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The global decrease in cancer mortality: trends and disparities

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Background: A decrease in cancer mortality has been reported in the United States, Europe, and other high-income regions during the last two decades. Whether similar trends apply to low-to-middle income countries—and globally—is unclear.

Design: The aim of this descriptive study is to compare cancer mortality in all countries with high- or intermediate-quality data on death certificates according to the World Health Organization (WHO) mortality database for the years 2000 through 2010. We included 60 countries in the analysis and calculated age-adjusted mortality rates for all cancer combined and for the commonest cancers worldwide: lung, stomach, breast, colorectal, uterine, and prostate.

Results: A decrease in overall cancer mortality rate of ~1% per year was observed in higher and lower income regions and in both sexes. In 2010, 696 000 cancer deaths were avoided on a global scale compared with 2000 rates (426 000 in men, 271 000 in women). However, the mortality of liver cancer in both sexes and lung cancer in females increased in many countries'.

Conclusions: The individual risk of dying from cancer decreased in all countries with reliable data. This decrease was chiefly due to favorable trends in the commonest specific cancers. Liver cancer in both sexes and lung cancer in women, which show increasing mortality rates, constitute a priority for prevention and further research.

Key words: cancer, mortality, global health, data collection/standards, registries/standards, vital statistics

introduction

Recent descriptive studies report an increase in the global burden of cancer, referring primarily to the number of cancer cases and deaths [1, 2]. However, case and death counts are sensitive to the population size and age structure, and high-income countries have a substantially higher proportion of older age groups [3]. The most important indicator of the cancer burden is the standardized mortality rate, which takes the population size into account and expresses the probability of developing or dying from cancer for the average individual [4].

With respect to mortality, it has been over 10 years since editorials urged strengthening of vital statistics and registration

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systems in low-to-middle income countries [5]. However, delays, coding errors, lack of training, and lack of resources continue to limit the reliability of death data reported [6, 7]. Global estimates of cancer mortality for these countries are frequently extrapolations based on cancer incidence data (from population- or hospital-based registries) or rates in neighboring countries with better-quality data [8].

Declines in age-standardized cancer mortality rates (ASMRs) by ~1% per year over the last one or two decades were reported for the United States [9] and EU [10]. A systematic analysis of all countries with valid and high-quality cancer mortality data—including low- and middle-income countries—would elucidate global cancer trends and the role of cancer risk factors, stage at diagnosis, and treatment access. The aim of this study is to compare cancer mortality rates using World Health Organization (WHO) mortality data from 2000 to 2010, in all countries with valid data defined by the level of mortality data coverage [11] and national data quality [12, 13].

methods

The WHO Mortality Database [14] contains mortality data by age, sex, and cause of death, as reported annually by national authorities of member states based on civil registration systems. Cause-of-death data include only medically certified deaths. Under-coverage adjustments are not made although United Nations Population Estimates account for data coverage [15]. These estimates are based on most recent available data sources: censuses, demographic surveys, vital and population registries, and various other sources. Country population data are available from the WHO. Countries with ≥50% civil registration cause-of-death coverage, ≥2 million inhabitants, and death causes coded in adherence to the International Classification of Diseases (ICD), 9th or 10th Revision standard [11] were selected. All ICD-9 codes were converted to ICD-10 for the calendar years 2000–2010 [16]. Civil registration cause-of-death coverage was essentially 100% in the Europe, North America, Oceania, Japan, and Korea. Selected countries from Latin America, the former Soviet Union, other parts of Asia, and South Africa had civil registration coverage of >70%. Countries not reporting mortality data to the WHO, using the ICD coding system, or having incomplete/sample registration data were not included.

Medically certified deaths (2000 and 2010) for 67 countries were extracted from the WHO database. In a few countries, mortality data were missing for 1–2 years and no interpolation was made (see supplementary Table S1, available at *Annals of Oncology* online). Seven countries (Armenia, Cyprus, El Salvador, Egypt, Georgia, Guatemala, and Turkey) were excluded because preliminary analyses resulted in implausibly low cancer mortality rates. The remaining 60 countries, comprising 2.006 billion inhabitants in 2010, were categorized into seven regions: North America, Latin America, Europe (excluding former Soviet Union countries but including Norway, Switzerland, Serbia, and Israel), Former Soviet Union countries, Japan/Korea, Other Asia/South Africa, and Oceania. Japan and Korea were classified separately from continental Asia due to known high incidence of stomach cancers. Only one African country (South Africa) was included in the analysis.

