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Disparities in cancer outcomes: A comprehensive analysis of cancer incidence, mortality, and prevalence in Europe

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Abstract

Cancer poses a substantial challenge in Europe's public health landscape, contributing significantly to illness burden, diminished productivity, and escalating health-care costs. This article investigates the extent to which disparities in cancer outcomes are associated with factors influencing the performance of cancer control initiatives within the European Union (EU). The characteristics of health-care systems play a pivotal role in shaping cancer outcomes through three key mechanisms: (i) Access to screening programs; (ii) quality and efficiency of health-care services; and (iii) health education and awareness programs. A multifactorial regression analysis was employed, utilizing the GLOBOCAN 2020 projections of cancer incidence, mortality, and prevalence based on the data from the International Agency for Research on Cancer. This analysis was delineated across 36 distinct cancer classifications by both gender and age categories. In countries with incomplete population coverage, patients may face limitations in accessing certain services or contend with significant financial obstacles. Furthermore, disparities in health-care service implementation, including diagnostic procedures, treatment modalities, and follow-up care, significantly affect cancer outcomes. In addition, systematic distinctions in care quality, such as early diagnosis, timely access to specialized care, and the presence of coordinated efforts, contribute significantly to diverse cancer outcomes. In conclusion, this article highlights the variations in cancer care provision across European countries, offering valuable insights for enhancing cancer patient care.

Keywords: Public healthcare; European countries; Cancer outcomes; Public policies; GLOBOCAN 2020

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1. Introduction

Cancer is a significant global health issue, presenting a pressing concern in Europe's public health landscape (Immergut, 2021). It serves as a considerable contributor to illness burden, reduced productivity, and rising health-care expenses (Bettio *et al.*, 2019). This study aims to evaluate the impact of health-care system attributes on age-standardized cancer mortality rates. We conducted a comprehensive analysis of available data about the distribution of cancer stages sourced from national cancer registries. In addition, the

research aims to characterize shifts in observed mortality rate patterns over time, leveraging longitudinal data on mortality.

While most European countries have established cancer control initiatives, a significant number of these programs either lack adequate attention or inadequately address crucial aspects, such as resource allocation, management, outcome quality evaluation, and financing. These elements are pivotal for ensuring the efficiency of a health-care system and the efficacy of individual cancer control programs (Asandului *et al.*, 2013). Three primary inquiries are explored to enhance understanding of the intrinsic value of national cancer care (European Commission, 2019; 2021; Teisberg *et al.*, 2020): (i) How does contemporary cancer-related health-care spending vary among European countries?; (ii) What correlations can be discerned between national cancer-related spending and cancer mortality rates?; and (iii) What is the additional expenditure associated with preventing each death in European countries? Across these inquiries, this study aims to contribute nuanced insights into the intricate interplay between health system dynamics and cancer outcomes on a national scale.

This intricate landscape is further complicated by pronounced disparities in cancer incidence, mortality, and prevalence, evident both across and within European Union (EU) member states, presenting a formidable challenge for public health practitioners (La Vecchia *et al.*, 2015). Addressing these disparities necessitates a nuanced understanding of health-care outcomes, underscoring the critical importance of comparative assessments across diverse health-care systems (Karanikolos *et al.*, 2013). Such assessments not only illuminate prevailing challenges but also provide invaluable insights for shaping health policies geared toward fostering equitable and effective cancer care (Patel *et al.*, 2020; Al Saud *et al.*, 2018). Within this context, the study strives to enrich comprehension of these intricacies and provide suggestions for potential policy actions geared toward improving cancer care outcomes throughout Europe. The findings highlight significant differences in health system characteristics and cancer burden among European countries. Particularly, countries with higher income levels typically exhibit more favorable health system metrics, including increased health-care spending relative to gross domestic product (GDP) and broader accessibility to universal health services. These countries also have lower age-standardized mortality rates, suggesting a positive association between health system performance and cancer outcomes. Moreover, the findings enhance understanding of the factors influencing cancer burden and highlight areas for targeted interventions to improve cancer care and management in European countries. Given the significant impact of cancer on individuals, national health systems, and the broader economic landscape, numerous European countries have instituted cancer control activities over the years. These initiatives manifest in the form of well-defined strategies and programs geared toward addressing the intricate challenges posed by cancer across both health-care and socioeconomic domains.

