BMJ Open

Estimating the indirect economic burden of cancer in Jordan: a retrospective observational study

Omar Rashdan

To cite: Rashdan O. Estimating the indirect economic burden of cancer in Jordan: a retrospective observational study. *BMJ Open* 2024;**14**:e082025. doi:10.1136/bmjopen-2023-082025

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-082025).

Received 12 November 2023
Accepted 21 May 2024

Faculty of Pharmacy, Middle East University, Amman, Jordan

Correspondence to
Dr Omar Rashdan;
orashdan@meu.edu.jo

ABSTRACT

Objective The aim of this study is to estimate the indirect economic burden of 22 cancer types in Jordan using both the human capital approach (HCA) and the value of a statistical life year (VSLY) approach. Additionally, this study aims to forecast the burden of these cancers for the next 5 years while employing time series analysis.

Design Retrospective observational study with a time series analysis.

Participants Disability adjusted life years records from the IHME Global Burden Disease estimates 2019 data.

Primary outcome measure Indirect economic burden of cancer in Jordan.

Results The mean total economic burden for all cancers is estimated to be $1.82 billion using HCA and $3.13 billion using VSLY approach. The cancers contributing most to the total burden are 'tracheal, bronchus and lung cancer' ($359.5 million HCA, $618.3 million VSLY), followed by 'colon and rectum cancer' ($300.6 million HCA, $517.1 million VSLY) and 'breast cancer' ($292.4 million HCA, $502.9 million VSLY). The indirect economic burden ranged from 1.4% to 2.1% of the gross domestic product (GDP) using the HCA, and from 2.3% to 3.6% of the GDP using the VSLY approach. The indirect economic burden is expected to reach 2.3 and 3.5 billion Intl$ by the year 2025 using the HCA and VSLY approach, respectively.

Conclusion The indirect economic burden of cancer in Jordan amounted to 1.4%–3.6% of total GDP, with tracheal, bronchus and lung cancer; colon and rectum cancer; and breast cancer contributing to over 50% of the total burden. This will help set national cancer spending priorities following Jordan's economic modernisation vision with regard to maximising health economic outcomes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Two valuation approaches (ie, human capital approach and value of a statistical life year) were used to estimate the indirect economic burden of 22 cancers in Jordan.
⇒ The results were presented as a proportion of the gross domestic product to facilitate cross-country comparisons.
⇒ The conservative valuation approach aligns with regional policy preferences, increasing its applicability.
⇒ The lack of data on informal care and direct disease costs in Jordan may limit the comprehensiveness of the analysis.

INTRODUCTION

The Hashemite Kingdome of Jordan, a middle-income country situated in the Middle East that has experienced significant economic challenges and stagnant economic growth in recent years; the COVID-19 pandemic, regional conflicts and the large influx of refugees have all had negative impacts on Jordan's national economy.[1] Health is a major contributor to a country's national economy, and cancer in particular is a significant health concern in Jordan, with a growing burden that requires calculated government interventions in light of the current stringent economic liquidity.[2 3] The high proportion of chronic diseases (including cancer) among refugees, has placed a significant economic burden on Jordan's healthcare system.[2] The United Nations High Commissioner for Refugees reported that breast cancer was the most common cancer among refugees in Jordan between 2011 and 2012.[2] Moreover, the International Agency for Research on Cancer reported that in 2020, there were 11 559 new cancer cases in Jordan; the most common types of cancer were breast cancer, accounting for 20.8% of all cases, followed by colorectal cancer (10.9%), lung cancer (9.1%), bladder cancer (4.9%) and leukaemia (4.9%).[4]

One way to understand the national burden of a disease is by looking at how it affects a person's quality of life, also known as health related quality of life, which combines mortality and morbidity into one overall score.[5] Disability adjusted life years (DALYs) is one of these measures which was first coined by Murray and Lopez[6]; DALYs represent the total years of life lost (YLLs) due to dying early from a disease and the proportion of 'healthy life years' lost because of living with a disease.

Understanding the burden of disease is crucial not only for assessing the impact on an individual's health, but also for evaluating the economic implications at a national

level.[7] The economic burden of a disease can be substantial, encompassing both direct costs (such as medical expenses) and indirect costs (such as productivity loss due to disability or premature death).[8] The indirect economic burden, in particular, represents a significant portion of the total cost of illness (COI); it includes the forgone value of economic output lost due to disease-related work absences (absenteeism), reduced productivity while at work (presenteeism) and premature death (mortality).[9] Therefore, by monetising the disease burden in terms of DALYs, we can estimate the potential productivity loss due to that specific disease. This information is invaluable for policy makers when establishing financing priorities for healthcare, as it provides a comprehensive view of the disease's impact on society.[10]

In the context of this study, understanding and quantifying the disease burden of various cancers in Jordan will provide insights into the forgone economic productivity due to these cancers; Hence, the aim of this work is to estimate the indirect economic burden of 22 cancer types in Jordan to aid in establishing cancer financing priorities from a national economic perspective. Moreover, time series analysis was applied for the time period 1990–2019 and the indirect economic burden was forecasted for the years 2020–2025, while presenting the results as a proportion of total gross domestic product (GDP) to facilitate international comparisons and transferability.

METHODS

Many methods have been adopted by health economists to value the economic burden due to disease. Two main methods are often employed[11 12]; first is value of a statistical life (VSL) approach which is based on the willingness-to-pay (WTP), where it estimates the disease burden by weighing the tradeoffs that individuals would be willing to make to reduce their chances of dying. The VSL approach often estimates the upper bound of the indirect economic burden.[13] The second (and the more commonly used) method is the human capital (HC) approach (HCA), or the forgone output approach, which is partial to the COI approach, where the forgone productivity of premature mortality and morbidity are monetised based on the projected economic output per capita.[7 13] In theory, the HCA should provide the lower bound estimates of the economic burden compared with the VSL approach; this is attributed to that the VSL further captures the utility derived from intangibles such as being alive and spending time with loved ones in addition to economic consumption, in contrast to the HCA where only tangible economic output is considered.[13]

Owing to the data scarcity of informal care and direct disease costs of cancer in Jordan, the analysis in this work was restricted to the financial value of lost productivity (indirect costs) from cancer patients due to premature mortality and morbidity from a national perspective. This is done by using country specific, age-adjusted DALYs reported by the Global Burden of Disease study 2019 estimates for Jordan.[14] When it comes to calculating the economic value of DALYs, it is generally better to use more cautious valuation methods. In this work, the most conservative estimation approach was always employed as policy makers in the region are still reluctant to consider indirect cost estimates in their reimbursement decisions. Using age-standardised DALY estimates provide more conservative estimations of the national economic loss compared with normal DALY values.[15]

