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Surveillance Analysis of Five Malignant Tumors Incidence in Panama from 2010-2020

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Abstract

Malignant tumors have developed as one of the most serious global health problems, with a current estimate that one in four people will develop a malignant tumor during their lifetime. In 2022, there were 20 million new cases diagnosed worldwide, resulting in 9.7 million deaths. Due to lifestyle changes, behavioral factors, and increased life expectancy, this rapid increase presents challenges for countries like Panama, where malignant tumors affect the individual and the national economy. Previous research focused on the mortality rate of malignant tumors in Panama but did not show the incidence trend or geographical characteristics of these tumors. In this study, we analyze data from 2010 to 2020 in Panama, the incidence trend, and differences of the five leading malignant tumors, such as C16-stomach, C18-colon, C34-lung, C42-hematopoietic system and reticuloendothelial, and C44: skin in terms of geographical distribution, gender, age, and economy were analyze. The results demonstrated a gradual increase from 2010 until peaking in 2019, with a temporary decline in 2015. Overall, females showed significantly higher rates than males ($p < 0.05$). Geographically, Herrera and Los Santos provinces developed as high-risk areas, while Indigenous regions showed concerning evidence of underreporting, reflecting potential healthcare access barriers. This research fills crucial gaps in understanding Panama's malignant tumor epidemiology and provides more foundations for public health policies. The findings highlight the urgent need for early adapted detection programs for vulnerable populations and prevention strategies addressing regional specificities, helping reduce the disease's human suffering and economic burden.

Keywords

Malignant Tumors, Incidence Trends, Geographical Distribution, Gender

Differences, Public Health

1. Introduction

Malignant tumors remain one of the most pressing global public health problems, ranking as a principal cause of death in the Americas [1]. Recent epidemiological studies demonstrate a persistent rise in global malignant tumor incidence due to demographic transitions, lifestyle factors, and environmental exposures [2]. Current estimates indicate that approximately 20 million new cases of malignant tumors have been diagnosed in 2022 alone, with projections suggesting continued increases in the coming decades [3].

In Panama, malignant tumors represent a major health concern, accounting for 17% of all deaths and an average of 14 new cases diagnosed [4]. Despite this burden, epidemiological studies on incidence trends and geographical distribution remain limited, particularly in Indigenous regions where data gaps hinder effective policy planning [5]. Previous research has focused on mortality, leaving critical gaps in understanding incidence patterns and their social determinants [6]. This research is significant because it has the potential to strengthen malignant tumor surveillance systems and prioritize interventions in high-incidence areas, a key strategy for reducing Panama's malignant tumor burden [7]. Additionally, it underscores the urgent need for improved data collection in Indigenous communities, where underreporting may mask critical health disparities [8].

Our research addresses these gaps through a thorough analysis of RNCP data, combining traditional epidemiological methods with geographic information systems. We focus on the five most common malignant tumor types, examining their distribution by gender, age, region, and association with income indicators. These malignant tumor types (C16: stomach, C18: colon, C34: lung, C42: hematopoietic system and reticuloendothelial, and C44: skin) were selected because they represent major malignant tumors affecting both males and females in Panama, allowing for a comprehensive analysis of their epidemiological behavior across genders. While other high-incidence malignant tumors, such as breast and prostate malignant tumors, are significant, their gender specificity limits combined analysis; thus, focusing on tumors impacting both sexes provides a balanced perspective on the burden of malignant tumors and social determinants in the population. The results will provide valuable scientific evidence while serving as a foundation for public policies to reduce oncological care inequalities.

Previous research has primarily focused on the mortality rate of malignant tumors in Panama, neglecting the trend of incidence and geographical characteristics of the tumors. By providing a recent situational analysis of malignant tumors in Panama, we can bridge the gap in statistical Panamanian literature reports related to malignant tumors and provide a reference to the government to evaluate the health policy of malignant tumors.

The study aims to analyze the incidence trends and geographical distribution of the five most common malignant tumors stomach, colon, Bronchi and lung, hematopoietic system and reticuloendothelial, and skin malignant tumors in Panama from 2010 to 2020. Specifically, it investigates variations by gender, age region, and socioeconomic status to identify high-risk populations and inform targeted public health interventions. The central research question is: Is there a significant spatial distribution difference in the incidence of malignant tumors across different regions, age groups, and genders in Panama from 2010 to 2020?

2. Background

In the past couple of decades, the incidence of malignant tumors has seen a worrisome increase due to alterations in our lifestyle, habits, and extended lifespan. There is not a distant problem but one that affects us directly, with an estimated one out of every four individuals facing the risk of developing a malignant tumor in their lifetime [9]. A malignant tumor can be caused by the abnormal multiplication of various cells within the body, leading to over a hundred diverse types of tumors. A malignant tumor, known as metastasis, could infiltrate surrounding healthy tissue and disseminate throughout the body via the bloodstream or lymphatic systems [10]. Internationally, a malignant tumor is a serious health problem, being one of the leading causes of death worldwide. Twenty million new malignant tumor cases and 9.7 million malignant tumor deaths were reported in 2022. Of these, 2.5 million new cases were lung malignant tumors (attributed to 12.4% of all new cases), followed by female breast malignant tumors with 2.3 million cases (attributed to 11.6%), colorectal malignant tumors with 1.9 million cases (attributed to 9.6%), prostate malignant tumor with 1.5 million cases (attributed to 7.3%), stomach cases with 970,000 cases (attributed to 4.9% of all new cases) [3]. The malignant tumor of the lung was the most frequent cause of mortality in men, while in females, it was a malignant tumor of the breast [3]. The urgency of this issue cannot be overstated, and immediate action is needed to address this growing problem.

At the international level, malignant tumors are a growing problem in low-income and middle-income countries, thus boosting efforts to help national governments solve the problems [11]. In 2012, reported cases of malignant tumors in Panama began to be electronically registered in the Panama National Register of Cancer of Panama (Registro Nacional del Cancer de Panama (RNCP)) [5], which provided an optimized database for estimating the mortality of tumors in Panama. Geographically, Panama comprises 10 provinces and 5 indigenous regions (Kuna Yala, Embera, Ngobe Bugle, Kuna of Madugandi, and Kuna of Wargandi) [12]. However, the tumor data of Kuna of Madugandi and Kuna of Wargandi were not available because of lacking data recording. National statistics of Panama reveal that malignant tumors are one of the biggest health problems, responsible for 17% of deaths, registering an average of 14 diagnosed cases and 7 deaths per day [4].

A malignant tumor is a public health problem in Panama, affecting the individual's health [13] and the economy of the family and country. The strain that this disease implies at the national level allows for estimating the demand for essential services and allocating available resources. A malignant impact not only on the patient's health but also on their finances, family, and the nation's economy. Such impact results from the excessive costs associated with diagnosis and treatment, as well as the decrease in productivity due to disabilities and premature deaths. Healthcare financing models, whether public or private, along with the presence or absence of social safety nets, such as compensation schemes in the event of illness-related job loss, significantly alter the extent and nature of the economic stress experienced. The financial burden on patients with malignant tumors and their support systems is substantial, even within healthcare systems that provide universal coverage [4] [14].

Major modifiable risk factors among the Panamanian population include tobacco use and ultraviolet (UV) radiation exposure. Tobacco consumption, which is related to multiple diseases including various malignant tumors, and cardiovascular and respiratory conditions, represents a significant public health burden in Panama. According to the Ministry of Health, the prevalence of tobacco use among individuals aged 15 and older is approximately 5%, with around 153,444 smokers nationwide and an estimated 2000 annual deaths attributable to tobacco-related causes [15] [16]. Tobacco not only increases the risk of lung malignant tumors but is also associated with other types of malignant tumors and contributes to chronic non-communicable diseases, such as hypertension and diabetes, which exacerbate morbidity and mortality in the population [15].