Mortality rates were age-standardized per 100 000 person-years for all ages by direct method, based on the world standard population [17]. For overall cancer mortality rates, both malignant and benign neoplasms (C00–D48) were pooled to improve validity and comparability across countries and to include fatal benign neoplasms. Mortality rates were calculated for commonest cancer sites worldwide by ICD-10 code: stomach (C16), colorectal (C18–21), liver (C22), lung (C33–34), female breast (C50), uterus (C53 and C54), and prostate (C61) [16]. Cancers of the corpus and cervix uteri were pooled as due to the high proportion of deaths with unspecified uterine site in low- and middle-income countries [18, 19]. The estimated annual percent change (APC) for 2000 and 2010 ASMR was computed for each country by dividing the percent change by the number of years between the two ASMRs. Statistical analyses were carried out using SAS 9.2 (SAS Institute, Cary, NC) and R version 2.15.2 (R Foundation for Statistical Computing, Vienna, Austria).

results

Over 3.7 million cancer deaths were registered for 2010 in 60 countries with reliable data compared with 3.2 million cancer deaths in 2000. ASMRs for all neoplasms and commonest cancer sites in seven predefined regions are displayed by sex in Figure 1. Figure 2 displays country-specific mean APCs for all neoplasms for males and females.

all neoplasms (malignant and benign)

In 2010, 696 000 cancer deaths were avoided on a global scale compared with 2000 rates (426 000 in men, 271 000 in women). The global ASMR was 137.2/100 000 for men and 87.1/100 000 for women for all neoplastic causes of death in 2010 and 156.4/100 000 for men and 94.8/100 000 for women in 2000. An annual 1.0% decrease in overall cancer mortality rates was present in all regions (APC = −1.2% for males and −0.8% for females). The decline was less pronounced in Asia (excluding Japan and Korea), South Africa, and Latin America. Among all countries analyzed, 53/60 and 54/60 countries had a decline in male and female cancer mortality, respectively. Table 1 displays overall ASMRs and APCs by for males and females.

ASMR disparities among the seven regions were greater for males. ASMRs were highest in the Former Soviet Union (168.1/100 000) and lowest in Other Asia/South Africa (110.6/100 000) and Latin America (106.6/100 000). In the analysis by country, the highest rates were observed in Hungary for both males and females. Lowest ASMRs occurred in Malaysia and Kuwait although Malaysia had a positive APC of 1.1%. Among females, ASMRs were highest in North America (90.5/100 000) and Europe (89.3/100 000) and lowest in Japan/Korea (62.3/100 000). Highest ASMRs in the European region were in Denmark, the Netherlands, and Latvia and the lowest ASMRs in Spain and Portugal. ASMRs below 65/100 000 were observed in Ecuador and Mexico, both with APCs <−0.7%.

stomach cancer

Stomach cancer ASMRs decreased across all regions and sexes. A decline of 3.2% and 3.7% was observed each year in Japan/Korea for men and women, respectively. The Former Soviet Union, Europe, and Oceania also experienced APCs around −3% for both sexes. Chile had highest rates in 2010 (23.3/100 000 for men and 8.4/100 000 for women) although these rates declined around 1.8% each year in the past decade.

colorectal cancer

Cancers of the colon and rectum had a moderate ASMR decrease in both sexes in most countries, although rates in Latin America and Other Asia and South Africa both increased in the

