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Original Paper

The Illusion of Escalation: A Critical Reassessment of Rising Trends in Colorectal Cancer Incidence: Case of Lebanon

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Abstract

Colorectal cancer (CRC) is widely recognized as an increasing global health issue, with many studies noting rising case numbers and forecasting significant future impacts. This paper critically evaluates the accuracy of these projections, suggesting that the perceived rise in CRC cases is primarily driven by three major non-epidemiological factors: global population growth, advances in medical information systems and cancer registries, and greater public awareness from health campaigns. When these factors are considered, the notion of a CRC surge may be greatly overstated. This work advocates for a revised understanding of CRC trends that includes raw incidence data alongside demographic, technological, and social changes. To support this, a quantitative analysis was conducted using secondary historical data from 1995 to 2025, employing multiple regression, robustness checks, and descriptive statistics. The findings indicate that awareness campaigns and internet access significantly influence the reported increase in CRC cases in Lebanon. These results challenge simplified views of rising incidence and underscore the importance of accounting for reporting and awareness efforts. They help clarify the actual factors affecting decision-making and guide prevention strategies by government agencies, non-governmental organizations, and healthcare providers aiming to reduce CRC cases both in Lebanon and globally.

Keywords

Colorectal Cancer, CRC, incidence, critical reassessment, contextualization, Lebanon

Introduction

Globally, approximately 28.4 million new cancer cases are expected in 2040, representing a 47% increase from 19.3 million cases in 2020, assuming that national rates from 2020 stay the same (Sung,

Ferlay, Siegel, et al., 2021). The largest relative increase is seen in countries with a low Human Development Index (HDI) at 95%, and in those with a medium HDI at 64%. When considering total cases, high HDI countries are projected to see the biggest absolute increase, with 4.1 million more new cases in 2040 compared to 2020. This estimate accounts only for population growth and aging, but it could worsen due to rising risk factors in various areas (Bray, Laversanne, Sung, et al., 2024).

Studies on colon cancer (CRC) show that the number of cases has increased over the years. Figure 1 compares the global population growth (6 billion in 2000 to more than 8 billion in 2020) with the total number of colorectal cancer cases recorded during that period (Naghavi, Malekzadeh, et al., 2019; Sung et al., 2021; UN, 2024). Future projections suggest that CRC cases will continue to rise, as shown in Figure 2, which displays the predicted total of new cases for all cancers combined (both genders) in 2040 based on the 4-Tier Human Development Index (Bray et al., 2024). Understanding the causes of these trends is crucial to determining whether colon cancer is truly becoming more common or if other factors are influencing these statistics.

The United Nations estimates that the global population will reach its maximum of about 10.3 billion near 2084 before experiencing a decline (Worldometer, 2025). This forecast relies on a medium-variant scenario that presumes a steady decline in the worldwide average fertility rate. In 2023, “the global population hit 8 billion and is projected to increase by approximately 1.9 billion by 2100, totaling 10.2 billion” (UN, 2024). Additionally, “the global population is increasing at an approximate annual rate of 0.85% in 2025” (Worldometer, 2025). The latest statistics from the International Agency for Research on Cancer (IARC) suggest that “yearly, there are approximately 1.9 million new colorectal cancer cases and over 900,000 deaths worldwide as a result of this disease” (IARC, 2025). Global Cancer statistics as part of the “GLOBOCAN project provides a set of data visualization tools to forecast future incidence and mortality for specific countries or regions from the 2022 to 2050, utilizing estimates of incidence, mortality, and prevalence of 36 specific cancer types along with all cancer sites combined in 185 countries or territories globally in 2022, segmented by sex and age group” (Bray et al., 2024).

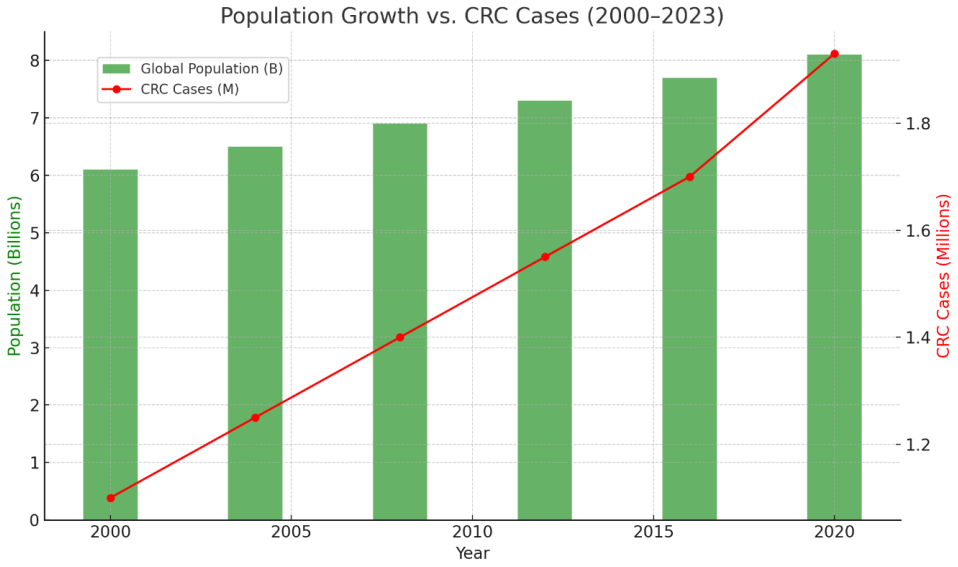

Figure 1. Comparing Global Population Growth

Source: Naghavi, Malekzadeh, et al. (2019), Sung et al. (2021), & UN (2024).

