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Cancer Research

Perspective

# Projecting Cancer Incidence and Deaths to 2030: The Unexpected Burden of Thyroid, Liver, and Pancreas Cancers in the United States

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## Abstract

Cancer incidence and deaths in the United States were projected for the most common cancer types for the years 2020 and 2030 based on changing demographics and the average annual percentage changes in incidence and death rates. Breast, prostate, and lung cancers will remain the top cancer diagnoses throughout this time, but thyroid cancer will replace colorectal cancer as the fourth leading cancer diagnosis by 2030, and melanoma and uterine cancer will become the fifth and sixth most common cancers, respectively. Lung cancer is projected to remain the top cancer killer throughout this time period. However, pancreas and liver cancers are projected to surpass breast, prostate, and colorectal cancers to become the second and third leading causes of cancer-related death by 2030, respectively. Advances in screening, prevention, and treatment can change cancer incidence and/or death rates, but it will require a concerted effort by the research and healthcare communities now to effect a substantial change for the future. *Cancer Res; 74(11); 2913–21. ©2014 AACR.*

## Introduction

Lung, breast, prostate, and colorectal cancer are considered to be the "big four" cancer types in the United States based on the fact that the incidence of these cancer types surpasses that of all other cancer types, excluding non-melanoma skin cancer (1). These cancer types, therefore, receive the most attention from government agencies such as the National Cancer Institute (NCI), as well as the pharmaceutical industry. For example, the NCI allocates the greatest proportion of its budget by disease site to breast cancer, followed by lung, prostate, and colorectal cancer (2).

The demographic shifts in the U.S. population have a major influence on the projected number of cancer cases for the future. Smith and colleagues (3) projected substantial increases in the number of cancer cases in 2020 and 2030 due to an increase in the number of adults 65 years and older as the baby boomer generation ages. The number of minorities is also increasing, and evidence indicates that some minority populations have higher cancer incidence rates and lower cancer survival rates compared with Whites, leading to an additional projected increase in those affected by cancer in future years (3).

In addition to increases in cancer incidence due to demographic changes, changes in both the incidence rates and death rates for specific cancers impact the future burden of these diseases. The cancer incidence rate, or number of cases per 100,000 people, for origin-specific cancer types is altered by factors such as a change in the prevalence of smoking or HPV infection (ref. 4, for example). Overall, the cancer-related death rate has been decreasing as a result of improved screening and therapeutic approaches to many cancer types (4, 5).

The impact of demographic shifts in the U.S. population on cancer incidence in 2020 and 2030 reported by Smith and colleagues (3) assumed that origin-specific cancer incidence rates averaged over the years 2003 to 2005 will remain constant through 2030. However, these rates are changing substantially for several cancer types, increasing an average of between 2.9% to 6.5% per year for liver, uterine, and thyroid cancers and decreasing an average of 2.0% to 3.3% per year for prostate and colorectal cancers (4, 5). In this report, we incorporated rate changes observed in the years 2006 to 2010 into the 2020 and 2030 incidence projections made on the basis of demographic changes. In addition, we projected the number of origin-specific cancer-related deaths in 2020 and 2030 based on these demographic changes as well as changes in the death rates. These results indicated that the incidence of thyroid, melanoma, and uterine cancer will surpass that of colorectal cancer by 2030, and the top cancer killers will be lung, pancreas, and liver cancers.

## Materials and Methods

### Projected cancer incidences

Projections of cancer incidences due to combined changes of demographics and incidence rates were calculated for the 12 most common cancers for men and 13 for women using the

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**Note:** Supplementary data for this article are available at Cancer Research Online (http://cancerres.aacrjournals.org/).

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projections previously reported by Smith and colleagues (3) and correcting them by applying the delay-adjusted average annual percentage change (AAPC) in the incidence rates for 2006 to 2010 for men and women reported by Edwards and colleagues (5). The projection for each cancer type is described mathematically as follows:

$$\text{for AAPC}_i > 0, \#\,\text{of Cases} = I_d \times \left(\frac{\text{AAPC}_i}{100} + 1\right)^n;$$

$$\text{for AAPC}_i < 0, \#\,\text{of Cases} = \frac{I_d}{\left(\frac{|\text{AAPC}_i|}{100} + 1\right)^n}$$

where $AAPC_i$ is the AAPC in incidence (5), $I_d$ is the projected incidence based on demographics (3), and $n$ is the adjustment in years. The number of years in the adjustment was 6, 16, and 26 for 2010, 2020, and 2030, respectively, to account for the fact that the Smith and colleagues projections were based on the 2003 to 2005 data. AAPC in incidence rates that are not statistically significantly different from zero were considered to be zero. Values for men and women were calculated separately and then added together for the total population value. All calculations were performed under the assumption that the AAPC in the incidence rates for 2006 to 2010 will remain the same over the entire time period.