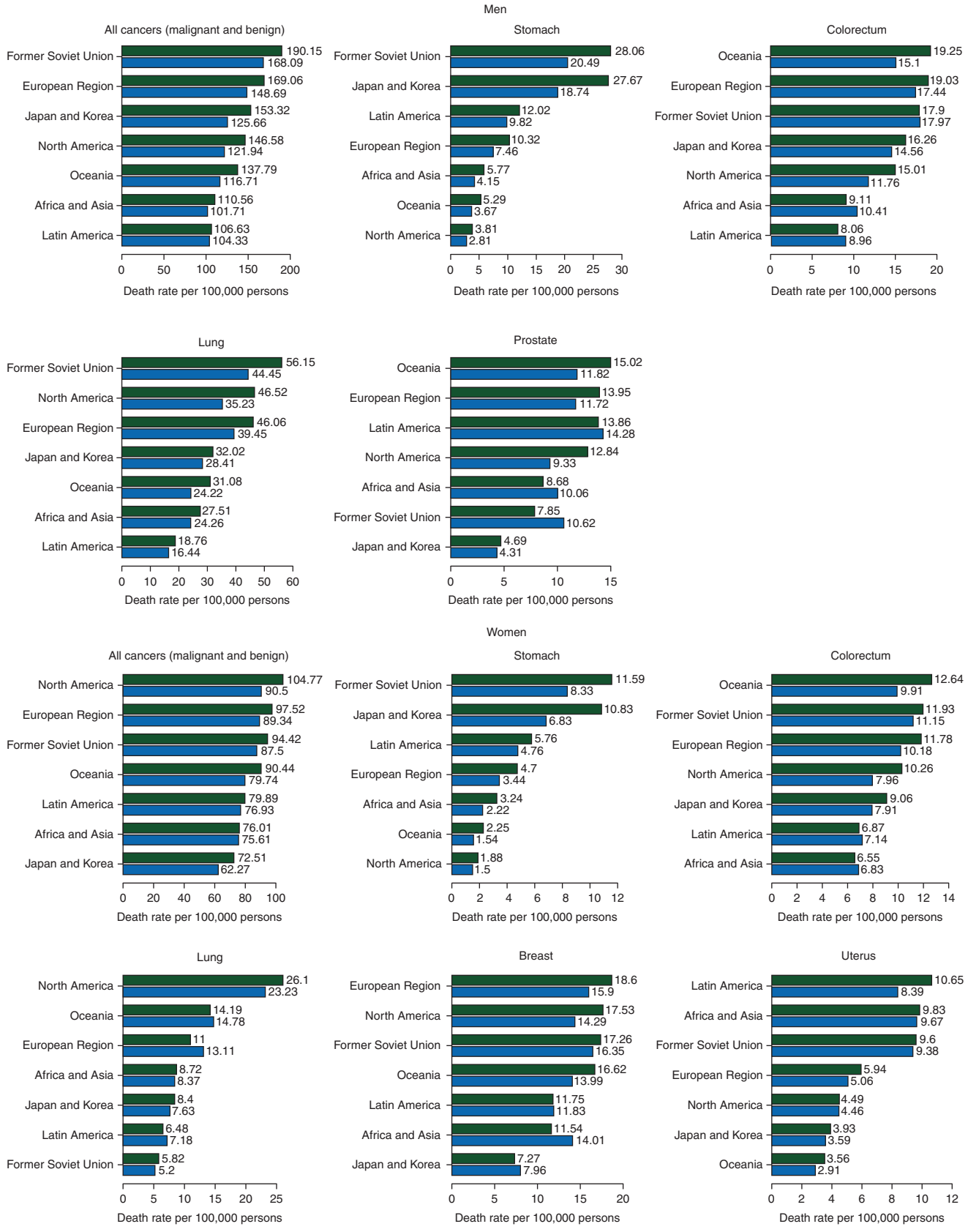

Figure 1. Age-standardized mortality rates for all neoplasms and commonest cancer mortalities in the seven predefined geographical regions, males and females, 2000 and 2010.

Figure 2. Annual percent change in cancer-specific mortality rates for males and females by country, 2000–2010.

past decade, and are approaching rates in the United States, Canada, and Europe. Oceania and North America had the strongest ASMR decline with APCs of <−2% for both sexes. Although colorectal cancer ASMRs in Europe declined in the past decade, not all countries experienced the decline. Among males, Latvia, Portugal, and Spain had APCs of +0.3%–0.7%. Largest increases in colorectal ASMRs (APC >3%) occurred in Romania, Malaysia, and Kuwait (females only). ASMRs for Malaysia and Kuwait remained lower than European and Former Soviet Union rates.

liver cancer

Liver cancer mortality was observed to have an APC of >+2.5% in North American, most Latin American, and some Asian countries. A decrease in liver cancer mortality was observed in Korea (>−2.0% in both males and females) and Japan (>−3.3%) although ASMRs in these countries and neighboring Asian countries remain among the highest in the world (25.6/100 000 in Korean males, 15.4/100 000 in Hong Kong males, 12.5/100 000 in Japanese males). Changes were inconsistent in European and Former Soviet Union countries; however, ASMRs remained in the range 3–7/100 000 for males, with the exception of Croatia (9.6/100 000) and Romania (10.7/100 000), and 1–3/100 000 for females. Liver cancer mortality ASMRs were comparably lower for both Latin American and North American males and females (0.3–3.8/100 000).