Additionally, excessive exposure to ultraviolet (UV) radiation, particularly in a tropical country like Panama, significantly increases the risk of skin malignant tumors, which ranks as the sixth most common malignant tumor in Panama [4]. Recent studies indicate that the highest ultraviolet (UV) radiation levels are recorded in the lowlands of the provinces of Chiriqui, and the Azuero Peninsula covers the provinces of Herrera, Los Santos, and part of Veraguas, where extreme UV indices occur on more than 85% of the days during the dry season [4]. The incidence of skin malignant tumors in Panama has risen, with estimates suggesting that 50% to 90% of skin malignant tumor cases are attributable to UV exposure [17]. Lack of awareness about the harmful effects of sun exposure, combined with cultural behaviors that favor tanning and unprotected sun exposure, increases the population's vulnerability to melanoma and other malignant tumors [18].

3. Materials and Methods

3.1. Study Sites

Panama, located in Central America, has a territorial extension of 75,517 km^2 and is bordered to the north by the Caribbean Sea, to the east by the Republic of Colombia, to the south by the Pacific Ocean, and to the west by the Republic of Costa Rica [4]. The present study included all 10 provinces and the 3 Indigenous regions. Due to the lack of data on these regions, our study excluded the Kuna of Madugandi and the Kuna of Wargandi areas in Panama.

3.2. Data Sources

A retrospective analysis was conducted using malignant tumor data from Panama's National Cancer Registry of Panama (Registro Nacional de Cáncer de Panamá, RNCP), a highly reliable and trusted source. The RNCP is a population-based information system that records all malignant tumor cases diagnosed through clinical and pathological methods in both public and private healthcare sectors. We extracted all malignant tumors reported between 2010 and 2020 from the registry. A total of 22 malignant tumor types were included, classified according to the International Classification of Diseases, 10th Revision (ICD-10: C00-C97) (**Table 1**). The RNCP database is publicly accessible through the Ministry of Health's official website: https://www.minsa.gob.pa/contenido/registro-nacional-del-cancer.

Table 1. List of all malignant tumors in the study.

ICD-10[a]	Name of malignant tumor
C16	Stomach
C18	Colon
C20	Straight
C22	Liver and intrahepatic bile ducts
C25	Pancreas
C32	Larynx
C34	Bronchi and lung
C42	Hematopoietic system and reticuloendothelial
C44	Skin
C50	Breast
C51	Vulva
C52	Vagina
C53	Cervix
C54	body of the uterus
C56	Ovarian
C61	Prostate
C64	Kidney
C67	Urinary bladder
C71	Brain
C73	Thyroid
C77	Lymph nodes
C80	Primary site unknown

[a]International Classification of Disease.

The demographic and socioeconomic data were obtained from.

1) The Ministry of Health (Ministerio de Salud de Panamá, MINSA, 2022) through their official guidelines published in the Official Gazette No. 29550-B [19].

2) The National Institute of Statistics and Census (Instituto Nacional de Estadística y Censo, INEC, 2017) using the 2017 Multidimensional Poverty Index [20].

3) Panama's Ministry of Economy and Finance (Ministerio de Economía y Finanzas, MEF), using their 2015 published datasets (https://www.mef.gob.pa).

3.3. Statistical Analysis

Equation (1) was used to calculate the incidence rate of the malignant tumors.

$$\text{Incidence} = \frac{\text{New cases reported}}{\text{population of the year}} \times 100,000 \tag{1}$$

For our data analysis, we relied on the robust capabilities of IBM SPSS 27. We rigorously tested the normality of the data and used mean ± standard deviation to de-scribe the data if the data followed a normal distribution. Otherwise, we used the median (interquartile range) to describe the data. For normal distribution data, we depended on the t-test or ANOVA to compare the population means, and we used the rank sum test to analyze the non-normal distributed data. Chi-square was used to compare the proportions among categorical data.

Equation (2) and Equation (3) were used to calculate the age-standardized incidence rates (ASIRs) for the period 2010 to 2020 using cases reported by the National Cancer Registry of Panama (RNCP) and annual population projections from the National Institute of Statistics and Census (INEC). The data were stratified by age groups, to account for demographic changes over time, the denominator was the average population from 2010 to 2020, adjusted accordingly. Age standardizations were performed through the direct method, employing the WHO 2000-2025 [21]. Standard population, which facilitates international comparability. The standard population proportions used were 65% for the 0 - 39 years age group, 30% for the 40 - 69 years group, and 5% for those aged 70 and above. Although this approximation slightly differs from the exact WHO values (0 - 39: 65.53%; 40 - 69: 29.22%; ≥70: 5.25%), it maintained epidemiological comparability by summing to 100%. Cases and populations were stratified into the same age groups for analysis.

Age-specific incidence rates:

$$\text{Rate age group} = \left(\frac{\text{New cases in age group}}{\text{Population in age group}}\right) \times 100,000 \tag{2}$$

Standard population (WHO world population):

$$\text{ASIR} = \sum\left(\frac{\text{Standard pop. in age group}}{\text{Total standard population}} \times \text{Rate age group}\right) \tag{3}$$

During the processing and analysis of data from the National Cancer Registry of Panama (2010-2020), missing values for key variables were imputed as zero, based on the assumption of the absence of reported cases in those specific records. This approach was grounded in a thorough review of the database, which comprises a total of 71,326 cases distributed across 22 different types of malignant tumors. The imputation strategy allowed for maintaining the integrity of the dataset for subsequent analyses, minimizing bias associated with missing information.

We used the Geographic Information System to present the spatial pattern of the annual average incidence of malignant tumors in the 10 provinces and 3 regions from 2010 to 2020. For the spatial representation of malignant tumor incidence in Panama, the Power BI Desktop was used with the Filled Map visual. The data included the names of the provinces and their corresponding incidence rates. In the visual, the location field was assigned to the province variable and the incidence rate to the color saturation. A custom color gradient palette was applied, where lighter tones represent lower values, and more intense tones represent higher incidence rates. The color scales and ranges were individually adjusted for each map and clearly indicated below each of the five maps, along with the labeling of the provinces, to facilitate visual interpretation. This tool allowed for clear and effective visualization of spatial distribution, facilitating the identification of patterns and geographic disparities in tumor incidence.

4. Results

4.1. Overall Incidence of 22 Malignant Tumors in Panama from 2010-2020

A total of 71,326 malignant tumor cases, including 22 different tumors, were reported in Panama from January 2010 to December 2020, with an average annual incidence of 163 cases per 100,000 persons. The incidence showed a gradual increase during the study period 2010-2014, a decrease in 2015, and a continuous increase in the incidence trend after 2015. The peak in the study period was in 2019, which showed around 200 cases per 100,000 people, as depicted in **Figure 1**.

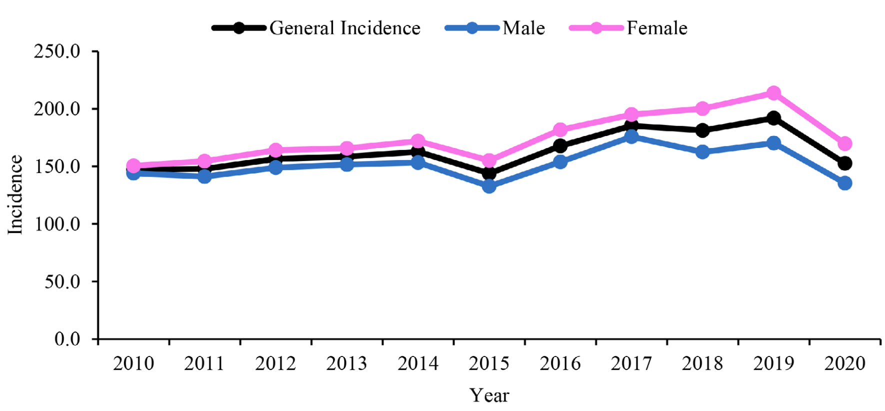


Figure 1. The annual incidence of malignant tumors in Panama from 2010 to 2020.