2. Methods

2.1. Incidence, survival, and mortality data

The age-standardized mortality rates for cancer at the national level were acquired from the International Agency for Research on Cancer (IARC), utilizing the GLOBOCAN 2020[1] estimates covering incidence, mortality, and prevalence across 36 different cancer types categorized by gender and age groups. However, there is currently no effective means of monitoring the ongoing changes in the cancer burden at the EU level. Factors contributing to declining prevalence and mortality rates include innovations in early detection, precision diagnostic technologies, and advancements in treatment modalities (Loud & Murphy, 2017). Lifestyle changes, preventive vaccines, and effective health-care policies have positively influenced cancer outcomes.

The categorization of countries based on income level and the allocation of government expenditure on healthcare were sourced from the World Health Organization (WHO) and the World Bank. The Universal Health Coverage Index (UHC Index), obtained from the WHO, is a comprehensive measure to gauge advancements toward achieving the United Nations (UN) Sustainable Development Goal (SDG) indicator 3.8.1, which assesses the coverage of fundamental health services. It incorporates various essential health interventions, encompassing reproductive, maternal, neonatal, and child health; infectious diseases; non-communicable diseases (NCDs); and health-care capacity and accessibility. The index is depicted on a scale ranging from 0 to 100, with higher scores indicative of superior performance (Kieny *et al.*, 2017).

Prior research has uncovered notable disparities in cancer incidence, mortality, and survival among industrialized countries (Afshar *et al.*, 2020; Bastos *et al.*, 2010). Examining these variations between countries and regions offers insights into health policy formulation, aiding in the identification of elements within health systems that contribute to improved outcomes (Renzi *et al.*,

[1] For the GLOBOCAN 2020 database, see https://gco.iarc.fr/today; ECIS - European Cancer Information System. *Incidence and mortality estimates 2023*. Available from: https://ecis.jrc.ec.europa.eu.

2023). Conducting analyses of outcomes across countries requires comparable data on patient characteristics, encompassing age distribution, methods of detection (screening or symptomatic), and pathological features, as well as information on health-care characteristics (European Commission, 2022; Lo *et al*., 2013).

2.2. Statistical analysis

Data analysis was performed utilizing the Statistical Package for the Social Sciences (version 28.0). Descriptive statistics for continuous variables involved the computation of means and standard deviations (SDs), while categorical variables were characterized by frequencies and proportions. Simple regression analyses were conducted to investigate the relationship between the outcome variable (cancer age-standardized mortality rate) and the exposure variables, including current health expenditure, UHC service, allocated funding for early cancer detection programs, and the number of dedicated public and private cancer centers per 10,000 individuals diagnosed with cancer.

The impact of independent variables on the outcomes of estimated age-standardized cancer incidence, mortality, and the estimated number of prevalent cases over a 5-year period in 2020 was evaluated using univariate linear regressions. Coefficients were estimated using the ordinary least squares method, and the explained variance was determined by calculating R-squared (R^2) values. Linear regressions were assessed for adherence to assumptions and diagnostic tests. The normality of residuals was assessed and validated through histograms and Kolmogorov–Smirnov tests. Examination of standardized residuals revealed the absence of outliers, as all residuals fell within the [−3; 3] interval. Homoscedasticity was evaluated by plotting standardized residuals against predicted values, indicating a random distribution of points with no discernible trend, thereby confirming this assumption.