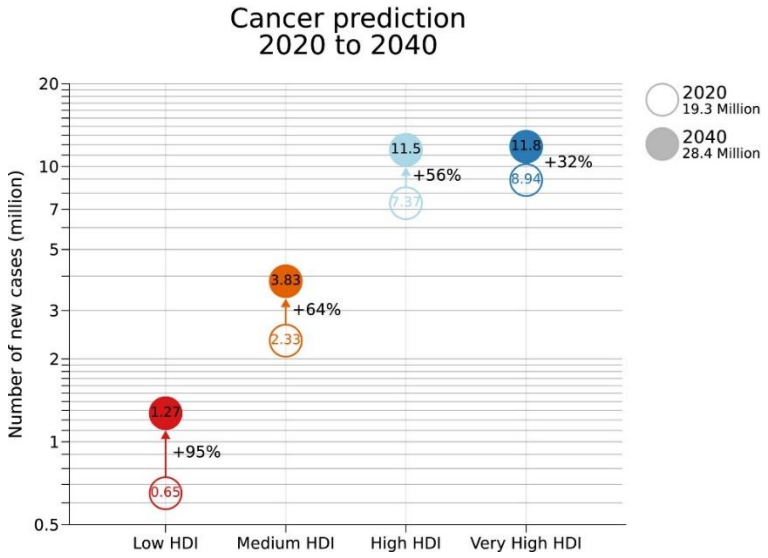

Figure 2. Projected Number of New Cases for All Cancers Combined in 2040

Source: Bray et al., 2024.

Islami et al. (2024) posit that "Risk factors associated with a Western lifestyle that have been shown to increase CRC risk include: Cigarette smoking, excess body weight, diet, including high consumption of alcohol and red and processed meat, and low consumption of fruits/vegetables, dietary fiber, and dietary calcium, and physical inactivity" (p. 407). In addition, Islami et al. (2024) estimated that "A significant proportion of CRC incidence among women and men in 2014 (50.8% and 58.2%, respectively) was attributable to these lifestyle factors." Thus, according to Bibbins-Domingo (2016), "there is a significant opportunity to reduce risk across the population through lifestyle modification.

The use of aspirin in selected individuals has also been demonstrated to reduce the likelihood of developing CRC." Moreover, Giglia & Chu (2016) contend that "Risk for developing CRC is associated with several identified hereditary CRC conditions; a family history of CRC;" Herszényi, Barabás, Miheller, et al. (2015) mention "medical conditions, including chronic inflammatory bowel disease;" while Peeters, Bazelier, Leufkens, De Vries, et al., 2015) add "type 2 diabetes;" and Baxter, Tepper, Durham, Rothenberger, et al. (2005) stress a "history of abdominal or pelvic radiation for a previous cancer." The breakdown of how CRC is diagnosed today is either symptomatically (due to pain, bleeding, etc.) or asymptomatically (detected via routine screening), where 60% of the cases fall under symptomatic diagnoses, and 40% under asymptomatic diagnoses (Wolf et al., 2018). Several key reasons contribute to the rise in colon cancer cases over the years (Naghavi, Murray, & Ikuta, 2019; Sung et al., 2021; Hejase, Hejase, Nemer, et al., 2020; UN, 2024; Hejase, Hejase, Kassem, et al., 2025a):

1. Aging Population: Colon cancer is more common in older adults. As life expectancy increases, more people live to ages where CRC risk is higher.
2. Population Growth: More people imply more absolute cases.
3. Lifestyle Changes: Like increased consumption of processed foods and red meat, sedentary behavior, obesity, low fiber intake, alcohol, and tobacco use.
4. Late Detection: Low awareness leads to late detection, which in turn increases CRC mortality rates. However, currently, improved detection with more widespread screening (like colonoscopy and FIT tests) catches more cases, especially early-stage CRCs that were previously undetected, and increased awareness, which means that more people are seeking care earlier.

Data showed that among adults under 55, the rate of CRC increased by 51% from 1994 to 2014, and the mortality rate rose by 11% from 2005 to 2015 (Wolf et al., 2018). Consequently, one of the most notable shifts in the literature over the last 10-15 years is the recognition that CRC rates in people under 50 are rising, particularly in the U.S., Canada, and various other developed nations. Such occurrences often emerge in later phases and tend to display increased aggression. This alteration is affecting many recent studies and adjustments in screening guidelines (e.g., starting at age 45 instead of 50 in the U.S.). Yet, the CRC literature overlooks specific facts that need to be recognized. For example, the increase in population is a vital factor. It is clear that as the population increases, the number of CRC cases also increases. Additionally, we live in the information age, suggesting that CRC case registries become more accurate as time progresses. Historically, many individuals died from CRC without any record of their cases. However, thanks to progress in technology and information systems, there has been a rise in reported cases of CRC, especially in developing countries. Moreover, societal awareness has grown over time because of efforts by NGOs, governments, and health agencies. The three factors, 'population growth, enhancements in case reporting, and increased public awareness,' are often neglected or inadequately considered in predictions or public messages. The three factors

highlighted are crucial to this study, requiring an in-depth examination of colorectal cancer trends to determine if the noted rise in CRC cases reflects an actual increase in incidence or is predominantly influenced by demographic shifts and improved data collection.

Thus, the central thesis is: Although colorectal cancer (CRC) incidence appears to be rising, as shown in Figure 3 (highlighting trends in different regions: North America, Europe, and Asia), this trend is partly an artifact of population growth, improved reporting mechanisms, and increased awareness. When these factors are considered, the relative risk may not be rising, but may even be declining.

