Shifting Battles in the War on Cancer*

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First Draft: September 14, 2011
This Draft: September 23, 2011

Abstract

As death rates from other major causes of disease fell over the last forty years, cancer death rates hardly moved. Progress also differed among cancer sites and by sex, race, and other socioeconomic characteristics. In this paper, we assess time trends in the years of life lost (YLL) due to specific cancers between 1970 and 2005 by sex and race. We also demonstrate how recent increases in YLL due to specific cancers are the result of differential contribution from changes in mortality from those cancers vis-à-vis from other causes of death. The YLL from cardiovascular disease declined steadily while increased for cancer. YLL differs among cancer sites and is highest for lung cancer, breast, prostate, and colorectal. By decomposing the change in YLL for a specific cancer, we are able to assess the direct impact of that cancer on population health. Progress against lung cancer has been greater for males than females.

Key Words: Cancer, Demography, Years of Life Lost

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*We thank David Asch and Valerie Lewis for helpful comments and suggestions. **Authors are listed reverse alphabetically and share authorship equally.**

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1 Introduction

About forty years ago president Nixon signed the National Cancer Act and declared a "war on cancer." Since that time, mortality rates from the leading causes of death have consistently declined. For example, mortality from diseases of the heart declined 61%, cerebrovascular disease declined 71%, and accidental injuries declined 36%. Mortality rates from cancer, however, declined only by 10% (US Census Bureau, 2010). This divergent pattern between cancers and other causes of death was also evident across cancer sites, and for different subgroups of the population such as sex, race and education level (Jemal et al., 2010; Clegg et al., 2002; Albano et al., 2007; Kinsey et al., 2008).

The health significance of a specific cancer is the result of a complex process. On the one hand, the burden of a specific cancer on population health depends on mortality changes on the cause itself. On the other hand, the burden also depends on how this change compares to mortality changes from other causes of death, which also compete for individuals' death.

In this study, we investigate time trends in years of life lost due to specific cancer sites between 1970 and 2005 by race and sex. We also demonstrate how recent increases in YLL due to specific cancers are the result of differential contribution from changes in mortality from those cancers vis-à-vis from other causes of death. Our results show that after four decades of medical research, we are still far from eliminating the burden of cancer on the population. However, there have been important progress made against some cancer sites, for example, breast and prostate.

2 Methods

2.1 Data

We obtained mortality data between 1969 and 2008 from the National Cancer Institute's Surveillance, Epidemiology, and End-Results (SEER) Registry, which processed National Center for Health Statistics Multiple-Cause-of-Death Detail Files. Pertinent information included age of death, sex, race, year of death, and cause of death. We classified causes of death based on the underlying cause into the following categories: cardiovascular disease, unintentional and intentional injury, diabetes, infectious disease, chronic obstructive pulmonary disease, the leading cancers for men (lung and bronchus, prostate, colon and rectum, pancreas, leukemia, liver, esophagus, urinary bladder, non-Hodgkin lymphoma, kidney and renal pelvis), and the leading causes of cancer for females (lung and bronchus, breast, colon and rectum, pancreas, ovary, leukemia, liver, non-Hodgkin lymphoma, corpus uteri, brain and other nervous system, and liver). All other cancers with mortality rates below 1 death per 100,000 person-years in 2000 were aggregated into an "all other cancers" category. Table 1 presents International Classification of Disease Versions 8, 9, and 10 codes for these causes of death. We also used population estimates from SEER, which were originally produced by the US Census Bureau, by age, sex, race, and year.

2.2 Analytic Methods

We first calculated age, sex, and race-specific death rates for all cause mortality, cardiovascular disease mortality, and cancer mortality (all cancers combined and specific sites) for single calendar years between 1970 and 2005. We then estimated the potential years of life lost (YLL) by year, sex, and race for cardiovascular, all cancers, and 12 specific cancer sites. YLL represents the estimated gain in life expectancy at birth if a cause of death is eliminated (Preston et al., 2000). Practically, YLL is estimated by setting death rates for a cause to zero and the death rates for all other causes remain the same. The result provides an estimate of how the specific cause of death affects the age distribution of deaths and summaries of this age distribution, such as life expectancy.

The final age group of our cause-specific mortality rates begins at 85 years. We allocated all-cause mortality into five year age groups above age 85 based on predicted values from a logistic model, which we fit to adult all-cause mortality between ages 30 and 84 years. The model has been shown to adequately estimate all-cause mortality for the older population (Boongarts, 2005, 2006).