Age standardised DALY rates for 22 cancers (ie, bladder cancer; brain and central nervous system cancer; breast cancer; cervical cancer; colon and rectum cancer; oesophageal cancer; gallbladder and biliary tract cancer; kidney cancer; larynx cancer; lip and oral cavity cancer; liver cancer; nasopharynx cancer; non-melanoma skin cancer; other pharynx cancer; ovarian cancer; pancreatic cancer; prostate cancer; stomach cancer; testicular cancer; thyroid cancer; tracheal, bronchus, and lung cancer; and uterine cancer) were used in this analysis along with their corresponding YLL (mortality) and year lived with disability (YLD) (morbidity) estimates. All values were provided with upper and lower estimates, in addition to the mean estimate value.[14] To model the indirect costs of the aforementioned cancers in Jordan, we further used population size and GDP per capita (GDPpc) data from the World Bank Group,[16] while life expectancy and gross national income (GNI) per capita (GNIpc) were extracted from the WHO.[17] Sources were selected based on the data availability for Jordan for the years 1990–2019.

Forgone economic loss estimates (indirect costs) were calculated for the year 2019 using same year current international dollars (Intl$), adjusted for purchasing power parity (PPP). The PPP approach allows for a more accurate comparison of economic data between countries by accounting for differences in cost of living and inflation rates.[18] This is particularly important in health economics where costs can vary significantly between countries due to differences in healthcare systems, wage levels and general price levels.[19] Hence, using PPP-adjusted international dollars would align the methodology with established practices in the field of health economics, enhancing the credibility and comparability of the results. Total DALYs were calculated for each corresponding year and cancer type by multiplying the DALY rate by the population estimates for the same year. Additionally, since the economic value of DALYs is influenced by the GDPpc, results were also expressed as a percentage of total GDP to provide a more useful measure in comparison to other countries. Time series analysis was conducted to investigate the overall cancer situation over the past 30 years. Following are the detailed methodologies used in this work for both the HC and the VSL approaches in addition to the time series analysis.

Human capital approach

Multiple researchers have implemented the use of GNIpc as a proxy for the monetary value of a DALY.[20–22] As with

previous studies, PPP approach was used instead of Atlas method for determining GNIpc. The PPP method is more accurate for cross-country income per capita comparisons as it accounts for differences in price levels among countries, facilitating cross-country comparison. For this work, and provided the conservative approach adopted, each DALY lost was valued as one GNIpc, although values of one, two and three times the GNIpc were suggested as proxies for each DALY.[23 24] For instance, in 2019, the total mean DALY estimate for breast cancer was 29 418.6843 DALYs, multiplied by the GNIpc Intl$, PPP value of 9940 gives the estimated forgone monetary value of 292 421 722 Intl$, PPP, noting that the numbers in the table have been rounded to enhance readability. The same approach was used to calculate the monetary value of the YLDs and YLLs.

VSL year approach

The VSL represents the maximum amount an individual is prepared to pay to reduce their risk of death; this approach is frequently employed by government bodies to assess the potential economic benefits of investments in areas with limited resources.[15 20 25] In countries where specific VSL studies have not been conducted, it is possible to use estimates from other countries after adjusting based on the GDP or GNI.[26 27]

Income-elasticity factor plays a crucial role in adjusting monetary estimates between countries with different income levels; as individuals in higher-income countries are generally willing to pay more to reduce their risk of death compared with individuals in lower-income countries reflecting the WTP.[28 29] In the context of this work, it is employed to adjust the VSL estimated from a high-income country (ie, USA) to a middle-income country (ie, Jordan). Provided that healthcare is a necessity rather than a luxury, and that its consumption does not increase proportionally with income, and owing to the conservative estimation approach adopted in this work, an income-elasticity factor of 0.85 was used to enhance the reliability of the VSL estimate, following Miller's recommendation.[30]

Estimates show that the VSL for the USA is US$7.2 million.[31] This number has remained constant over the past 5 years[31 32]; hence, no inflation adjustment was employed. After adjusting for the GNIpc following Kotagal *et al*[27]; the VSL for Jordan in 2019 amounts to US$1.157 million using an elasticity factor of 0.85 adopted from Miller.[30] On the other hand, a recent study by Sweis[31] reported that the world average VSL is estimated to be US$1.3 million. This estimate is also in line with another study where the VSL was estimated to be US$1.3 million for upper-middle income countries.[32]

It can be seen that both VSL estimates ($1.157 million and $1.3 million) are close to each other, validating the utility of the GNI transferability approach in calculating national VSL estimates. However, in this work, the VSL for Jordan was assumed to be US$1.3 million following Sweis[31] and Viscusi and Masterman.[32] Consequently, the VSL year (VSLY) can be derived from the VSL by dividing the VSL by the life expectancy,[22] which was 76.04 years in Jordan for 2019; this calculation resulted in a VSLY value of $17 096 in Jordan, which will be used to assign a monetary value to each DALY in this work. For instance, in 2019, the total mean DALY estimate for breast cancer was 29 418.6843 DALYs, multiplied by the calculated value of VSLY 17 096.26512 gives the estimated forgone monetary value of $292 421 722, noting that the numbers in the table have been rounded to enhance readability. The same approach was used to calculate the monetary value of the YLDs and YLLs.

Time series analysis and forecasting

DALY rates from 1990 to 2019 were used as the base case for the time series analysis. Using both the HC and VSLY estimates, the total annual cancer indirect economic burden was summed for all 22 cancers and is further used for the analysis. DALY rate and the total economic burden were investigated against time using Excel. Changes in the annual DALY rate and cumulative total economic burden were also highlighted. Forecasting was done using SPSS V.23 expert modeller module for indirect economic loss estimates up to the year 2025 using the HCA.

Patient and public involvement

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. The data used in this study are anonymised and were obtained from publicly available databases, which means they do not contain any information that could be used to identify individual patients. However, the results of this study can help inform public health policies and set national cancer spending priorities, which could indirectly benefit patients and the public in Jordan.

