad groups of neoplasms on the basis of the projected population data.

For the predictions, we assumed no effect of calendar year beyond 2016. This assumption implies that any previous secular trend in health care delivery or diagnostic quality associated with neoplasm-related hospitalization rates reached a plateau in 2016. The assumption also implied that potential risk factors for neoplasm incidence not included in the regression model would remain constant. Hence, the only variables with accommodated future changes associated with neoplasm hospitalization rate were projected population counts per region, age, and sex. We assessed how well the model fits our data using visual inspection of the Pearson residual plot for each group of neoplasms.

We report the empirical (2012-2017) and predicted (2022-2032) hospitalization counts with 95% CIs and corresponding P values as well as relative rates (RRs) with 95% CI and P values from Wald tests.

Data cleaning, analysis, and predictions were performed using Stata v15.[32] Stata codes, as well as the GHS patient and Ghana Statistical Service population data sets, can be obtained from the principal investigator upon request.

The study was approved by the GHS Ethics Review Committee (GHS-ERC: 002/12/17).

RESULTS

Participants

A total of 2,915,936 inpatient records were identified from 2012 to 2017. After excluding all cases for other diagnoses (n = 2,887,164), records with incomplete data (n = 1,383), and duplicate records (n = 762), the study population comprised 26,627 records of hospitalization for neoplasms (Fig 1). The overall sociodemographic characteristics of patients are presented in Table 1, and detailed breakdowns of all neoplasms are shown in the Appendix Table A1.

Description of Patients Hospitalized for Neoplasms

From Table 1, out of the 26,627 hospitalization records analyzed in this study, 9,463 (35.5%) were due to malignant disease, 15,362 (57.7%) due to benign neoplasms, and 1,802 (6.8%) due to neoplasms of unknown or uncertain behaviors (D37-D47). The median age among patients with malignancies was 50 years (interquartile range [IQR], 34-66 years), among patients with benign neoplasms was 39 years (IQR, 32-45 years), and among patients with neoplasms of uncertain or unknown behaviors was 37 years (IQR, 22-55 years). The median duration of hospitalization was 4 days irrespective of malignancy
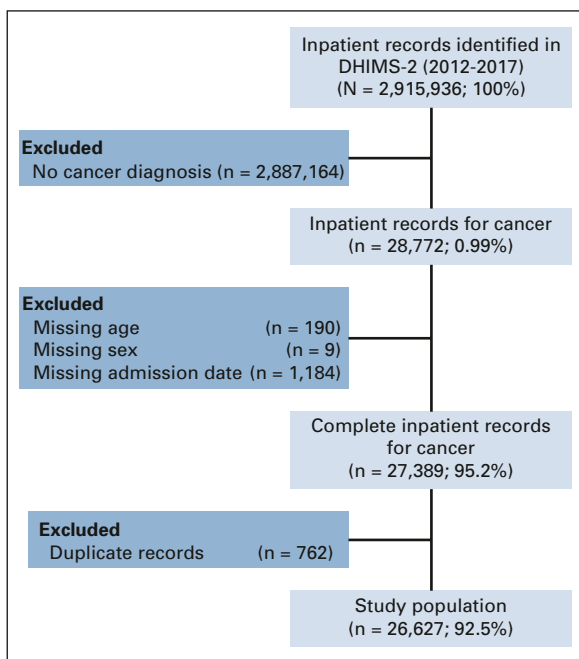

FIG 1. Study flowchart of hospitalized patients in the Ghana Health Service DHIMS-2 database, 2012-2017. DHIMS-2, District Health Information Management System 2.

TABLE 1. Characteristics of Patients Hospitalized for Cancer Between 2012 and 2017 in Ghana

Variables	C00-C97	D10-D36	D37-D48	Overall
No. (row %)	9,463 (35.5)	15,362 (57.7)	1,802 (6.8)	26,627
Age, years, median (IQR)	50 (34-66)	39 (32-45)	37 (22-55)	
Hospitalization duration, days, median (IQR)	4 (2-8)	4 (2-5)	3 (1-6)	
No. (column %)				
Sex				
Male	4,156 (43.9)	1,325 (8.6)	878 (48.7)	6,359 (23.9)
Female	5,307 (56.1)	14,037 (91.4)	924 (51.3)	20,268 (76.1)
Year				
2012	714 (7.6)	134 (0.9)	146 (8.1)	994 (3.7)
2013	1,245 (13.2)	349 (2.3)	285 (15.8)	1,879 (7.1)
2014	1,734 (18.3)	2,097 (13.7)	370 (20.5)	4,201 (15.8)
2015	1,961 (20.7)	3,867 (25.2)	348 (19.3)	6,176 (23.2)
2016	2,274 (24.0)	4,998 (32.5)	381 (21.1)	7,653 (28.7)
2017	1,535 (16.2)	3,917 (25.5)	272 (15.1)	5,724 (21.5)
Region				
Ashanti	387 (4.1)	960 (6.3)	73 (4.1)	1,420 (5.3)
Brong Ahafo	1,485 (15.7)	1,776 (11.6)	274 (15.2)	3,535 (13.3)
Central	655 (6.9)	1,221 (8.0)	142 (7.9)	2,018 (7.6)
Eastern	1,471 (15.5)	2,195 (14.3)	247 (13.7)	3,913 (14.7)
Greater Accra	1,085 (11.5)	2,619 (17.1)	380 (21.1)	4,084 (15.3)
Northern	1,355 (14.3)	548 (3.6)	204 (11.3)	2,107 (7.9)
Upper East	439 (4.6)	299 (2.0)	79 (4.4)	817 (3.1)
Upper West	167 (1.8)	364 (2.4)	44 (2.4)	575 (2.2)
Volta	1,652 (17.5)	3,349 (21.8)	243 (13.5)	5,244 (19.7)
Western	767 (8.1)	2,031 (13.2)	116 (6.4)	2,914 (10.9)
Age group, years				
0-4	251 (2.7)	190 (1.2)	128 (7.1)	569 (2.1)
5-9	177 (1.9)	100 (0.7)	78 (4.3)	355 (1.3)
10-14	174 (1.8)	87 (0.6)	66 (3.7)	327 (1.2)
15-19	267 (2.8)	243 (1.6)	107 (5.9)	617 (2.3)
20-24	366 (3.9)	530 (3.5)	138 (7.7)	1,034 (3.9)
25-29	536 (5.7)	1,499 (9.8)	158 (8.8)	2,193 (8.2)
30-34	640 (6.8)	2,595 (16.9)	146 (8.1)	3,381 (12.7)
35-39	742 (7.8)	2,840 (18.5)	145 (8.1)	3,727 (14.0)
40-44	737 (7.8)	3,010 (19.6)	136 (7.6)	3,883 (14.6)
45-49	725 (7.7)	2,185 (14.2)	117 (6.5)	3,027 (11.4)
50-54	793 (8.4)	957 (6.2)	116 (6.4)	1,866 (7.0)
55-59	694 (7.3)	410 (2.7)	107 (5.9)	1,211 (4.6)
60-64	762 (8.1)	205 (1.3)	102 (5.7)	1,069 (4.0)
65-69	549 (5.8)	136 (0.9)	69 (3.8)	754 (2.8)
70-74	759 (8.0)	154 (1.0)	77 (4.3)	990 (3.7)
75-79	707 (7.5)	119 (0.8)	60 (3.3)	886 (3.3)
80-100	584 (6.2)	102 (0.7)	52 (2.9)	738 (2.8)
Educational level				

(Continued on following page)