The change in YLL over time that is attributed to a specific cancer depends on the change in mortality for the cause itself compared to the change for all other causes (Beltrán-Sánchez et al., 2008). We decompose the change in YLL into the gross change, the net change, and the adjustment, which we now define.

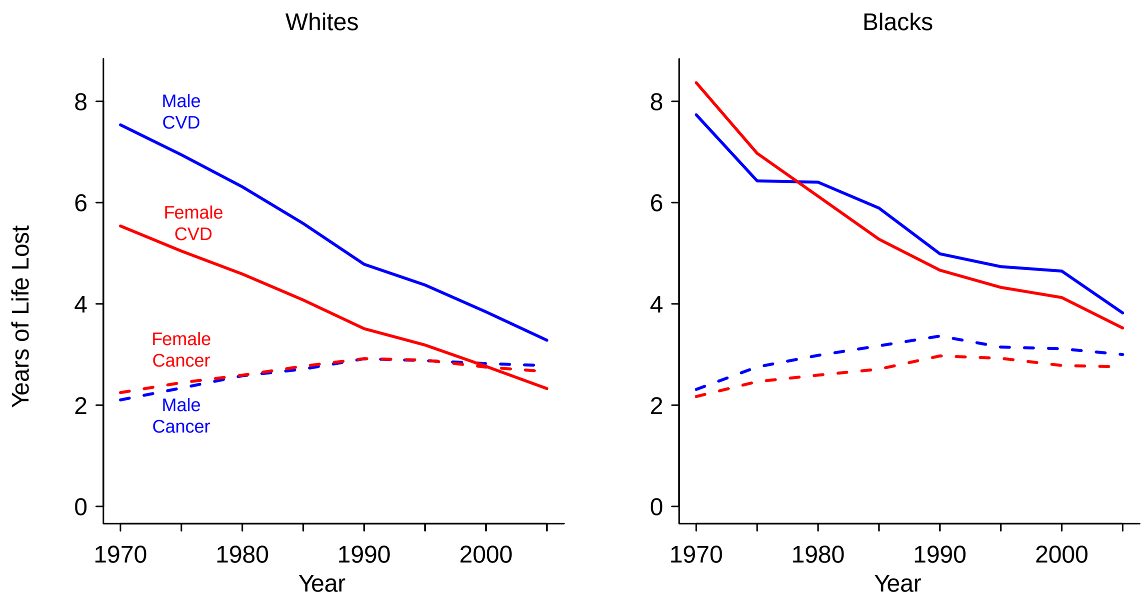
Suppose two causes of death operate in a population, A and B, and the mortality rates of either cause may change over time. We estimate the YLL for cause A at time 1 and time 2 and compute the change in YLL as their difference ("gross change"). Now suppose mortality from cause A declined over the period ("net change"). Then we would expect cause A to be responsible for fewer YLL at time 2 than at time 1. We must also consider the change in mortality from cause B ("adjustment"). Any decline from cause B will yield an increase in the YLL due to cause A. If the decline from cause B was large enough, compared to the decline from cause A, we will observe an increase in YLL for cause A. This example demonstrates the observed increase in YLL for some cancers, which we show in Section 3.1, may not be entirely due to increases in cancer mortality rates. On the contrary, it may well be the case that mortality rates from some cancer sites have declined over time but their decline has been offset by even larger declines in mortality rates from all other causes. By decomposing the changes in YLL for a specific cancer, we are able to disentangle the differential contribution of changes in mortality from that cancer vis-à-vis changes in other causes.

3 Results

3.1 Potential Years of Life Lost

For all race-sex groups, the potential YLL from CVD decreased over time while the potential YLL from cancer increased (Figure 1). In other words, there were more years of life lost to cancer in 2005 than in 1970. If CVD mortality had been completely eliminated in white females, their life expectancy in 1970 would have been 5.5 years higher compared to 2.2 years higher if cancer mortality had been completely eliminated. By 1998, the potential YLL from cancer equaled that from CVD and thereafter exceeded it. By 2005, the potential YLL was 2.7 years for cancer and 2.3 years for CVD. For white males and blacks, the difference in potential YLL between cancer and CVD narrowed, although did not fully converge. Among black males, for example, the potential YLL increased from 2.3 years in 1970 to 3.0 years in 2005 for cancer compared to a decrease from 7.7 years in 1970 to 3.8 years in 2005 for CVD.