The average number of cases reported for males was around 152 cases per 100,000, while for women, it was 175 cases per 100,000, with females having a significantly higher incidence than men, highlighting the need for gender-specific research and interventions throughout the decade, with a p-value of 0.006, indicating a statistically significant difference in the incidence rates between the years, **Table 2**.

Table 2. Comparison of the incidence of malignant tumors by gender in Panama from 2010 to 2020.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	*t* (*p*)
Male	144.1	141.2	149.0	151.6	153.4	132.8	153.9	175.8	162.5	170.3	135.5	151.8 ± 13.6	3.085
Female	150.5	154.6	164.1	165.7	172.0	155.1	181.8	195.0	200.2	213.7	169.7	174.7 ± 20.6	0.006

4.2. The Five Leading Malignant Tumors in Panama from 2010-2020

Our study, covering the period of 2010-2020, calculated the average incidence of 22 malignant tumors. The results, as shown in **Table 3**, revealed the top three incidences of malignant tumors in C61, C53, and C50. However, these tumors, which affected only males or females, were excluded from our study. We will now shift our focus to the five leading malignant tumors in Panama C44, C16, C18, C42, and C34. This in-depth analysis will form a significant part of our study. The selected malignant tumor types represent major contributors to the overall cancer burden in Panama, affecting both males and females. Analyzing these tumors allowed for a comprehensive assessment of their epidemiological behavior across genders, enabling a more direct comparison of risk factors.

Table 3. Description of 22 malignant tumors incidence from 2010 to 2020.

ICD-10	Minimum	Maximum	Mean	Std. Deviation
C61	29.1	72.1	52.3	13.8
C53	19.7	37.2	29.9	5.3
C50	15.8	42.9	24.9	7.1
C44*	8.0	21.4	15.9	4.1
C16*	8.8	11.4	10.2	0.7
C54	8.0	11.6	9.9	1.4
C18*	6.9	11.0	9.1	1.4
C42*	6.1	9.7	7.9	1.1
C34*	6.1	8.5	7.6	0.6

Continued

C56	4.7	5.6	5.2	0.3
C73	2.9	6.6	4.5	1.2
C80	3.4	5.1	4.3	0.6
C22	3.2	4.9	4.0	0.5
C77	2.2	4.5	3.5	0.7
C64	2.4	4.5	3.5	0.8
C20	2.5	4.6	3.3	0.7
C71	2.5	3.9	3.0	0.5
C25	2.0	3.8	3.0	0.5
C67	1.4	2.5	1.9	0.3
C32	1.1	1.9	1.5	0.2
C51	0.4	0.9	0.7	0.2
C52	0.3	0.9	0.7	0.2

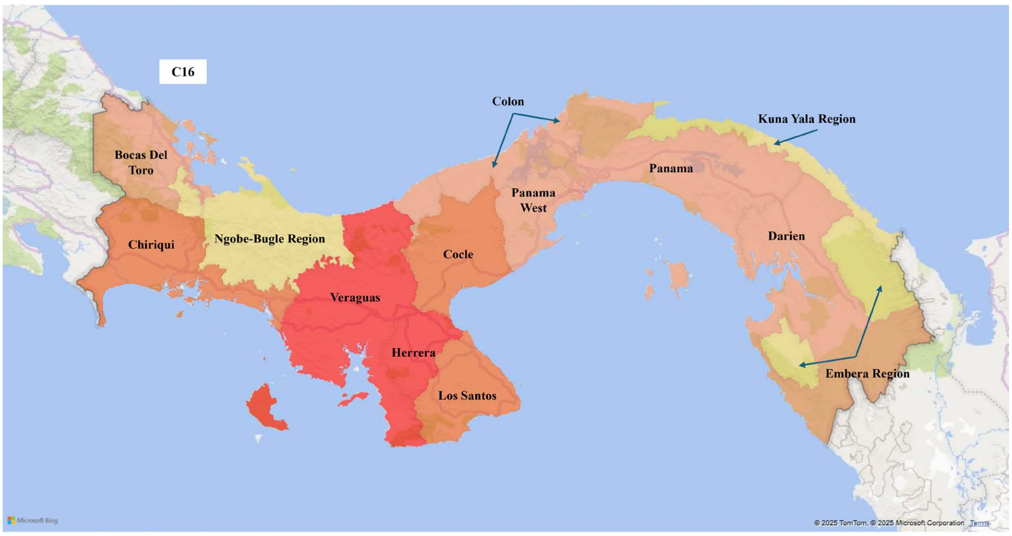
Note: *Five leading malignant tumors with the highest incidence for both genders.

4.3. The Geographic Distribution of Five Leading Malignant Tumors in Panama from 2010-2020

The geographical distribution of the average incidence of the five leading malignant tumors is a significant factor in understanding the prevalence and impact of these diseases. Figure 2 indicates that Herrera and Los Santos frequently reported the highest incidence rates among these tumors, highlighting the need for targeted interventions in these regions.

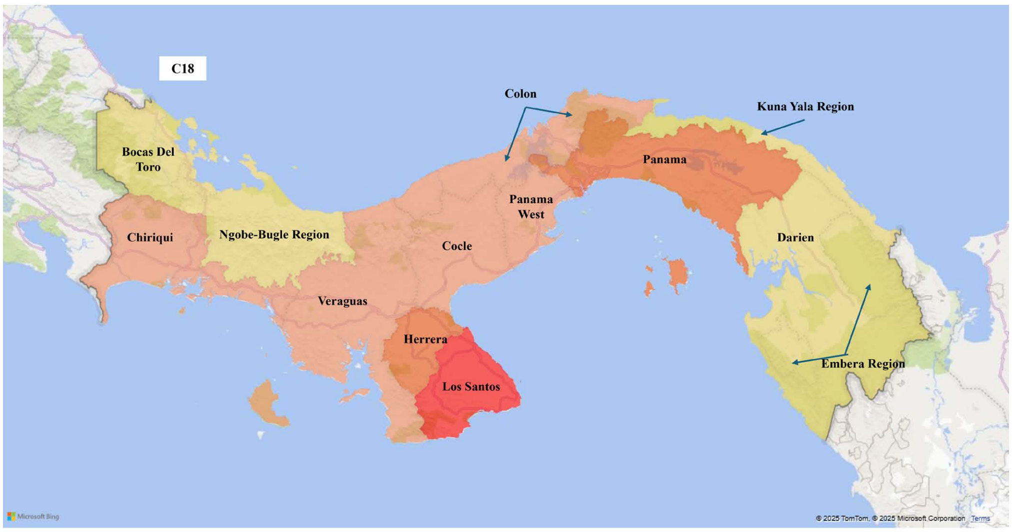
For C16, the provinces of Herrera and Veraguas exhibit the highest average annual incidence rates at 18.5 and 18.1 per 100,000, respectively, with a national average of 9.6 (Figure 2(a)), Los Santos and Herrera with the highest rates of C18 at 20.5 and 17.5 per 100,000, against a national average of 7.6 (Figure 2(b)); moreover, C34 incidence was notably higher in Los Santos and Herrera, with a national average of 5.9 (Figure 2(c)), The C42 had a relatively consistent incidence across provinces, averaging 6.7 per 100,000, with Los Santos and Herrera reporting the highest rates (Figure 2(d)), The C44 incidence was most prevalent in Los Santos and Herrera, with a national average of 16.4 per 100,000 (Figure 2(e)). Notably, Herrera experienced a significant increase in incidence rates for C16 and C44 malignant tumors in 2019, suggesting the need for targeted interventions. Meanwhile, provinces with Indigenous populations, such as Embera Region and Kuna Yala Region, often reported low or zero incidence rates, which might indicate underreporting or lower actual incidence. These provincial-level insights were crucial for shaping Panama's regional malignant tumor prevention and treatment strategies.