TABLE 1. Characteristics of Patients Hospitalized for Cancer Between 2012 and 2017 in Ghana (Continued)

Variables	C00-C97	D10-D36	D37-D48	Overall
None	1,832 (19.4)	4,595 (29.9)	400 (22.2)	6,827 (25.6)
Primary	5,005 (52.9)	5,826 (37.9)	825 (45.8)	11,656 (43.8)
JHS/middle school	991 (10.5)	1,483 (9.7)	189 (10.5)	2,663 (10.0)
SHS/secondary	911 (9.6)	1,874 (12.2)	237 (13.2)	3,022 (11.4)
Tertiary	723 (7.6)	1,582 (10.3)	151 (8.4)	2,456 (9.2)
Occupation				
Unemployed	3,066 (32.4)	2,665 (17.4)	706 (39.2)	6,437 (24.2)
Employed	4,646 (49.1)	9,675 (63.0)	807 (44.8)	15,128 (56.8)
Unspecified	1,750 (18.5)	2,985 (19.4)	289 (16.0)	5,024 (18.9)
Health insurance				
No	1,333 (14.1)	1,414 (9.2)	296 (16.4)	3,043 (11.4)
Yes	7,948 (84.0)	13,694 (89.1)	1,497 (83.1)	23,139 (86.9)
Surgical procedure				
No	6,244 (66.0)	8,735 (56.9)	973 (54.0)	15,952 (59.9)
Yes	2,777 (29.3)	6,256 (40.7)	774 (42.9)	9,807 (36.8)
Comorbidity				
No	6,987 (73.8)	12,446 (81.0)	1,519 (84.3)	20,952 (78.7)
Yes	2,476 (26.2)	2,916 (19.0)	283 (15.7)	5,675 (21.3)
Outcome at discharge				
Alive	8,429 (89.1)	15,295 (99.5)	1,725 (95.7)	25,449 (95.6)
Died	1,016 (10.7)	60 (0.4)	73 (4.1)	1,149 (4.3)

NOTE. C00-C97 malignant neoplasms; D10-D36 benign neoplasms; D37-D47 neoplasms of uncertain or unknown behavior. Some variables had missing values (ie, education 3, occupation 38, health insurance 445, surgical procedure 868, and outcome at discharge 29).

Abbreviations: IQR, interquartile range; JHS, junior high school; SHS, senior high school.

status. However, the IQR for patients with malignancies ranged from 2 to 8 days and that of patients with benign disease ranged from 2 to 5. The median duration of stay was 3 days for patients with neoplasms of unknown or uncertain behaviors. For patients with malignant and benign diseases, the annual number of hospitalizations increased from 714 (7.6%) and 134 (0.9%) in 2012 to 2,274 (24.0%) and 4,998 (32.5%) in 2016, respectively. Although there was an increase in hospitalization because of neoplasms of unknown or uncertain behaviors (D37-D47) from 2012 to 2013, it kept fluctuating for the subsequent years.

The regional hospitalization rates showed that the Volta region recorded the highest proportions of admissions for both malignant (1,652; 17.5%) and benign disease (3,349; 21.8%) admissions. Among patients with neoplasms of unknown or uncertain behaviors, most of the records were from the Greater Accra region (380; 21.1%). Most of the patients with any of the neoplasms either had no education (6,437; 24.2%) or completed primary education (11,656; 43.8%). Unemployment and health insurance ownership were reported by the majority of patients (15,128 [56.8%] and 23,139 [86.9%]). Comorbidity (2,476; 26.2%) and case fatality (1,016; 10.7%) were highest among patients with

malignancies. The lowest comorbidity proportion was among patients with neoplasms of uncertain or unknown behaviors (283; 15.7%), and the lowest case fatality among patients with benign disease (60; 0.4%). Since this was a nationwide study, hospitals classified as district/government/municipal (11,290; 42.4%) or regional (6,739; 25.3%) accounted for most hospitalizations, especially for those because of benign neoplasms. The six university/teaching hospitals included in the study recorded more neoplasms of uncertain or unknown behaviors (109; 6.1%), malignant (434; 4.6%), and benign (433; 2.8%). The remaining sections of the results focus on malignant neoplasms as the benign tumors could be described as mainly precancerous lesions.

Modeling Past Hospitalizations (2012-2017)

The Poisson regression for hospitalization because of any neoplasm showed an annual RR of 1.43 (95% CI, 1.36 to 1.52; $P < .001$). The overall rate of female patients was three times compared with that of male patients (RR, 3.04; 95% CI, 2.11 to 4.37; $P < .001$), modified by age. In the age-sex-specific strata, females in age groups 20-24 years to 45-49 years have higher RRs between 1.29 and 2.29 compared with males. In the other age groups, females have lower age-sex-specific strata RRs between 0.15 and

0.94 compared with males. The remaining overall results are shown in Figure 2 and Appendix Table A2.

The annual RR for hospitalization because of malignant neoplasms (C00-C97) was 1.23 (95% CI, 1.19 to 1.27; $P < .001$). For malignant neoplasms, the RR for female patients compared with male patients was 1.53 (95% CI, 1.00 to 2.34; $P = .048$).

Compared with patients age 25-29 years, diagnosed with malignant, younger patients had lower hospitalization rates and older patients had higher hospitalization rates. Among the younger patients with malignant diagnoses, the RRs ranged from 0 to 4 years (RR, 0.37; 95% CI, 0.23 to 0.59; $P < .001$) to 45-49 years (RR, 2.28; 95% CI, 1.51 to 3.44; $P < .001$), whereas much higher rates were observed among older patients in the range of (RR, 2.89; 95% CI, 1.91 to 4.39; $P < .001$) from 55 to 59 years to (RR, 22.84; 95% CI, 15.04 to 34.70; $P < .001$) among patients age 75-59 years. The RRs in each neoplasm category increased with age, especially among the high-risk group compared with patients age 25-29 years (Fig 2 and Appendix Table A2).

All regions except the Eastern Region showed a statistically significant RR compared with the Greater Accra region (reference region). The highest RR (1.33; 95% CI, 1.09 to 1.61; $P = .004$) and lowest RR (0.24; 95% CI, 0.18 to 0.32; $P < .001$) for hospitalization because of malignant neoplasms were in the Volta and Upper West regions, respectively.

The RRs for age and sex interaction were significantly lower for females < 10 years and those above 60 years with malignancies. Rates for the other neoplasms are shown in Figure 2 and Appendix Table A2.

Predicting Future Neoplastic Hospitalizations (2022-2032)

We present the predictions of malignant neoplasms (C00-C97) here, whereas the predictions of benign and neoplasm of uncertain or unknown behaviors are shown in Appendix Figures A1 and A2.

The visual inspection of the Pearson residual plot for each group of neoplasms showed no variation between the observed and the fitted values according to Appendix Figures A3A-A3C.

