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ECONOMIC BURDEN OF DISABILITY ADJUSTED LIFE YEARS (DALYs) OF CANCER IN TURKEY

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Abstract

Aim: Cancer is one of the leading causes of premature death in the world. However, the economic burden of cancer at the country level is unknown. This study aims to estimate the economic loss of disability-adjusted life years (DALYs) lost due to cancer between 1990 and 2019 in Turkey.

Methods: The economic value of DALYs lost to cancer has been estimated using the human capital approach. This study used disability-adjusted life years and gross domestic product (GDP) per capita to estimate economic loss due to DALYs in Turkey.

Results: Total economic loss due to cancer due to DALYs in 1990 was estimated as $ 3,366,235,623 (CI: $3,366,235,623- $ 5,822,580,496). In 2019, the total economic loss due to DALYs-related cancer was estimated to be $21,219,951,335 (95% CI: $16,172,564,722- $26,781,505,239). While the economic value

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of DALYs lost due to cancer was 3.0 (CI: 2.23-3.86) % of GDP in 1990 in Turkey, it was 2.79 (95% CI: 2.13-3.52) % of GDP in 2019.

Conclusion: According to the findings obtained from the research findings, an economic value of roughly 2.8 % of the GDP in Turkey shows that due to cancers. The first cancer, which constitutes the highest economic value of DALYs are lung cancer (28%) with 5.9 billion $. This finding necessitates the meticulous implementation of Turkey's national cancer policy for cancer prevention in Turkey.

Keywords: Cancer, indirect costs, DALYs, human capital

INTRODUCTION

In the 21st century, cancer is a disease that threatens the health of societies, the leading cause of premature death, and the single most important obstacle to increasing life expectancy in Turkey, as it is in every country in the world (Bray et al., 2018; Yılmaz et al., 2011; Demirer, 2014). Globally, it was estimated that 19,3 million new cancer cases and 10 million people died from cancer in 2020 (Sung et al., 2021). There are 62 thousand of new cancer cases in Turkey and 140 thousand cancer-related deaths in 2019 (Demirer, 2014). Given its high incidence, long-term health effects, and rising treatment costs, cancer poses a significant disease and societal burden on patients, families, reimbursement agencies, and the health system. Long-term disability and premature death from cancer have a significant economic impact. The value of lost life years represents the largest societal cost (Bhanvadia et al., 2021).

The economic burden of cancer is very high in all countries, causing loss of productivity due to morbidity and premature death due to cancer, as well as health expenditures. As the costs of cancer treatment increase, cancer prevention and early detection screening programs become cost-effective and cost-saving (Walker, 1997). Factors such as aging, obesity, alcohol consumption, poor diet and, lack of exercise contribute to cancer types, Surgery is responsible for 65% of cancer treatment worldwide (McCormick, 2018).

A significant portion of cancer patients cannot access adequate care, mainly due to weak health systems, inadequate national services, inequalities in access to cancer care, and high financial costs, leading to early cancer deaths. Cancer is therefore a costly disease for society with potentially large impacts on productivity and the economy (Hanly, Soerjomataram, & Sharp,

2015). Cancer also has an economic impact on society. An important element of this economic impact is the cost of lost productivity due to premature death from cancer (Hanly & Sharp, 2014).

Everyone around the world deserves to live a long life in full health. To achieve this goal, health policymakers need a comprehensive picture of what disease cripples and kills people by time, age and gender, Information about fatal and non-fatal cancer-related outcomes is needed to set priorities in cancer control. DALYs are a key measure for such purposes (Murray & Lopez, 1996).

The expected increase in cancer incidence and prevalence requires well-designed and efficient cancer control programs as implemented in best practice country examples. In this context, existing programs should be developed and implemented with well designed planning and budgeting strategies to increase the average survival and quality of life of cancer patients. In addition, reducing the financial burden of cancer treatment costs with the increase in cancer cases and prevalence reveals and emphasizes the need for an effective long-term cancer control strategy in Turkey (Yilmaz et al., 2011). The aim of this study is to estimate the economic loss of disability-adjusted life years (DALYs) lost due to cancer between 1990, 2019 in Turkey.

1. RESEARCH METHODOLOGY

The economic value of DALYs lost to cancer has been estimated using the human capital approach. This study used disability-adjusted life years and gross domestic product (GDP) per capita to estimate economic loss due to DALYs in Turkey. Individuals are productive members of the economy. The annual economic contribution of an individual is GDP per capita. Years lost due to disability or death are considered non-productive and not contributing to GDP (Dalal & Svanström, 2015). DALY is one of the components commonly used in estimating the economic burden of disease (Yiğit & Yiğit, 2019).