RESULTS

Table 1 shows the detailed indirect economic burden for each investigated cancer type in Jordan for the year 2019 using two approaches: The HCA and the VSLY approach. The mean estimates, along with their corresponding lower and upper bounds are presented for each type of cancer (a summary of total DALYs, YLLs and YLDs for all cancer types is available in online supplemental table 1). The mean total economic burden for all cancers is estimated to be $1.82 billion using HCA and $3.13 billion using VSLY approach. The cancers contributing most to the total burden are 'tracheal, bronchus and lung cancer' ($359.5 million HCA, $618.3 million VSLY), followed by 'colon and rectum cancer' ($300.6 million HCA, $517.1 million VSLY) and 'breast cancer' ($292.4 million HCA, $502.9 million VSLY). These three cancers alone account for over 50% of the total indirect economic burden in Jordan.

Table 1 Indirect economic burden of cancers in Jordan for the year 2019 using two estimation approaches; HCA and VSLY, along with their upper and lower bounds (international $, purchasing power parity (PPP))

Cause	Measure	HCA (GNICP) ($)*	HCA (GNICP) upper ($)	HCA (GNICP) lower ($)	VSLY ($)†	VSLY upper estimate ($)	VSLY lower estimate ($)	Percent of total measure
Tracheal, bronchus, and lung cancer	DALYs	359 461 738	435 769 039	294 157 689	618 254 846	749 499 298	505 935 396	19.8
	YLLs	355 994 421	431 411 212	291 347 960	612 291 247	742 004 071	501 102 813	5.9
	YLDs	3 467 317	4 897 323	2 304 235	5 963 599	8 423 132	3 963 160	20.2
Colon and rectum cancer	DALYs	300 631 391	361 205 774	250 399 393	517 069 816	621 254 494	430 673 482	16.5
	YLLs	291 878 292	350 429 984	243 666 914	502 014 956	602 720 716	419 093 980	14.8
	YLDs	8 753 101	12 035 107	6 082 513	15 054 862	20 699 737	10 461 595	16.6
Breast cancer	DALYs	292 421 722	370 580 967	227 538 031	502 949 627	637 379 322	391 353 169	16.1
	YLLs	274 858 590	349 370 519	215 239 352	472 741 985	600 898 493	370 200 103	29.8
	YLDs	17 563 134	25 091 103	11 262 824	30 207 646	43 155 347	19 371 452	15.6
Pancreatic cancer	DALYs	122 708 131	145 653 819	101 900 313	211 051 383	250 516 731	175 263 055	6.7
	YLLs	121 565 733	144 328 181	100 999 688	209 086 519	248 236 705	173 714 029	1.9
	YLDs	1 142 399	1 580 670	773 058	1 964 864	2 718 668	1 329 618	6.9
Stomach cancer	DALYs	116 462 057	140 501 601	96 762 449	200 308 471	241 655 193	166 426 205	6.4
	YLLs	115 024 573	138 783 647	95 674 042	197 836 075	238 700 405	164 554 204	2.4
	YLDs	1 437 485	2 014 281	966 248	2 472 396	3 464 455	1 661 895	6.5
Brain and central nervous system cancer	DALYs	104 031 012	128 261 181	73 899 330	178 927 743	220 602 329	127 102 871	5.7
	YLLs	102 171 238	126 247 306	72 583 638	175 729 032	217 138 573	124 839 952	3.2
	YLDs	1 859 774	2 640 405	1 145 698	3 198 711	4 541 354	1 970 538	5.8
Prostate cancer	DALYs	100 280 762	129 749 616	70 332 162	172 477 515	223 162 358	120 967 534	5.5
	YLLs	92 435 660	118 870 683	64 764 393	158 984 362	204 451 179	111 391 271	13.3
	YLDs	7 845 103	11 502 321	4 777 774	13 493 155	19 783 373	8 217 514	5.3
Bladder cancer	DALYs	72 023 131	90 032 941	57 550 956	123 875 910	154 851 814	98 984 548	4.0
	YLLs	67 098 172	83 608 419	53 348 494	115 405 246	143 801 982	91 756 539	8.4
	YLDs	4 924 960	6 874 958	3 355 129	8 470 666	11 824 557	5 770 641	3.8
Liver cancer	DALYs	55 684 275	69 408 183	44 848 815	95 773 957	119 378 339	77 137 549	3.1
	YLLs	55 063 775	68 532 323	44 373 874	94 706 730	117 871 908	76 320 675	1.1
	YLDs	620 501	876 164	413 901	1 067 228	1 506 955	711 887	3.1
Ovarian cancer	DALYs	48 916 127	63 254 672	35 145 137	84 133 106	108 794 632	60 447 744	2.7
	YLLs	47 497 482	61 665 186	33 971 025	81 693 113	106 060 802	58 428 336	2.4
	YLDs	1 418 645	2 096 301	850 432	2 439 994	3 605 526	1 462 698	2.7

Continued

Table 1 Continued

Cause	Measure	HCA (GNICP) ($)*	HCA (GNICP) upper ($)	HCA (GNICP) lower ($)	VSLY ($)†	VSLY upper estimate ($)	VSLY lower estimate ($)	Percent of total measure
Kidney cancer	DALYs	36356935	44179603	29322157	62531972	75986539	50432532	2.0
	YLLs	34960489	42526833	28089704	60130160	73143865	48312780	2.4
	YLDs	1396446	1924589	952079	2401812	3310190	1637525	2.0
Gallbladder and biliary tract cancer	DALYs	33346021	40864783	26905142	57353361	70285228	46275396	1.8
	YLLs	32907519	40367775	26572575	56599161	69430400	45703399	0.7
	YLDs	438502	605312	289452	754200	1041105	497842	1.9
Oesophageal cancer	DALYs	27819105	34442131	22106212	47847364	59238612	38021495	1.5
	YLLs	27467457	33965667	21821908	47242547	58419119	37532508	0.6
	YLDs	351649	494676	232712	604817	850816	400251	1.6
Cervical cancer	DALYs	27364474	36540678	19759736	47065422	62848000	33985683	1.5
	YLLs	26493262	35496010	19189076	45566986	61051227	33004179	1.5
	YLDs	871211	1298812	526029	1498436	2233887	904742	1.5
Lip and oral cavity cancer	DALYs	25598897	31349604	21047610	44028725	53919633	36200757	1.4
	YLLs	24833962	30403347	20416905	42713078	52292121	35115979	1.3
	YLDs	764935	1065206	507235	1315647	1832097	872418	1.4
Uterine cancer	DALYs	24365078	31673733	18288022	41906623	54477116	31454413	1.3
	YLLs	22554102	29130917	17058305	38791841	50103610	29339366	3.1
	YLDs	1810977	2698468	1123937	3114783	4641219	1933111	1.3
Larynx cancer	DALYs	18092020	23836177	13916013	31117300	40996943	23934794	1.0
	YLLs	17409778	23016905	13365702	29943882	39587837	22988287	1.2
	YLDs	682242	999844	462599	1173419	1719677	795646	1.0
Thyroid cancer	DALYs	15298388	19372190	12451279	26312404	33319125	21415530	0.8
	YLLs	13406804	16855294	10916696	23058982	28990198	18776130	3.2
	YLDs	1891584	2852605	1191716	3253422	4906327	2049687	0.8
Nasopharynx cancer	DALYs	13419692	16629932	10690279	23081147	28602587	18386705	0.7
	YLLs	12875271	15926475	10247242	22144774	27392681	17624704	0.9
	YLDs	544420	774263	363978	936374	1331691	626022	0.7
Non-melanoma skin cancer	DALYs	10159358	12254474	8503462	17473550	21077036	14625496	0.6
	YLLs	10102278	12201069	8455516	17375374	20985182	14543033	0.1
	YLDs	57081	85989	36755	98175	147897	63217	0.6