From 2012 to 2016, the annual number of hospitalizations among males were 442 (319 malignant) to 1,503 (1,002 malignant), and among females 587 (415 malignant) to 6,020 (1,272 malignant). We predict that the yearly number of hospitalizations of male patients with malignant neoplasm in 2022 will be 1,349 (95% CI, 1,285 to 1,413), corresponding to a 34.6% increase compared with 2016. For females, we predict 1,776 (95% CI, 1,715 to 1,837) hospitalizations, representing a 39.6% increase compared with 2016. For 2026, the projected number of hospitalizations of male patients with malignant neoplasm is 1,470 (95% CI, 1,391 to 1,549) corresponding to a 46.7% increase compared with 2016. For females, the prediction is 1,926 (95% CI, 1,849 to 2,002), representing a 51.4% increase compared with 2016. In 2032, the corresponding predictions are 1,655 (95% CI, 1,549 to 1,760) for males and 2,155 (95% CI, 2,052 to 2,258) for females (Fig 3 and Table 2), representing a 65.2% and 69.4% increase in males and females, respectively, compared with 2016.
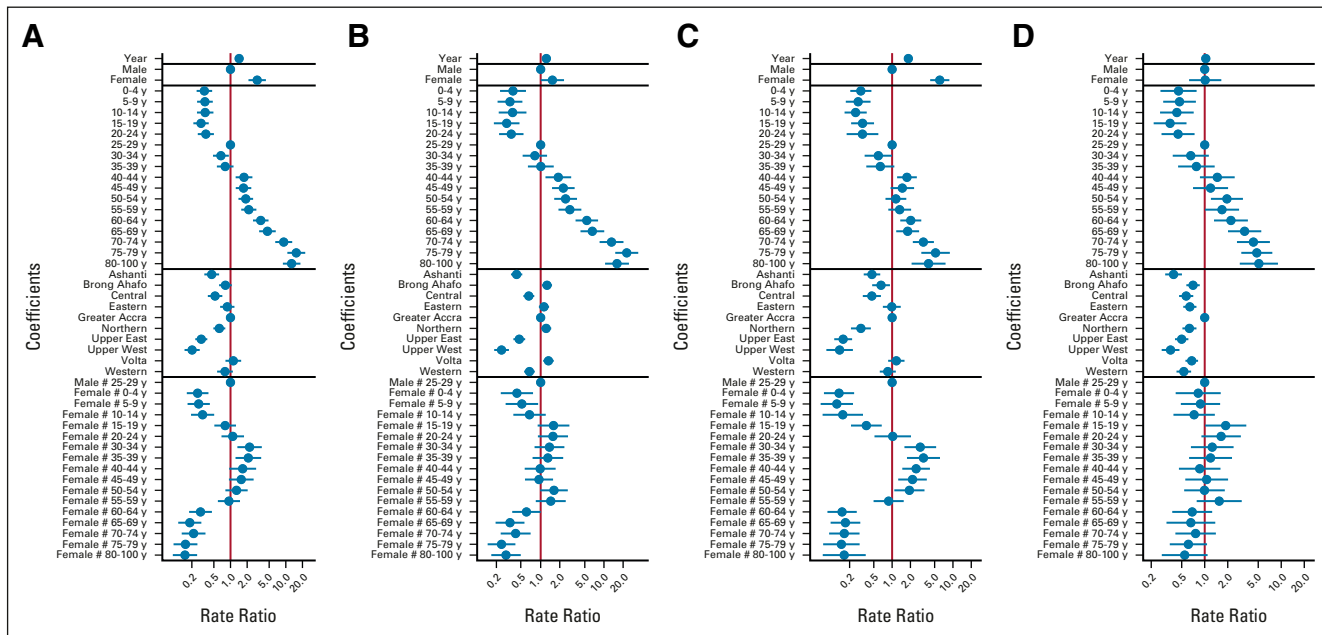

FIG 2. Coefficient and 95% CI plot from the Poisson regression model for patients hospitalized because of neoplasms: (A) neoplasms, (B) C00-C97, (C) D10-D36, and (D) D37-D47.

DISCUSSION

We demonstrated the usefulness of routinely collected health data (2012-2017) in estimating the current and future burden because of hospitalizations for neoplasms in Ghana in the absence of a national population-based cancer registry.[6,18,28] To our knowledge, our study is the first to provide a nationwide estimate of hospitalizations for all different neoplasms among different hospital types in Ghana. The documented annual number of all hospitalizations of patients with neoplasms increased by 672.8% in 6 years. The increase was largely influenced by benign tumors. This large increase could partly be explained by the ambitious efforts by the GHS to improve its health information system in 2012.[33] It should be noted that only hospitalization rates are available at the national level as no national cancer registry currently exists. Additionally, cancers and other NCDs in sub-Saharan Africa are estimated to increase.[6]

The burden because of hospitalization of women with neoplasms was three times higher than that of men, consistent with the results from smaller studies on the demographics of patients with cancer.[17,18,21] However, the rates for hospitalization of female patients with malignant disease were about twice that for men, whereas hospitalization rates of women with benign disease were six times those of their male counterparts. The higher proportion of female patients with neoplasms was obvious across the 10 regions of Ghana, which could probably be explained by high cervical and breast neoplasms. This distribution is also consistent across the different hospital types involved in the study. Patients with malignancies were a decade older than the other patients in our study, in contrast to previous smaller studies in Ghana.[17,18,26] On the basis of regional population distribution, one would expect that the highest number of all neoplasms would have been recorded in the

Greater Accra and Ashanti regions. However, this was not the case. The highest number of hospitalizations for both malignant and benign neoplasms was in the Volta region. Presumably, this could be due to a specialized hospital with foreign assistance in caring for patients with fibroid, making the hospital accessible to the whole country, especially to the people of the Greater Accra region and the Republic of Togo. Also, a probable reason for the low number of hospitalizations in the two biggest regions (Greater Accra and Ashanti) could be due to the teaching hospitals with associated cancer registries in these two regions,[17,28] which do not contribute data to the DHIMS-2.

The overall high increase in the observed and predicted burden of the different neoplasms could be plausibly because of the high burden of leiomyoma of uterus (unspecified), and female malignant neoplasm of the breast, cervix uteri, prostate, and ovary compared with the other neoplasms.[16-18,21,26,28,34]

The Poisson regression model showed a 23% (RR, 1.23) increase in the annual rates for malignant neoplasm admissions over the 6 years. The Volta region recorded the highest RRs of 1.33 for patients with malignancies. The stronger increase in hospitalization rates of patients between ages 30 and 75+ years for malignant neoplasm and neoplasms of uncertain or unknown behaviors reflects the general age distribution of cancer incidence previously reported from some teaching hospitals in Ghana.[17,18]

We predicted the number of neoplastic-related hospitalizations over 10 years until 2032 on the basis of the available population forecast for this time period. Nevertheless, limiting the prediction to a shorter time interval is preferred because of large uncertainties in very long-term population estimates.[35-37] In our predictions, we estimated that 1,349 and 1,776 male and female patients with malignant cancers would be hospitalized in 2022. Subsequently, the
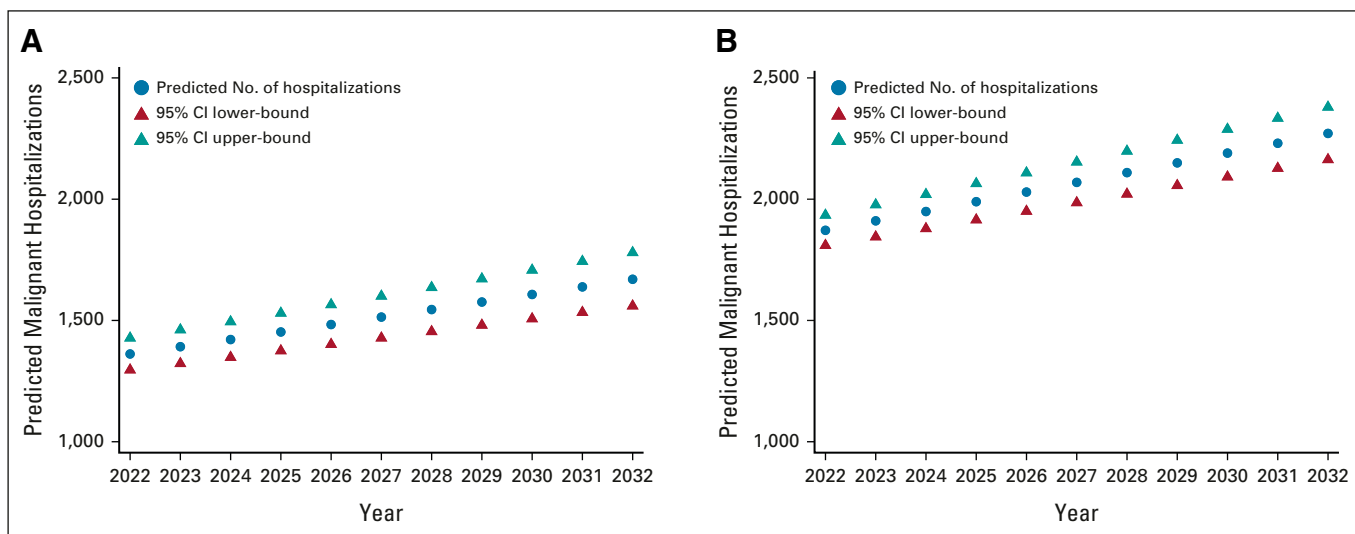