3. Results

3.1. Association between estimated age-standardized incidence and mortality rates and the number of prevalent cases based on continuous and categorical independent variables

Among the 28 European countries with comprehensive health system data, various indicators displayed a significant increase across the spectrum from low-income to high-income countries. These indicators include the UHC Index, current health expenditure as a percentage of GDP ($p = 0.0002$), allocated funding for early detection initiatives, existence of early cancer detection guidelines, availability of national cancer plans, presence of cancer referral systems, availability of early cancer detection services, number of dedicated public and private cancer centers per 10,000 cancer patients, and availability of pathology services (European Commission, 2022).

The highest estimates of age-standardized cancer incidence rates (Table 1) were found in Anglo-EU countries[2] (372.80), Nordic EU countries[3] (303.6), and Continental EU countries[4] (316.92) (and the Continental European[5] country, Switzerland [317.60]). In contrast, the age-standardized cancer incidence rates were lower for Southeastern[6] (267.00) and Southern[7] EU countries (266.27). Age-standardized mortality rates were higher in Central Eastern EU[8] countries (129.98), Southeastern EU countries (128.30), and Baltic[9] EU countries (120.97). Spearman rank correlations revealed a coefficient of $R^2 = 0.159$ ($p = 0.419$) between age-standardized cancer incidence rates and age-standardized cancer mortality rates, indicating no significant association between cancer incidence and mortality. Conversely, a positive correlation was observed between prevalence and cancer incidence, with a coefficient of $R^2 = 0.792$ ($p < 0.001$), as anticipated.

Table 2 displays descriptive findings for continuous independent variables, concerning health expenditure as a percentage of GDP, the provision of UHC services, allocated funding for early detection programs, and the presence of both public and private cancer centers. The mean health expenditure for the assessed countries was 9.20% of GDP (SD = 1.96). UHC service had a mean of 82.32 units (Euros) (SD = 3.98), ranging from 73.00 to 88.00 units (Euros). Dedicated funding for the early detection program had a mean of 2.61 units (Euros) (SD = 1.40), with a minimum of 0.00 units (Euros) and a maximum of 4.00 units (Euros). Public and private cancer centers ranged from 0.30 to 21.50 units, with a mean of 4.60 units (SD = 4.59).

Table 3 displays descriptive results for categorical independent variables of 27 EU countries and Switzerland. From the unadjusted analyses, the categorical independent variables were notably more implicated in high-income countries compared to low-income countries. Most of the countries under study were categorized by the World Bank as high-income countries (92.9%). Approximately 75% of countries lacked early detection programs, 67.9% possessed referral systems, and 82.1% had operational NCD cancer plans.

[2] Ireland
[3] Denmark, Finland, and Sweden
[4] Austria, Belgium, France, Germany, Luxembourg, and the Netherlands
[5] Switzerland
[6] Bulgaria, Croatia, and Romania
[7] Cyprus, Greece, Italy, Malta, Portugal, and Spain
[8] Czechia, Hungary, Poland, Slovakia, and Slovenia
[9] Estonia, Latvia, and Lithuania

Table 1. Descriptive results for estimated age-standardized cancer incidence and mortality rates and number of prevalent cancer cases in 2020

Country region	Estimated age-standardized incidence rates per 100.000 individuals, median (std)		
	Age-standardized cancer incidence rates	Age-standardized cancer mortality rates	Number of prevalent cancer cases (5-year period)
Anglo-EU	372.80 (-)	104.90 (-)	2304.30 (-)
Baltic EU	291.13 (11.67)	120.97 (4.22)	1789.43 (46.35)
Central Eastern EU	300.78 (25.84)	129.98 (18.10)	1815.68 (262.78)
Continental Europe	317.60 (-)	83.30 (-)	2663.00 (-)
Continental EU	316.92 (37.74)	100.45 (7.70)	2248.28 (417.60)
Nordic EU	303.63 (42.02)	95.07 (16.20)	2286.27 (132.76)
Southeastern EU	267.00 (22.11)	128.30 (7.48)	1502.43 (193.48)
Southern EU	266.27 (16.71)	95.88 (10.54)	1735.88 (268.74)