Continued

Table 1 Continued

Cause	Measure	HCA (GNICP) ($)*	HCA (GNICP) upper ($)	HCA (GNICP) lower ($)	VSLY ($)†	VSLY upper estimate ($)	VSLY lower estimate ($)	Percent of total measure
Other pharynx cancer	DALYs	7 425 993	9 400 667	5 938 812	12 772 308	16 168 641	10 214 438	0.4
	YLLs	7 322 485	9 263 775	5 853 010	12 594 280	15 933 194	10 066 861	0.2
	YLDs	103 507	149 736	66 535	178 027	257 538	114 437	0.4
Testicular cancer	DALYs	6 668 588	9 087 977	4 789 357	11 469 612	15 630 831	8 237 437	0.4
	YLLs	5 653 084	7 879 511	4 023 747	9 723 001	13 552 335	6 920 628	1.7
	YLDs	1 015 504	1 869 734	456 658	1 746 612	3 215 842	785 427	0.3
Total cancers	DALYs	1818534896	2244049741	1446252357	3127782165	3859644801	2487476230	100.0
	YLLs	1759574427	2170281038	1401979766	3026373331	3732766602	2411329756	100.0
	YLDs	58 960 475	84 427 868	38 141 497	101 408 845	145 211 390	65 601 322	100.0

*GNIpc 2019=9940 Intl$, PPP.
†VSLY multiplier=$17 096 Intl$, PPP.
DALYs, disability adjusted life years; GNIpc, gross national income per capita; HCA, human capital approach; VSLY, value of a statistical life year; YLDs, years lived with disability; YLLs, years of life lost.

In terms of morbidity, 'breast cancer' stands out with the highest contribution from total cancer morbidity ($17.6 million HCA, $30.2 million VSLY), followed by 'prostate cancer' ($7.8 Million HCA, $13.5 million VSLY) and 'colon and rectum cancer' ($8.6 million HCA, $15.1 million VSLY). On the other hand, 'non-melanoma skin cancer' has the lowest morbidity contributions, ($57 081 HCA $98 175 VSLY). Conversely, mortality costs are highest for tracheal, bronchus and lung cancer ($355.9 million HCA, $612.3 million VSLY), colon and rectum cancer ($291.9 million HCA, $502 million VSLY) and breast cancer ($274.9 million HCA, $472.7 million VSLY).

The per cent contribution of different types of cancers from the total indirect economic burden cancer are also presented in table 1. Each type of cancer is listed with its corresponding percentage contribution out of that total specific measure. In terms of morbidity; 'breast cancer' has the highest contribution with 29.8% of total cancer morbidity burden, followed by 'prostate cancer' at 13.3% and 'colon and rectum cancer' at 14.8%. On the other end of the spectrum, 'non-melanoma skin cancer' and 'other pharynx cancer' have the lowest disability contributions, both less than 1% of the total disability burden. On the other hand; 'tracheal, bronchus and lung cancer' contribute the most to mortality with 20.2% of total cancers mortality, followed by 'colon and rectum cancer' at 16.6% and 'breast cancer' at 15.6%. This underscores the severe health impact of these cancers which consequently reflects on the economic burden. When considering both morbidity and mortality (ie, total burden); 'tracheal, bronchus and lung cancer' contribute the most to the total cancer measure with 19.8%, followed by 'colon and rectum cancer' at 16.5% and 'breast cancer' at 16.1%. Interestingly, while testicular cancer has a relatively low total cost, it has a high disability contribution (13.3%), indicating a significant impact on patients' quality of life despite its lower prevalence or mortality rate.

Table 2 shows the indirect economic burden due to each cancer type as a per cent of GDP in Jordan for the year 2019. The total economic burden of all cancers, when considering both the HCA and the VSLY approaches, accounted for a significant portion of Jordan's GDP where the indirect economic burden ranged from 1.4% to 2.1% of the GDP using the HCA, and from 2.3% to 3.6% of the GDP using the VSLY approach.

Time series impact of cancer burden in Jordan for the years 1990–2019 is depicted in figures 1 and 2. Figure 1 illustrates the annual DALY rate attributed to cancer in Jordan; although the graph showcases fluctuations in DALY rate, yet overall, the burden seems to be going in a downward direction with a total of 11% reduction in total DALYs over the investigated 30 years. On average, DALYs decreased by 0.37% annually. Conversely in figure 2, we observe an interesting trend. Despite the decrease in the burden of disease in terms of DALYs, the indirect economic impact of cancer has more than doubled, increasing from $80.85 HCA per capita (HCApc) to $169.98 HCApc. This represents a total increase of 210% over the investigated 30 years, with an average

Table 2 Indirect economic burden due to each cancer type as a per cent of GDP in Jordan* for the year 2019