FIG 3. Yearly number and 95% CI of empirical and predicted neoplastic hospitalizations from Poisson regression model by sex: (A) male and (B) female.

TABLE 2. Yearly Number and 95% CI of Empirical and Predicted Cancer Hospitalization Cases From Poisson Regression Model by Sex

	C00-C97		D10-D36		D37-D48	
Year	Male, No. (95% CI)	Female, No. (95% CI)	Male, No. (95% CI)	Female, No. (95% CI)	Male, No. (95% CI)	Female, No. (95% CI)
Empirical hospitalization counts						
2012	319	415	53	82	70	90
2013	529	716	121	228	141	144
2014	756	978	211	1,886	180	190
2015	881	1,080	311	3,556	166	182
2016	1,002	1,272	359	4,639	182	199
Predicted hospitalization counts						
2022	1,349 (1,285 to 1,413)	1,776 (1,715 to 1,837)	975 (856 to 1,094)	7,939 (7,823 to 8,055)	383 (306 to 460)	414 (337 to 492)
2023	1,379 (1,312 to 1,447)	1,813 (1,749 to 1,877)	996 (867 to 1,126)	8,105 (7,977 to 8,232)	392 (309 to 474)	423 (341 to 505)
2024	1,408 (1,337 to 1,480)	1,850 (1,782 to 1,918)	1,018 (877 to 1,159)	8,270 (8,131 to 8,409)	400 (312 to 487)	431 (344 to 519)
2025	1,439 (1,364 to 1,514)	1,888 (1,816 to 1,960)	1,040 (887 to 1,193)	8,439 (8,288 to 8,590)	409 (316 to 501)	440 (347 to 533)
2026	1,470 (1,391 to 1,549)	1,926 (1,849 to 2,002)	1,062 (897 to 1,227)	8,608 (8,444 to 8,771)	417 (319 to 516)	449 (351 to 548)
2027	1,500 (1,417 to 1,583)	1,964 (1,883 to 2,044)	1,084 (906 to 1,261)	8,777 (8,601 to 8,954)	426 (322 to 530)	458 (354 to 562)
2028	1,531 (1,444 to 1,618)	2,002 (1,917 to 2,087)	1,106 (916 to 1,296)	8,947 (8,758 to 9,137)	435 (325 to 545)	467 (357 to 577)
2029	1,562 (1,470 to 1,654)	2,040 (1,951 to 2,129)	1,128 (926 to 1,331)	9,118 (8,916 to 9,320)	443 (328 to 559)	476 (360 to 592)
2030	1,593 (1,496 to 1,689)	2,078 (1,984 to 2,172)	1,151 (935 to 1,366)	9,289 (9,074 to 9,504)	452 (330 to 574)	485 (363 to 607)
2031	1,624 (1,523 to 1,724)	2,117 (2,018 to 2,215)	1,173 (944 to 1,401)	9,461 (9,233 to 9,689)	461 (333 to 589)	494 (366 to 622)
2032	1,655 (1,549 to 1,760)	2,155 (2,052 to 2,258)	1,195 (954 to 1,437)	9,633 (9,392 to 9,875)	470 (335 to 604)	503 (368 to 637)

NOTE. C00-C97 malignant neoplasms; D10-D36 benign neoplasms; D37-D47 neoplasms of uncertain or unknown behavior.

year-to-year relative increase in the number of predicted hospitalization counts increases from 2.1% in 2023 to 6.4% in 2026 and doubles in 2032 for patients with malignancies. Hospitalizations of male patients were predicted to slightly increase by 22.7%, compared with 21.3% for females. These estimates were made assuming that the same level of health care delivery in 2016 is maintained as is (doctor-to-patient ratio, health education, and availability of health facilities), and lifestyle risk factors remain unchanged. The year 2016 was chosen as the reference year, as the DHIMS-2 database had incomplete data for 2017. Assuming constant external factors on hospitalization because of neoplasms, leaving only demographic development driving the change in hospitalization rates from 2016 onward represents a conservative compromise, given the large uncertainty in making specific predictions about the relevant individual influences. It aims to balance a possibly increasing trend in health care availability with a possible success of prevention efforts reducing all neoplasm incidence.[35,37-39] We also did not provide predictions from years 2017 through 2021 because this period elapsed while our study was ongoing.

In line with similar global estimates,[1,5,7] we extended our predictions to 10 years, although this increases the uncertainty.[39-41] Our long-term predictions aim to raise awareness of the expected increase in the burden of all neoplasms among inpatients across the different regions and corresponding challenges to health services planning. Our predictions will also allow for future comparison studies with observed data to benchmark and validate attempts to use administrative health data for future resource planning.

The overall increase in the estimated burden of the different neoplasms among hospitalized patients is consistent with the globally estimated cancer burden.[2,5,7]

It should be noted that we were not able to calculate incidence rates and that hospitalization may only be partly correlated with incidence. A major limitation of this study is the fact that most of the neoplasms especially the malignancies were diagnosed as unspecified. In addition, the two biggest teaching hospitals in Ghana do not contribute data on neoplasms to the DHIMS-2 database. However, the majority of the inpatients from these two hospitals also receive medical care in the majority of hospitals involved in this study before patient referral. Also, about 70% of the benign cases in the teaching

hospitals are referred from district and regional hospitals, minimizing the effect further. However, the effect on our estimates with regards to hospitalization because of malignant neoplasms may be moderate. Further limitations are implied by the unavailability of modifiable risk factors in the DHIMS-2 database for our study population. This could bias the prediction in the case of a drastic change in these factors. Another important fact to consider is the dominance of fibroid, breast, cervical, and prostate cancers, which, when detected early,[16] can reduce the overall number of hospitalizations.

The interpretation of our predictions must be done with caution, as future changes in the diagnostic, therapeutic, and preventive conditions could result in higher or lower hospitalization rates. Our prediction of neoplasm-related hospitalization rates in Ghana is an essential support to the public health measures, planning hospitals' capacity to admit the increasing number of neoplastic patients, and to estimate the national burden of all neoplasms among hospitalized patients.[37,42]

In conclusion, the reported study has three major implications: resource allocation, improved data on all neoplasm-related hospitalizations and neoplasm-related policies in Ghana, and usefulness of routine health databases. First, the projected nationwide hospitalization trend for malignant cancers, benign, and neoplasms of uncertain or unknown behavior could be used in efficient health care planning, resource allocation, and hospital management. Second, the data from this study are a strong contribution to the body of knowledge on the types of neoplasms in Ghana and the usefulness of the DHIMS-2 database. Finally, the empirical and estimated hospitalizations because of neoplasms could possibly be used in prioritizing neoplasm-related policies such as early detection measures, prevention programs, and outpatient management.