(a)



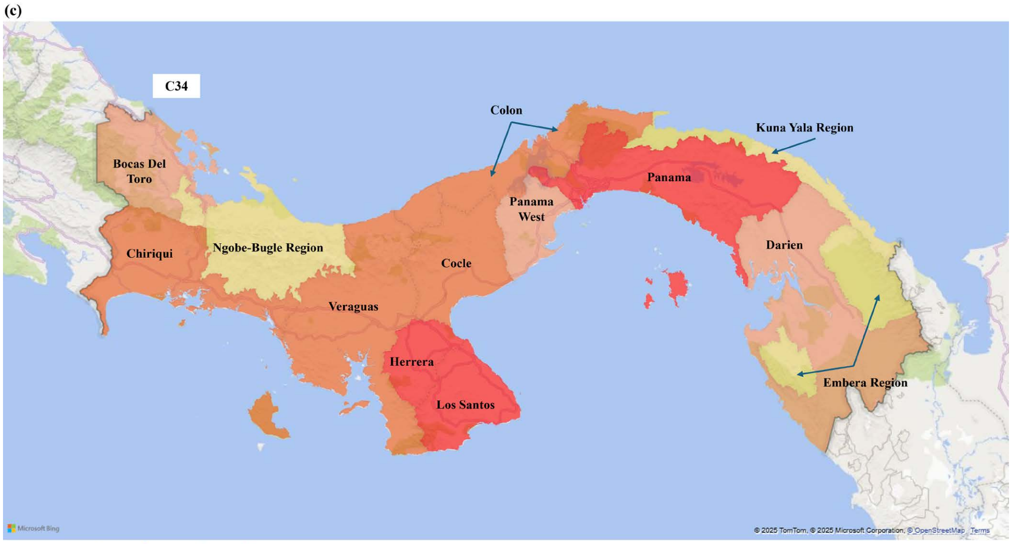
RANGE TUMOUR ● 0.0-5.0 ● 11.0-15.0 ● 16.0-20.0 ● 6.0-10.0

(b)



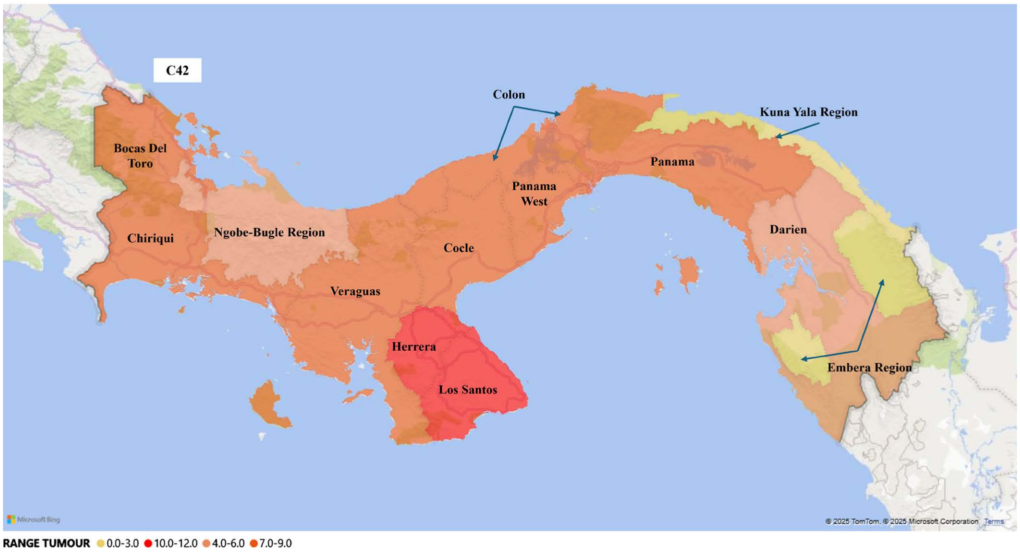
RANGE TUMOUR ● 0.0-5.0 ● 11.0-15.0 ● 16.0-21.0 ● 6.0-10.0

(c)



RANGE TUMOUR ● 0.0-3.0 ● 10.0-12.0 ● 4.0-6.0 ● 7.0-9.0

(d)



(e)

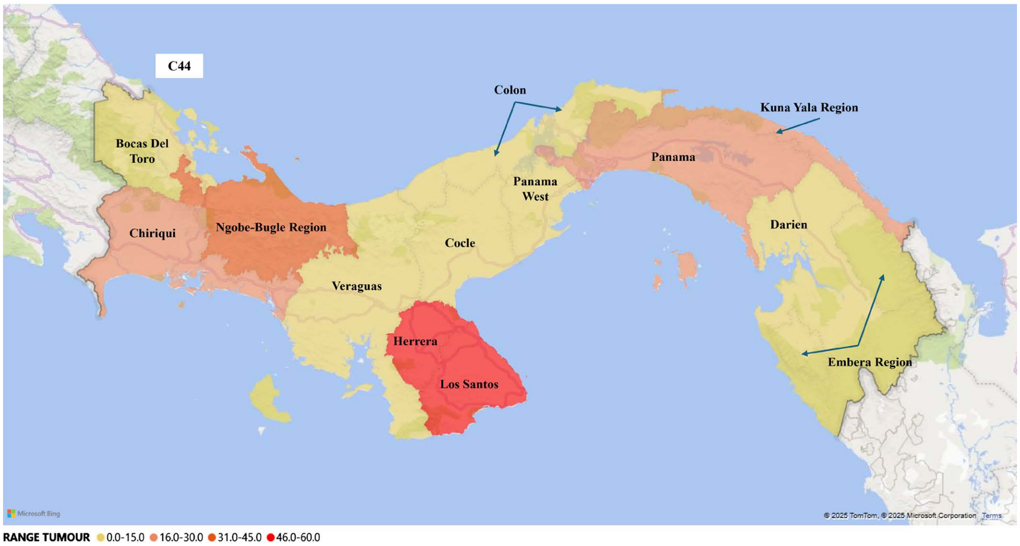


Figure 2. Distribution of the malignant tumors per province in Panama during 2010-2020 of the five leading malignant tumors. Scale bar: 1 cm = 100 km. (a) C16-Stomach, (b) C18-Colon, (c) C34-Bronchi and lungs, (d) C42-Hematopoietic system and reticuloendothelial and (e) C44-Skin.

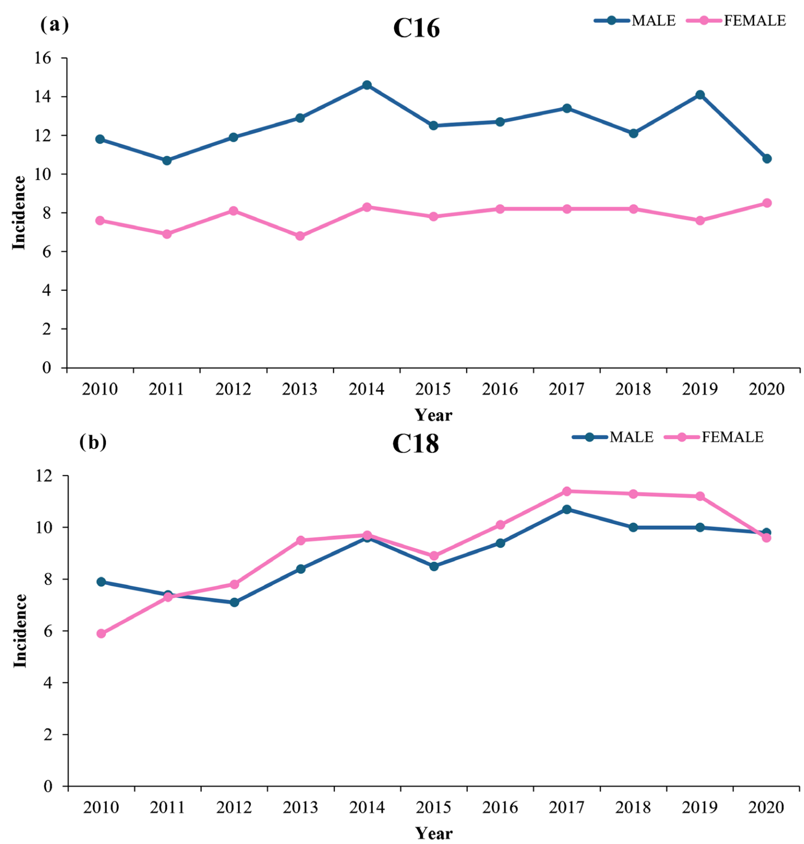
4.4. Comparison of Five Leading Malignant Tumors Incidence by Gender in Panama from 2010-2020