Note: Countries are classified as follows: Anglo-EU: Ireland; Nordic EU: Denmark, Finland, and Sweden; Continental EU: Austria, Belgium, France, Germany, Luxembourg, and the Netherlands; Continental Europe: Switzerland; Southeastern EU: Bulgaria, Croatia, and Romania; Southern EU: Cyprus, Greece, Italy, Malta, Portugal, and Spain; Central Eastern EU: Czechia, Hungary, Poland, Slovakia, and Slovenia; Baltic EU: Estonia, Latvia, and Lithuania; EU: European Union.

Table 2. Descriptive results for continuous independent variables

Variable	*n*	Minimum	Maximum	Mean	Standard deviation
Health expenditure as a percentage of GDP	28	5.80	12.80	9.20	1.96
Universal health coverage service	28	73.00	88.00	82.32	3.98
Dedicated funding for early detection program	28	0.00	4.00	2.61	1.40
Public and private cancer centers	24	0.30	21.50	4.60	4.59

Abbreviation: GDP: Gross domestic product.

Table 3. Descriptive results for categorical independent variables

Variable	*n*	%
Income group according to the World Bank		
High	26	92.9
Upper-middle	1	3.6
Upper-middle	1	3.6
Early cancer detection program		
No	14	75.0
Yes	7	25.0
Unknown	7	25.0
Referral systems		
No	6	21.4
Yes	19	67.9
Not sure	3	10.7
Non-communicable disease cancer plan		
Not available	3	10.7
Operational	23	82.1
Under development	1	3.6

Tables 4-6 showcase linear regression analyses that explore univariate associations between various factors and key cancer-related metrics for 2020. Specifically, the tables investigate the relationships between estimated age-standardized cancer incidence, estimated age-standardized mortality, and the estimated number of prevalent cases over a 5-year period with several critical variables. These variables comprise health expenditure as a percentage of GDP, UHC service provision, specific funding allocation for early detection initiatives, the presence of early cancer detection programs, referral systems, and the availability of both public and private cancer centers.

These regression analyses aim to unravel the individual impacts of each of these factors on cancer incidence, mortality, and prevalence. The inclusion of diverse variables allows for a nuanced understanding of the potential influence of health-care expenditure, the extent of UHC, funding dedicated to early detection initiatives, the presence of early cancer detection programs, the efficiency of referral systems, and the availability of public and private cancer centers. By analyzing these univariate associations, the study

Table 4. Univariate associations for estimated age-standardized cancer incidence in 2020

Variable	β	Standard error	95% confidence interval	*p*
Health expenditure as a percentage of GDP	3.59	3.44	−3.48; 10.65	0.307
Universal health coverage service	1.90	1.68	−1.56; 5.37	0.269
Dedicated funding for early detection program	3.51	4.87	−6.50; 13.52	0.478
Cancer early detection program	−7.78	16.74	−42.81; 27.26	0.647
Referral systems	2.81	12.11	−22.07; 27.70	0.818
Public and private cancer centers	−0.71	1.73	−4.30; 2.88	0.684

Abbreviation: GDP: Gross domestic product.

Table 5. Univariate associations for estimated age-standardized mortality in 2020

Variable	β	Standard error	95% confidence interval	*p*
Health expenditure as a percentage of GDP	−5.18	1.56	−8.38; −1.97	0.003
Universal health coverage service	−2.75	0.74	−4.27; −1.23	0.001
Dedicated funding for early detection program	0.13	2.61	−5.23; 5.49	0.961
Cancer early detection program	8.25	8.54	−9.62; 26.12	0.346
Referral systems	8.11	6.22	−4.68; 20.90	0.204
Public and private cancer centers	−1.05	0.78	−2.67; 0.57	0.193

Abbreviation: GDP: Gross domestic product.