DALY can also be evaluated with the one-year value of GDP per capita to arrive at an estimate of the DALY's economic value (Brown, 2008; WHO, 2002). Since the economic value of DALYs measured here is affected by the size of GDP per capita, expressing these values as a percentage of each country's GDP will provide a more meaningful assessment for cross-country comparison The economic value of DALYs as a percentage of the country's GDP actually reveals

the extent of the economic loss associated with each cancer in that country (John & Ross, 2010). Premature death and non-fatal disability from any disease or injury reduces the stock of health and therefore human capital. For this reason, many scientists have pioneered the application of the human capital approach (HCA) to value human life (Muthuri & Kirigia, 2020).

Data on GDP, GDP per capita (GDPPC) and current healthcare expenditure per capita (CHEPC) were obtained from the WHO (2022), OECD (2022), Turkish Statistics Institute (TUİK, 2022) and the World Bank database (WB, 2022). Data on DALYs were obtained from the Global Burden of Disease (GBD) estimates for 1990, 2019 (IHME, 2022). The Global Burden of Disease Study estimates the burden of diseases globally over the past 30 years. The GBD Study uses extensive data and methods to summarize and compare disease burden by age, sex, country, cause and year. The methods of the GBD Study have been reported in detail elsewhere. Those who want to read in detail can refer to these resources (Hay et al., 2017; Naghavi et al., 2017; Vos et al., 2017). Brief information about DALYs is given.

DALYs measure health loss from both fatal and non-fatal burdens. DALYs are the sum of life years lost due to premature death (YLLs) and life years lost due to disability (YLDs). One DALY represents 1 year of healthy life lost. Examining the levels and trends of DALYs facilitates rapid comparison between different diseases and injuries (Hay et al., 2017; Vos et al., 2017).

In this research, the human capital approach was applied to convert the DALYs lost due to cancer in Turkey in 1990 and 2019 into their economic equivalents. The total monetary value of DALYs (TMVD) lost in Turkey from 30 cancer disease is the sum of the monetary value of DALYs lost from each i^{th} cancer disease (MVD_i),

$$TMVD = \sum_{i=1}^{t=30}(MVD_1 + MVD_2 + \cdots \ldots \ldots \ldots + MVD_t) \quad (1)$$

$$MVD_1 = \{DALY_1 \text{ x } (GDPPC\text{-}CHEPC)\} \quad (2)$$

$$MVD_2 = \{DALY_2 \text{ x } (GDPPC\text{-}CHEPC)\} \quad (3)$$

$$MVD_k = \{DALY_t \text{ x } (GDPPC\text{-}CHEPC)\} \quad (4)$$

As the DALY data in this study were obtained from the global burden of disease project, the validity of the findings is subject to the validity of the estimates of the DALYs. GBD is the

only organization that provides an evidence-based estimation of DALYs from all countries. Therefore, it is assumed that the DALYs data are correct.

This article uses publicly available data. No personal data was used in the research. Therefore, this study does not require ethical permission.

2.FINDINGS

The estimated economic value of DALYs by cancer types and the economic share of DALYs in GDP (%) in Turkey for 1990 and 2019 are presented in Table 1 and Table 2. Total economic loss due to cancer due to DALYs in 1990 was estimated as $ 3,366,235,623 (95% CI: $3,366,235,623- $ 5,822,580,496). In 2019, the total economic loss due to DALYs-related cancer was estimated to be $21,219,951,335 (95% CI: $ 16,172,564,722- $26,781,505,239).

Tables 1 and 2 also show economic losses from cancers as a proportion of GDP. While the economic value of DALYs lost due to cancer was 3.0 (95% CI: 2.23-3.86) % of GDP in 1990 in Turkey, it was 2.79 (95% CI: 2.13-3.52) % of GDP in 2019.

Table 1 presents the economic values of DALYs for 30 different cancer types in 1990. The top 5 cancers that accounted for the highest economic value of DALYs in 1990; tracheal, bronchus, lung cancer (22.9%), stomach cancer (12.25%), leukemia (12.25%), colon and rectum cancer (7.29%), brain and central nervous (6.24%) were detected.