Although not all private hospitals admitting patients with neoplasms contribute data to the GHS database, we believe that all the regional, district, mission, and the private hospitals on the DHIMS-2 platform are adequate for us to generalize our findings to cover the whole country. The evidence from our study also paves the way for future nationwide studies assessing the diagnostic, treatment, and management capacities of the various hospitals other than the teaching hospitals to which neoplastic patients seek care.

AFFILIATIONS

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DATA SHARING STATEMENT

The data used in this study would be published along with the manuscript.

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Data analysis and interpretation: All authors
Manuscript writing: All authors
Final approval of manuscript: All authors
Accountable for all aspects of the work: All authors

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

No potential conflicts of interest were reported.

REFERENCES

1. Benziger CP, Roth GA, Moran AE: The global burden of disease study and the preventable burden of NCD. Glob Heart 11:393-397, 2016

2. Institute for Health Metrics and Evaluation (IHME): Findings From the Global Burden of Disease Study 2017. Seattle, WA, IHME, The Lancet, 2018

3. United Nations: General Assembly. Political Declaration of the High-Level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases. Geneva, Switzerland, WHO, 2011, pp 13

4. World Health Organization: Third United Nations high-level meeting on NCDs, 2018. https://www.who.int/ncds/governance/third-un-meeting/en2018

5. World Health Organization: Global Health Observatory (GHO) data: NCD mortality and morbidity 2019. https://www.who.int/gho/ncd/mortality_morbidity/en/

6. Gouda HN, Charlson F, Sorsdahl K, et al: Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: Results from the Global Burden of Disease Study 2017. Lancet Glob Health 7:e1375-e1387, 2019

7. Dalal S, Beunza JJ, Volmink J, et al: Non-communicable diseases in sub-Saharan Africa: What we know now. Int J Epidemiol 40:885-901, 2011

8. World Health Organization: Noncommunicable diseases country profiles 2014, 2014. https://apps.who.int/iris/handle/10665/128038

9. World Health Organization: Noncommunicable Diseases Country Profiles 2018. Geneva, Switzerland, World Health Organization, 2018, License CC BY-NC-SA 3.0 IGO2018

10. Ferlay J, Colombet M, Soerjomataram I, et al: Estimating the global cancer incidence and mortality in 2018: GLOBOCAN sources and methods. Int J Cancer 144:1941-1953, 2019

11. Benchimol EI, Smeeth L, Guttmann A, et al: The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. PLoS Med 12:e1001885, 2015

12. Safran C: Using routinely collected data for clinical research. Stat Med 10:559-564, 1991

13. Spasoff RA: Epidemiologic Methods for Health Policy. Oxford, UK, Oxford University Press, 1999

14. Clarke GM, Conti S, Wolters AT, et al: Evaluating the impact of healthcare interventions using routine data. BMJ 365:l2239, 2019

15. Morrato EH, Elias M, Gericke CA: Using population-based routine data for evidence-based health policy decisions: Lessons from three examples of setting and evaluating national health policy in Australia, the UK and the USA. J Public Health (Oxf) 29:463-471, 2007

16. World Health Organization: Cancer 2018. https://www.who.int/newsroom/fact-sheets/detail/cancer

17. Calys-Tagoe BN, Yarney J, Kenu E, et al: Profile of cancer patients' seen at Korle Bu teaching hospital in Ghana (a cancer registry review). BMC Res Notes 7:577, 2014

18. Laryea DO, Awuah B, Amoako YA, et al: Cancer incidence in Ghana, 2012: Evidence from a population-based cancer registry. BMC Cancer 14:362, 2014

19. Ministry of Health: National Strategy for Cancer Control in Ghana 2012-2016. 2011. https://www.iccp-portal.org/sites/default/files/plans/Cancer%20Plan%20Ghana%202012-2016.pdf

20. Nartey Y, Hill PC, Amo-Antwi K, et al: Cervical cancer in the Greater Accra and Ashanti regions of Ghana. J Glob Oncol 3:782-790, 2016

21. Ohene-Yeboah M, Adjei E: Breast cancer in Kumasi, Ghana. Ghana Med J 46:8-13, 2012

22. Quayson S, Wiredu E, Adjei D, et al: Breast cancer in Accra, Ghana. J Med Biomed Sci 3:21-26, 2014

23. District Health Information Software 2 (DHIS2): DHIS 2 in action 2020. 2020. https://www.dhis2.org/inaction

24. Ghana Statistical Service: 2010 Population and Housing Census Report. Accra, Ghana, Ghana Statistical Service, 2014

25. WHO: International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) Version for 2010. https://icd.who.int/browse10/2010/en#/IX

26. Amoako YA, Awuah B, Larsen-Reindorf R, et al: Malignant tumours in urban Ghana: Evidence from the city of Kumasi. BMC Cancer 19:267, 2019

27. Bray F, Znaor A, Cueva P, et al: Planning and developing population-based cancer registration in low-and middle-income settings. Lyon, France, IARC (International Agency for Research on Cancer). 2014

28. Thomas AS, Kidwell KM, Oppong JK, et al: Breast cancer in Ghana: Demonstrating the need for population-based cancer registries in low-and middle-income countries. J Glob Oncol 3:765-772, 2017

29. Ghana Statistical Service: Legal mandate 2019. http://statsghana.gov.gh/aboutgss.php?category=MjkwMzA1NjI0LjE0MTU=/webstats/oq43q9p651

30. Cameron AC, Trivedi PK: Regression Analysis of Count Data: Cambridge, England, Cambridge University Press, 2013

31. Hilbe J: Robust variance estimators for MLE Poisson and negative binomial regression. Stata Tech Bull 8, 1999

32. StataCorp LLP: Stata Statistical Software (Version Release 14). College Station, TX, StataCorp LLP, 2015

33. Adaletey DL, Jolliffe B, Braa J, et al: Peer-performance review as a strategy for strengthening health in-formation systems: A case study from Ghana. J Health Inform Afr 2, 2014

34. International Agency for Research on Cancer: The Global Cancer Observatory. Globocan, 2018. Ghana, Africa, International Agency for Research on Cancer: 2019

35. Dyba T, Hakulinen T: Do cancer predictions work? Eur J Cancer 44:448-453, 2008

36. Dyba T, Hakulinen T, Päivärinta L: A simple non-linear model in incidence prediction. Stat Med 16:2297-2309, 1997

37. Godlewski D, Wojtys P, Antczak A: Predictions of cancer incidence in Wielkopolska in 2018. Contemp Oncol (Pozn) 16:38-43, 2012

38. Comber H: Trends in Irish Cancer Incidence 1994-2002 With Projections to 2020. Cork, Ireland, National Cancer Registry, 2006

39. Hakulinen T, Teppo L, Saxén E: Do the predictions for cancer incidence come true? Experience from Finland. Cancer 57:2454-2458, 1986

40. French D, Catney D, Gavin A: Modelling predictions of cancer deaths in Northern Ireland. Ulster Med J 75:120-125, 2006

41. Møller H, Fairley L, Coupland V, et al: The future burden of cancer in England: Incidence and numbers of new patients in 2020. Br J Cancer 96:1484-1488, 2007