Figure 1: Years of Life Lost, Cardiovascular Disease and Cancer

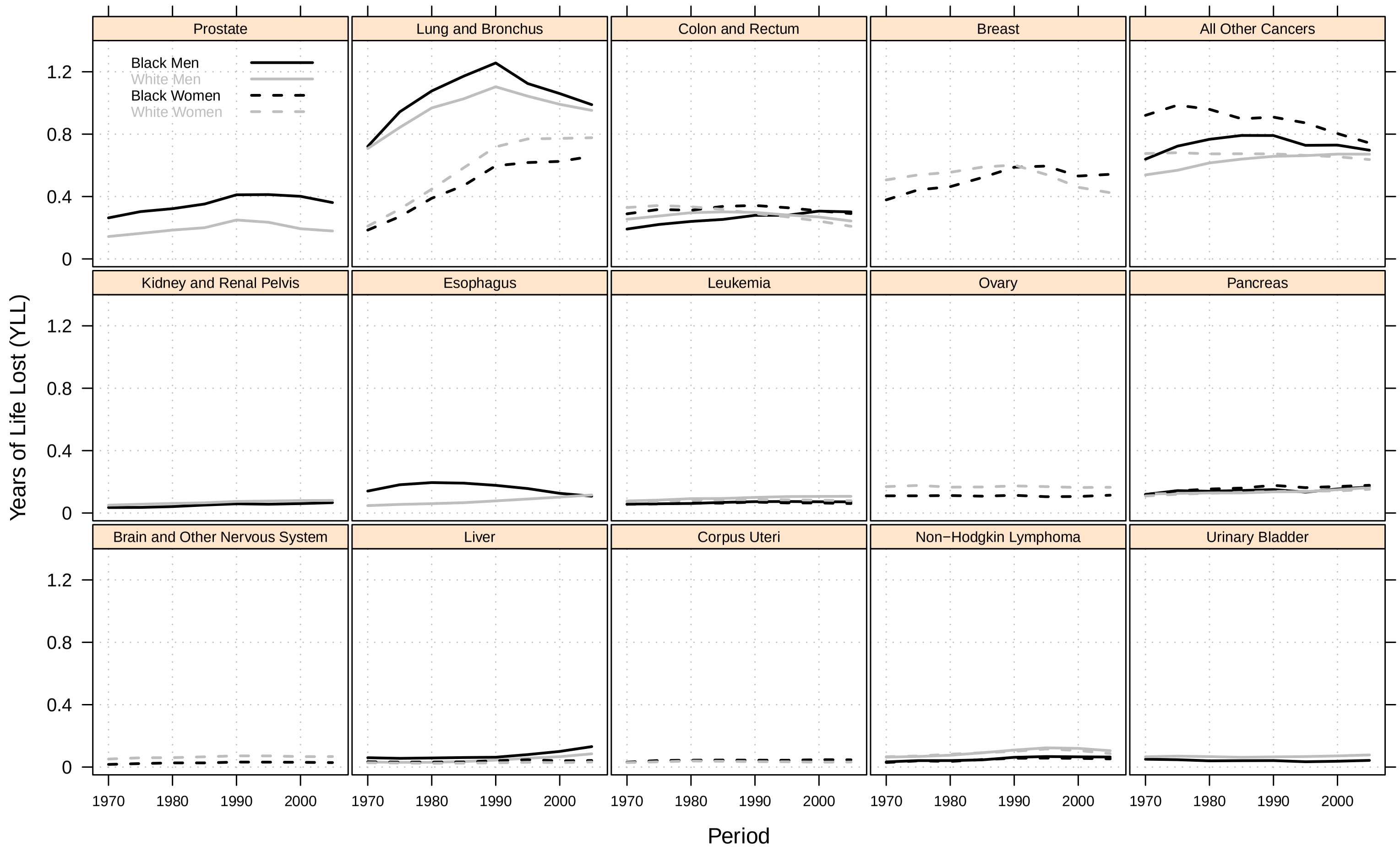


Years of Life Lost Over Time by Sex, Race, and Cause. The left (right) panel shows the years of life lost from cardiovascular disease (CVD) for white (black) males and females. CVD is denoted as a solid line and cancer is denoted as a dashed line.