**Projected cancer-related deaths**

Any additional cancer types identified as being in the top 10 cancers killers for men or women were added to the previous list of most common cancers: these include brain and central nervous system (CNS), esophagus, and ovary. Projections of deaths of the most common and most deadly cancers (a total of 14 cancer types for men and 16 cancer types for women) due to the combined changes of demographics and death rates were calculated using the 2010 number of deaths for men and women as provided by SEER*Stat Database (6) and applying the AAPC in death rates from 2006 to 2010 for men and women reported by Edwards and colleagues (5). The number of deaths in 2020 and 2030 were calculated by adjusting for demographic changes by determining the percentage increase in new cancer cases in 2020 and 2030 relative to 2010 reported by Smith and colleagues (3), and this number was adjusted by the AAPC in the death rates for 10 years for the 2020 projections, and for 20 years for the 2030 projections. The calculation for the projected deaths for each cancer type is described mathematically as follows:

$$\text{for AAPC}_d > 0,\ \#\,\text{of Deaths} = D_{2010} \times \Delta I_d \left(\frac{\text{AAPC}_d}{100} + 1\right)^n;$$

$$\text{for AAPC}_d < 0, \#\,\text{of Deaths} = \frac{D_{2010} \times \Delta I_d}{\left(\frac{|\text{AAPC}_d|}{100} + 1\right)^n}$$

where $\text{AAPC}_d$ is the AAPC in death (5), $D_{2010}$ is the 2010 actual death (6), $\Delta I_d$ is the increase of projected incidences based on demographics for 2020 and 2030 relative to 2010 projected incidences, and $n$ is the adjustment in years: 10 and 20 years for 2020 and 2030, respectively. AAPC in death rates that are not statistically significantly different from zero were considered to be zero. Separate calculations for men and women were combined to derive the projection for the total population. All calculations were performed under the assumption that the AAPC in death rates will remain the same over the next 20 years.

The AAPCs in death rates for thyroid cancer in males and females, and melanoma in females were not reported in Edwards and colleagues' report and were calculated using the National Center of Health Statistic mortality data as provided by the SEER*Stat Database (6). The Joinpoint Regression program (version 4.04, accessed December 2013; NCI, Bethesda, MD) was used with up to five joinpoints allowed in the period 1975 to 2010 as described by Edwards and colleagues (5).

## Results and Discussion

**Cancer incidences**

Projected cancer incidence based on changing demographics and AAPC in incidence rates for the 12 most common cancers in men and 13 most common cancers in women are reported in Table 1. The leading cancer sites in 2030 are predicted to be prostate, lung, and melanoma for men and breast, thyroid, and uterine for women. This ranking differs from the ranking in 2010 (Table 1), the estimates for 2014 (1), and the ranking based on demographic changes alone (3), in which the leading cancer sites for men are prostate, lung, and colorectal and breast, lung, and colorectal for women. For men, the discrepancy is due to the average annual percentage increase in melanoma (2.4%), and the average annual percentage decrease in colorectal cancer (−3.3%) incidence. For women, the average annual percentage increase of thyroid (6.5%) and uterine (2.9%), and the average annual percentage decrease of colorectal (−3.0%) cancer incidence accounts for the difference.

Combined sex analysis shows that breast, prostate, and lung cancers will remain the highest in absolute number of cases for the next 20 years (Table 1 and Fig. 1A). The AAPC in incidence rate for breast cancer is not changing significantly, whereas the AAPCs in incidence rate for lung and prostate cancers are decreasing by 1% to 2% per year (Table 1). Although the AAPCs in incidence of these cancers are expected to remain stable or decrease slightly, the projected increase in absolute number of cases is due to the anticipated increase in older individuals (age > 65) and minorities, some of which have higher cancer incidence rates. For example, the incidence rate of prostate cancer in Black men exceeds the average for all races and ethnicities by 50% (220.0 and 146.6, respectively; ref. 5). Because these demographic changes are substantial, they overcome the decreasing AAPC and lead to an increase in overall case number. This suppression of the AAPC in incidence rate by the demographic changes is not expected to continue indefinitely; for example, by 2030 the total number of prostate cancer cases is projected to decrease slightly compared with 2020 (Table 1 and Fig. 1A).