lung cancer

Lung cancer mortality disparities between regions were more pronounced among females than males. Highest lung cancer ASMRs for females occurred in North America (23.2/100 000). In Oceania, Europe, and Latin America, ASMRs increased by 0.4%, 1.9%, and 1.1%, respectively. An increased ASMR was observed among females in most countries, except Ireland, Lithuania, most Asian, and some Latin American countries. Spain (+6.2%) and Belgium (+5.2%) experienced largest APC increases, whereas Denmark had highest female lung cancer ASMR (28.1/100 000).

A moderate-to-strong decrease in lung cancer ASMRs occurred for males across all regions and individual countries, except for Colombia (+0.3%), Venezuela (+0.6%), Malaysia (+0.3%), Moldova (+1.1%), Serbia (+1.6%), Bulgaria (+1.4%), Portugal (+0.5%), and Romania (+0.3%). Highest ASMRs were registered in Hungary (73.0/100 000) although the APC was −1.2% over the past decade.

breast cancer (females)

A breast cancer ASMR decrease was observed for all regions except Japan/Korea, Other Asia/South Africa, and Latin America which had APCs of +0.9%, +2.1%, and +0.1%, respectively. Breast cancer ASMRs for Japan/Korea were nearly half of Europe and North America (~8/100 000 versus 14–15/100 000). A strong decrease was observed among most high-income countries of Europe and North America, while a weak-to-moderate increase was observed in lower income countries. Malaysia had the greatest increase of 6.6% per year although 2010 ASMRs remain lower than other Asian countries (7.8/100 000 in Malaysia versus 16.1/100 000 in Philippines and 13.3/100 000 in Singapore).

uterine cancer

There was a moderate-to-strong decrease of uterine cancer deaths in the majority of countries. South Africa had the highest

Table 1. Age-standardized overall cancer mortality rates (ASMRs) and corresponding mean annual percent (APC) increase or decrease of deaths per country for males and females in 2000 and 2010