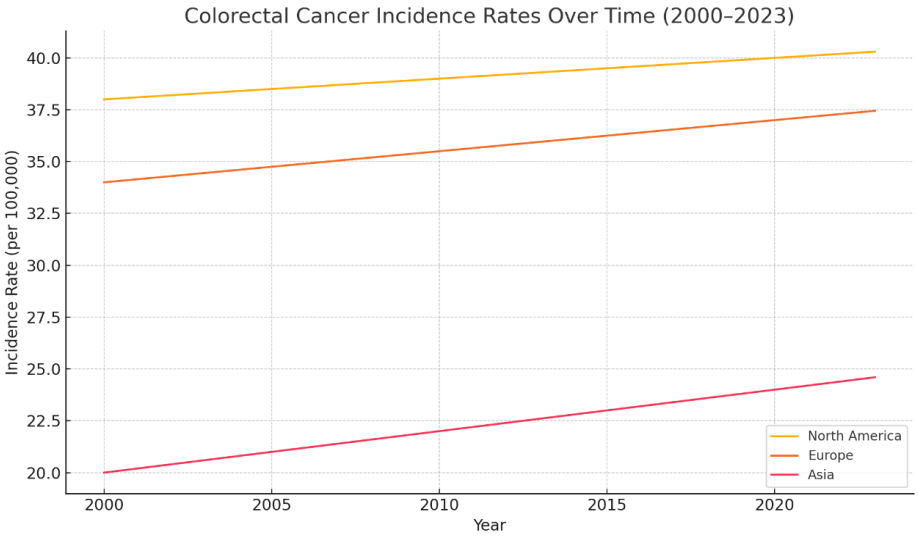

Figure 3. The Incidence Rates of Colorectal Cancer from 2000 to 2023

Source: Sung et al., 2021.

Improvements in Case Registry

Improved data systems uncover additional cases that were previously unnoticed or unlogged. Enhancements in electronic health records, cancer databases, and diagnostic systems have led to a rise in CRC cases. The concept of documenting data on every cancer case in specific communities originated in the early twentieth century, and the quantity of these cancer registries has steadily increased since then. Initially, their main focus was on detailing cancer patterns and trends. Subsequently, numerous individuals could track the enrolled patients and assess survival rates. In the last twenty years, the role of registries has expanded to include the organization and evaluation of cancer control strategies, as well as the care of individual cancer patients (Parkin, 2006; Townsend, Jones, Jones, et al., 2021; Lemmon, Hanna, Hall, et al., 2021).

The cancer registry is defined as a “framework for collecting, storing, examining, and understanding data on people with cancer” (NCI, n.d.). The cancer registry's worth grows when it allows for the examination and assessment of current trends (Muir & Nectoux, 1977). Population-based cancer registries (PBCRs) seek to capture all instances of cancer that arise within a defined population. The

initial PBCRs were created more than 60 years ago. The count has consistently increased. Parkin (2006) informs that "In 1966, 32 registries shared their results in volume I of Cancer Incidence in Five Continents, and forty years later, there were 449 members of the International Association of Cancer Registries accounting for 21% of the world's population." Figure 4 depicts the effects of enhanced cancer registries on CRC documentation by illustrating the number of colorectal cancer cases reported before and after the establishment of national cancer registries in selected countries.

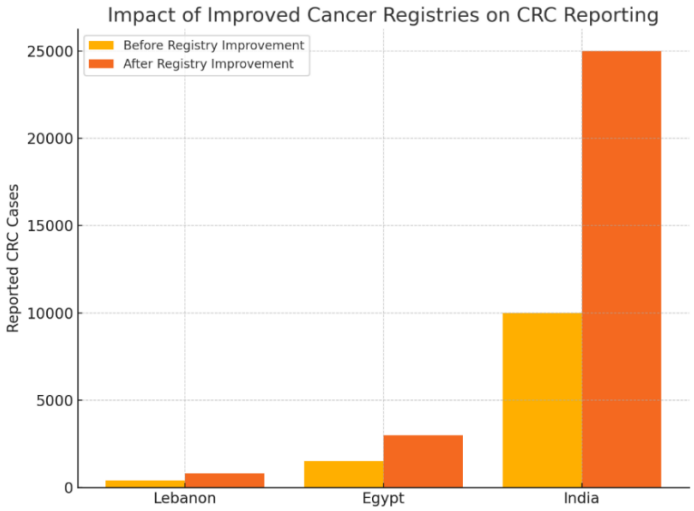

Figure 4. The Effects of Enhanced Cancer Registries on CRC Documentation

Source: Parkin, 2006.

The National Cancer Registry (NCR) in Lebanon, established by the Ministry of Public Health in 1998, is a population-based system for tracking cancer incidence (MOPH, 2025). It records cancer cases by site, morphology, age, and gender to support epidemiological studies and guide public health actions. The NCR collects data through both a "capture" system (passive data collection from physician reports) and a "recapture" system (active data collection from laboratories), and it is continuously updated. The population-based cancer registry in Lebanon was inactive for several years due to multiple security events before being officially restarted in 2002. The exact years of inactivity are not explicitly mentioned in the search results. But the registry was not operational for a period before 2002 because of the effects of war. According to Lakkis, El-Kibbi, & Osman (2021), "This registry is considered to be nearly a complete tally of all reported cases in Lebanon. The NCR accounts for over 90% of cancer instances in Lebanon, not including in situ lesions." The NCR publishes its cancer incidence statistics on the MOPH's official website (MOPH, 2025). Table 1 shows the retrieved data, currently available, spanning from 2005 to 2020.

Table 1 displays the number of CRC incidence cases (Colon plus Rectum) reported by MOPH in Lebanon (MOPH, 2025). Unfortunately, the MOPH has registry records up to the year 2020. The count of CRC cases for the last four years (2021-2024) was obtained by fitting a simple linear regression line

to the data corresponding to the years 2005 - 2020. The overall model was statistically significant, $F(1, 13) = 301.31$, $p < .001$, $R^2 = 0.96$.