Table 6. Univariate associations for the estimated number of prevalent cases (5-year period) in 2020

Variable	β	Standard error	95% confidence interval	*p*
Health expenditure as a percentage of GDP	3.59	3.44	−3.48; 10.65	0.307
Universal health coverage service	1.90	1.68	−1.56; 5.37	0.269
Dedicated funding for early detection program	3.51	4.87	−6.50; 13.52	0.478
Cancer early detection program	−7.78	16.74	−42.81; 27.26	0.647
Referral systems	2.81	12.11	−22.07; 27.70	0.818
Public and private cancer centers	−0.71	1.73	−4.30; 2.88	0.684

Abbreviation: GDP: Gross domestic product.

aims to enhance understanding of the multifaceted factors influencing cancer outcomes. These findings can potentially inform strategies and policies aimed at optimizing health systems and improving overall cancer care and management.

3.2. Association between health expenditure, UHC, and age-standardized mortality in 2020

When examining the relationship between estimated age-standardized mortality rates in 2020 and key variables, notable correlations were observed. Specifically, health expenditure as a percentage of GDP ($p = 0.003$) and UHC services ($p = 0.001$) exhibited significant associations. Their unstandardized coefficients (i.e., $\beta = -5.18$ and -2.75, respectively) suggest that elevated levels of these variables correlate with reduced estimates of age-standardized mortality in 2020 (Table 5).

Figures 1 and 2 confirm the inverse relationship between age-standardized mortality rates in 2020 and both health expenditure as a percentage of GDP and UHC services. These findings suggest that as the values (corresponding to health expenditure as a percentage of GDP and UHC services) increase, the corresponding age-standardized mortality rates tend to decrease. Moreover, regression analysis revealed a pattern within Baltic European countries (i.e., Latvia, Estonia, and Lithuania), Southeastern European countries (i.e., Bulgaria, Croatia, and Romania), and Central Eastern European countries (i.e., Czechia, Hungary, Poland, Slovakia, and Slovenia), indicating higher age-standardized mortality rates in 2020, alongside lower health expenditure as a percentage of GDP and reduced UHC services. This analysis suggests a trend toward elevated age-standardized mortality rates within these regions.

Conversely, countries within continental Europe (including Luxembourg, Austria, Belgium, France,

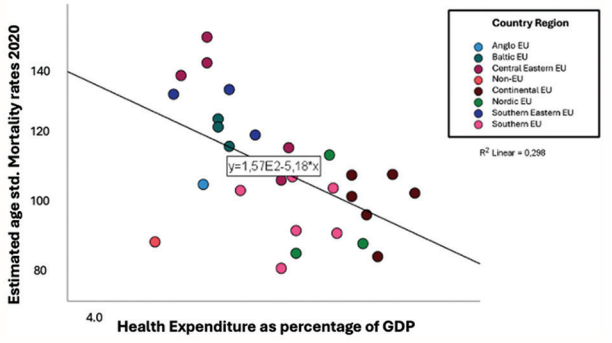

Figure 1. Linear regression for estimated age-standardized mortality in 2020 based on health expenditure as a percentage of gross domestic product by country region.
Note: Countries are classified as follows: Anglo-EU: Ireland; Nordic EU: Denmark, Finland, and Sweden; Continental EU: Austria, Belgium, France, Germany, Luxembourg, and the Netherlands; Continental Europe: Switzerland; Southeastern EU: Bulgaria, Croatia, and Romania; Southern EU: Cyprus, Greece, Italy, Malta, Portugal, and Spain; Central Eastern EU: Czechia, Hungary, Poland, Slovakia, and Slovenia; Baltic EU: Estonia, Latvia, and Lithuania; EU: European Union.