This analysis demonstrated that the incidence rates of malignant tumors exhibited complex temporal and gender-specific patterns. While some malignant tumors showed similar trends in both genders, others demonstrated distinct variations. We calculated the average incidence of the five leading malignant tumors from 2010-2020, and the results in Table 4 showed the incidence rates of various malignant tumors across genders over a specified period, revealing complex trends and fluctuations in the prevalence of these diseases. The results showed that C18 and C42 demonstrated significantly higher incidence rates in males than in females ($p < 0.001$). Notably, most malignant tumors exhibited varying levels of fluctuation in their incidence rates over the observed period.

Table 4. Comparison the average incidence of five leading malignant tumors from 2010-2020 by gender (Mean ± Standard deviation).

ICD-10	Male	Female	*t*	p
C16	12.5 ± 1.2	7.8 ± 0.6	11.432	<0.001
C18	9.0 ± 1.2	9.3 ± 1.8	−0.555	0.585
C34	9.4 ± 0.7	5.7 ± 0.7	12.189	<0.001
C42	8.5 ± 1.4	7.3 ± 1.1	2.060	0.053
C44	15.6 ± 4.1	16.2 ± 4.6	−0.347	0.732

Examining the specific tumor types reveals intriguing patterns. For C16, male and female incidence rates fluctuated slightly, peaked in 2014, and dipped in 2013 and 2020, respectively. Notably, the incidence rate remained consistently higher in males throughout the observed period (**Figure 3(a)**). For C18 a gradual increase in male incidence until 2017, followed by a slight decrease, while female incidence gradually increased until 2016 and then declined after that. Initially, female rates lagged male rates, but by 2020, the incidence rate almost equaled each other in both genders (**Figure 3(b)**).



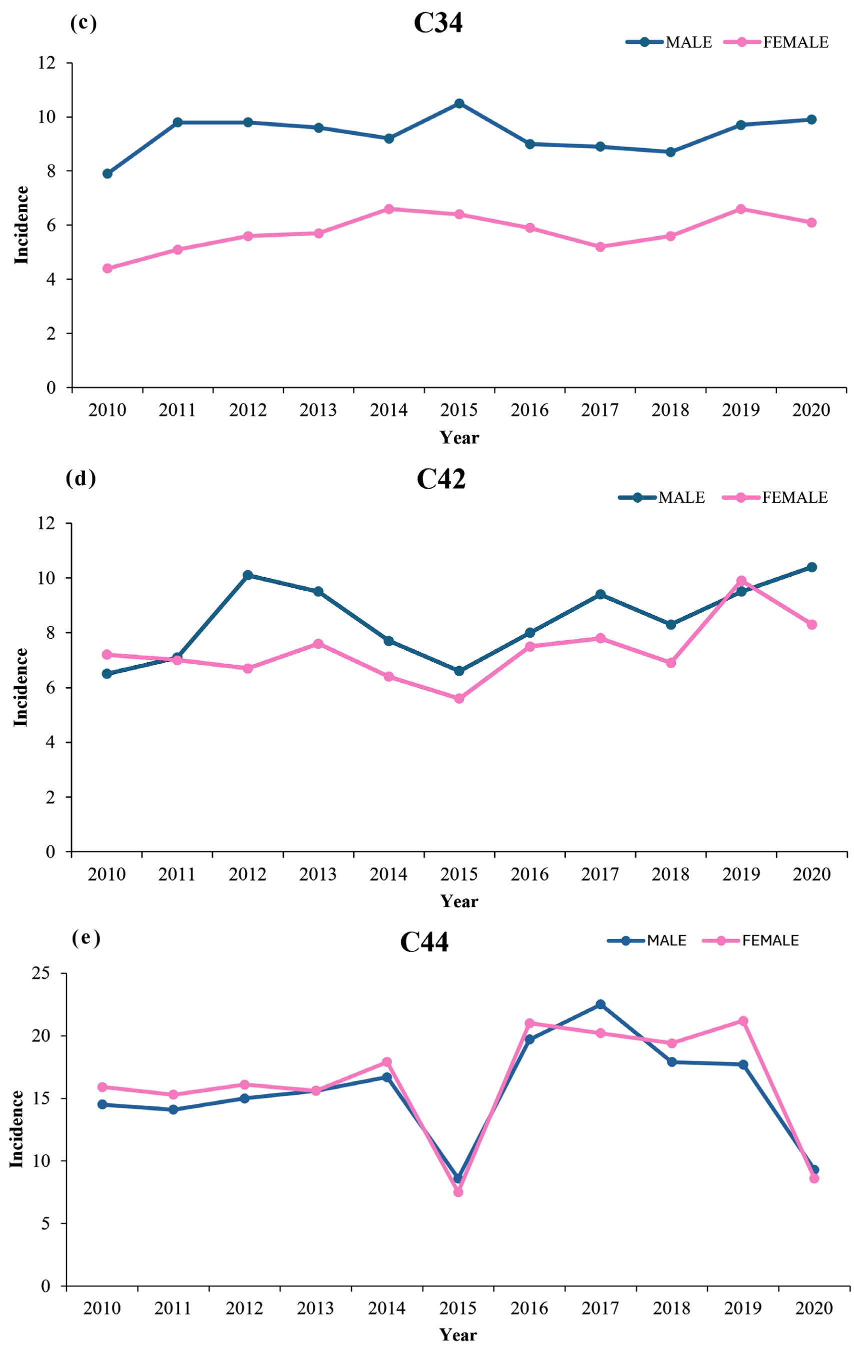


Figure 3. The average incidence of the five leading malignant tumors by gender in Panama during 2010-2020. (a) C16-Stomach, (b) C18-Colon, (c) C34-Bronchi and lungs, (d) C42-Hematopoietic system and reticuloendothelial and (e) C44-Skin.

In contrast, the incidence rate of C34 demonstrated a consistent trend of higher rates in males compared to females. Male incidence rates gradually increased until 2015, followed by minor fluctuations, while the female incidence rates gradually increased until 2013 and then experienced minor fluctuations, remaining significantly lower than males (**Figure 3(c)**). For C42, male incidence rates showed a steady increase throughout the observed period, while female rates gradually increased until 2017 and then slightly decreased, initially exceeding male rates but falling below by 2020 (**Figure 3(d)**). For C44 exhibited a significant decrease in incidence rates for both genders throughout the period. While female rates were initially higher than male rates, the two incidence rates of both genders converged by 2020 (**Figure 3(e)**).