The regression equation was: CRC Cases = 530.9 + 49.57 * (Number of Years).

Where the years 2005, 2006, 2007, … were numbered as 1, 2, 3, … The significant regression coefficient used to predict CRC cases based on the year numbers, $\beta = 49.57$, $t(13) = 17.36$, $p < .001$, with a 95% CI [43.45, 55.70]. For each additional year, CRC cases were predicted to increase by around 50 cases (Table 1, forecasted cases are bold and grey, 2021 to 2024).

Table 1. Total CRC Yearly Incidence Cases as per the NCR of the MOPH in Lebanon

Year	Total CRC Cases	Year	Total CRC Cases
2005	583	2015	1093
2006	646	2016	1019
2007	680	2017	1272
2008	721	2018	1174
2009	758	2019	1360
2010	796	2020	1258
2011	879	**2021**	**1373**
2012	944	**2022**	**1423**
2013	991	**2023**	**1472**
2014	1062	**2024**	**1522**

Source: MOPH, 2025.

Influence of Population Growth

Without time normalization (over the years), raw CRC case counts are misleading. Raw case numbers will rise with population growth; this does not necessarily mean risk per person is on the rise. Thus, to eliminate the influence of time on CRC incidence, we need to consider the number of CRC cases for a certain group. Classically, time influence is eliminated by dividing the yearly incidence cases by the year's population size, then multiplying the result by 100,000 to obtain the CRC incidence rate per 100,000 people. This simple calculation eliminates the time influence due to population growth. Table 2 presents the CRC cases per 100,000 people in Lebanon for the years '2005 - 2024.'

Table 2. Total CRC Yearly Incidence Cases per 100,000 People in Lebanon

Year	Total CRC Cases	Total Population *	CRC Cases (Per 100,000)
2005	583	4,671,102	12.48
2006	646	4,751,136	13.6
2007	680	4,844,118	14.04

2008	721	4,925,354	14.64
2009	758	4,992,287	15.18
2010	796	5,041,288	15.79
2011	879	5,096,020	17.25
2012	944	5,235,742	18.03
2013	991	5,743,436	17.25
2014	1062	6,346,990	16.73
2015	1093	6,472,469	16.89
2016	1019	6,323,060	16.12
2017	1272	6,160,128	20.65
2018	1174	5,984,119	19.62
2019	1360	5,794,594	23.47
2020	1258	5,702,398	22.06
2021	1373	5,718,122	24.01
2022	1423	5,744,489	24.77
2023	1472	5,773,493	25.5
2024	1522	5,805,962	26.21

*Lebanon Population, Historical Data 1950-2025 (Macrotrends LLC, 2025)

Influence of Public Awareness and Screening Campaigns

Higher detection rates are a success of awareness efforts, not a sign of an epidemic. Moreover, growth in public awareness, screening programs, and non-governmental organizations (NGO) involvement leads to increased detection of pre-symptomatic or early-stage cases. Thus, more awareness leads to early diagnosis (Hejase, Haidous, HejaseBazzi, 2025b), hence more recorded cases in registries, again inflating the perceived increase.

This work is set in Lebanon, where the SAID NGO is one of the most active civil organizations promoting CRC awareness. Its extensive efforts have been highly recognized and praised by the Ministry of Public Health. This recognition led to the launch of Lebanon's first national campaign for early colorectal cancer screening on March 15, 2019, at the Lebanese Ministry of Public Health (Hejase et al., 2020). SAID NGO is a Beirut-based nonprofit founded by Hana Nemer, whose strong dedication to CRC screening is driven by the preventable loss of her husband to the disease. It is the only organization in Lebanon solely focused on raising awareness and providing free colorectal cancer screenings. The organization aims to increase public understanding of colorectal cancer and its prevention and advocates for a nationwide screening program to systematically combat the disease (GCCA, 2024).

SAID NGO hosts various educational events throughout the year to raise awareness about colorectal cancer in Lebanon and to educate the public on the importance of early screening. They participate in

health forums and conferences, distribute educational flyers, deliver informative lectures, and appear on talk shows on local TV and radio stations. Additionally, the NGO organizes an annual Walkathon for Colorectal Cancer Awareness Month (March) and maintains regular walking groups to motivate people to reduce their risks of colorectal cancer and improve overall health through physical activity (SAID, 2025). Table 3 presents a summary of the total annual activities conducted by the NGO over the years since its founding. One may notice that during 2020-2021, the years officially declared as the COVID-19 pandemic, the number of activities decreased, and for statistical purposes, the related figures were replaced by the average of 2019 and 2022, approximately 63 awareness events.

Table 3. Summary of the Total Annual Activities Done by SAID NGO over the Years

Year	Awareness Events
2016	21
2017	43
2018	57
2019	69
2020	3 ***(63)***
2021	14 ***(63)***
2022	56
2023	85
2024	85

Influence of the Information Age

The rapid expansion of the Internet and mobile phone subscriptions serves as a robust proxy for the penetration of the information age into modern societies (Bashir, Hejase, Danach, et al., 2022; Bashir, Hejase, Yassin, et al., 2023). Increased digital connectivity provides populations with unprecedented access to health information through official health websites, online campaigns, and social media platforms. In the context of colorectal cancer (CRC), such access has been transformative: Individuals are now more aware of risk factors, symptoms, and the importance of early screening, leading to higher rates of medical consultations and subsequent diagnoses. Moreover, ministries of health and international organizations increasingly utilize digital platforms to disseminate awareness campaigns, while patients themselves share experiences online, further normalizing discussions around CRC. Thus, rising CRC case reports in recent years may be understood not only as a reflection of epidemiological trends but also as an artifact of heightened awareness and detection facilitated by the spread of the Internet and mobile technologies. Lebanon stands as a clear example of the aforementioned argument. Table 4 presents the number of individuals using the Internet (% of population). According to the International Telecommunication Union (ITU, 2025), “Internet users are individuals who have used the

Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV, etc."