42. Bray F, Moller B: Predicting the future burden of cancer. Nat Rev Cancer 6:63-74, 2006

APPENDIX
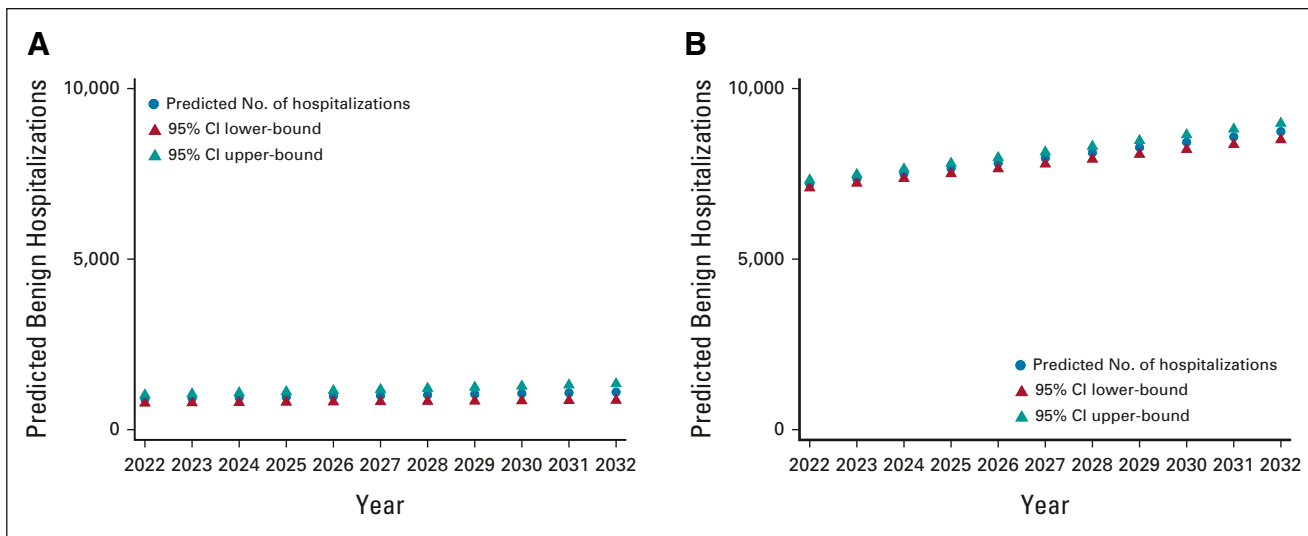
FIG A1. Three main blocks of neoplasms according to the International Classification of Diseases, 10th Revision, classification of neoplasms in the Ghana Health Service District Health Information Management System 2 database, 2012-2017: (A) male and (B) female.

FIG A2. Yearly number and 95% CI of empirical and predicted hospitalizations because of neoplasms of uncertain or unknown behaviors from Poisson regression model by sex: (A) male and (B) female.

FIG A3. Pearson residual plot for (A) malignant cancers, (B) benign tumors, and (C) neoplasms of uncertain or unknown behaviors.

TABLE A1. Breakdown of Neoplasms by Broad Categories

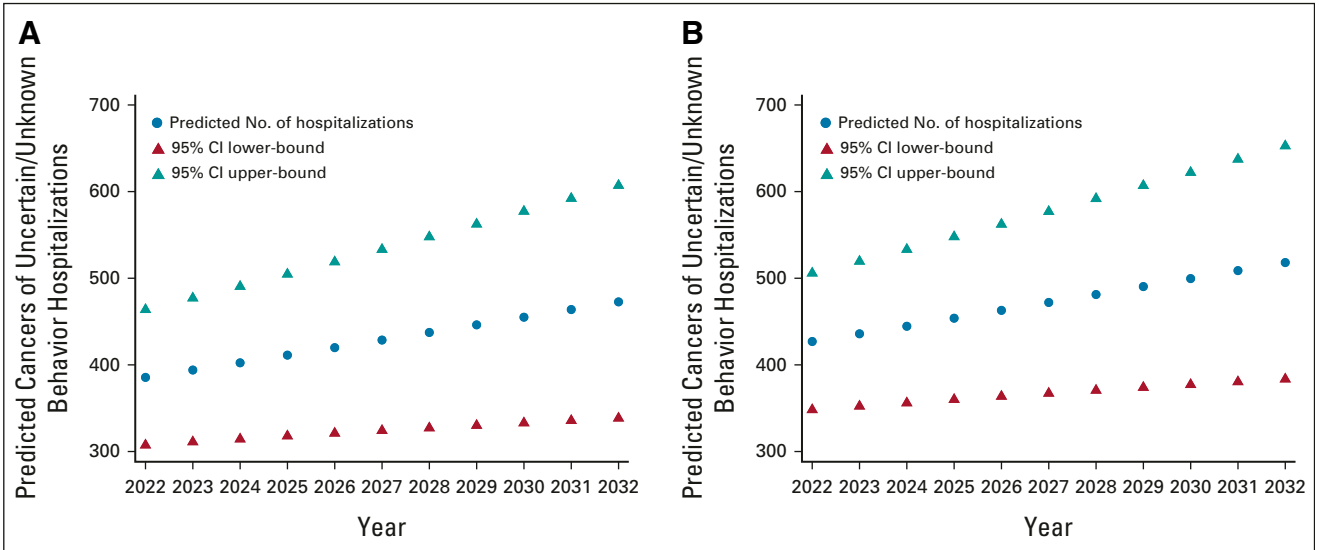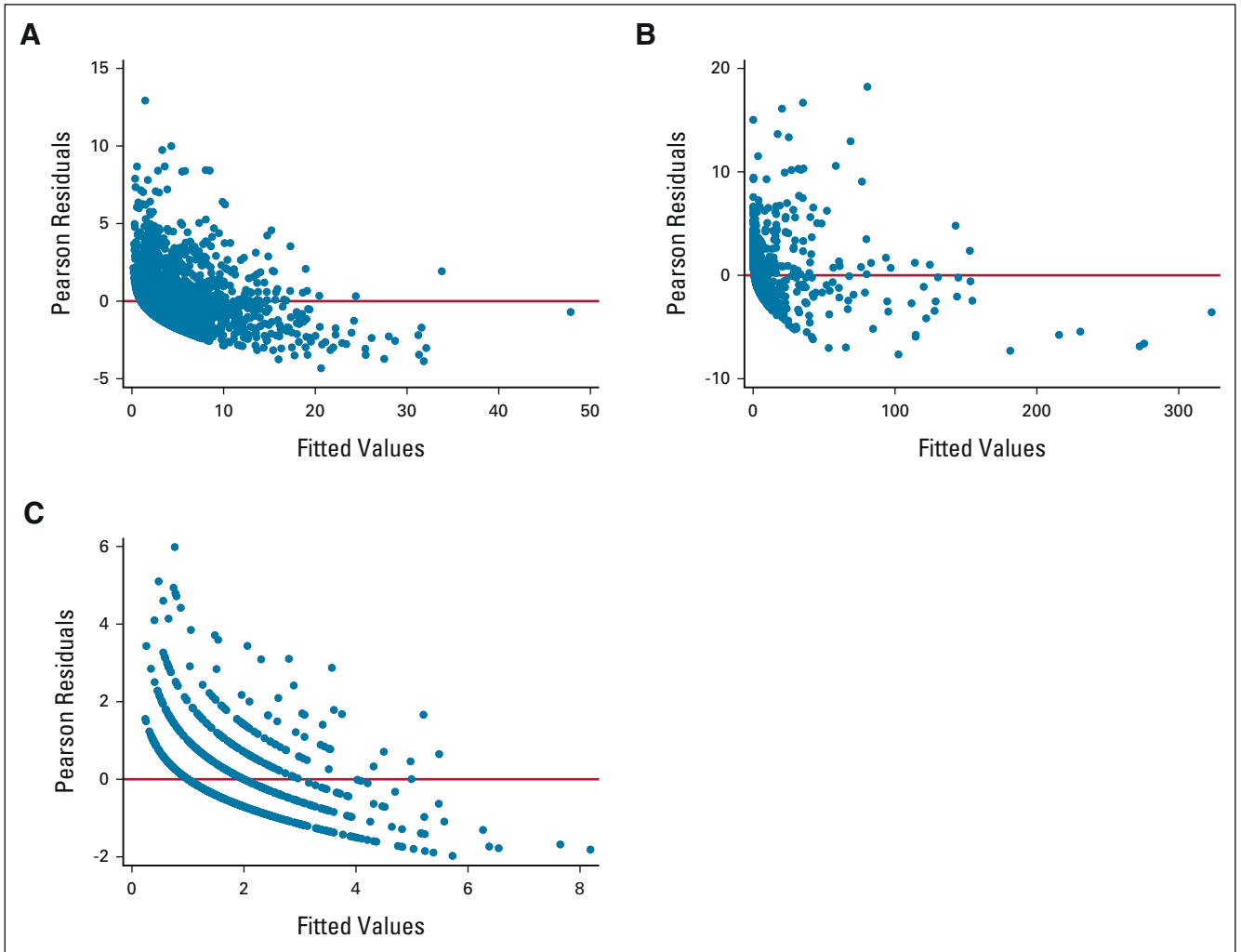| Variables	C00-C97	D10-D36	D37-D48	Overall
Neoplasm block categories, No. (column %)	9,463 (35.5)	15,362 (57.7)	1,802 (6.8)	26,627
C00-C14 malignant neoplasms of lip, oral cavity, and pharynx	271 (2.9)	—	—	271 (1.0)
C15-C26 malignant neoplasms of digestive organs	1,839 (19.4)	—	—	1,839 (6.9)
C30-C39 malignant neoplasms of respiratory and intrathoracic organs	313 (3.3)	—	—	313 (1.2)
C40-C41 malignant neoplasms of bone and articular cartilage	301 (3.2)	—	—	301 (1.1)
C43-C44 melanoma and other malignant neoplasms of skin	53 (0.6)	—	—	53 (0.2)
C45-C49 malignant neoplasms of mesothelial and soft tissue	191 (2.0)	—	—	191 (0.7)
C50-C50 malignant neoplasm of breast	1,656 (17.5)	—	—	1,656 (6.2)
C51-C58 malignant neoplasms of female genital organs	1,572 (16.6)	—	—	1,572 (5.9)
C60-C63 malignant neoplasms of male genital organs	1,599 (16.9)	—	—	1,599 (6.0)
C64-C68 malignant neoplasms of urinary tract	262 (2.8)	—	—	262 (1.0)
C69-C72 malignant neoplasms of eye, brain, and other parts of central nervous system	80 (0.9)	—	—	80 (0.3)
C73-C75 malignant neoplasms of thyroid and other endocrine glands	81 (0.9)	—	—	81 (0.3)
C76-C80 malignant neoplasms of ill-defined, secondary, and unspecified sites	880 (9.3)	—	—	880 (3.3)
C81-C96 malignant neoplasms, stated or presumed to be primary, of lymphoid, hematopoietic, and related tissue	365 (3.9)	—	—	365 (1.4)
D10-D36 benign neoplasms	—	15,362 (100.0)	—	15,362 (57.7)