4.5. Comparison of Five Leading the Malignant Tumors Incidence by Age-Group in Panama from 2010-2020

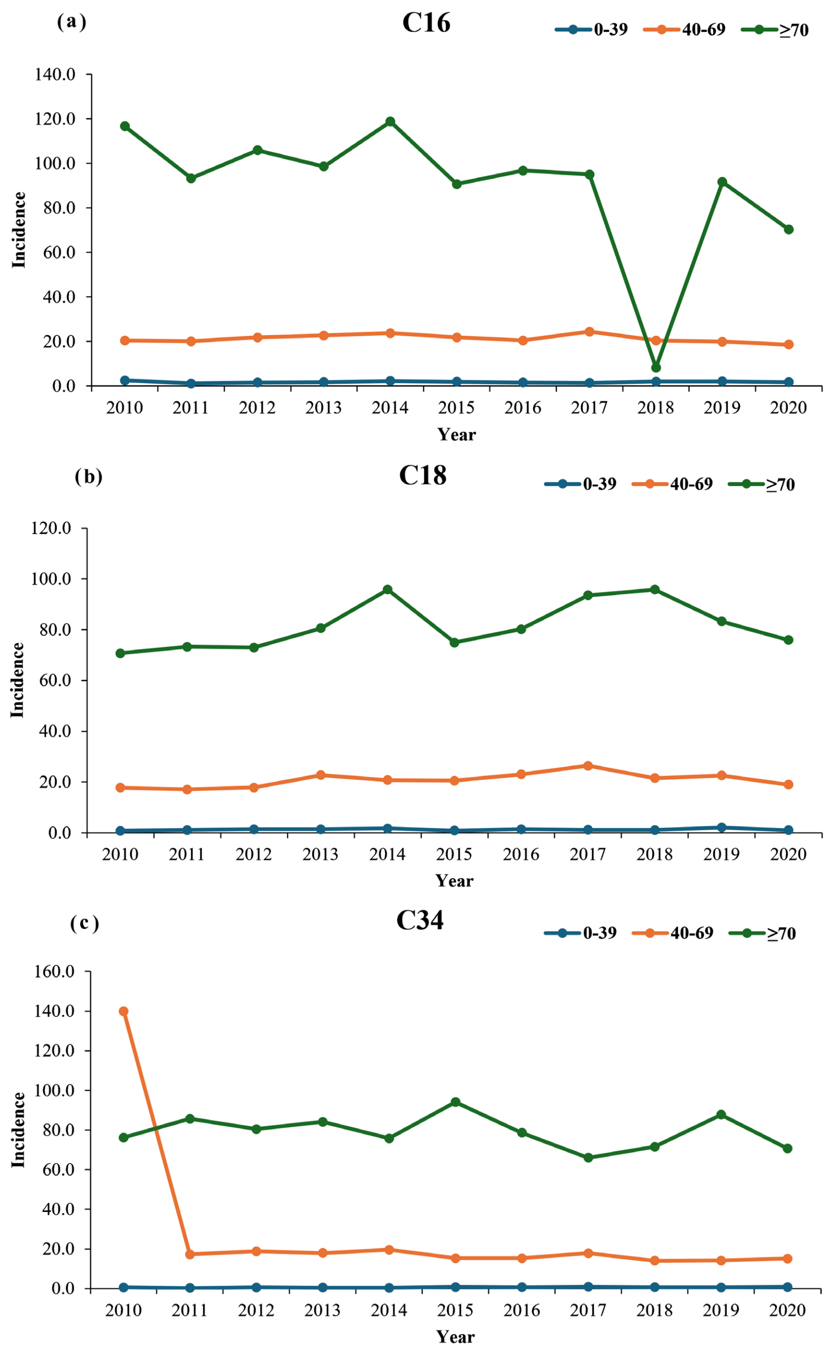
This analysis unveils the intricate relationship between age and malignant tumor incidence, providing significant insights. The RCNP data revealed three distinct age groups: 0 - 39, 40 - 69, and ≥70. Notably, the over 70 age group exhibited the highest incidence of all five leading malignant tumors, followed by 40 - 69 and 0 - 39, as depicted in **Table 5** and **Figure 4**. This data underscores the inverse relationship between age and the incidence of the five leading malignant tumors.

Table 5. Comparison of five leading malignant tumors incidence in three age group in Panama (Mean ± SD).

ICD	0 - 39	40 - 69	≥70	*F*	p
C16	1.8 ± 0.4	21.3 ± 1.8	89.5 ± 26.8	96.840	<0.001
C18	1.3 ± 0.4	20.8 ± 2.8	76.4 ± 20.0	122.076	<0.001
C34	0.6 ± 0.2	16.3 ± 2.0	73.5 ± 21.0	108.959	<0.001
C42	3.7 ± 0.6	13.8 ± 2.2	43.1 ± 11.6	99.064	<0.001
C44	2.3 ± 0.9	32.6 ± 9.7	151.5 ± 56.4	62.557	<0.001

In this study, the incidence of the five leading malignant tumors varied across three age groups. Generally, for malignant tumors C16 and C18 in young people, incidence slightly decreased from 2010 to 2020, while in older adults, fluctuations were recorded with increases up to certain years, followed by decreases. For C16, the incidence rate in the age group 0 - 39 fluctuated slightly, with a general decrease from 2010 to 2020. The age group 40 - 69 showed a similar trend, increasing until 2017 and decreasing until 2020. However, the age group ≥70 exhibited high variability, with a peak in 2014 and a significant drop in 2018 (**Figure 4(a)**). For C18 followed a similar pattern, with the age group 0 - 39 displaying a general decrease in incidence rates, while the age group 40 - 69 experienced an increase until 2017 and then a decrease. Age group ≥70, once again, demonstrated considerable variability, peaking in 2014 and declining significantly in 2015 (**Figure 4(b)**). For the C34, it exhibited a comparable trend. The age group 0 - 39 showed a slight fluctuation with a general decrease, while the age group 40 - 69 showed a decrease in 2011 with slight fluctuation. Age group ≥70, in line with the previous tumor types, displayed a high degree of variability, peaking in 2015 and decreasing significantly in 2017 (**Figure 4(c)**).

The incidence rate of C42 varied slightly. The age group 0 - 39 demonstrated a general increase in incidence rates, while the age group 40 - 69 experienced an increase until 2014 and then an increase. However, the age group ≥70 showed a unique pattern, with a peak in 2013 and a subsequent significant decrease in 2015 and showed another peak in 2017 (**Figure 4(d)**). The C44 highlighted a distinct trend. The age group 0 - 39 exhibited a general increase, while the age group 40 - 69 displayed an increase until 2017, followed by a decrease. Age group ≥70, similar to other tumor types, showed significant variability, peaking in 2014 and decreasing drastically in 2015 (**Figure 4(e)**).



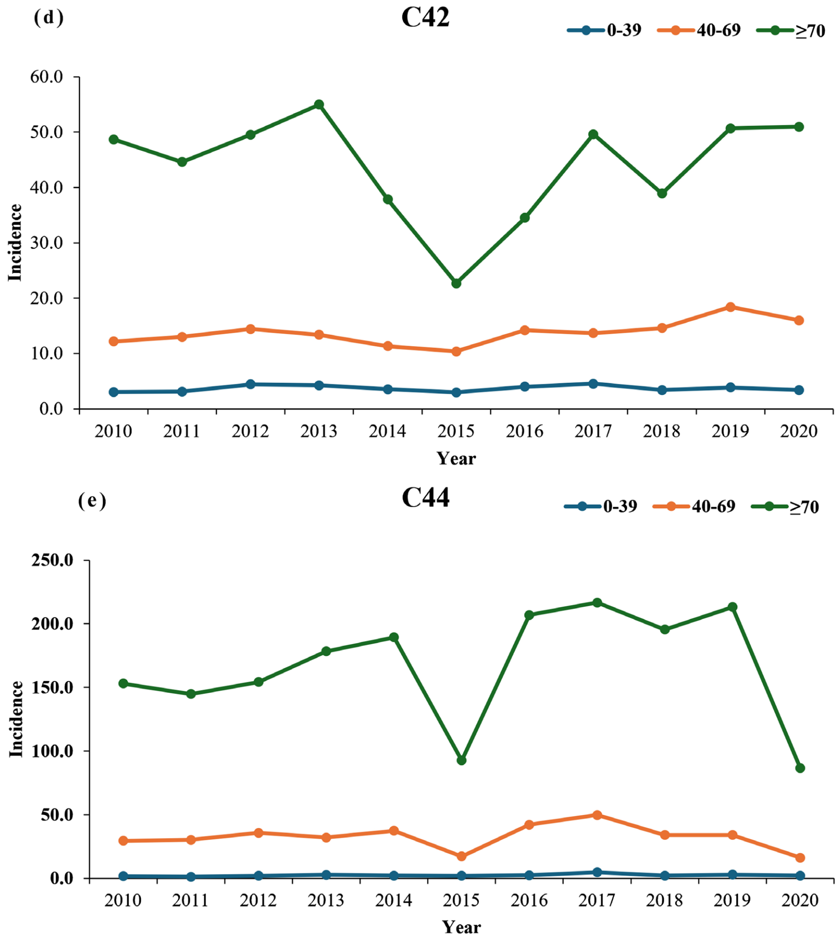


Figure 4. Comparison of the malignant tumors per age group in Panama during 2010-2020 of the 5 leading malignant tumors. (a) C16-Stomach, (b) C18-Colon, (c) C34-Bronchi and lungs, (d) C42-Hematopoietic system and reticuloendothelial and (e) C44-Skin.