We observe considerable differences in the level of YLL over time among cancer sites (Figure 2). YLL was greatest for lung, followed by all other cancers, prostate (males) and breast (females), and colorectal. For example, if lung cancer had been completely eliminated in 1970, life expectancy would have been 0.72 years higher for black males and 0.71 years higher for white males. Consistently higher for blacks than whites, YLL peaked for both groups in 1990 and declined thereafter.

For females, YLL for lung cancer increased monotonically and was consistently higher for whites. We observe a divergent pattern for breast cancer−the crossover between white and blacks occurred in 1990, after which the YLL from breast cancer was higher for blacks than whites.

Figure 2: Years of Life Lost By Cancer Site



Years of Life Lost Over Time by Cancer Site, Sex, and Race. Each panel shows the years of life for white (grey lines) and black (black lines) males (solid lines) and females (dashed lines).

3.2 Decomposition of Years of Life Lost by Cancer Site

As discussed in Section 2.2, the change in YLL over time that is attributed to a specific cancer depends on the change in mortality for the specific cancer compared to the change for all other causes. In Figures 3, 4, 5, 6, we calculate the gross contribution to the change in YLL over time from a specific cancer, adjust for all other causes, and calculate the net contribution in the change in YLL over time from a specific cancer. For example, we consider lung cancer in males. Between 1970 and 1975, the gross change in the YLL from lung cancer was 0.22 years for blacks and 0.13 years for whites (a positive change indicates an increase in YLL). After adjusting for changes in all other cause mortality, the net change in YLL from lung cancer was 0.14 years for blacks and 0.06 years for whites. The net change represents the change in YLL from lung cancer that is directly attributable to changes in lung cancer mortality. Over time, the net change declined and became negative in 1990, which indicates a decrease in YLL. The net change was larger for blacks than whites. Between 2000 and 2005, declines in lung cancer mortality directly contributed to a 0.15 year decline in the YLL from lung cancer for blacks and 0.10 year decline in the YLL from lung cancer for whites. We observe a similar pattern for prostate cancer. The net change in YLL from prostate cancer, which are directly attributable to changes in prostate cancer mortality, were more negative for black than whites, 0.08 years compared to 0.03 years. In other words, after adjusting for changes in all other cause mortality, the declines in prostate cancer mortality contributed to a larger reduction in the YLL from prostate cancer for black males, compared to white males.

For females, we do not observe a similar shift in the net change in YLL from lung cancer. Historically, the net change was positive for white and blacks and after 1995 was nearly 0 years. The net change in YLL from breast cancer was more negative for white females after 1990, compared to black females. For example, after adjusting for changes in all other cause mortality, declines in breast cancer mortality lead to a 0.05 year reduction in the YLL from breast cancer for white females between 2000 and 2005 versus 0.01 year reduction for black females.