(Continued on following page)

TABLE A1. Breakdown of Neoplasms by Broad Categories (Continued)

Variables	C00-C97	D10-D36	D37-D48	Overall
D37-D48 neoplasms of uncertain or unknown behavior	—	—	1,802 (100.0)	1,802 (6.8)
Top 10 individual malignancies, No. (column %)				
C50.9 malignant neoplasm: breast, unspecified	1,656 (17.5)			
C61 malignant neoplasm of prostate	1,582 (16.7)			
C53.9 malignant neoplasm: cervix uteri, unspecified	890 (9.4)			
C22.0 malignant neoplasm: liver cell carcinoma	1,494 (15.8)			
C56 malignant neoplasm of ovary	538 (5.7)			
C76.2 malignant neoplasm of other and ill-defined sites: abdomen	204 (2.2)			
C67.9 malignant neoplasm: bladder, unspecified	223 (2.4)			
C83.7 Burkitt lymphoma	154 (1.6)			
C41.9 malignant neoplasm: bone and articular cartilage, unspecified	205 (2.2)			
C34.9 malignant neoplasm: bronchus or lung, unspecified	239 (2.5)			

NOTE. C00-C97 malignant neoplasms; D10-D36 benign neoplasms; D37-D47 neoplasms of uncertain or unknown behavior.

TABLE A2. Relative Rates, 95% CI, and *P* Value From the Poisson Regression Model for Neoplastic Patients Hospitalized Between 2012 and 2017