4.6. Comparison of Provincial Socioeconomic Levels

Panamanian provinces were classified into high-income and low-income categories to assess oncological outcome disparities based on the 2017 Multidimensional Poverty Index (MPI) published by INEC (2022). Using the national average poverty rate of 19.1% as the threshold, provinces were categorized as high-income (MPI ≤ 19.1%)—including Panama, Panama West, Colon, Los Santos, Herrera, and Chiriqui; and low-income (MPI > 19.1%) comprising Cocle, Veraguas, Bocas del Toro, Darien, and Indigenous regions (Kuna Yala, Ngobe-Bugle, and Embera) (Figure 5, Table 6). This classification aligns with the Ministry of Health's priority zones identified in the Official Gazette No. 29550 (MINSA, 2022). To complement the analysis of crude incidence, age-standardized incidence rates (ASIRs) were calculated to adjust for differences in an age structure. The results showed that provinces classified as high-income had ASIRs that ranged from 153.76 to 207.30 per 100,000 inhabitants. It is important to note that 4 of the 6 provinces classified as high-income (Herrera, Los Santos, Panama and Chiriqui) are among the provinces with the highest ASIRs, suggesting a strong association between income level and malignant tumor burden. The low-income provinces showed ASIRs between 21.59 and 155.06 per 100,000 inhabitants. These data suggest that, while there is an overlap in the ranges, high-income provinces tend to have higher ASIRs compared to low-income provinces.

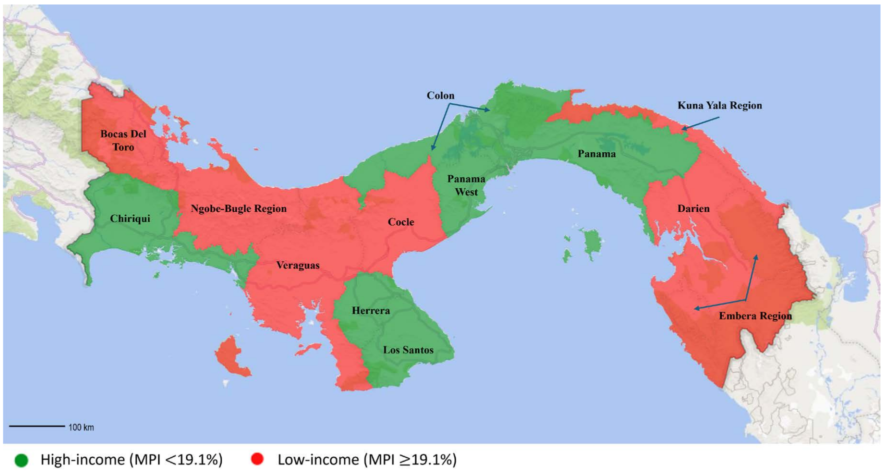


Figure 5. Division of Panama provinces based on Multidimensional Poverty Index (2017). Scale bar: 1.5 cm = 100 km (lower left corner).

Table 6. Division of Panama provinces based on multidimensional poverty index (2017).

Provinces	MPI	%	Category	ASIRs*
Los Santos	4.2%		High Income	195.7
Herrera	7.2%		High Income	207.3
Chiriqui	12.4%	MPI < 19.1%	High Income	173.9
Panama	15.6%		High Income	181.9
Panama West	15.6%		High Income	94.3
Colon	16.4%		High Income	153.7
Veraguas	19.1%		Low Income	174.9
Cocle	22.6%		Low Income	155.1
Darien	40.0%		Low Income	107.4
Bocas del Toro	44.6%	MPI ≥ 19.1%	Low Income	139.5
Embera	70.8%		Low Income	32.6
Kuna Yala	91.4%		Low Income	60.2
Ngobe Bugle	93.4%		Low Income	21.6

*Rate 100,000 per person.

Given that the Multidimensional Poverty Index (MPI) is a composite indicator that integrates multiple socioeconomic dimensions including income, education, health access, housing quality, and employment it serves as a consolidated measure of socioeconomic status.

The region was divided into two regions: low-income and high-income. From the results in **Table 7**, we found that the average incidence of the five leading malignant tumors was 4.6 for the low-income and 11.8 for the high-income. The incidence rate of the five leading malignant tumors varies between provinces with different socioeconomic levels. In general, provinces with high incomes tend to have a higher incidence than provinces with low incomes, particularly for C44.

Table 7. Comparison of the incidence of five leading malignant tumors in different income provinces, Mean (Interquartile range).

ICD	Low-income	High-income	*Z*	p
C16	7.8 (11.5)	9.9 (5.6)	−2.790	0.005
C18	1.8 (7.3)	11.2 (7.3)	−7.245	<0.001
C34	3.1 (6.2)	8.4 (3.8)	−6.587	<0.001
C42	5.1 (5.1)	8.6 (3.5)	−5.472	<0.001
C44	5.1 (11)	20.9 (35.2)	−6.087	<0.001

5. Discussion

Since Tomlinson and Wilson, in 1945 [22], published their pioneering epidemiological studies on malignant tumors in Panama, focusing on individuals of African descent, significant progress has been made in malignant tumor surveillance and treatment. Over the past two decades, the National Institute of Census and Statistics and the National Cancer Registry monitored and recorded mortality and morbidity, providing valuable data for malignant tumor research and policymaking [5]. This study provides a comprehensive and detailed analysis of the incidence and distribution of malignant tumors in Panama from 2010 to 2020. The findings reveal critical trends and patterns significantly impacting Panama's public health, malignant tumor treatment, and prevention [4].

5.1. Overall Incidence Trends (2010-2020)

The overall incidence of malignant tumors in Panama gradually increased from 2010 to 2014, followed by a temporary decline in 2015. This decline could be attributed to fluctuations in the reporting process, changes in healthcare access, or external factors such as economic downturns. Explaining the causes of this decline could offer significant insights into the multifactorial influence on malignant tumor detection and reporting in Panama [6]. The subsequent rise until 2019 marked the peak during the study period. This trend is consistent with the global patterns, which show that the incidence of malignant tumors has been steadily increasing, particularly in low-and middle-income countries (LMICs) [23] [24]. The rise in the incidence of malignant tumors can be attributed to several factors, including environmental exposure, an aging population, and lifestyle changes such as smoking, alcohol consumption, sedentary behavior, and unhealthy diets [7] [25].