By 2030 thyroid, melanoma, and uterine cancers are projected to surpass colorectal cancer to become the fourth, fifth, and sixth highest in absolute cases, respectively (Table 1

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**Table 1.** Projected incidences based on changing demographics and average annual percentage change in incidence rates

| | Men | | Women | | |
|---|---|---|---|---|---|
| Cancer sites | AAPC[a] | # of Cases[b] | AAPC[a] | # of Cases[b] | All # of Cases[b] |
| All | | | | | |
| 2010 | −0.6 | 808,000 | NS | 761,000 | 1,569,000 |
| 2020 | | 961,000 | | 900,000 | 1,861,000 |
| 2030 | | 1,086,000 | | 1,049,000 | 2,135,000 |
| Bladder | | | | | |
| 2010 | NS | 57,000 | −0.4 | 19,000 | 76,000 |
| 2020 | | 72,000 | | 21,000 | 93,000 |
| 2030 | | 89,000 | | 24,000 | 113,000 |
| Breast | | | | | |
| 2010 | | | NS | 226,000 | 226,000 |
| 2020 | | | | 262,000 | 262,000 |
| 2030 | | | | 294,000 | 294,000 |
| Colon and rectum | | | | | |
| 2010 | −3.3 | 72,000 | −3.0 | 68,000 | 139,000 |
| 2020 | | 65,000 | | 61,000 | 127,000 |
| 2030 | | 58,000 | | 56,000 | 114,000 |
| Kidney and renal pelvis | | | | | |
| 2010 | NS | 30,000 | NS | 18,000 | 48,000 |
| 2020 | | 37,000 | | 22,000 | 59,000 |
| 2030 | | 44,000 | | 25,000 | 69,000 |
| Leukemia | | | | | |
| 2010 | 0.4 | 27,000 | 0.6 | 20,000 | 46,000 |
| 2020 | | 33,000 | | 24,000 | 57,000 |
| 2030 | | 42,000 | | 30,000 | 73,000 |
| Liver and intrahepatic bile | | | | | |
| 2010 | 3.7 | 19,000 | 2.9 | 7,000 | 26,000 |
| 2020 | | 34,000 | | 13,000 | 47,000 |
| 2030 | | 62,000 | | 21,000 | 83,000 |
| Lung and bronchus | | | | | |
| 2010 | −1.9 | 107,000 | −1.2 | 95,000 | 202,000 |
| 2020 | | 115,000 | | 104,000 | 219,000 |
| 2030 | | 116,000 | | 109,000 | 225,000 |
| Melanoma | | | | | |
| 2010 | 2.4 | 47,000 | 1.7 | 32,000 | 79,000 |
| 2020 | | 70,000 | | 41,000 | 111,000 |
| 2030 | | 98,000 | | 53,000 | 151,000 |
| Non-Hodgkin lymphoma | | | | | |
| 2010 | 0.7 | 38,000 | NS | 31,000 | 69,000 |
| 2020 | | 49,000 | | 37,000 | 86,000 |
| 2030 | | 64,000 | | 44,000 | 108,000 |
| Oral cavity and pharynx | | | | | |
| 2010 | NS | 25,000 | −0.9 | 10,000 | 35,000 |
| 2020 | | 30,000 | | 11,000 | 41,000 |
| 2030 | | 34,000 | | 12,000 | 46,000 |
| Pancreas | | | | | |
| 2010 | 1.3 | 22,000 | 1.4 | 22,000 | 43,000 |
| 2020 | | 31,000 | | 31,000 | 62,000 |
| 2030 | | 43,000 | | 44,000 | 88,000 |