Table 1. The estimated economic value of DALYs by cancer type and economic share of DALYs in GDP (%) for 1990

Cancer Type	Economic Value of DALYs (US$)			Economic Value of DALYs as %GDP			Rank Economic Value of DALYs	
	Value	Lower	Upper	Value	Lower	Upper	%	Rank
Bladder cancer	81,746,397	64,647,747	100,818,883	0.05	0.04	0.07	1.81	12
Brain and central nervous system cancer	282,055,061	127,699,515	430,692,561	0.19	0.08	0.29	6.24	5
Breast cancer	222,322,086	176,170,792	283,378,879	0.15	0.12	0.19	4.92	7
Cervical cancer	70,896,906	44,341,284	89,744,792	0.05	0.03	0.06	1.57	15
Colon and rectum cancer	329,754,772	264,612,906	409,318,588	0.22	0.18	0.27	7.29	4
Esophageal cancer	60,272,015	42,782,297	78,007,471	0.04	0.03	0.05	1.33	16
Gallbladder and biliary tract cancer	53,806,183	40,446,459	67,036,432	0.04	0.03	0.04	1.19	18

Hodgkin lymphoma	35,806,492	28,333,924	47,158,029	0.02	0.02	0.03	0.79	21
Kidney cancer	58,010,163	45,075,857	76,437,915	0.04	0.03	0.05	1.28	17
Larynx cancer	79,582,312	56,585,936	98,985,092	0.05	0.04	0.07	1.76	13
Leukemia	553,889,511	388,370,033	756,441,530	0.37	0.26	0.50	12.25	3
Lip and oral cavity cancer	26,967,829	21,429,463	33,357,033	0.02	0.01	0.02	0.60	25
Liver cancer	101,423,981	80,929,911	123,931,523	0.07	0.05	0.08	2.24	10
Malignant skin melanoma	24,552,721	12,799,546	39,719,813	0.02	0.01	0.03	0.54	26
Mesothelioma	29,163,622	20,813,795	45,691,525	0.02	0.01	0.03	0.64	23
Multiple myeloma	42,380,660	24,571,217	64,769,295	0.03	0.02	0.04	0.94	19
Nasopharynx cancer	35,682,301	28,503,035	43,136,372	0.02	0.02	0.03	0.79	22
Non-Hodgkin lymphoma	162,346,014	119,376,111	205,482,386	0.11	0.08	0.14	3.59	8
Non-melanoma skin cancer	17,183,205	14,440,445	20,602,407	0.01	0.01	0.01	0.38	29
Other malignant neoplasms	243,164,947	203,994,743	291,543,742	0.16	0.14	0.19	5.38	6
Other neoplasms	22,121,758	17,114,504	34,295,067	0.01	0.01	0.02	0.49	27
Other pharynx cancer	9,504,535	7,277,033	12,051,761	0.01	0.00	0.01	0.21	30
Ovarian cancer	74,202,487	41,820,481	134,434,866	0.05	0.03	0.09	1.64	14
Pancreatic cancer	128,198,919	102,673,813	160,934,999	0.09	0.07	0.11	2.83	9
Prostate cancer	100,784,533	71,290,616	127,268,812	0.07	0.05	0.08	2.23	11
Stomach cancer	554,206,593	466,977,318	634,536,690	0.37	0.31	0.42	12.25	2
Testicular cancer	27,583,497	17,354,958	45,165,697	0.02	0.01	0.03	0.61	24
Thyroid cancer	19,709,292	14,768,097	24,262,062	0.01	0.01	0.02	0.44	28
Tracheal, bronchus, and lung cancer	1,037,722,382	797,590,854	1,293,079,134	0.69	0.53	0.86	22.94	1
Uterine cancer	37,812,036	23,442,934	50,302,426	0.03	0.02	0.03	0.84	20
Total	**4,522,855,851**	**3,366,235,623**	**5,822,580,496**	**3.00**	**2.23**	**3.86**	**100.00**	

The first five cancers that constitute the highest economic value of DALYs in 2019 (Table 2). It was determined as tracheal, bronchus, lung cancer (27.9%), colon and rectum cancer (9.7%), stomach cancer (8.5%), breast cancer (6.7%), pancreatic cancer (6.2%). As can be seen in Tables 1 and 2, we can see that there was a change in cancer types that constitute the highest economic values of DALYs between 1990 and 2019. Breast cancer, which was 7th in 1990, rose to 4th in 2019. Likewise, pancreatic cancer, which was 9th in 1990, rose to 5th in 2019.