Table 4. Percentage of Internet Subscriptions over the Years in Lebanon

Year	Individuals using the Internet (% of population) *	Year	Individuals using the Internet (% of population) *
1995	0.0716	2010	43.7
1996	0.14	2011	52
1997	1.24	2012	61.2
1998	2.72	2013	70.5
1999	5.38	2014	73
2000	7.95	2015	74
2001	6.78	2016	76.1
2002	7	2017	78.2
2003	8	2018	80.9
2004	9	2019	81.5
2005	10.1	2020	82.1
2006	15	2021	82.7
2007	18.7	2022	82.8
2008	22.5	2023	83.5
2009	30.1		

* (World Bank Group, 2025a)

To support the argument that the Internet has significantly influenced CRC information, the authors extracted the data depicted in Table 5 from a study performed by Hejase et al. (2025a) conducted from February 2025 to May 2025, where they surveyed 660 CRC-aware respondents, and the majority (36.97%) indicated that the Internet is their main source of information (ibid, p. 91).

Table 5. Main Source of CRC Information

My information about CRC comes from:	Number of "Agrees" among 660 respondents	Percent
Physician	216	32.73%
Nurse	225	34.09%
Friend	223	33.79%
Family	205	31.06%
Newspaper	170	25.76%
Magazine	112	16.97%

Media	135	20.45%
Internet	**244**	**36.97%**
Awareness Campaigns	46	6.97%
Education	10	1.5%

Source: A. Hejase et al., 2025a, p. 91.

In another study performed by Nemer, Hejase, Hejase, et al. (2016), among those who have heard or read about colon cancer (461 respondents), "the majority of the respondents (29.9%) indicated that the Internet is their major source of Information about CRC" (p. 15). Likewise, in 2020, another study was performed, and among those aware of CRC (781 respondents), "18.7% indicated that their major source of information about CRC is the Internet" (Hejase et al., 2020, p. 193).

Another very important Information Age feature is related to the use of mobile cellular devices. According to the World Bank Group (2025b), "Individuals using mobile cellular phones refers to the number of subscriptions to a public mobile-telephone service that provides access to the public switched telephone network (PSTN) using cellular technology. It includes the number of postpaid subscriptions and the number of active prepaid accounts." Table 6 presents the yearly number of mobile cellular subscriptions, the total Lebanese population, and the number of mobile cellular subscriptions per 100 people, which is obtained by dividing the number of yearly subscriptions by the total population, then multiplying the result by 100.

Table 6. The Number of Mobile Cellular Subscriptions per 100 People in Lebanon

Year	Mobile cellular subscriptions (IT.CEL.SETS) *	Population, total (SP.POP.TOTL)	Mobile cellular subscriptions (per 100 people)
1995	120,000	3,960,735	3.03
1996	198,000	4,034,781	4.91
1997	373,900	4,108,405	9.10
1998	505,300	4,181,281	12.09
1999	627,000	4,255,277	14.75
2000	743,000	4,329,340	17.16
2001	766,754	4,401,918	17.42
2002	775,104	4,463,504	17.37
2003	795,460	4,525,508	17.58
2004	884,445	4,599,279	19.23
2005	993,557	4,671,102	21.27
2006	1,106,430	4,751,136	23.29
2007	1,260,000	4,844,118	26.01

2008	1,427,000	4,925,354	28.97
2009	2,390,320	4,992,287	47.88
2010	2,863,660	5,041,288	56.80
2011	3,456,650	5,096,020	67.83
2012	3,755,170	5,235,742	71.72
2013	3,884,760	5,743,436	67.64
2014	4,387,280	6,346,990	69.12
2015	4,657,650	6,472,469	71.96
2016	4,277,040	6,323,060	67.64
2017	4,399,090	6,160,128	71.41
2018	4,424,190	5,984,119	73.93
2019	4,237,960	5,794,594	73.14
2020	4,288,220	5,702,398	75.20
2021	4,288,220	5,718,122	74.99
2022	4,251,770	5,744,489	74.01
2023		5,773,493	
2024		5,805,962	

*Total Number of Mobile Phone Subscribers (Maxinomics, 2022);

Population Total & (World Bank Group, 2025b).

Mobile cellular subscriptions per 100 people (World Bank Group, 2025c).

Methodology

The Model to predict CRC cases per 100,000 people in Lebanon

Based on the data presented earlier (year, mobile cellular subscriptions per 100 people, individuals using the Internet as % of the population, and number of ‘Awareness Events’ as predictors; together with the number of CRC cases per 100,000 people as dependent variable), we shall perform a multiple linear regression using the collected data, which is presented in Table 7. Note that the data missing for the years 2023 and 2024 were filled as follows: For mobile cellular subscriptions, in 2023, the penetration rate was around 85% of the total population (Kemp, 2023); additionally, in 2024, the penetration rate was 87.6% (Kemp, 2024). Likewise, in 2024, the Internet penetration rate was 90.1% of the population (Kemp, Digital 2024: Lebanon, 2024).