Figure 3: Potential Years of Life Lost By Cancer Site, Black Male

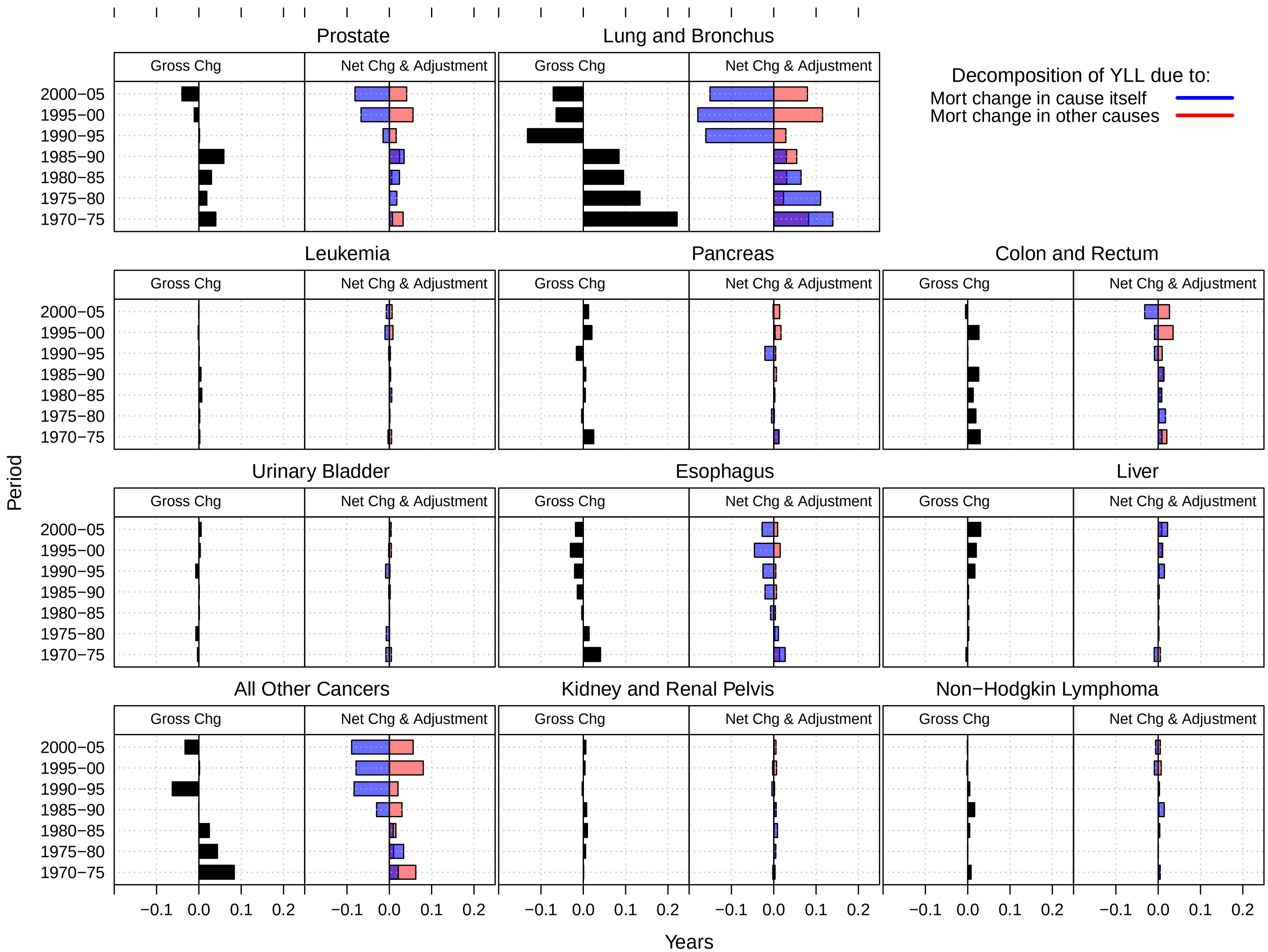