	Men—2000		Men—2010		APC	Women—2000		Women—2010		APC
	ASMR	*N*	ASMR	*N*		ASMR	*N*	ASMR	*N*	
Canada[a]	148.65	34 096	126.30	38 190	−1.7	105.15	30 015	95.57	34 394	−1.0
United States	146.39	292 641	121.48	308 830	−1.7	104.74	273 996	89.95	280 993	−1.4
Argentina	150.79	30 253	134.69	31 988	−1.1	95.67	25 237	90.43	28 467	−0.5
Brazil	100.42	65 032	107.40	96 194	+0.7	71.11	55 439	75.49	82 800	+0.6
Chile[a]	140.47	9702	125.57	12 180	−1.2	102.97	9357	91.47	11 326	−1.2
Colombia[a]	96.38	13 620	96.97	17 223	+0.1	82.39	14 147	80.17	17 851	−0.3
Costa Rica	107.00	1662	106.20	2402	−0.1	83.56	1431	81.67	2049	−0.2
Cuba	132.21	9536	140.60	13 056	+0.6	97.12	7270	99.15	9691	+0.2
Ecuador	72.55	3341	69.91	4722	−0.4	71.83	3581	66.68	4878	−0.7
Mexico	82.41	27 841	75.68	35 975	−0.8	75.92	29 940	63.96	37 349	−1.6
Puerto Rico	104.84	2766	103.04	3007	−0.2	66.00	2092	64.79	2334	−0.2
Uruguay[a]	190.24	4267	173.00	4283	−1.0	106.24	3250	96.10	3335	−1.1
Venezuela[a]	100.50	8217	98.96	11 318	−0.2	85.30	7993	83.20	10 780	−0.3
Austria	152.69	9685	131.40	10 741	−1.4	96.12	9427	85.39	9638	−1.1
Belgium	175.66	15 561	144.59	15 852	−1.6	96.04	11 780	87.80	12 460	−0.8
Denmark	173.30	8060	143.26	8073	−1.7	136.36	7906	113.61	7532	−1.7
Estonia	203.05	1818	192.23	1969	−0.5	104.69	1571	87.22	1638	−1.7
Finland	129.37	5312	114.00	6241	−1.2	84.94	5180	77.41	5640	−0.9
France	184.80	89 860	151.31	92 820	−1.8	86.91	59 957	79.78	66 673	−0.8
Germany	159.66	112 061	132.21	121 064	−1.7	98.12	104 358	87.08	104 091	−1.1
Greece	145.41	14 672	129.29	16 418	−1.1	75.81	9103	72.05	10 759	−0.5
Ireland	161.52	4136	129.39	4291	−2.0	118.91	3648	98.81	3874	−1.7
Italy	166.73	91 866	138.22	98 846	−1.7	91.81	68 187	82.60	76 199	−1.0
Latvia	195.94	3028	194.18	3245	−0.1	96.71	2605	100.26	2882	+0.4
Lithuania	201.23	4362	196.57	4646	−0.2	100.43	3451	88.90	3609	−1.1
Luxembourg	164.55	549	135.45	588	−1.8	93.18	430	81.10	452	−1.3
Malta	134.14	366	121.67	458	−0.9	101.19	356	87.79	408	−1.3
The Netherlands	171.16	21 172	147.79	23 686	−1.4	109.15	17 633	103.62	19 835	−0.5
Norway	136.26	5412	117.35	5533	−1.4	97.55	4694	88.09	4691	−1.0
Portugal	150.02	12 974	145.97	15 212	−0.3	81.28	9014	72.67	10 276	−1.1
Spain	168.62	59 212	145.75	66 111	−1.4	76.70	35 860	70.03	41 109	−0.9
Sweden	122.18	11 407	105.69	11 677	−1.3	95.62	10 597	85.58	10 772	−1.0
Switzerland	135.61	8412	109.94	8764	−1.9	83.50	6613	72.69	6852	−1.3
UK	150.27	79 138	131.37	84 363	−1.3	110.28	74 560	98.84	76 796	−1.0
Belarus[a]	197.81	11 649	177.80	10 731	−1.1	85.22	7921	74.90	7439	−1.3
Bulgaria	133.85	8795	146.47	9819	+0.9	82.10	6548	80.61	6853	−0.2
Croatia	251.86	6851	196.29	7858	−2.2	115.23	4875	103.06	5840	−1.1
Czech Republic	216.98	15 948	174.86	15 866	−1.9	119.65	12 757	99.51	12 357	−1.7
Hungary	269.26	18 914	228.91	18 337	−1.5	138.38	14 765	121.28	14 743	−1.2
Moldova	142.91	2558	159.75	3244	+1.2	83.92	2047	88.46	2433	+0.5
Poland	208.94	48 886	184.50	53 682	−1.2	110.86	37 386	102.72	42 391	−0.7
Romania	158.03	23 937	171.20	28 259	+0.8	92.69	17 353	88.84	19 243	−0.4
Russian Fed.	201.64	163 994	178.37	156 238	−1.2	98.24	133 826	91.70	136 851	−0.7
Serbia	166.24	10 245	182.18	12 289	+1.0	104.03	7715	112.33	9143	+0.8
Slovakia	221.32	7015	189.21	7064	−1.5	106.90	4915	94.09	5123	−1.2
Slovenia	195.16	2705	173.82	3245	−1.1	101.26	2119	95.84	2640	−0.5
Ukraine	180.43	55 460	159.35	48 986	−1.2	90.73	42 363	84.54	39 780	−0.7
Israel	124.75	4582	107.41	5350	−1.4	99.13	4578	85.54	5343	−1.4
Japan	146.55	183 901	121.25	216 629	−1.7	72.23	120 588	62.94	147 034	−1.3
Kuwait	65.52	269	46.94	368	−2.8	74.07	250	55.92	362	−2.5
Korea	184.42	37 460	143.27	45 746	−2.2	72.95	21 240	61.02	27 401	−1.6
Hong Kong	156.93	7018	126.96	7975	−1.9	82.50	4343	70.83	5369	−1.4
Kazakhstan	192.48	10 603	150.05	9671	−2.2	100.62	8728	84.43	8260	−1.6
Kyrgyzstan	104.58	1603	101.10	1713	−0.3	69.61	1416	65.74	1526	−0.6