*(Continued on the following page)*

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**Table 1.** Projected incidences based on changing demographics and average annual percentage change in incidence rates (Cont'd)

| | Men | | Women | | |
|---|---|---|---|---|---|
| Cancer sites | AAPC[a] | # of Cases[b] | AAPC[a] | # of Cases[b] | All # of Cases[b] |
| Prostate | | | | | |
| 2010 | −2.0 | 218,000 | | | 218,000 |
| 2020 | | 235,000 | | | 235,000 |
| 2030 | | 228,000 | | | 228,000 |
| Thyroid | | | | | |
| 2010 | 5.4 | 11,000 | 6.5 | 34,000 | 45,000 |
| 2020 | | 21,000 | | 71,000 | 92,000 |
| 2030 | | 39,000 | | 144,000 | 183,000 |
| Uterine corpus | | | | | |
| 2010 | | | 2.9 | 52,000 | 52,000 |
| 2020 | | | | 82,000 | 82,000 |
| 2030 | | | | 122,000 | 122,000 |

Abbreviation: NS, nonsignificant.
[a]Edwards et al., (ref. 5, Table 1).
[b]All projections for 2010 were calculated using rounded incidences from Smith et al. (3), and projections for 2020 and 2030 were calculated using the previous unrounded incidence projections, then rounded to the nearest 1,000.

and Fig. 1A). Colorectal cancer is exceptional in that it is the only cancer site expected to decrease in incidence and absolute cases from 2010 to 2030 (Fig. 1A). Thyroid cancer is notable in that it is increasing dramatically in both men (5.4% AAPC) and women (6.5% AAPC). Melanoma incidences are increasing by an average of 2.4% per year in men and 1.7% per year in women, and uterine cancer shows a substantial 2.9% average increase in incidence per year. Liver cancer also shows a remarkable 3.7% AAPC in incidence rate increase in men and 2.9% in women, and is projected to become the 11th most frequent cancer diagnosis in 2030 with an estimated 83,000 cases. When the AAPCs in incidence rate from a 10-year time span (2001–2010) are used, breast, prostate, lung, thyroid, and melanoma remain the top cancer diagnoses projected for 2030 with lung cancer exceeding prostate cancer (Supplemental Table S1 and Fig. S1A).

### Cancer-related deaths

Projected cancer-related deaths based on changing demographics and AAPC in cancer-related death rate for the most common and the most deadly cancers are reported in Table 2. In 2010 (Table 2), and estimated for 2014 (1), lung, prostate, and colorectal cancers were the top cancer killers in men, with breast substituting for prostate as the second leading cancer killer in women. By 2030, the leading causes of cancer-related death are projected to be lung, liver, and pancreas for men, and lung, breast, and pancreas for women. Death projections for the top cancers killers in both males and females combined are shown in Table 2 and Fig. 1B. For these origin-specific cancers, the total deaths for both sexes are projected to decrease for breast, colorectal, and prostate cancers, whereas deaths from pancreas, liver, leukemia, and bladder are projected to increase. Deaths from lung cancer are projected to decrease in males but increase in females throughout the 20-year time period, but lung cancer will remain the number one cancer killer throughout the entire time period. Total deaths due to pancreas cancer are projected to increase dramatically to become the second leading cause of cancer-related deaths before 2030. Deaths from liver cancer will also increase dramatically so that liver cancer is projected to become the third leading cause of cancer-related deaths by 2030. Using AAPC in death rates from a 10-year time span (2001–2010) results in pancreas and colorectal cancer causing an equivalent number of deaths in 2020 and the same ranking of lung, pancreas, and liver cancers as the top cancer killers in 2030 (Supplementary Table S2 and Fig. S1B).

It should be noted that the AAPC in both incidence and death rates from 2006 to 2010 was assumed to remain constant through 2030. Changes in treatment strategies have the potential to alter the death rate, and changes in screening or prevention strategies can alter both the incidence and death rates. Along these lines, it is noted that any changes in the demographics of the population measured in the SEER database from 2006 to 2010 may be incorporated in both the demographic adjustment and the AAPC adjustment, resulting in an overestimate of the projected number of cases or number of deaths. However, it should be realized that decreases in both incidence and death rates for several cancer types were observed, despite the increases in the number of individuals 65 years of age and older and the minority distribution. This suggests that factors specific to cancer prevention and treatment are the overriding contributors to the AAPC values, and that combining demographic changes with changes in incidence and death rates changes provides a reasonable estimate of the projected number of cases and deaths. Also note that demographic changes, but not changes in the incidence rate, were considered when projecting the number of deaths. This results in a probable underestimation of the number of deaths