Cause	Economic burden as a per cent of GDP (lower (%), upper (%))—HCA	Economic burden as a per cent of GDP (lower (%), upper (%))—VSLY
Tracheal, bronchus and lung cancer	0.345 (0.283, 0.418)	0.592 (0.485, 0.717)
Colon and rectum cancer	0.289 (0.241, 0.347)	0.496 (0.413, 0.595)
Breast cancer	0.281 (0.219, 0.356)	0.482 (0.376, 0.611)
Pancreatic cancer	0.118 (0.098, 0.140)	0.203 (0.169, 0.241)
Stomach cancer	0.112 (0.09, 0.135)	0.193 (0.160, 0.232)
Brain and central nervous system cancer	0.100 (0.071, 0.123)	0.172 (0.122, 0.212)
Prostate cancer	0.097 (0.068, 0.125)	0.166 (0.116, 0.215)
Bladder cancer	0.069 (0.055, 0.087)	0.119 (0.095, 0.149)
Liver cancer	0.054 (0.043, 0.067)	0.092 (0.074, 0.115)
Ovarian cancer	0.047 (0.034, 0.061)	0.081 (0.058, 0.105)
Kidney cancer	0.035 (0.028, 0.043)	0.060 (0.04, 0.073)
Gallbladder and biliary tract cancer	0.032 (0.026, 0.039)	0.055 (0.045, 0.068)
Oesophageal cancer	0.027 (0.021, 0.033)	0.046 (0.037, 0.057)
Cervical cancer	0.026 (0.019, 0.035)	0.045 (0.033, 0.061)
Lip and oral cavity cancer	0.025 (0.020, 0.030)	0.042 (0.035, 0.052)
Uterine cancer	0.023 (0.018, 0.031)	0.040 (0.030, 0.052)
Larynx cancer	0.017 (0.013, 0.023)	0.030 (0.023, 0.039)
Thyroid cancer	0.015 (0.012, 0.019)	0.025 (0.021, 0.032)
Nasopharynx cancer	0.013 (0.010, 0.016)	0.022 (0.018, 0.028)
Non-melanoma skin cancer	0.010 (0.008, 0.012)	0.017 (0.014, 0.020)
Other pharynx cancer	0.007 (0.006, 0.009)	0.012 (0.010, 0.016)
Testicular cancer	0.006 (0.005, 0.009)	0.011 (0.008, 0.015)
Total cancers	**1.722 (1.375, 2.117)**	**2.926 (2.341, 3.586)**

*Jordan's GDP for 2019 was 103 760 457 734 Intl$, purchasing power parity.
GDP, gross domestic product; HCA, human capital approach; VSLY, value of a statistical life year.

annual increase in the total cancer economic burden per capita of 2.43%. This increase can mostly be attributed to the tripling of the per capita income in Jordan over the past 30 years. However, when we consider the total cancer economic burden as a percentage of the total GNI, an interesting trend emerges. Figure 3 shows that the relative economic burden of total cancer has actually decreased, from 1.9% to around 1.7% (ie, 11.1% decrease). This suggests that while the absolute economic impact of cancer has increased, the relative economic burden, when considered as part of Jordan's overall economic output, has slightly decreased, reflecting the improvement in overall DALYs.

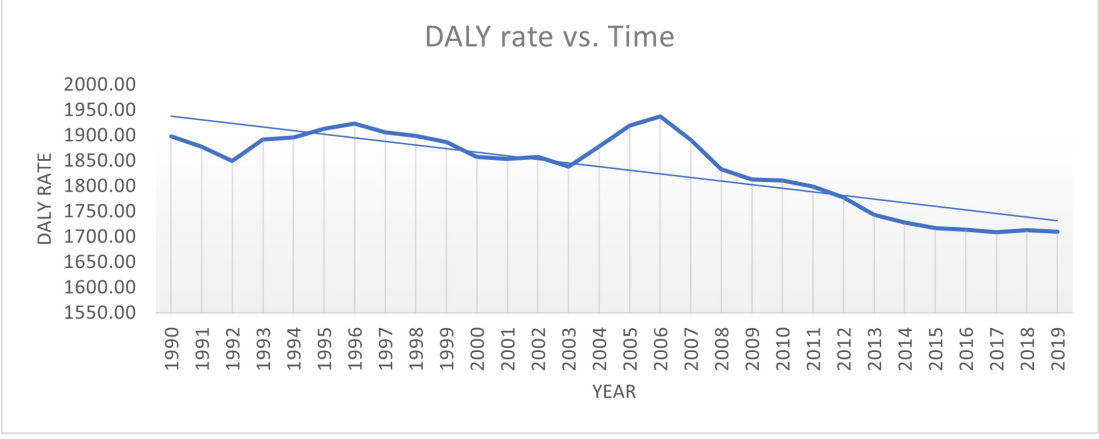

Figure 1 Total disability adjusted life year (DALY) rates of the 22 in Jordan 1990–2019.

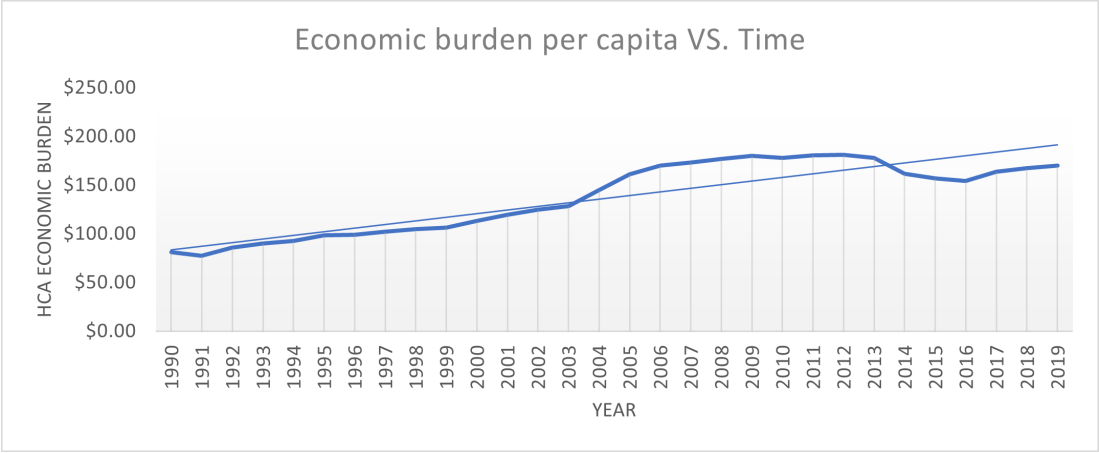

Figure 2 Indirect economic burden per capita of the 22 cancers in Jordan 1990–2019 in (Intl$, purchasing power parity). HCA, human capital approach.

Table 3 shows the forecasted estimates for total economic cancer burden for the investigated 22 cancers in billion Intl$, PPP along with their lower and upper estimates using both the HC and the VSLY approaches; for the HCA, the total economic burden increases from 1.9 billion Intl$ in 2020 to 2.3 billion Intl$ in 2025. Similarly, for the VSLY approach, the total economic burden increases from 3.2 billion Intl$ in 2020 to 3.5 billion Intl$ in 2025.