Figure 4: Potential Years of Life Lost By Cancer Site, White Male

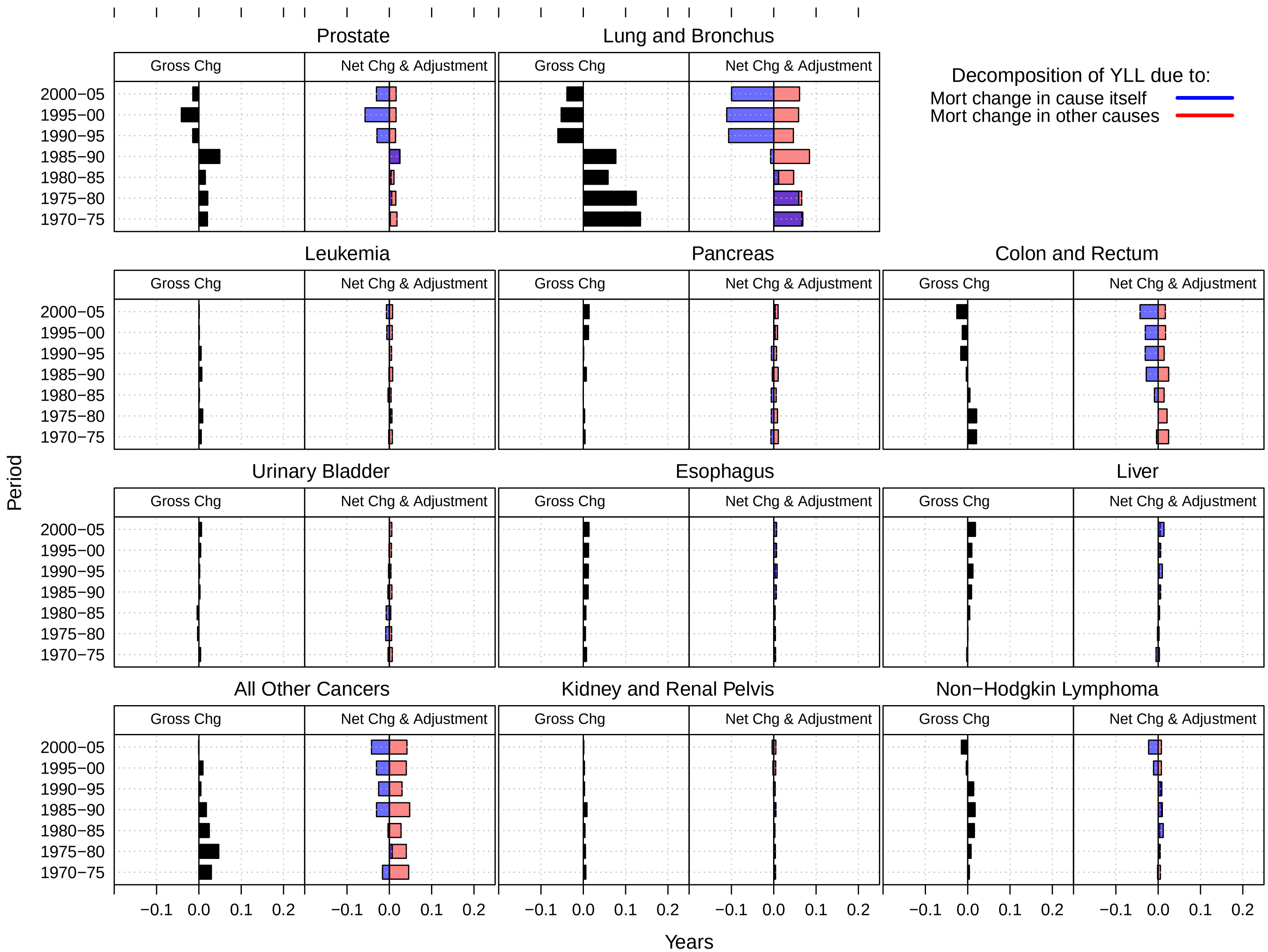


Figure 5: Potential Years of