5.2. Gender Differences in Incidence

One of the most notable observations in the overall incidence of this study is the high incidence of malignant tumors in females relative to males, with an average annual rate of 175 cases per 100,000 females compared to 152 cases per 100,000 males. This contrasts with the global trend, where males generally have a higher incidence of malignant tumors; the higher incidence of malignant tumors in females in Panama, particularly breast and cervical malignant tumors, can be linked to a biological, including differences in health-seeking behavior and access to the screening program, which are among the most common malignant tumors affecting women in the worldwide [26]. The gender differences in malignant tumors highlight the role of the biological, behavioral, and social factors in the malignant tumor risk; for example, hormonal differences between males and females may influence the development of certain malignant tumors, while differences in health-seeking behavior and access to healthcare services may also play a role [26].

5.3. Geographic Disparities and Risk Factors

These geographic disparities highlight the need for targeted interventions in high-incidence provinces such as Herrera, Los Santos, and Veraguas, which reported the highest incidence rates of the five leading malignant tumors. These provinces are among the more affluent regions in Panama, which suggests a correlation between higher socioeconomic status and increased malignant tumor incidences; this could be due to better access to healthcare services, leading to higher detection rates, or lifestyle factors associated with higher income levels, such as diet, smoking, and alcohol consumption [27].

The high incidence of C44 in these provinces can be related to greater exposure to ultraviolet (UV) radiation due to outdoor activities or sunbathing, which are common in affluent populations [28]; something similar happens to the C16 it can be related to dietary factors, such as high consumption of salted or smoked food, which are known risk factors for this typical malignant tumor [29]. In contrast, the Indigenous regions such as Embera, Kuna Yala, and Ngobe Bugle reported lower or zero incidence rates, which indicates underreporting or lower incidence due to differences in lifestyles, environmental factors, or genetic predisposition. The lack of data collection from Indigenous regions highlights the need to improve malignant tumor surveillance and data collection to ensure that malignant tumor prevention and treatment strategies are inclusive and equitable [8]. In comparison with the latest situational analysis of malignant tumors in Panama published by the Ministry of Health, the results of the five leading malignant tumors have similar behavior with some di differences such as, in C18 and C44, the female has the highest incidence than the male, and the C42 exist a significant different between gender where the male have the highest.

5.4. Age-Related Incidence and Implications

The study found that the incidence of malignant tumors increased significantly with age, consistent with global trends, where aging is a major risk factor for malignant tumors [30]. As individuals grow older, the cumulative effects of genetic mutations, declining immune systems, and prolonged exposure to environmental and lifestyle risk factors contribute to a higher probability of developing malignant tumors [31]-[33]. According to the United Nations World Population Prospects (2019) [34], Panama's population continues to age, with an expected 23.5% of the population being 60 years older by 2050. The burden of malignant tumors is likely to increase; this demographic underscores the urgent need for policies that promote early detection, prevention, and access to malignant tumor care for older adults. The population in Panama is aging rapidly, and this is changing the landscape of the healthcare system, bringing with it an increase in chronic diseases, including malignant tumors. Aging in older adults often means facing the dual challenges of declining health and increased vulnerability to malignant tumors [30] [35].

5.5. Income Level and Access to Healthcare

The analysis of malignant tumors by income level revealed that high-income provinces in Panama tend to report higher incidence rates, with ASIRs ranging from 153.76 to 207.30 per 100,000 inhabitants, compared to low-income provinces, where ASIRs range from 21.59 to 155.06 per 100,000 inhabitants. While there is an overlap in the ASIR ranges, this difference can be attributed to several factors, such as better access to healthcare services in high-income areas leads to higher detection rates, as individuals in these regions are more likely to undergo regular screenings and diagnostic tests [27]. Another factor can be the lifestyle factor associated with higher income levels, such as diets high in processed foods, increased tobacco use, and higher alcohol consumption, which may contribute to increasing the malignant tumor risks [29]. In contrast, low-income provinces can experience underreporting due to limited access to healthcare, resulting in lower recorded incidence rates despite potentially high actual prevalence. This highlights the need to improve malignant tumor surveillance and data collection in low-income areas to ensure equitable and inclusive prevention and treatment strategies [23].

5.6. Broader Disparities, Social Determinants, and Comparison to Other Countries

Disparities in malignant tumor incidence rates in Panama partly reflect the uneven distribution of modifiable risk factors and social determinants of health. The high prevalence of tobacco and alcohol consumption in certain regions, along with intense exposure to ultraviolet radiation in sun-rich areas, contribute to the incidence of lung, skin, and related malignant tumors [15] [36]. Additionally, infectious agents such as human papillomavirus (HPV), family history, and genetic mutations explain the elevated rates of breast and cervical malignant tumor, especially among women over 45 years old [12] [16]. Despite advances in early detection programs, access barriers persist in rural and vulnerable communities, limiting coverage and effectiveness [15]. Lifestyle changes, such as rising obesity rates and reproductive factors, together with sociocultural barriers like fear, shame, and lack of awareness, hinder early detection in women, contributing to a higher incidence compared to men—a pattern that diverges from global trends [37] [38]. Finally, cultural, and social influences, including media and social networks, shape perceptions and preventive behaviors. Compared to other Central American countries such as Costa Rica, Guatemala and Ecuador, Panama shows similarities in increasing malignant tumor incidence associated with lifestyle changes, although with variations in mortality and predominant types of malignant tumor [39]. These findings underscore the need for comprehensive interventions addressing both biological and social factors to reduce malignant tumor burden and improve health equity.

6. Conclusions

In conclusion, this situational analysis of malignant tumor incidence in Panama from 2010 to 2020 reveals critical trends and disparities that warrant urgent and targeted action. While the overall trends of the top five malignant tumors mirror global patterns, our findings underscore the unique challenges and specific needs within Panama.

Firstly, the persistently higher incidence of malignant tumors among women, particularly breast and cervical malignant tumors, necessitates strengthened screening programs and culturally sensitive health education initiatives. Secondly, the pronounced geographic disparities call for tailored interventions in high-incidence provinces, focusing on modifiable risk factors such as UV exposure and dietary habits. Simultaneously, intensified efforts are essential to enhance data collection and improve access to care in underserved Indigenous regions.

Finally, with Panama's aging population, proactive policies promoting early detection, prevention, and equitable access to malignant tumor care are paramount. By addressing these key areas, Panama can effectively reduce its malignant tumor burden, improve health equity, and ensure a healthier future for all its citizens.

7. Limitations

One of the main limitations of this study was the quality and availability of the data, particularly in the Indigenous regions such as Embera, Kuna Yala, and Ngobe Bugle, which may have underestimated the true incidence of the malignant tumors, leaving communities already facing significant barriers to healthcare in the shadow. Differences in the detection rates between high- and low-income provinces also reveal a question: Do higher rates in high-income areas reflect a greater prevalence of diseases or better access to diagnostic services? Also, there is a lack of data on individual risk factors, such as dietary habits or environmental exposure. These limitations underscore the need for improved data collection systems but also require a more equitable and compassionate approach to addressing health disparities.

While the use of rounded proportions for age standardization may slightly underestimate the absolute incidence rates, it is unlikely to significantly affect the observed trends. Future studies could validate these findings using the exact WHO population proportions and conduct sensitivity analyses to evaluate the impact of these minor differences. This approach aligns with previous local studies and ensures comparability across temporal and spatial analyses.

Abbreviations and Acronymous

1) RNCP: Panama National Register of Cancer of Panama (Registro Nacional del cancer de Panama

2) MEF: Ministry of Economy and Finance (Ministerio de Economía y Finanzas)

3) ICD: International classification of diseases

4) LMICs: Low-middle-income countries

5) INEC: National Institute of Statistics and Census (Instituto Nacional de Estadística y censo)

6) MPI: Multidimensional Poverty Index (MPI)

7) MINSA: Ministry of Health (Ministerio de Salud de Panamá)

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Ethical Approval

This study involved the analysis of publicly available, de-identified data obtained from the National Cancer Registry of Panama (RNCP), accessible through the Ministry of Health's official website. As the data is anonymized and does not contain any information that could identify individual patients, formal ethical approval was not required. However, we adhere to all relevant data protection guidelines and regulations.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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