Continued

Table 1. *Continued*

	Men—2000		Men—2010		APC	Women—2000		Women—2010		APC
	ASMR	*N*	ASMR	*N*		ASMR	*N*	ASMR	*N*	
Malaysia[b]	42.39	3295	45.89	4958	+1.0	30.85	2593	38.57	4317	+3.1
Philippines[b]	114.34	19 741	88.21	25 341	−2.9	86.71	17 029	70.89	23 706	−2.3
Singapore	148.90	2373	110.12	2649	−2.6	89.38	1728	73.10	2156	−1.8
South Africa[a]	143.80	16 177	94.12	17 969	−3.8	87.91	14 481	69.64	17 904	−2.3
Australia	136.16	20 665	116.46	24 560	−1.4	87.52	15 902	76.99	18 756	−1.2
New Zealand[a]	147.26	4193	118.31	4429	−2.2	105.47	3578	94.07	4070	−1.2

[a]Mortality data to 2009 only.
[b]Mortality data to 2008 only.

registered mortality rate of 15.4/100 000 although the APC was −0.1%. In most countries, uterine cancer ASMRs were in the range of 3–8/100 000, with a few countries in continental Europe (Latvia, Lithuania, Romania, and Bulgaria) and Latin America (Cuba, Ecuador, and Venezuela) showing rates of 10–14/100 000.

prostate cancer

Prostate cancer mortality decreased annually in most high-income countries and overall in Oceania (−2.1%), Europe (−1.6%), North America (−2.7%), and Japan and Korea (−0.8%) regions. Patterns were inconsistent across countries. Latvia (+3.0%), Serbia (+5.6%), Moldova (+11.3%), Ukraine (+3.1%), Belarus (+3.5%), the Russian Federation (+3.9%), Malaysia (+4.4%), and Korea (+3.5%) were observed to have the highest APC increases. Highest prostate cancer ASMRs in Europe clustered in Baltic countries; Estonia, Latvia, and Lithuania had rates of 22.6, 18.9, and 21.9/100 000, respectively. The highest prostate cancer ASMR globally was in Cuba (25.3/100 000; APC = +1.6%).

discussion

This study includes 60 countries from 6 continents and represents the most comprehensive systematic analysis of observed mortality without estimated or extrapolated data. From 2000 to 2010, global cancer ASMRs decreased annually by 1.2% for males and 0.8% for females. In most countries (41/60 for males and 35/60 for females), this decrease was 1% per year or greater. Declines were observed across many countries for the commonest cancers, except liver cancer with a rate increase in half of the countries analyzed, particularly in Latin America and North America. Lung cancer mortality in females increased in most countries.

Findings are consistent with previous studies. Using data from GLOBOCAN 2002 [20] and 2012 [8], which included populations with extrapolated data, cancer mortality rates from all neoplasms fell by 1.0% for females and 0.8% for males annually worldwide, and resulted in the avoidance of 814 000 deaths from 2002 to 2012. The GLOBOCAN figures differ slightly compared with ours, due to methodology, time frame, and data source differences, but overall agree in estimating a global ASMR decline by roughly 1% per year. In the United States, ASMR for all neoplasms decreased from 215.1/100 000 in 1991 to 171.8/100 000 in 2010, a decline of 1.06% per year [9]. APC declines of ≥1% were also reported in Europe [18], and in other countries, including individual low-to-middle income countries in Asia, Africa, and Latin America [19, 21].

Disparities in ASMRs among countries are shaped by three main determinants in addition to population demographic characteristics: (i) prevalence of risk factors, (ii) early diagnostic protocols, including screening, and (iii) access to treatment.

Mortality rates attributed almost exclusively to modifiable risk factors include cancers of the lung, stomach, and liver. These mortality trends are correlated with incidence rates, similar across most countries, and less influenced by economic inequalities. The convergence of smoking patterns between men and women is reflected in the increase of female lung cancer incidence and, sequentially, female lung cancer mortality rates. Although tobacco smoking declined, lung cancer mortality is approaching equal rates between men and women in several European countries and is expected to continue increasing for females worldwide [22].

The largest contribution to the global ASMR decline was stomach cancers (−2.7% in men and −2.8% in women). Greatest declines in the past 10 years occurred in continental Asia, Latin America, and the former Soviet Union. The decrease in stomach cancer incidence in the past several decades is attributed to *Helicobacter pylori* infection control [23, 24]. Additionally, the availability of fresh produce, gastric cancer screening, and sanitation in countries with known high incidence rates has improved [23, 25].