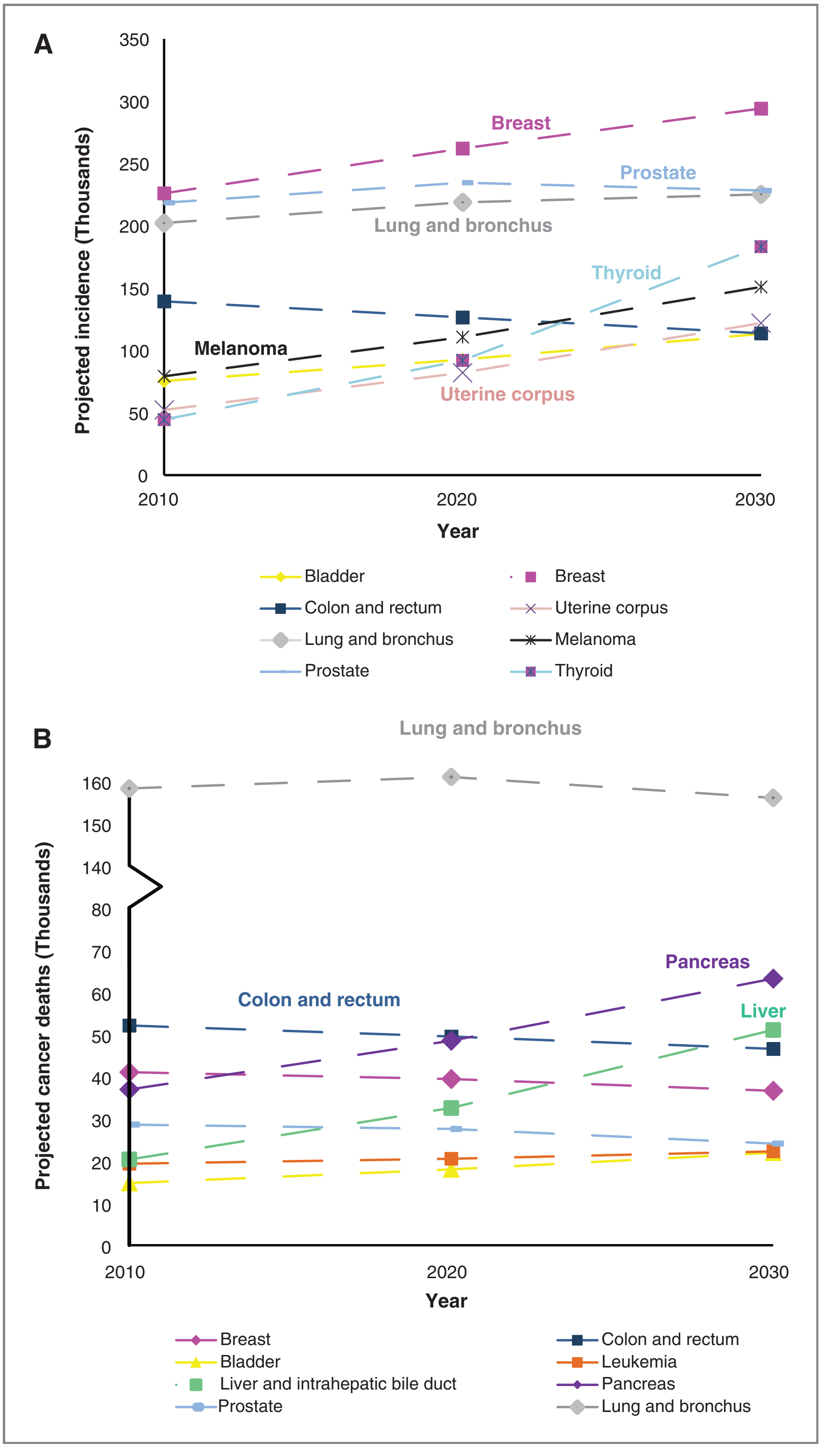


Figure 1. Projected cancer incidence and deaths, both sexes. A, incidence projections of the top eight cancers by 2030 due to demographic changes and the AAPC in incidence rates. All cancer sites shown have at least 110,000 cases projected by 2030 when both the demographic and AAPC factors are taken into consideration. B, death projections of the top cancer killers due to demographic changes and the AAPC in death rates. All cancer sites shown have at least 25,000 cases projected in 2020 or 2030.