Table 7. Data to be Used in the Modelling Process

Year	Mobile cellular subscriptions (per 100 people)	Individuals using the Internet (% of population)	Awareness Events	CRC Cases (Per 100,000)
1995	3.03	0.0716		
1996	4.91	0.14		
1997	9.10	1.24		
1998	12.09	2.72		
1999	14.75	5.38		
2000	17.16	7.95		
2001	17.42	6.78		
2002	17.37	7		
2003	17.58	8		
2004	19.23	9		
2005	21.27	10.1		12.48
2006	23.29	15		13.6
2007	26.01	18.7		14.04
2008	28.97	22.5		14.64
2009	47.88	30.1		15.18
2010	56.80	43.7		15.79
2011	67.83	52		17.25
2012	71.72	61.2		18.03
2013	67.64	70.5		17.25
2014	69.12	73		16.73
2015	71.96	74		16.89
2016	67.64	76.1	21	16.12
2017	71.41	78.2	43	20.65
2018	73.93	80.9	57	19.62
2019	73.14	81.5	69	23.47
2020	75.20	82.1	63	22.06
2021	74.99	82.7	63	24.01
2022	74.01	82.8	56	24.77
2023	**85.00**	83.5	85	25.5
2024	**87.60**	**90.1**	85	26.21

However, the number of CRC awareness events is not available for the years before 2016, since in Lebanon, the national awareness events started in 2016. Consequently, for the case of Lebanon, we

shall only use the data that corresponds to the years 2016 to 2024. Thus, Table 8 presents the selected rows extracted from Table 7 to be used in the calculation of the multiple linear regression model.

Table 8. Data to be Used in the Multiple Linear Regression Model

Year	Mobile cellular subscriptions (per 100 people)	Individuals using the Internet (% of population)	Awareness Events	CRC Cases (Per 100,000)
2016	67.64	76.1	21	16.12
2017	71.41	78.2	43	20.65
2018	73.93	80.9	57	19.62
2019	73.14	81.5	69	23.47
2020	75.20	82.1	63	22.06
2021	74.99	82.7	63	24.01
2022	74.01	82.8	56	24.77
2023	**85.00**	83.5	85	25.5
2024	**87.60**	**90.1**	85	26.21

Regression Analysis

The compiled Lebanese national-level annual data for 2016–2024, including CRC cases per 100,000 population, internet penetration (% of population using the internet), mobile subscriptions (% of population), and the number of awareness events conducted. The dependent variable investigated is 'CRC cases per 100,000.' The three predictors (independent variables) were initially considered: Mobile cellular subscriptions, Internet penetration, and awareness events. Regression 'Stepwise' elimination excluded mobile subscriptions due to high correlation with internet penetration and lack of statistical significance ($p > \alpha$=5%). Year (time) was also excluded, as it served only as a proxy for underlying processes already captured by internet and awareness variables. The final model retained internet penetration and awareness events as significant predictors of CRC cases.

Results and Findings

Regression Findings

Findings from the multiple linear regression demonstrated a highly robust and statistically significant overall impact among the Individuals using the Internet (% of population), Awareness Events, and CRC Cases (Per 100,000), $\{F(2, 7) = 1040.94, p < .001, R^2 = 1, R^2_{adj} = 1\}$.

The individual predictors were examined further and indicated that Individuals using the Internet (% of population) ($t = 8.334$, $p = .000$) was a significant predictor in the model. Likewise, the Awareness Events predictor was a significant predictor in the model ($t = 3.719$, $p = .007$) (See Table 9).

Table 9. Results of the Multiple Linear Regression

	Coeff	SE	t-stat	Lower $t_{0.025}(7)$	Upper $t_{0.975}(7)$	Stand Coeff	p-value	VIF
Internet (%)	0.192	0.023	8.334	0.138	0.247	0.000	0.000	3.916
Awareness Events	0.112	0.030	3.719	0.041	0.183	0.890	0.007	3.916

Thus, based on Table 9, the final model is estimated as:

CRC = 0.192*(Internet %) + 0.112*(Awareness Events)

Outcomes from the above-mentioned regression equation showed a highly significant collective impact that was statistically robust among the Individuals using the Internet (% of population), Awareness Events, and CRC Cases (Per 100,000) ($F(2, 7) = 1040.94$, $p < .001$, $R^2 = 99.7\%$). The model was estimated without an intercept, reflecting the theoretical expectation that without awareness activities and internet penetration, reported cases would be negligible.

Robustness Analysis

Regression was performed with ordinary least squares (OLS) and HC1 robust standard errors (Heteroskedasticity-Consistent standard error used in regression analysis to correct for the assumption of constant error variance). Model fit was assessed with both centered and uncentered R^2. Diagnostics included Durbin–Watson and Breusch–Godfrey for serial correlation, Breusch–Pagan and White tests for heteroscedasticity, RESET for functional form, Jarque–Bera and Shapiro–Wilk for residual normality, variance inflation factors (VIF) for multicollinearity, and influence diagnostics (leverage and Cook's distance). The results showed that the model fit was strong, with centered $R^2 = 0.815$ (adjusted $R^2 = 0.788$) and uncentered $R^2 = 0.997$. Residual plots and RESET testing indicated a correct functional form. No evidence of serial correlation (Durbin–Watson ≈ 2, Breusch–Godfrey $p > 0.05$) or heteroscedasticity (Breusch–Pagan $p > 0.05$, White $p > 0.05$) was detected. Residuals were approximately normal (Jarque–Bera, Shapiro–Wilk $p > 0.05$). As for multicollinearity, according to Zheng (2023), "VIF should be somewhere between 3 and 5. If there are relatively few Independent Variables, such as two." In this case, VIF < 5, therefore considered moderate and acceptable. In conclusion, influence diagnostics showed no problematic outliers.

Interpretation

Each 1% increase in Internet penetration was associated with 0.192 additional CRC cases per 100,000, while each 'Awareness Event' was associated with 0.112 additional cases per 100,000, holding other factors constant. These results suggest that rising reported CRC cases reflect increased detection and reporting capacity, rather than necessarily higher true incidence. The joint model is statistically strong as per the obtained values of the F-test and R^2. Figure 5 shows the comparison between observed and predicted CRC incidences.