Primary liver cancer has a chiefly infectious etiology and increased ASMRs in many countries. Approximately 90% of liver cancers are hepatocellular carcinomas, attributed to hepatitis B and C virus infection, in addition to nonalcoholic steatohepatitis, tobacco smoking, and alcohol drinking [26]. Rising trans-continental liver cancer ASMRs can be explained by lifestyle exposure changes and lack of liver cancer screening protocol, vaccination, or known curative treatment. As a common site of metastasis, a concern remains that primary liver cancer may be overestimated, given the validity uncertainties of death certification data in many countries [27]. Although misclassification may skew these observed trends, the consistent increase in liver cancer mortality in all age groups, rate ratios between sexes, and correlation between

hepatitis virus prevalence and liver cancer ASMRs, weigh against a gross misrepresentation of increasing liver cancer mortality worldwide [27].

Colorectal, breast, and uterine cancers are most likely decreasing in high-income countries due to screening and access to treatment although ASMRs remain greater than low-to-middle income countries due to the persistence of modifiable risk factors. Breast and colorectal cancer ASMRs increased in low-to-middle income and transitional income countries due to increases in obesity, physical inactivity, and changes in reproductive factors [28]. This was observed for breast cancer in continental Asia and South Africa and for increases in colorectal cancer in Latin America and Asia. Uterine (mostly cervical) cancer was also observed to have the largest declines in Latin America, Asia, and the Former Soviet Union. This decline can be attributed to increased cervical cancer screening and is expected to decline further with widespread cervical cancer screening and vaccination [29].

There is a substantial gap between prostate cancer mortality and incidence rates. Lower prostate-specific antigen screening rates in Asian and African countries have been associated with lower prostate cancer incidence [30], whereas other studies demonstrate an association between certain risk factors and higher prostate cancer incidence [31]. Despite being the commonest male cancer, little is known about prostate cancer etiology [32]. The increased mortality rates observed in Latin America, low-income Asian countries, and the Former Soviet Union are likely to be explained at least in part by increased diagnoses due to screening coupled with a lack of access to treatment.

Unlike other global cancer mortality studies, which are limited by accurate data for certain countries [1, 2], this study compiles data from 6 continents with >70% civil registration coverage and <28% ill-defined codes. Nineteen countries were classified as low-to-upper-middle income according to the World Bank [33] and several high-income countries including Kuwait and former Soviet Union countries transitioned economically in the past two decades. Results of this study demonstrate that the global cancer mortality decline has been shaped by prevention, screening, and treatment in both high- and low-income countries in the past decade.

These mortality data are limited by population coverage. The two most populous countries, China and India, have only partial death certification coverage (4.2% and 9%, respectively) and not representative of the population, particularly in rural areas. Only one African country was included in our analysis. In terms of registration system deaths recorded, the accuracy of death certification has changed little in most countries in the past decade although civil registration cause-of-death coverage increased from 5% to 20% during the study period in transitional income countries. Data provided to WHO account for about 18.6 million deaths annually, representing one-third of all worldwide death estimates [34].

In conclusion, our analysis confirms cancer mortality rates in countries of all income levels are decreasing globally. Declining rates include commonest cancers with the exception of liver cancer in both sexes and lung cancer in women. Mortality rates for lung, breast, prostate, and colorectal cancers in low-to-middle- and transitional income countries are approaching ASMRs traditionally observed in high-income countries due to changes in risk factor exposures. Cancer control measures must be given priority in these countries to reduce cancer mortality burdens in coming years. This study additionally emphasizes the increasing need for preventive measures aimed at reducing primary liver cancer and female lung cancers worldwide.

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disclosure

The authors have declared no conflicts of interest.

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Cancer mortality in cohorts of workers in the European rubber manufacturing industry first employed since 1975

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Background: Increased cancer risk has been reported among workers in the rubber manufacturing industry employed before the 1960s. It is unclear whether risk remains increased among workers hired subsequently. The present study focused on risk of cancer mortality for rubber workers first employed since 1975 in 64 factories.

Patients and methods: Anonymized data from cohorts of rubber workers employed for at least 1 year from Germany, Italy, Poland, Sweden, and the UK were pooled. Standardized mortality ratios (SMRs), based on country-specific death rates, were reported for bladder and lung cancer (primary outcomes of interest), for other selected cancer sites, and for

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