**Table 2.** Projected deaths based on demographic and annual percentage change in death rates

| | Men | | Women | | |
|---|---|---|---|---|---|
| Cancer site | AAPC[a] | # of Deaths[c] | AAPC[a] | # of Deaths[c] | All # of Deaths[c] |
| All | | | | | |
| 2010 | −1.8 | 309,000 | −1.4 | 280,902 | 589,902 |
| 2020 | | 326,000 | | 289,000 | 615,000 |
| 2030 | | 327,000 | | 293,000 | 620,000 |
| Bladder | | | | | |
| 2010 | NS | 10,428 | −0.4 | 4,302 | 14,730 |
| 2020 | | 13,000 | | 5,000 | 18,000 |
| 2030 | | 16,000 | | 6,000 | 22,000 |
| Brain and other CNS | | | | | |
| 2010 | NS | 7,977 | −0.9 | 6,187 | 14,164 |
| 2020 | | 9,000 | | 7,000 | 16,000 |
| 2030 | | 11,000 | | 7,000 | 17,000 |
| Breast | | | | | |
| 2010 | | | −1.9 | 40,996 | 40,996 |
| 2020 | | | | 39,000 | 39,000 |
| 2030 | | | | 37,000 | 37,000 |
| Colon and rectum | | | | | |
| 2010 | −2.5 | 27,073 | −2.9 | 24,972 | 52,045 |
| 2020 | | 27,000 | | 23,000 | 49,000 |
| 2030 | | 26,000 | | 21,000 | 47,000 |
| Esophagus | | | | | |
| 2010 | NS | 11,416 | −1.5 | 3,074 | 14,490 |
| 2020 | | 14,000 | | 3,000 | 17,000 |
| 2030 | | 14,000 | | 3,000 | 17,000 |
| Kidney and renal pelvis | | | | | |
| 2010 | −0.9 | 8,436 | −0.9 | 4,783 | 13,219 |
| 2020 | | 10,000 | | 5,000 | 15,000 |
| 2030 | | 10,000 | | 6,000 | 16,000 |
| Leukemia | | | | | |
| 2010 | −0.9 | 11,060 | −1.3 | 8,274 | 19,334 |
| 2020 | | 12,000 | | 8,000 | 20,000 |
| 2030 | | 14,000 | | 9,000 | 22,000 |
| Liver and intrahepatic bile | | | | | |
| 2010 | 2.5 | 13,657 | 1.6 | 6,647 | 20,304 |
| 2020 | | 22,000 | | 10,000 | 33,000 |
| 2030 | | 36,000 | | 15,000 | 51,000 |
| Lung and bronchus | | | | | |
| 2010 | −2.9 | 87,698 | −1.4 | 70,550 | 158,248 |
| 2020 | | 85,000 | | 76,000 | 161,000 |
| 2030 | | 78,000 | | 78,000 | 156,000 |
| Melanoma[b] | | | | | |
| 2010 | 0.3 | 6,002 | −0.5 | 3,152 | 9,154 |
| 2020 | | 7,000 | | 3,000 | 10,000 |
| 2030 | | 8,000 | | 3,000 | 12,000 |
| Non-Hodgkin lymphoma | | | | | |
| 2010 | −2.6 | 11,047 | −3.2 | 9,247 | 20,294 |
| 2020 | | 10,000 | | 8,000 | 18,000 |
| 2030 | | 10,000 | | 7,000 | 17,000 |
| Oral cavity and pharynx | | | | | |
| 2010 | −1.2 | 5,815 | −0.9 | 2,659 | 8,474 |

*(Continued on the following page)*

**Table 2.** Projected deaths based on demographic and annual percentage change in death rates (Cont'd)

| | Men | | Women | | |
|---|---|---|---|---|---|
| Cancer site | AAPC[a] | # of Deaths[c] | AAPC[a] | # of Deaths[c] | All # of Deaths[c] |
| 2020 | | 6,000 | | 3,000 | 9,000 |
| 2030 | | 6,000 | | 3,000 | 9,000 |
| Ovary | | | | | |
| 2010 | | | −1.9 | 14,572 | 14,572 |
| 2020 | | | | 14,000 | 14,000 |
| 2030 | | | | 14,000 | 14,000 |
| Pancreas | | | | | |
| 2010 | 0.5 | 18,699 | 0.5 | 18,189 | 36,888 |
| 2020 | | 25,000 | | 24,000 | 48,000 |
| 2030 | | 32,000 | | 31,000 | 63,000 |
| Prostate | | | | | |
| 2010 | −3.1 | 28,560 | | | 28,560 |
| 2020 | | 28,000 | | | 28,000 |
| 2030 | | 24,000 | | | 24,000 |
| Thyroid[b] | | | | | |
| 2010 | 1.22 | 723 | 0.5 | 963 | 1,686 |
| 2020 | | 900 | | 1,000 | 2,000 |
| 2030 | | 1,000 | | 1,000 | 2,000 |
| Uterine corpus | | | | | |
| 2010 | | | 0.4 | 8,402 | 8,402 |
| 2020 | | | | 10,000 | 10,000 |
| 2030 | | | | 12,000 | 12,000 |