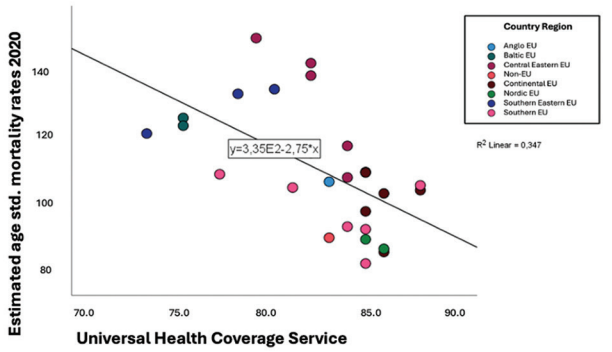

Figure 2. Linear regression for estimated age-standardized mortality in 2020 based on universal health coverage service by country region.
Note: Countries are classified as follows: Anglo-EU: Ireland; Nordic EU: Denmark, Finland, and Sweden; Continental EU: Austria, Belgium, France, Germany, Luxembourg, and the Netherlands; Continental Europe: Switzerland; Southeastern EU: Bulgaria, Croatia, and Romania; Southern EU: Cyprus, Greece, Italy, Malta, Portugal, and Spain; Central Eastern EU: Czechia, Hungary, Poland, Slovakia, and Slovenia; Baltic EU: Estonia, Latvia, and Lithuania; EU: European Union.

Germany, the Netherlands, and Switzerland), along with Nordic countries (Denmark, Finland, and Sweden) will display lower age-standardized mortality rates in 2020. Furthermore, these countries tend to showcase elevated health expenditure as a percentage of GDP and increased levels of UHC services. This observation implies that, on average, these regions portray a blend of reduced mortality rates alongside relatively higher levels of health expenditure and UHC.

Southern European countries, including Cyprus, Greece, Italy, Malta, Portugal, and Spain, occupy an intermediate position between the aforementioned groups. They exhibit trends akin to those observed in Continental and Nordic countries, indicating a propensity for lower mortality rates alongside increased levels of health expenditure and UHC, in contrast to Baltic, Southeastern, and Central Eastern countries. No significant associations were identified with age-standardized cancer incidence or the number of prevalent cases in 2020 (over a 5-year period).

In summary, the regression analyses indicate regional patterns in the relationship between age-standardized mortality rates, health expenditure, and UHC. The results suggest that certain groups of countries, such as those in continental Europe and the Nordic region, tend to have lower mortality rates along with higher levels of health expenditure and UHC, while Baltic, Southeastern, and Central Eastern countries tend to exhibit the opposite pattern. Southern European countries fall in between these two groups in terms of the observed variables.

4. Discussion

Our analysis introduces novel insights, emphasizing that countries with lower cancer mortality rates possess distinctive attributes, notably characterized by enhanced coverage of essential health services and a higher prevalence of public cancer centers. In addition, this investigation reveals a compelling correlation among countries that have achieved sustained reductions in cancer mortality, indicating a scenario where most cancers are diagnosed at early stages.

A comprehensive examination of cancer care policies is essential to identify best practices, allocate resources efficiently, and integrate preventive measures. Data from the WHO in 2022 underscore the variation in healthcare expenditures and cancer treatment outcomes among European countries. Notably, EU countries, such as Portugal, Denmark, and Spain, demonstrate higher healthcare expenditures coupled with more favorable cancer treatment outcomes compared to other countries, such as Estonia, Hungary, and Ireland. The difference in healthcare spending and treatment outcomes raises a crucial question about the underlying cancer care policies in European countries. While some countries invest more in healthcare, yielding better results in cancer treatment, the lack of a comprehensive examination of overall cancer care policies within the EU impedes a deeper understanding of these disparities.

Exploring these nuances is imperative to identify best practices and areas that require improvement across the EU. Furthermore, a comprehensive examination of cancer care policies can provide valuable insights into effective

public health strategies, the allocation of resources, and the integration of preventive measures. Understanding the correlation between health-care expenditures and treatment outcomes can inform evidence-based policy-making aimed at optimizing cancer care systems.