DISCUSSION

This analysis highlights the significant indirect economic burden associated with various types of cancer in Jordan, emphasising the urgent need for effective prevention, early detection and calculated treatment strategies on a national level. These findings provide a comprehensive picture of the economic burden of different types of cancers, offering valuable insights for policymakers, healthcare providers and researchers in prioritising resources and strategies in cancer control. Moreover, the significant economic burden of these cancers provides a strong economic argument for investing in cancer control, both in terms of healthcare costs and the broader impact on society.

The results indicate that in Jordan, the three cancer groups contributing most to the total indirect costs are tracheal, bronchus and lung cancer; colon and rectum cancer; and breast cancer, respectively. These three cancer groups combined account for over half of the total indirect economic burden cause by cancer in Jordan, indicating their substantial national economic impact. In terms of absolute morbidity costs, the results show that the highest morbidity costs were associated with tracheal, bronchus and lung cancer, followed by colon and rectum cancer, breast cancer and prostate cancer. A global investigation reported significant international disparities for tracheal, bronchus and lung cancer.[33] Moreover, a systematic review reported that the indirect costs of breast cancer in women, were significantly high.[19] Breast cancer high morbidity proportion highlights the long-term impact of these cancers on patients' quality of life and the importance of specific supportive care and rehabilitation in cancer management strategies. Conversely, non-melanoma skin cancer's low morbidity contributions can

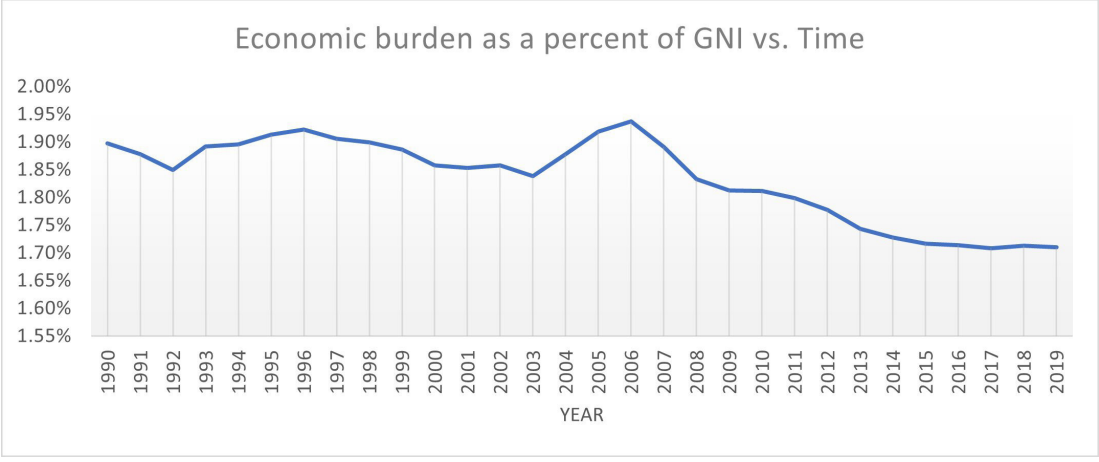

Figure 3 Indirect economic burden of the 22 cancers in Jordan as a per cent of gross national income (GNI) 1990–2019.

Table 3 Indirect economic burden forecast due to the 22 cancers in Jordan for the years 2020–2025 in billion Intl$, purchasing power parity

Year	Total economic burden (lower, upper)—HCA	Total economic burden (lower, upper)—VSLY approach
2020	1.9 (1.8, 2.0)	3.2 (3.1, 3.3)
2021	2.0 (1.9, 2.1)	3.3 (3.0, 3.5)
2022	2.0 (1.9, 2.2)	3.3 (2.9, 3.7)
2023	2.1 (1.9, 2.4)	3.4 (2.8, 4.0)
2024	2.2 (1.9, 2.5)	3.5 (2.6, 4.3)
2025	2.3 (1.9, 2.7)	3.5 (2.5, 4.5)

HCA, human capital approach; VSLY, value of a statistical life year.

be an indication of relatively lower severity/prevalence or better management of these cancers. The mortality costs are highest for tracheal, bronchus and lung cancer; colon and rectum cancer; and breast cancer, underscoring the urgent need for effective interventions to reduce mortality from these cancers. Testicular cancer, despite its relatively low total cost, has a high disability contribution, indicating a significant impact on patients' quality of life despite its lower prevalence or mortality rate. Given the above, it is important to note that the costs associated with cancer are multifaceted and can vary widely depending on numerous factors such as the stage of cancer at diagnosis, the patient's overall health, the specific treatments used, and the country's healthcare system; hence, each country should design its own management programme not influenced by general international guidelines.

Regarding the time series analysis, it was obvious that the DALY rate has been decreasing over the years, indicating a reduction in the overall burden of cancer in terms of mortality and morbidity. While a decreasing DALY rate might suggest fewer people are suffering from cancer, those who do get cancer might be living longer due to improved treatments.[34] This could lead to increased direct costs over time as patients require ongoing treatment. However, from a societal perspective, and due to the increase in mortality age, the additional direct costs are easily offset by the indirect benefits achieved. Fluctuations in cancer DALY rate over this three-decade period can be attributed to various factors; for instance, changes in cancer incidence rates, influenced by factors like lifestyle, genetics and environmental exposures, can lead to fluctuations in DALYs.[35] Also, improvements in cancer screening and early detection programmes may have reduced DALYs by diagnosing cancer at earlier, more treatable stages.[36 37] Moreover, advances in cancer treatments, better healthcare infrastructure, and increased access to medications have contributed to improving cancer survival rates and reducing the YLDs.[38] The interplay of these factors reflects the dynamic nature of cancer's burden on the Jordanian population's overall health over time.

A similar recent global study[39] employed a unique methodology, using a decision analytical model that incorporates economic feedback. This model assessed health outcomes associated with changes in labour force supply and investment diversions. The study's findings for upper-middle-income countries indicated that the economic burden of cancer was 0.535% (0.353%–0.779%) of the GDP. This figure is nearly half of the estimates for Jordan using the HCA. This discrepancy can be primarily attributed to differences in methodology, the incorporation of broader economic factors such as labour supply and investment diversion, the types of cancer considered, and the scope of the study. However, if we adjust the HCA used in the Jordan study to incorporate the unemployment rate, the estimates become more aligned with the global study. Further incorporation of the investment diversion may bring the results even closer. Moreover, the forecasted increase in the economic burden of cancer in the Jordan study aligns with the global study's projection of an increasing economic toll of cancers, underscoring the need for continued research and investment in cancer prevention and treatment.