Abbreviation: NS, nonsignificant.
[a]Edwards et al. (ref. 5, Table 2).
[b]The AAPCs for thyroid cancer–related death rates for males and females, and for melanoma cancer–related death rates for females, were calculated using the (SEER) Program SEER*Stat Database: Mortality - All COD, Aggregated With State, Total U.S. (1969–2010) and Joinpoint Regression program was used (version, 4.0.4, accessed, December 2013) with maximum 5 joinpoint using the 1975–2010 mortality data.
[c]2010 deaths were generated from SEER*Stat. Projected deaths for 2020 and 2030 >1,000 are rounded to the nearest 1,000; deaths <1,000 are rounded to the nearest 100. Projections for 2020 and 2030 were calculated using 2010 unrounded deaths generated from SEER*Stat.

for those cancers with large positive AAPCs in incidence rate (thyroid, liver, melanoma, and pancreas), but prevents the overestimation caused by incidence trends that are incorporated in death-rate trends. If AAPC in incidence rates is considered in projecting cancer-related deaths, the increase in pancreas and liver cancers is even more pronounced (ref. 7 and data not shown).

### Changes in the ranking of site-specific cancers

The decrease in colorectal cancer, falling from the top four in incidence and top two in deaths, seems to be primarily the result of advances in colorectal cancer screening (8). Colorectal cancer incidence rates have declined since the mid 1980s, and randomized clinical trials demonstrated that fecal occult-blood screening is effective in decreasing incidence of colorectal cancer (9). Using mathematical modeling, Edwards and colleagues concluded that the decline observed in colorectal cancer–related death rates is consistent with a major contribution from screening, with smaller contributions from risk factor reduction and improved treatments (10). Colonoscopy was recommended as a screening test in 1997 and rates of colorectal cancer screening continued to increase through the 2000s, supporting the further decline in colorectal cancer incidence and mortality as a result of screening advances (10).

The dramatic increase in the number of thyroid cancer cases has been explored with the conclusion that this is not an epidemic of disease but a consequence of increased diagnosis, particularly in women (11–13). This conclusion is reached, in part, because of the lack of an increase in thyroid cancer–related deaths. Thyroid cancer, which is generally treated by surgical resection, has an overall 98% 5-year survival rate (1). The 2% of cases that succumb to thyroid cancer are primarily rare and highly aggressive subsets, including diagnoses of anaplastic and medullary thyroid cancer (12). In a 2007 lecture, Heller concluded that what was needed was not better detection of occult disease, but a means to distinguish those patients who may not need treatment at all from those who will almost certainly do poorly (12). His call to the research community was for a better understanding of the molecular and genetic basis that characterizes high-risk thyroid cancer, and an improvement in the treatment of advanced and aggressive disease. The call to healthcare professionals was to refocus their efforts on identifying and curing those few patients whose disease is likely to shorten their lives. As the trend is anticipated to continue into the next decades, there is even more need to prepare for the onslaught of diagnoses and to increase efforts in risk stratification to ensure appropriate therapeutic response.