Life Lost By Cancer Site, Black Female

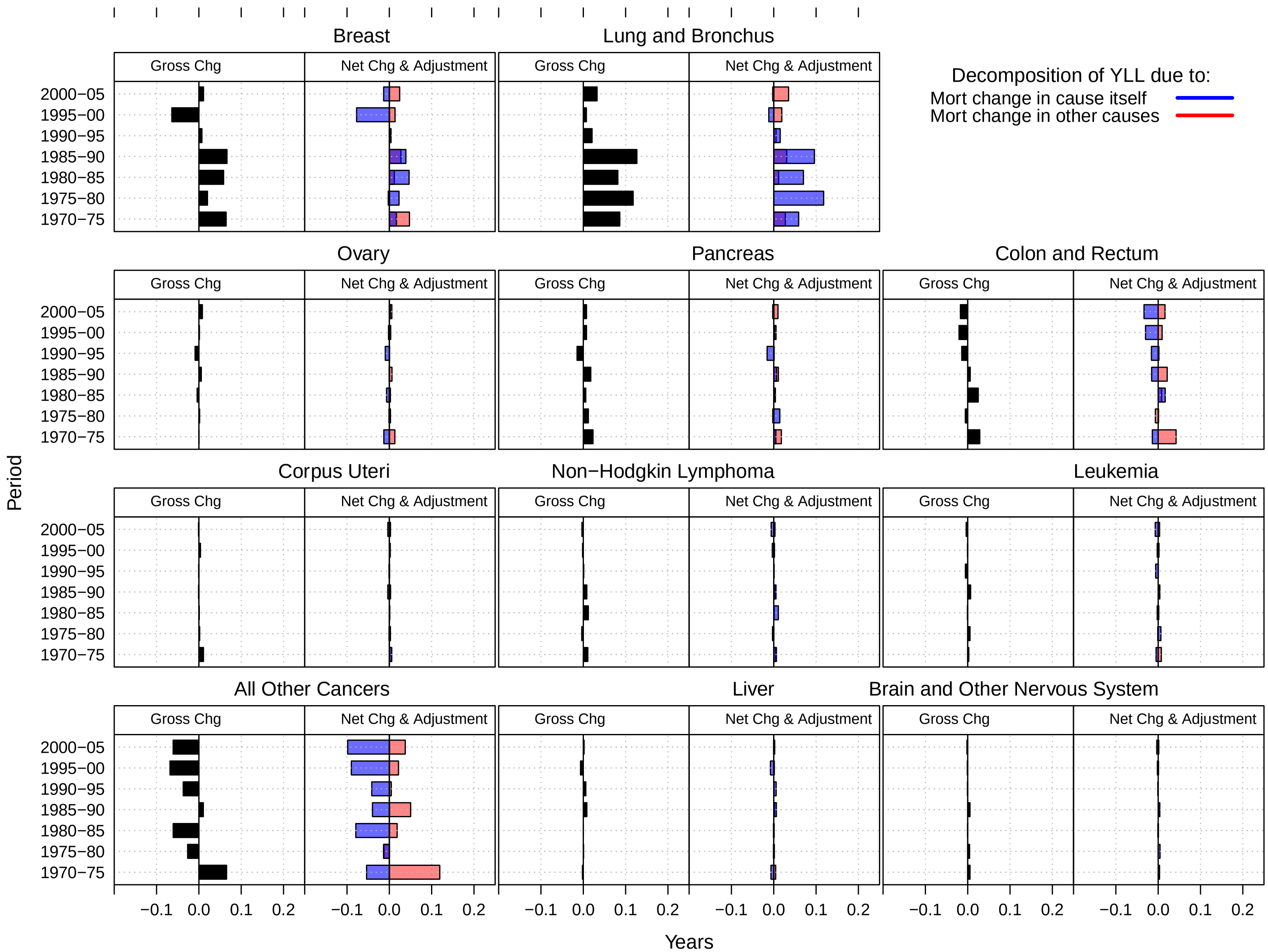
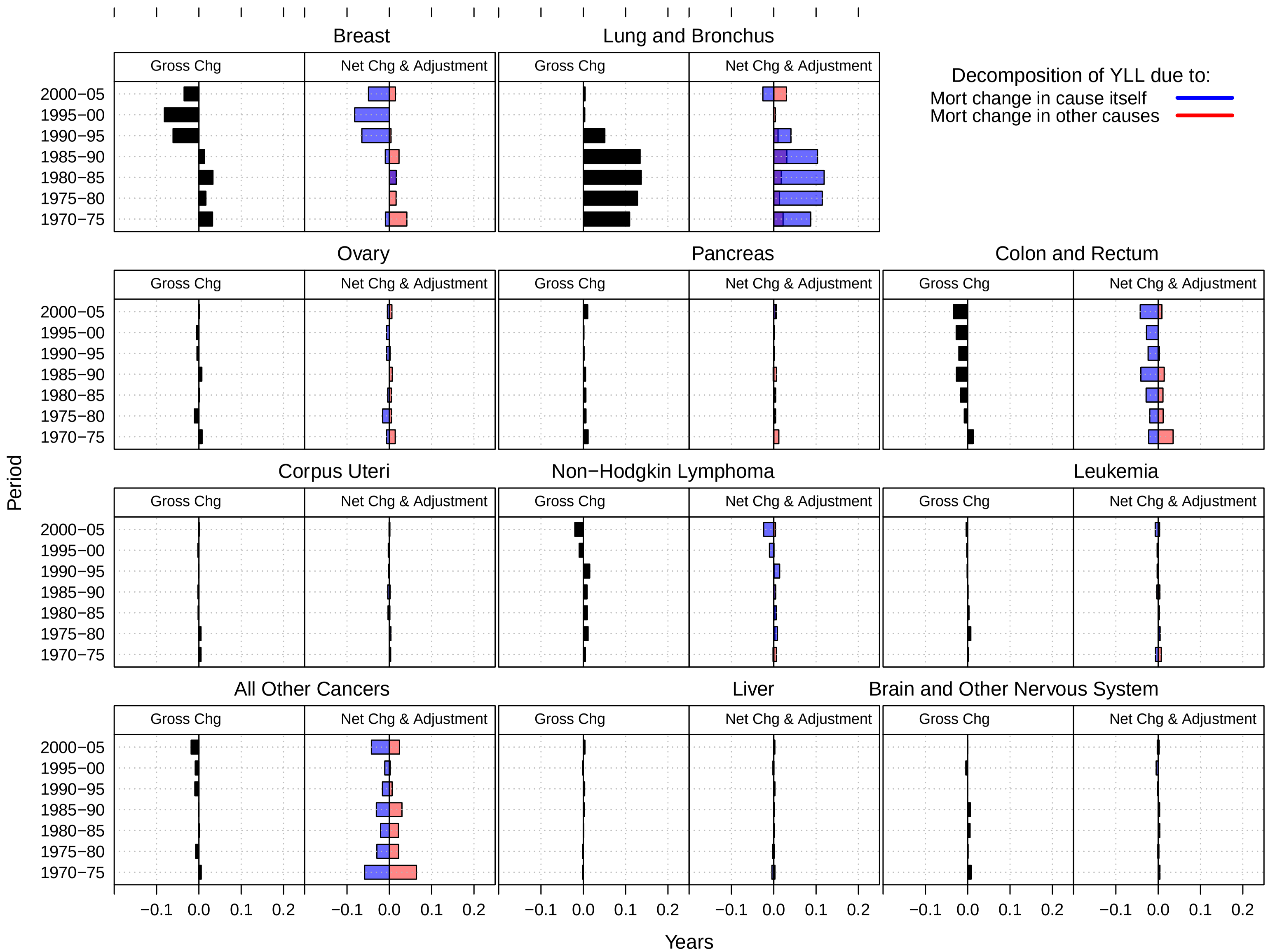