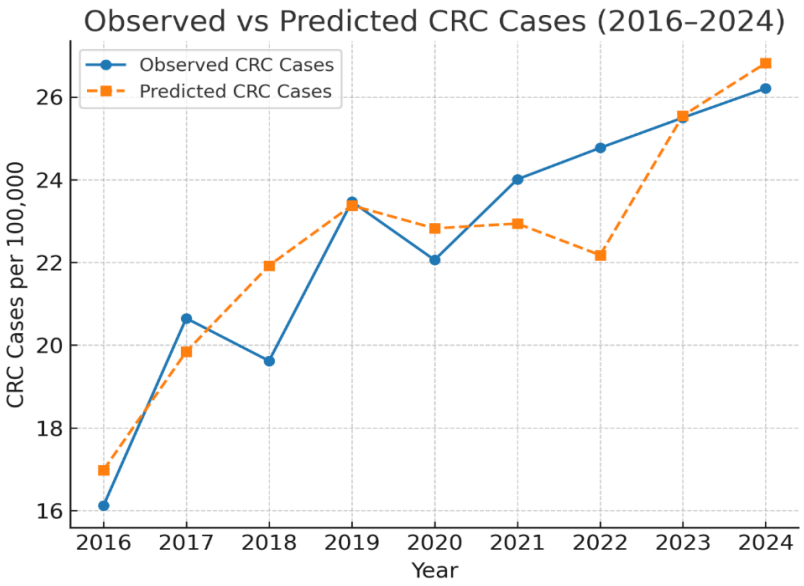

Figure 5. Observed vs Predicted CRC incidences (2016-2024).

No Intercept is a defensible issue since the theoretical rationale in our context, with near-zero awareness and near-zero internet penetration, reported CRC cases would be expected to be extremely low (reporting/detection channels vanish). Moreover, practically, dropping the intercept stabilizes the model (avoids a noisy constant) and yields coefficients that match across software.

The relationship between CRC incidences and predictors relationship

R-squared (R^2) equals 99.7%. Therefore, the predictors explain 99.7% of the variability of CRC incidences around the zero (Adjusted R-squared equals 99.6%).

The Multiple Correlation Coefficient (R) is 0.9983, which means there is a highly significant relationship between the forecasted and the actual data.

Goodness of fit

Overall regression: Right-tailed, $F_{(2,7)} = 1040.94$, p-value = 0.000. Since p-value < α (0.05), we reject the null hypothesis, H_0, that the overall regression model was insignificant. Moreover, the predictor independent variables Internet (%) and Awareness Events are statistically significant (p-value < 0.01).

Model Validation and Robustness

Residual normality

Linear regression presumes that residual errors follow a normal distribution. The Shapiro-Wilk test is a statistical method employed to determine if a data sample originates from a normally distributed population (Khatun, 2021). The test computes a W statistic, and a low W value (along with its associated low p-value) indicates that the data is probably not normally distributed. The Shapiro-Wilk test is especially beneficial for smaller sample sizes (e.g., n < 50). It is frequently utilized when there is a need to confirm the normality assumption before conducting other statistical tests that depend on it, such as t-tests and ANOVA (Malato, 2025). Figure 6 displays the graph for checking the normality of

residuals. The p-value for the Shapiro-Wilk test is 0.966. It is presumed that the data follows a normal distribution.

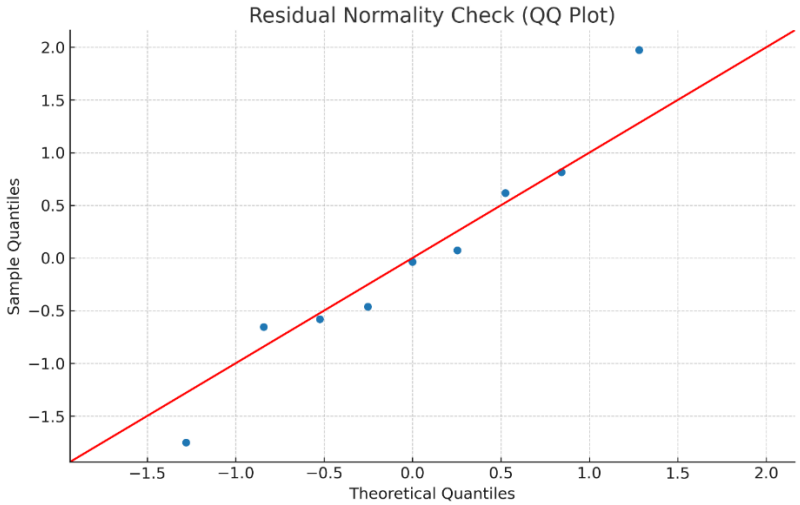

Figure 6. Residuals Normality Check

Homoskedasticity (homogeneity of variance)

The White test p-value equals 0.916 (F=0.089). It is assumed that the variance is homogeneous. The White test is a statistical test for heteroskedasticity in regression models, meaning it checks if the variance of the model's error terms is constant across all observations. Proposed by Halbert White in 1980, it's a more general test than the Breusch-Pagan test, allowing for non-linear and interactive effects of independent variables on the error variance. The test works by running an auxiliary regression with squared residuals as the dependent variable and includes the original independent variables, their squared terms, and their cross-products as independent variables. If the test statistic is significant, the null hypothesis of homoskedasticity is rejected, indicating the presence of heteroskedasticity. A significant p-value (typically less than 0.05) leads to the rejection of the null hypothesis, indicating that heteroskedasticity is present (Rehal, 2023).