The dramatic increase in the anticipated number of deaths due to cancer of the pancreas and liver is a wake-up call to the research and healthcare systems in the United States. Although there will be only an estimated 33,000 new cases of liver and intrahepatic bile duct cancer in the United States in 2014 (1), hepatocellular carcinoma (the most common type of liver cancer) is the most frequent solid tumor worldwide and the third leading cause of global cancer-related deaths (14). Current treatment strategies for hepatocellular carcinoma are limited, with surgery and a single approved drug, sorafenib, as options (15). Pancreas cancer has the lowest 5-year relative survival rate of those cancers reported by the American Cancer Society, at 6% (1). Surgery is the only potentially curative option for pancreatic cancer, but less than 20% of patients are eligible for surgical resection (16). Treatments for metastatic pancreatic cancer are minimally effective, and the most recent clinical trial leading to a drug approval extended median overall survival to 8.5 months (17). A detailed examination of the death rate trends for pancreatic cancer since 1970 revealed complex patterns that are largely unexplained by known risk factors (18). If we want to change the death rate for these diseases, it is necessary to increase the investment in understanding them and identifying early detection strategies and therapeutic targets that can be translated and tested in clinical trials. Given the extensive process required to validate an early detection biomarker for clinical use (19) and the estimated 7.9 years required for clinical testing and approval of a new cancer therapy (20), there is clearly a need to invest in basic, translational, and clinical research now to be prepared for the dramatic increase expected in the next 10 to 20 years.

Attention has been called to the projected top three cancer killers in 2030: lung, pancreatic, and liver cancer, through the *Recalcitrant Cancer Research Act* signed into law by President Obama in January 2013 (21). Recalcitrant cancers, which are defined as those that have 5-year relative survival rates below 50%, include cancers of the pancreas (6%), lung (16.6%), liver (18%), esophagus (19%), stomach (29%), brain (35%), ovary (44%), and multiple myeloma (45%; ref. 22). The Act directs the NCI to develop strategic plans, referred to as scientific frameworks, for pancreatic and lung cancers and other recalcitrant cancers at the director's discretion. The scientific framework for pancreatic ductal adenocarcinoma was recently released and includes four specific recommendations with initial plans for their implementation (23). These initiatives include basic, translational, and clinical approaches to improving early detection and treatment of pancreatic adenocarcinoma. The scientific framework for small-cell lung cancer is expected by July 2014.

The Recalcitrant Cancer Research Act, passed with the support of several patient advocacy groups, lays the foundation for a more focused and organized effort from the research community in identifying and preparing for the cancers that claim the most lives. The predictions arising from this report indicate that an even more vigorous approach should be pursued, integrating the research, health care, and advocacy communities. Efforts at improving treatments for advanced or aggressive cancers will improve survival rates in the short term with the hope of an eventual improvement in mortality rates. Efforts toward improved detection with subsequent elimination of premalignant conditions or preventive strategies will decrease both the incidence and the number of deaths from these diseases. A concerted effort from all stakeholders—scientists, clinicians, and the public—will have the greatest chance of altering the predictions arising from this work and substantially improving the future for those to be diagnosed with the deadliest cancers.

## Disclosure of Potential Conflicts of Interest

B.D. Smith received commercial research grant from Varian Medical Systems. No potential conflicts of interest were disclosed by the other authors.

The authors or their immediate families have been affected by a diagnosis of breast, lung, ovarian, pancreatic, prostate, and thyroid cancers, and deaths from lung, pancreatic, and ovarian cancer.

## Authors' Contributions

**Conception and design:** B.D. Smith, R. Aizenberg, L.M. Matrisian
**Development of methodology:** L. Rahib, B.D. Smith, L.M. Matrisian
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**Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis):** L. Rahib, R. Aizenberg, A.B. Rosenzweig, L.M. Matrisian
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Cancer Research

Correction

# Correction: Projecting Cancer Incidence and Deaths to 2030: The Unexpected Burden of Thyroid, Liver, and Pancreas Cancers in the United States

In this article (Cancer Res 2014;74:2913–21), which appeared in the June 1, 2014, issue of *Cancer Research* (1), the formulae used for projecting cancer deaths were reproduced incorrectly. The correct formulae are included below. The publisher regrets this error.

The online version has been corrected and no longer matches the print.

$$\text{for } \mathrm{AAPC}_d > 0,\ \#\,\text{of Deaths} = D_{2010} \times \Delta I_d \left(\frac{\mathrm{AAPC}_d}{100} + 1\right)^n;$$
$$\text{for } \mathrm{AAPC}_d < 0,\ \#\,\text{of Deaths} = \frac{D_{2010} \times \Delta I_d}{\left(\frac{|\mathrm{AAPC}_d|}{100} + 1\right)^n}$$

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# Projecting Cancer Incidence and Deaths to 2030: The Unexpected Burden of Thyroid, Liver, and Pancreas Cancers in the United States

Lola Rahib, Benjamin D. Smith, Rhonda Aizenberg, et al.

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