Figure 6: Potential Years of Life Lost By Cancer Site, White Female



4 Conclusion

This study has three main findings. First, the YLL from CVD steadily declined for all race-sex groups while increasing for cancer. For white females, cancer now contributes a greater number of years of life lost than CVD. For white males and blacks, the crossover in YLL from CVD and cancer may soon occur. Second, the YLL differs among cancer sites and is highest for lung cancer, breast, prostate, and colorectal. Third, by decomposing the change in YLL for a specific cancer, we are able to assess the direct impact of that cancer on population health.

Measures of mortality are used by state and federal governments to allocate health care expenditures and prioritize public health efforts. YLL is a commonly used measure of the impact and burden of a disease on a population. Our findings are consistent with a recent British study that also found YLL was highest for lung, breast, and colorectal (Burnet et al., 2005).

We acknowledge several limitations in this study. First, variability and biases in death certificate data, especially cause of death and age at death, may distort temporal patterns in mortality rates and affect the estimation of YLL. Assessments that compare hospital diagnosis and cause of death listed on the death certificate have found detection and confirmation rates exceeding 90% for several prevalent cancers. Second, although cause-specific mortality only operates below age 85 in our model, mortality conditions below this age accounted for over 90% of the increases in life expectancy between 1970 and 2005 for each race-sex category. Furthermore, using the underlying cause of death classification for the older population becomes increasingly difficult as multiple diseases are present.

Forty years have elapsed since Nixon's declaration of war on cancer. Determining the extent of progress in this national effort depends on both mortality patterns of specific cancers and mortality patterns of other causes of death. Future work should compare the research priority (e.g., funding level) for a specific cancer with its burden on the population.

Table 1: Causes of Death

Cause of Death	ICD-8 (1968-1978)	ICD-9 (1979-1994)	ICD-10 (1995+)
Lung and Bronchus Cancer	162,163	162, 163	C33,C34,C38.4,C45.0
Prostate Cancer	185	185	C61
Colon and Rectum Cancer	153,154	153, 154	C18, C19, C20
Pancreatic Cancer	157	157	C25
Leukemia	204-207	204-208	C91-C95
Liver Cancer	155-156	155-156	C22-C24
Esophageal Cancer	150	150	C15
Urinary Bladder Cancer	188, 189.9	188, 189.3-189.4, 189.8-189.9	C67, C68.0-C68.1, C68.8-C68.9
Non-Hodgkins Lymphoma	200, 202	200, 202	C83-C85
Kidney and Renal Pelvis Cancer	189.0-189.2	189.0-189.2	C64-C66
Cardiovascular Disease	390-398, 402, 404, 410-429, 400-401, 403, 430-438, 440, 441, 442-448	390-398, 402, 404, 410-429, 401, 403, 430-438, 440, 441, 442-448	I00-I09, I11, I13, I20-I51, I10, I12, I60-I69, I70, I71, I72-I78
Unintentional and Intentional Injury	800-949, 950-959, 960-978	800-949, 950-959, 960-978	V01-X59, Y85-Y86, X60-X84, Y87.0, U01.1, X85-Y09, Y35, Y87.1, Y89.0
Diabetes	250	250	E10-E14
Infectious Diseases	470-474, 480-486	480-487	J10-J18
Chronic Obstructive Pulmonary Disease	490-493, 519.3	490-496	J40-J47

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