The provision of cancer care systems that are not only effective but also affordable is a complex undertaking requiring a multifaceted approach. To achieve this, it is imperative to integrate effective public health strategies and employ policy intelligence that analyzes the financial landscape associated with cancer care—both in terms of prevention and treatment.

Preventive health policies play a crucial role in this endeavor. Initiatives, such as vaccination programs, tobacco control policies, and campaigns promoting healthy behaviors, are instrumental in reducing the incidence of cancer. By addressing risk factors and encouraging a health-conscious society, these policies contribute significantly to preventing the onset of the disease. In addition, screening and early detection programs are vital components, as they enable the identification of cancer at its earliest and most treatable stages.

Nevertheless, ensuring accessible and efficient cancer care transcends prevention alone. This involves thoroughly assessing the expenses linked to cancer treatment, including diagnosis, therapeutic procedures, supportive measures, and rehabilitation efforts. Understanding the economic implications of cancer treatment is essential for devising sustainable and accessible health-care systems. Furthermore, the integration of effective public health strategies encompasses the development of robust health-care infrastructures, ensuring timely access to diagnostic technologies, treatment modalities, and specialized medical professionals. In addition, policy intelligence plays a pivotal role in optimizing resource allocation, fostering research and development, and creating a conducive environment for innovation in cancer care (Pucci *et al.*, 2019).

Interpreting the data on age-standardized incidence, mortality, and prevalence rates for various European countries provides valuable insights into the effectiveness of cancer policies:

i. Age-standardized incidence rates: Higher incidence rates may indicate either a higher prevalence of risk factors or improved diagnostic capabilities. Countries with advanced health-care systems and effective screening programs might be more adept at detecting and diagnosing cancer cases, leading to a higher reported incidence. Ireland, Denmark, and the Netherlands, for instance, exhibit relatively higher incidence rates, implying potential effectiveness in cancer prevention and early detection.
ii. Age-standardized mortality rates: Lower mortality rates may indicate better treatment outcomes, early detection, and access to quality healthcare. Switzerland, France, and Denmark have lower mortality rates, suggesting effective cancer care policies and health-care systems.
iii. Prevalence rates: Higher prevalence rates may indicate a combination of successful treatments, longer survival, and possibly higher incidence rates. The Netherlands, Switzerland, and Germany exhibit higher prevalence rates, suggesting effective treatment and ongoing care, potentially contributing to longer survival.

Analyzing these data collectively considers the dynamic interplay between prevention, early detection, and treatment efforts. Higher incidence rates can suggest effective early detection strategies, particularly in countries with well-established health-care infrastructures and proactive early detection initiatives. Consequently, this leads to more cases being identified and diagnosed at earlier, more treatable stages, resulting in a higher number of reported incidence rates.

While higher incidence rates may indicate a positive outcome in terms of early detection, they also suggest that the cost of treatment could be more affordable and less expensive. Early-stage cancer diagnosis often leads to more effective and less resource-intensive treatments, reducing the financial burden associated with advanced and prolonged treatments. Therefore, the apparent paradox of higher incidence rates positively reflects effective health-care systems that emphasize early detection, resulting in improved health outcomes and potentially more cost-effective treatments (Ades *et al.*, 2013).

Nonetheless, it is essential to thoroughly examine the individual policies and methodologies within each nation to grasp the intricacies underlying the documented rates. Factors such as health-care infrastructure, access to screening programs, treatment accessibility, and public health initiatives all contribute to the overall effectiveness of a country's cancer policies. In addition, ongoing research and analysis are necessary to continuously refine and improve these policies based on emerging evidence and changing demographics. The lack of comprehensive assessment across Europe hinders cooperation, the exchange of knowledge, and the establishment of universally accepted best practices. By conducting a thorough analysis, policymakers can identify successful approaches that contribute to better cancer treatment outcomes, thereby guiding the formulation of policies that enhance the overall efficiency and effectiveness of cancer care across Europe.