To mitigate the indirect productivity losses associated with cancer, several policy strategies could be considered. Implementing return-to-work programmes can expedite the process of cancer survivors rejoining the workforce, thereby reducing productivity losses.[40] Expanding coverage for supportive care services can address physical and mental health impairments that contribute to disability costs.[41] Investing in research to reduce long-term disability can help lower productivity losses by minimising the long-term effects of cancer and its treatment.[42] Promoting early detection and prevention can lead to higher survival rates and lower long-term disability, as many cancers are more manageable when detected early.[43] Finally, transitioning to value-based reimbursement models can incentivise healthcare providers to focus on long-term outcomes and quality of life, which can ultimately reduce indirect productivity losses.[44 45] These strategies aim to lessen the economic burden of cancer, but their effectiveness would need to be evaluated in the context of Jordan's healthcare system and patient population.

The economic burden presented in this study represents the indirect costs associated with cancer in Jordan. These costs, quantified in terms of DALYs, reflect the lost economic productivity due to premature death and disability from cancer. Policymakers could use this information in a cost-benefit analysis when considering different interventions. For instance, if an intervention could reduce the total cancer burden by 5%, this could potentially result in a 5% reduction in these indirect costs. By investing in effective interventions, policymakers have the opportunity to significantly reduce the economic impact of cancer, thereby promoting both public health and economic productivity.

While this work provides comprehensive estimates for indirect economic burden for 22 types of cancer in

Jordan, it does not cover all types of cancers. Notably, cancers such as leukaemia, non-Hodgkin's lymphoma, endometrial cancer, melanoma and skin cancer are not discussed in this paper. These exclusions are a limitation of the current study and suggest an opportunity for future research. Also, national non-gender specific estimates were used for calculating the economic burden of cancer. This approach could potentially introduce bias, particularly for gender-specific cancers. Future research should aim to incorporate gender-specific estimates to enhance the accuracy of the economic burden calculations. Moreover, it is important to note that each type of cancer has unique characteristics and challenges, and the findings of this paper may not be applicable to the excluded types. it is also important to note that while these methods are widely used, they do have limitations; the VSL method assumes that individuals have perfect information about risks and that they can trade off wealth for risk in a frictionless market. Similarly, furthermore, the use of the HCA excludes non-market productivity which can underestimate the burden. On the other hand, while the DALY metric has been extensively used in burden of disease studies, it is important to acknowledge its limitations. One significant critique is that the disability weights used in DALY calculations are not adjusted to reflect regional or cultural variations in health perceptions and values.[46] This lack of adjustment may lead to potential biases in the estimated burden of disease, as the same health state may be perceived differently across different cultures or regions.[47] Moreover, the DALY method assumes that a year of healthy life is equally valuable at all ages, hence age-standardised DALYs were used instead to minimise the value difference across age groups. Finally, it is worth noting that the data used is up to the year 2019, that is before COVID-19, hence forecasting estimates for the next 5 years may be conservative provided the COVID-19 comorbidity.

Conclusion

This study highlights the significant indirect economic burden of cancer in Jordan amounting to 1.4%–3.6% of total GDP, with tracheal, bronchus and lung cancer; colon and rectum cancer; and breast cancer contributing most to the total costs. Despite a decrease in the DALY rate over the years, the economic impact of cancer on Jordan's economy is still growing. Further research is needed to explore the cost-effectiveness of different cancer control strategies and to update these estimates as new data becomes available. Collaborative efforts are needed on a global scale to tackle this issue, including sharing research, knowledge and best practices, while working collectively to advocate for policies that will reduce the global cancer burden.

Contributors As the sole author of this manuscript, OR is the sole contributor to the conception, design, data acquisition, analysis, interpretation and drafting of the original and revised manuscript. OR agrees to be the guarantor for all aspects of the work. During the preparation of this work, OR used Microsoft's Bing GPT in order to improve readability and language. After using this tool, the author comprehensively reviewed and edited the content as needed and take full responsibility for the content of the publication.

Funding The author has not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. GBD estimates are available for download from the Global Health Data Exchange and are available freely for non-commercial users under the Open Data Commons Attribution License (https://ghdx.healthdata.org/gbd-2019).

ORCID iD

Omar Rashdan http://orcid.org/0000-0002-5192-4823

REFERENCES

1 Badarin E. Jordan's economic, security and political challenges under COVID-19. *Mediterranean Politics* 2022;27:665–73.
2 Nimri O. Influx of foreign refugees to Jordan and its overall burden on cancer care. cancer care in countries and societies in transition: individualized care in focus 2016. 2016;99–104.
3 Piabuo SM, Tieguhong JC. Health expenditure and economic growth-a review of the literature and an analysis between the economic community for central African States (CEMAC) and selected African countries. *Health Econ Rev* 2017;7:23.
4 Ferlay J, Ervik M, Lam F, *et al*. International agency for research on cancer 2020. *Glob Cancer Obs Cancer Today* 2020;419:1–2.
5 Brown ML, Lipscomb J, Snyder C. The burden of illness of cancer: economic cost and quality of life. *Annu Rev Public Health* 2001;22:91–113.
6 Murray CJ, Lopez AD. Global mortality, disability, and the contribution of risk factors: global burden of disease study. *Lancet* 1997;349:1436–42.
7 Drummond ME, Sculpher MJ, Torrance GW, *et al*. Methods for the Economic Evaluation of Health Care Programmes.Available: https://academic.oup.com/book/54294
8 Chen C, Song J, Xu X, *et al*. Analysis of influencing factors of economic burden and medical service utilization of diabetic patients in China. *PLoS ONE* 2020;15:e0239844.
9 Rashdan O, Brodszky V. Productivity loss in patients with chronic diseases: A pooled economic analysis of Hungarian cost-of-illness studies. *Value Health Reg Issues* 2020;22:75–82.
10 Sachs JD. Macroeconomics and health: investing in health for economic development. *Rev Panam Salud Publica* 2002;12:143–4.
11 Narain U, Sall C. Methodology for Valuing the Health Impacts of Air Pollution: Discussion of Challenges and Proposed Solutions. World Bank, Available: http://hdl.handle.net/10986/24440
12 World Heath Organization. WHO guide to identifying the economic consequences of disease and injury. 2009.
13 Hammitt JK, Robinson LA. The income elasticity of the value per statistical life: transferring estimates between high and low income populations. *J Benefit Cost Anal* 2011;2:1–29.