Multicollinearity: Inter-correlations among the predictors

The Variance Inflation Factor (VIF) is a statistical measure that identifies multicollinearity (correlation between predictor variables) in a multiple regression model. Verma (2024) posits that “VIF values are calculated for each predictor, and values above 10 are often considered a strong indicator of multicollinearity that may require attention. A VIF value of 1 indicates no correlation.” However, Zheng (2023) asserts that “If VIF is somewhere between 3 and 5, especially if there are relatively few Independent Variables, such as two, then there is moderate multicollinearity." In this study, VIF = 3.916 for both predictors; therefore, it is considered moderate and acceptable (Chehimi & Hejase, 2025).

Core Assumption Checks

- **Linearity / Functional Form:** Ramsey RESET (powers up to 2), p-value > 0.05, this implies no evidence of omitted nonlinear terms (given small n).
- **Error Independence (Serial Correlation):** Durbin–Watson ~ 2.
- **Breusch–Godfrey (lags = 2)**: p-value > 0.05. Thus, no serial correlation was detected.
- **Homoskedasticity:** Breusch–Pagan with an intercept added *only for the auxiliary test design* (this is standard): p-value > 0.05. Also, White test (with constant in the auxiliary regression): p-value > 0.05. Thus, no evidence of heteroskedasticity.
- **Normality of Residuals:** Jarque–Bera, Shapiro–Wilk, and Anderson–Darling reported. All p-values > 0.05, implying residuals are approximately normal.
- **Multicollinearity: VIF** for **Internet Users** (3.916) and **Awareness Events** (3.916) reported in Table 9 are moderate (reflecting common upward trends).
- **Influence / Outliers**: In regression analysis, an individual point can significantly affect the overall regression outcomes, yet it's also feasible to encounter a distinct outlier that minimally influences the results. The observation with greater leverage has a heightened capacity to impact the estimated regression line. Cook's Distance, also known as Cook's D, can be used to assess the impact that each data point has on the regression line. This measure is also affirmative, where elevated values indicate greater influence. Greenwood (2022) posits that "A general guideline is that Cook's D values exceeding 1.0 indicate distinctly influential points, values above 0.5 suggest some level of influence, while values below 0.5 represent points that do not affect the slope coefficients of the regression model." No observation exceeds the usual concern limits. No observation breaches the typical concern thresholds.

Discussion

The increase in CRC cases per 100,000 can be clearly attributed to heightened public awareness efforts and greater internet access, aligning with our argument that enhanced detection/reporting (instead of genuine incidence growth) leads to inflated observed case numbers. This analysis reveals that CRC case numbers in Lebanon between 2016 and 2024 are closely tied to the increase in internet access and the frequency of awareness campaigns. These results indicate that the perceived rise in CRC cases is attributed to improved detection and awareness rather than solely biological or environmental incidence variations. Access to the internet can enhance public involvement in screening initiatives and health information, while awareness activities can rally communities and promote medical check-ups. Collectively, these indicators reflect advancements in case detection.

Our findings caution against interpreting rising case numbers solely as a sign of a heavier disease load. Instead, the data indicate a considerable impact of data access and health promotion initiatives on the documented CRC statistics. This has important policy implications: Health planners must differentiate between perceived and real changes in incidence when allocating resources. Future research should

expand this analysis to incorporate longer durations and additional factors, like the implementation of screening programs and diagnostic capabilities.

Importantly, this study highlights that perceived increases in CRC incidence may partially reflect changes in reporting methods rather than genuine epidemiological growth. These findings underscore the importance of situating cancer data within the broader sociotechnical context.

Conclusion

This study reveals that awareness campaigns and internet access heavily influence the rise in reported CRC cases in Lebanon. These findings challenge the notion of a simple increase in incidence and highlight the importance of considering reporting practices and awareness efforts. Lebanon is a specific case, and future studies should apply this framework in other countries with larger datasets to see if these mechanisms can be applied more broadly. Our results underscore the vital role of detection and reporting systems in shaping cancer statistics. Policies should recognize that an increase in reported cases may indicate more successful case detection rather than a true rise in incidence.

Strengths

The advantages and merit of this research involve incorporating social determinants into cancer trend analysis, thorough diagnostic evaluations, and leveraging Lebanon as a natural experiment amid a phase of swift digital adoption. The present research demonstrates:

1. **An Authentic Contribution**

We are contesting a prevailing narrative by incorporating overlooked factors (population increase, enhanced records, better data, and awareness initiatives). That's precisely what robust academic research usually accomplishes: It reinterprets existing information with a clearer, more detailed perspective.

2. **Robust Supporting Proof**

We have supported our claim using trustworthy sources (GLOBOCAN, WHO, UN, IARC), reliable references, and now additionally with persuasive visuals. This provides both scholarly and visual legitimacy.

3. **Prompt and Relevant**

As health awareness increases and global health data systems improve, our critique of raw-case trend analyses is particularly relevant, especially for transitioning countries (such as those in the Arab world).

Limitations

Researchers such as Cao, Chen, & Katz (2024) and Nye (2024) caution that studies with small sample sizes could lead to spurious correlations, that is, can produce misleading outcomes and false correlations, even if they are 'statistically significant.' Consequently, it is essential to closely evaluate

results from special cases research studies. In this study, the sample consists of a small size (nine observations) and is based on national-level aggregates, not considering individual-level risk factors such as genetics or diet. Consequently, broad conclusions cannot be made, and definitive causation cannot be determined from the observed correlations. However, incorporating a thorough robustness analysis into the forecasting models provides new insights that merit further exploration. Furthermore, although detection bias exists, the article highlights the authentic epidemiological trends shown by the increase in early-onset CRC (under 50) reported. It states that a thoroughly documented phenomenon cannot be solely attributed to enhanced detection.

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