5. Conclusion

This study represents a notable achievement as it uncovered correlations between essential health system attributes, particularly the degree of UHC gauged by the UHC Index, and the availability of public cancer centers measured by their number per 10,000 individuals diagnosed with cancer. These factors are identified as predictors for improving cancer mortality rates.

Based on the extensive dataset, it is indicated that in countries where late-stage cancer diagnoses are common, a focused approach toward cancer early detection initiatives should strive to attain a target where 60% of invasive cancers are detected at stage I or II. This threshold emerges as a significant measure for effective cancer downstaging efforts.

These discoveries provide substantial direction for the WHO in its worldwide endeavors to enhance cancer outcomes. The data emphasizes the crucial influence of health system attributes and targeted interventions in fostering advancements in cancer mortality rates globally. This analysis underscores the vital significance of sufficient early detection, combined with prompt access to affordable and efficacious cancer treatment, as the fundamental requirement for attaining enduring decreases in cancer mortality across the globe (Santucci *et al.*, 2020).

The 2030 UN SDGs emphasize the significance of ensuring universal access to high-quality health-care services without imposing financial burdens. Although per-capita income typically reflects a country's UHC Index score, there are discrepancies in performance among countries sharing similar income levels. Effective UHC performance is associated with the portion of a nation's health-care budget administered through governmental and social health insurance programs.

The UHC index serves as a metric to monitor progress toward SDG indicator 3.8.1 and is based on key interventions related to essential health services, covering reproductive, maternal, neonatal, and child health, infectious diseases, and NCDs, as well as health-care capacity and accessibility. Notably, a previous study spanning from 1990 to 2010 across 79 countries found that increased unemployment correlated with higher mortality rates in aggregated cancers (including female breast, prostate, and colorectal cancers) (Duggan *et al.*, 2021; Maruthappu *et al.*, 2016). However, it was observed that the implementation of UHC appeared to offer a protective effect against this correlation, indicating the potential beneficial impact of UHC in mitigating the adverse consequences of rising unemployment on cancer mortality.

This study recognizes several inherent limitations in its analytical methodology. Firstly, the reliance on data from the IARC based on GLOBOCAN 2020 estimates introduces potential challenges. The accuracy and reliability of these estimates are contingent upon the quality and comprehensiveness of the data reported by individual countries. Disparities in data collection methods, reporting standards, and health-care infrastructures could impact the robustness of the findings. In addition, the utilization of country-level data, often sourced from surveys, presents another constraint. Nevertheless, data curated by the WHO undergoes stringent scrutiny for accuracy through technical assessments conducted at the national level.

However, reliance on data reported by countries, including cancer registration and the oversight of crucial health system elements, may lead to incomplete or potentially insufficient information in certain instances. Another limitation arises from possible disparities in the timing of data collection, which introduces complexities in the correlational analysis when the data are not contemporaneous. To mitigate this, the study prioritized the utilization of the most recent WHO (2020) reports to minimize temporal discrepancies. Furthermore, the analysis concentrates on a specific timeframe (2020) for cancer-related metrics. Cancer outcomes, health-care expenditures, and health system attributes may have evolved over time, and the study does not accommodate these temporal fluctuations.

The current analysis may not entirely encapsulate shifts in cancer care and health-care policies, and certain health system attributes might not precisely reflect real-world practices within countries. For example, while national-level cancer management guidelines may exist, their adherence at the local or subnational level is not guaranteed. Likewise, the presence of early detection services does not necessarily imply comprehensive coverage among the broader population. To address this complexity, the WHO integrates data on the dedicated funding allocated for these services—an indicator of their actual implementation.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Investigation: Maria Asensio

Methodology: Maria Asensio
Writing – original draft: Maria Asensio
Writing - review & editing: All authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Data are available from the GLOBOCAN 2020 database, see https://gco.iarc.fr/today; ECIS - European Cancer Information System. *Incidence and mortality estimates 2023*. Available from: https://ecis.jrc.ec.europa.eu.

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