14 Network GBoDC. Global Burden of Disease Study 2019 (GBD 2019) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME): IHME, 2020.
15 Carrasco LR, Lee LK, Lee VJ, *et al*. Economic impact of Dengue illness and the cost-effectiveness of future vaccination programs in Singapore. *PLoS Negl Trop Dis* 2011;5:e1426.
16 Group WB. Gross Domestic Product per Capita. 2023.
17 World Health Organization. National Economic Indicators. 2023.
18 Palacios A, Rojas-Roque C, González L, *et al*. Direct medical costs, productivity loss costs and out-of-pocket expenditures in women with breast cancer in Latin America and the Caribbean: a systematic review. *Pharmacoeconomics* 2021;39:485–502.
19 Mohammadpour S, Soleimanpour S, Javan-Noughabi J, *et al*. A Systemmatic literature review on indirect costs of women with breast cancer. *Cost Eff Resour Alloc* 2022;20:68.
20 Alkire B, Hughes CD, Nash K, *et al*. Potential economic benefit of cleft lip and palate repair in sub-Saharan Africa. *World J Surg* 2011;35:1194–201.
21 Alkire BC, Vincent JR, Burns CT, *et al*. Obstructed labor and Caesarean delivery: the cost and benefit of surgical intervention. *PLoS ONE* 2012;7:e34595.
22 Saxton AT, Bhattacharya M, Sivaraj D, *et al*. Assessing the cost and economic impact of tertiary-level pediatric cancer care in Tanzania. *PLoS One* 2022;17:e0273296.
23 World Health Organization. Macroeconomics and Health Report of the Commission on Macroeconomics and Health: Investing in Health for Economic Development. Geneva: WHO, 2002.
24 Bertram MY, Lauer JA, De Joncheere K, *et al*. Cost–effectiveness thresholds: pros and cons. *Bull World Health Organ* 2016;94:925–30.
25 Hughes CD, Babigian A, McCormack S, *et al*. The clinical and economic impact of a sustained program in global plastic surgery: valuing cleft care in resource-poor settings. *Plast Reconstr Surg* 2012;130:87e–94e.
26 Alkire BC, Bergmark RW, Chambers K, *et al*. Head and neck cancer in South Asia: macroeconomic consequences and the role of the head and neck surgeon. *Head & Neck* 2016;38:1242–7.
27 Kotagal M, Agarwal-Harding KJ, Mock C, *et al*. Health and economic benefits of improved injury prevention and trauma care worldwide. *PLoS One* 2014;9:e91862.
28 Viscusi WK, Masterman CJ. Income Elasticities and global values of a statistical life. *J Benefit Cost Anal* 2017;8:226–50.
29 Pendzialek JB, Simic D, Stock S. Differences in price Elasticities of demand for health insurance: a systematic review. *Eur J Health Econ* 2016;17:5–21.
30 Miller TR. Variations between countries in values of statistical life. *J Trans Eco Policy* 2000;169–88.
31 Sweis NJ. Revisiting the value of a statistical life: an international approach during COVID-19. *Risk Manag* 2022;24:259–72.
32 Viscusi WK, Masterman CJ. Income elasticity and the global value of a statistical life. *SSRN Journal* 2017;17.
33 Wang C, Wu Z, Xu Y, *et al*. Disparities in the global burden of tracheal, bronchus, and lung cancer from 1990 to 2019. *Chinese Med J Pulmon Crit Care Med* 2023;1:36–45.
34 Hanna TP, King WD, Thibodeau S, *et al*. Mortality due to cancer treatment delay: systematic review and meta-analysis. *BMJ* 2020;371:m4087.
35 Zhao J, Xu L, Sun J, *et al*. The global trends in incidence, death, burden and risk factors of early-onset cancer from 1990 to 2019. *Bmjonc* 2023;2:e000049.
36 Skrundevskiy AN, Omar OS, Kim J, *et al*. Return on investment analysis of breast cancer screening and Downstaging in Egypt: implications for developing countries. *Value Health Reg Issues* 2018;16:22–7.
37 Arafa MA, Sallam S, Jriesat S. Colorectal cancer screening amongst first degree relatives of colon cancer cases in Jordan. *Asian Pac J Cancer Prev* 2011;12:1007–11.
38 Global Burden of Disease 2019 Cancer Collaboration, Kocarnik JM, Compton K, *et al*. Cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life years for 29 cancer groups from 2010 to 2019: a systematic analysis for the global burden of disease study 2019. *JAMA Oncol* 2022;8:420–44.
39 Chen S, Cao Z, Prettner K, *et al*. Estimates and projections of the global economic cost of 29 cancers in 204 countries and territories from 2020 to 2050. *JAMA Oncol* 2023;9:465–72.
40 Zegers AD, Coenen P, Bültmann U, *et al*. Supporting participation in paid work of cancer survivors and their partners in the Netherlands: protocol of the sustained Employability in cancer patients and their partnerS (STEPS) multi-centre randomized controlled trial and cohort study. *BMC Public Health* 2021;21:1844.
41 Evans Webb M, Murray E, Younger ZW, *et al*. The supportive care needs of cancer patients: a systematic review. *J Cancer Educ* 2021;36:899–908.
42 Chien S-C, Chang Y-H, Yen C-M, *et al*. Predicting long-term care service demands for cancer patients: A machine learning approach. *Cancers (Basel)* 2023;15:4598.
43 Rebbeck TR, Burns-White K, Chan AT, *et al*. Precision prevention and early detection of cancer: fundamental principles. *Cancer Discov* 2018;8:803–11.
44 Leao DLL, Cremers H-P, van Veghel D, *et al*. The impact of value-based payment models for networks of care and Transmural care: A systematic literature review. *Appl Health Econ Health Policy* 2023;21:441–66.
45 Seymour EK, de Souza JA, Fendrick AM. Incorporating value-based care into oncology. *Cancer J* 2020;26:311–22.
46 Anand S, Hanson K. Disability-adjusted life years: a critical review. *J Health Econ* 1997;16:685–702.
47 Rice ZS, Liamputtong P. Cultural determinants of health, cross-cultural research and global public health. In: *Handbook of Social Sciences and Global Public Health*. Springer, 2023: 689–702.