Table 2. Estimated economic value of DALYs by cancer types and economic share of DALYs in GDP (%) for 2019

Cancer Types	Economic Value of DALYs (US$)			Economic Value of DALYs as %GDP			Rank Economic Value of DALYs	
	Value	Lower	Upper	Value	Lower	Upper	%	Rank
Bladder cancer	518,960,835	635,829,343	411,321,093	0.07	0.05	0.08	2,45	11
Brain and central nervous system cancer	1,058,154,884	1,462,986,378	505,535,727	0.14	0.07	0.19	4,99	7
Breast cancer	1,428,587,526	1,798,582,219	1,123,026,979	0.19	0.15	0.24	6,73	4
Cervical cancer	232,550,575	294,715,353	161,475,539	0.03	0.02	0.04	1,10	18

Colon and rectum cancer	2,062,529,710	2,534,399,153	1,640,060,841	0.27	0.22	0.33	9,72	2
Esophageal cancer	267,180,346	334,974,751	203,016,931	0.04	0.03	0.04	1,26	16
Gallbladder and biliary tract cancer	209,514,492	316,501,293	160,074,104	0.03	0.02	0.04	0,99	19
Hodgkin lymphoma	78,743,114	109,343,760	60,572,238	0.01	0.01	0.01	0,37	29
Kidney cancer	368,314,564	464,018,223	290,200,504	0.05	0.04	0.06	1,74	14
Larynx cancer	282,962,412	357,588,811	218,026,615	0.04	0.03	0.05	1,33	15
Leukemia	1,140,815,645	1,401,633,795	917,684,940	0.15	0.12	0.18	5,38	6
Lip and oral cavity cancer	120,571,163	151,139,958	94,779,986	0.02	0.01	0.02	0,57	23
Liver cancer	469,170,089	583,108,325	369,915,067	0.06	0.05	0.08	2,21	12
Malignant skin melanoma	119,400,646	161,841,823	68,017,360	0.02	0.01	0.02	0,56	24
Mesothelioma	140,891,966	180,482,497	106,094,979	0.02	0.01	0.02	0,66	21
Multiple myeloma	261,749,786	349,379,270	164,819,872	0.03	0.02	0.05	1,23	17
Nasopharynx cancer	107,496,414	134,044,047	84,492,181	0.01	0.01	0.02	0,51	25
Non-Hodgkin lymphoma	655,537,019	800,052,013	528,062,198	0.09	0.07	0.11	3,09	10
Non-melanoma skin cancer	86,395,266	107,384,936	69,227,690	0.01	0.01	0.01	0,41	28
Other malignant neoplasms	824,935,442	1,003,618,370	671,096,130	0.11	0.09	0.13	3,89	8
Other neoplasms	139,331,278	221,777,046	100,441,464	0.02	0.01	0.03	0,66	22
Other pharynx cancer	40,307,174	51,853,085	31,396,916	0.01	0.00	0.01	0,19	30
Ovarian cancer	450,194,981	594,176,474	278,965,138	0.06	0.04	0.08	2,12	13
Pancreatic cancer	1,317,985,660	1,640,005,102	1,050,184,224	0.17	0.14	0.22	6,21	5
Prostate cancer	712,406,604	927,502,946	508,649,142	0.09	0.07	0.12	3,36	9
Stomach cancer	1,809,706,107	2,239,914,718	1,433,787,167	0.24	0.19	0.29	8,53	3
Testicular cancer	95,417,002	131,249,140	69,100,287	0.01	0.01	0.02	0,45	27
Thyroid cancer	96,117,719	127,833,143	73,830,130	0.01	0.01	0.02	0,45	26
Tracheal, bronchus, and lung cancer	5,921,356,345	7,398,930,385	4,661,426,711	0.78	0.61	0.97	27,90	1
Uterine cancer	202,666,572	266,630,920	117,274,606	0.03	0.02	0.04	0,96	20
Total	21,219,951,335	26,781,505,239	16,172,564,722	2.79	2.13	3.52	100.00	

The economic value of disability-adjusted life years due to cancer by age and gender (1990, 2019) is given in Table 3. Accordingly, it was determined that while the economic loss due to cancer was 62% in men in 1990, it was 38% in women, In 2019, this rate was found to be 63% for men and 37% for women. It was determined that approximately 50% of the economic loss due to cancer in 1990 and 2019 was in the 50-69 age group.