Coefficients	C00-C97 IRR (95% CI)	P	D10-D36 IRR (95% CI)	P	D37-D48 IRR (95% CI)	P	Overall IRR (95% CI)	P
Year	1.23 (1.19 to 1.27)	< .001	1.85 (1.70 to 2.01)	< .001	1.03 (0.99 to 1.08)	.114	1.43 (1.36 to 1.52)	< .001
Sex								
Male	Ref		Ref		Ref		Ref	
Female	1.53 (1.00 to 2.34)	.048	6.07 (4.22 to 8.73)	< .001	1.01 (0.62 to 1.65)	.953	3.04 (2.11 to 4.37)	< .001
Age group, years								
0-4	0.37 (0.23 to 0.59)	< .001	0.31 (0.21 to 0.46)	< .001	0.45 (0.26 to 0.78)	.004	0.34 (0.24 to 0.47)	< .001
5-9	0.33 (0.21 to 0.51)	< .001	0.28 (0.17 to 0.44)	< .001	0.47 (0.29 to 0.77)	.003	0.34 (0.25 to 0.48)	< .001
10-14	0.36 (0.22 to 0.60)	< .001	0.25 (0.17 to 0.38)	< .001	0.43 (0.26 to 0.72)	.001	0.35 (0.25 to 0.49)	< .001
15-19	0.29 (0.18 to 0.46)	< .001	0.33 (0.21 to 0.50)	< .001	0.35 (0.22 to 0.58)	< .001	0.29 (0.21 to 0.40)	< .001
20-24	0.34 (0.22 to 0.54)	< .001	0.33 (0.18 to 0.59)	< .001	0.45 (0.27 to 0.74)	.002	0.36 (0.26 to 0.50)	< .001
25-29	Ref		Ref		Ref		Ref	
30-34	0.81 (0.52 to 1.26)	.350	0.59 (0.35 to 1.00)	.049	0.66 (0.38 to 1.13)	.130	0.67 (0.48 to 0.93)	.018
35-39	1.01 (0.63 to 1.61)	.982	0.64 (0.38 to 1.09)	.099	0.78 (0.45 to 1.35)	.372	0.80 (0.57 to 1.13)	.212
40-44	1.90 (1.19 to 3.03)	.007	1.75 (1.21 to 2.55)	.003	1.46 (0.87 to 2.47)	.155	1.75 (1.24 to 2.49)	.002
45-49	2.28 (1.51 to 3.44)	< .001	1.47 (0.94 to 2.30)	.088	1.19 (0.70 to 2.02)	.515	1.72 (1.24 to 2.38)	.001
50-54	2.47 (1.64 to 3.74)	< .001	1.15 (0.78 to 1.71)	.477	1.95 (1.20 to 3.16)	.007	1.89 (1.39 to 2.57)	< .001
55-59	2.89 (1.91 to 4.39)	< .001	1.33 (0.87 to 2.05)	.193	1.68 (1.01 to 2.81)	.047	2.14 (1.56 to 2.94)	< .001
60-64	5.35 (3.55 to 8.06)	< .001	2.03 (1.36 to 3.02)	.001	2.20 (1.32 to 3.67)	.002	3.53 (2.55 to 4.87)	< .001
65-69	6.54 (4.25 to 10.08)	< .001	1.80 (1.17 to 2.78)	.008	3.32 (2.01 to 5.48)	< .001	4.65 (3.29 to 6.59)	< .001
70-74	13.13 (8.51 to 20.26)	< .001	3.26 (2.19 to 4.86)	< .001	4.33 (2.64 to 7.11)	< .001	9.17 (6.45 to 13.06)	< .001
75-79	22.84 (15.04 to 34.70)	< .001	5.18 (3.02 to 8.90)	< .001	4.80 (3.01 to 7.65)	< .001	15.48 (10.67 to 22.46)	< .001
80-100	16.03 (10.39 to 24.74)	< .001	3.97 (2.09 to 7.55)	< .001	5.10 (2.87 to 9.07)	< .001	12.76 (8.86 to 18.38)	< .001
Region								
Ashanti	0.42 (0.34 to 0.51)	< .001	0.47 (0.34 to 0.64)	< .001	0.39 (0.30 to 0.50)	< .001	0.46 (0.34 to 0.62)	< .001
Brong Ahafo	1.26 (1.05 to 1.51)	.012	0.66 (0.47 to 0.92)	.014	0.70 (0.58 to 0.86)	.001	0.81 (0.62 to 1.05)	.117
Central	0.65 (0.53 to 0.79)	< .001	0.46 (0.33 to 0.65)	< .001	0.57 (0.46 to 0.71)	< .001	0.53 (0.39 to 0.71)	< .001
Eastern	1.13 (0.94 to 1.36)	.207	0.99 (0.70 to 1.39)	.943	0.64 (0.52 to 0.78)	< .001	0.87 (0.65 to 1.18)	.377
Greater Accra	Ref		Ref		Ref		Ref	
Northern	1.22 (1.02 to 1.47)	.033	0.31 (0.21 to 0.45)	< .001	0.63 (0.51 to 0.78)	< .001	0.63 (0.49 to 0.81)	< .001
Upper East	0.46 (0.37 to 0.57)	< .001	0.16 (0.11 to 0.22)	< .001	0.50 (0.41 to 0.61)	< .001	0.30 (0.23 to 0.38)	< .001
Upper West	0.24 (0.18 to 0.32)	< .001	0.14 (0.08 to 0.23)	< .001	0.36 (0.27 to 0.47)	< .001	0.20 (0.15 to 0.28)	< .001
Volta	1.33 (1.09 to 1.61)	.004	1.17 (0.86 to 1.60)	.313	0.68 (0.56 to 0.82)	< .001	1.12 (0.81 to 1.56)	.482

(Continued on following page)

TABLE A2. Relative Rates, 95% CI, and *P* Value From the Poisson Regression Model for Neoplastic Patients Hospitalized Between 2012 and 2017 (Continued)

Coefficients	C00-C97 IRR (95% CI)	*P*	D10-D36 IRR (95% CI)	*P*	D37-D48 IRR (95% CI)	*P*	Overall IRR (95% CI)	*P*
Western	0.67 (0.55 to 0.81)	< .001	0.85 (0.63 to 1.15)	.290	0.53 (0.43 to 0.66)	< .001	0.80 (0.57 to 1.11)	.173
Age, years, and sex interaction								
0-4#Sex	0.42 (0.23 to 0.76)	.004	0.13 (0.08 to 0.24)	< .001	0.82 (0.42 to 1.62)	.570	0.25 (0.16 to 0.40)	< .001
5-9#Sex	0.50 (0.28 to 0.91)	.023	0.12 (0.07 to 0.23)	< .001	0.88 (0.49 to 1.59)	.672	0.27 (0.17 to 0.42)	< .001
10-14#Sex	0.67 (0.37 to 1.20)	.178	0.15 (0.07 to 0.33)	< .001	0.73 (0.39 to 1.36)	.315	0.31 (0.19 to 0.51)	< .001
15-19#Sex	1.59 (0.90 to 2.84)	.113	0.38 (0.21 to 0.68)	.001	1.88 (1.01 to 3.50)	.046	0.80 (0.51 to 1.26)	.334
20-24#Sex	1.56 (0.90 to 2.70)	.110	1.02 (0.51 to 2.04)	.948	1.64 (0.90 to 2.97)	.103	1.10 (0.69 to 1.75)	.696
25-29#Sex	1.38 (0.80 to 2.37)	.248	2.90 (1.59 to 5.29)	< .001	1.25 (0.66 to 2.38)	.489	2.21 (1.33 to 3.68)	.002
30-34#Sex	1.30 (0.74 to 2.27)	.357	3.28 (1.76 to 6.13)	< .001	1.19 (0.62 to 2.27)	.594	2.10 (1.23 to 3.58)	.006
35-39#Sex	0.98 (0.56 to 1.72)	.948	2.48 (1.47 to 4.18)	.001	0.86 (0.46 to 1.61)	.636	1.66 (0.95 to 2.91)	.076
40-44#Sex	0.94 (0.56 to 1.57)	.818	2.16 (1.26 to 3.72)	.005	1.06 (0.56 to 2.02)	.859	1.57 (0.94 to 2.62)	.088
45-49#Sex	1.62 (0.98 to 2.68)	.059	1.92 (1.09 to 3.41)	.025	0.99 (0.54 to 1.83)	.981	1.29 (0.81 to 2.05)	.289
50-54#Sex	1.44 (0.84 to 2.49)	.187	0.88 (0.49 to 1.55)	.649	1.55 (0.79 to 3.04)	.207	0.94 (0.59 to 1.49)	.783
55-59#Sex	0.60 (0.36 to 1.00)	.051	0.15 (0.09 to 0.26)	< .001	0.69 (0.38 to 1.25)	.219	0.29 (0.18 to 0.46)	< .001
60-64#Sex	0.33 (0.19 to 0.55)	< .001	0.17 (0.10 to 0.30)	< .001	0.66 (0.32 to 1.37)	.266	0.18 (0.11 to 0.30)	< .001
65-69#Sex	0.40 (0.23 to 0.69)	.001	0.16 (0.09 to 0.29)	< .001	0.76 (0.41 to 1.40)	.378	0.22 (0.13 to 0.35)	< .001
70-74#Sex	0.24 (0.15 to 0.40)	< .001	0.15 (0.07 to 0.29)	< .001	0.61 (0.35 to 1.07)	.086	0.15 (0.09 to 0.25)	< .001
80-100#Sex	0.28 (0.17 to 0.48)	< .001	0.16 (0.07 to 0.37)	< .001	0.55 (0.27 to 1.09)	.087	0.15 (0.09 to 0.25)	< .001

NOTE. C00-C97 malignant neoplasms; D10-D36 benign neoplasms; D37-D47 neoplasms of uncertain or unknown behavior.
Abbreviation: IRR, incidence rate ratio.