Table 3. Estimated economic value of DALYs due to cancer by age and gender (1990, 2019)

Age Group	1990			
	Female	**Male**	**Both**	**%**
0-14	260.725.319	286.946.639	547.671.957	12,1
15-49	564.538.887	710.465.309	1.275.004.196	28,2
50-69	668.405.931	1.394.252.698	2.062.658.629	45,6
70+	224.668.455	412.252.255	636.920.711	14,1
All ages	1.718.338.592	2.803.916.901	4.522.255.492	100
%	38,0	62,0	100	
Age Group	2019			
	Female	**Male**	**Both**	**%**
0-14	248.004.948	314.360.619	562.365.567	2,7
15-49	1.976.648.984	2.409.608.241	4.386.257.225	20,7
50-69	3.441.054.291	7.288.914.221	10.729.968.511	50,6
70+	2.145.605.876	3.396.559.526	5.542.165.402	26,1
All ages	7.811.314.099	13.409.442.607	21.220.756.706	100
%	36,8	63,2	100	

4. DISCUSSION

Cancer causes many important health problems in terms of both the disease burden (morbidity and mortality) and the economic burden resulting from the disease burden, For this reason, the economic impact of a disease is considered as an important health policy problem in developed countries, In this study, the economic burden of life years adjusted for disability due to cancer was estimated in Turkey.

In Turkey, the economic burden of 30 different types of cancer due to premature death, disability and disease was estimated to be 4,522,855,851-$ in 1990. This amount constitutes 3.0 % of the gross domestic product. In 2019, this economic burden constituted 21,219,951,335-$ and 2.79 % of the gross domestic product. There are many studies in the literature on the economic burden of cancer lost to mortality and morbidity. These studies are briefly summarized below.

In a study by John and Ross, they estimated the economic value of disability-adjusted life years lost due to cancer to measure the indirect economic burden of cancer in the world. Accordingly, they found that 83 million DALYs with an economic value of 895 billion US$, roughly 1.5% of the world gross domestic product, were lost due to cancers in 2008. The top three types of cancer that account for the highest economic value of DALYs are lung cancer (19.9%),

US$ 178 billion, cancer of the colon/rectum (11.0%) US$ 99 billion and breast cancer (9.8%) 88 billion. It was determined in US dollars. The economic value of DALYs lost due to cancer is 2.22% of gross domestic product in low-income countries and 1.69% in high-income countries. For nearly half of the world's countries, the economic value of cancer-related DALYs was found to be more than one percent of annual gross domestic product (John & Ross, 2010). World Health Organization determined that the total annual economic impact of cancer globally is $1.16 trillion, This result represents approximately 1.5% of the world's gross domestic product (McCormick, 2018).

The economic burden of cancer in the USA has been determined to be approximately 1.8% of the gross domestic product (Walker, 1997), A study conducted in Chile found that it spends US$ 2,100 million (1% GDP) on cancer care and treatment. It has also been estimated that the national income lost due to DALYs cancer in Chile is 3.5 billion US$. This result shows that cancer has a major economic impact in Chile (Jimenez de la Jara et al., 2015).

Another study aimed to determine the average costs of cancer-related disability-adjusted life years and to highlight possible differences in economic estimates obtained by various approaches. According to this study, the total and indirect pooled costs per DALY were 9,150 USD (95% CI: 5,560–15,050) and 3,890 USD (95% CI: 2,570–5,880), respectively. In addition, the cancer-related cost per DALY was found to be an average of 32% (95% CI: 24-42%) of the gross domestic product per capita of the respective countries. However, it is stated that this calculation can be strongly affected by fluctuations depending on cancer type and other parameters such as country and health care costs (Garlasco et al., 2022).

In Mexico, the economic costs of breast cancer (morbidity, premature death) due to inadequate breastfeeding in women have been identified. As a result of the research, it was determined that the economic cost of breast cancer due to insufficient breastfeeding in women is 245 million USD. In addition, medical costs constitute 80% of the economic burden, and income losses and opportunity costs for caregivers were found to be 15% and 5%, respectively (Unar-Munguía et al., 2017).

5. CONCLUSIONS AND RECOMMENDATIONS

According to the findings obtained from the research findings, an economic value of roughly 2.79 % of the GDP in Turkey shows that due to cancers. This includes the indirect costs of cancer and does not include the direct costs. The first cancer, which constitutes the highest economic value of DALYs are lung cancer (28%) with 5.9 billion $. Colon/rectum cancer with 2.1 billion $ (9.7%) and stomach cancer with 1.8 billion $ (8.5%). This finding necessitates meticulous implementation of the Turkey's national cancer policy for cancer prevention. In addition, the creation and strengthening of cancer registries and the training of health manpower (oncology specialists and other health professionals related to cancer) will minimize the cancer disease burden.

The years of life lost due to cancer in Turkey have led to significant economic losses. Therefore, it is necessary to strengthen the national health system and other systems that address the social determinants of health. In addition, there is an urgent need for economic evaluation studies that identify, evaluate and compare the costs and outcomes associated with cancer preventive and therapeutic interventions in Turkey.

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