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MRAC Mortality Risk Analysis Committee

MIB Risk Revealed

MORTALITY

All-Cause Mortality for Life Insurance Applicants with a History of Prostate Cancer

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Objective. – To determine the all-cause mortality of life insurance applicants diagnosed with prostate cancer currently or at some time in the past.

Background. – Prostate cancer is common and a frequent cause of cancer death. Both the frequency of prostate cancer in men and its propensity for causing premature mortality require insurance company medical directors and underwriters to have a good understanding of prostate cancer-related mortality trends, patterns, and outcomes in the insured population.

Methodology. – Life insurance applicants with reported prostate cancer were extracted from data covering United States residents between November 2007 and November 2014. Information about these applicants was matched to the Social Security Death Master (SSDMF) file for deaths occurring from 2007 to 2011 and to another commercially available death source file (Other Death Source, ODS) for deaths occurring from 2007 to 2014 to determine vital status. Actual to Expected (A/E) mortality ratios were calculated using the Society of Actuaries 2015 Valuation Basic Table (2015VBT), select and ultimate table (age last birthday) and the 2013 US population as expected mortality ratios. All expected bases were not smoker distinct.

Results. – The study covered applicants between the ages of 45 and 75 and had approximately 405,000 person-years of exposure. Older aged applicants had a lower mortality ratio than those who were younger. Applicants 45 to 54 had the highest mortality ratios in the first year after diagnosis which steadily decreased in years 6 to 10 with an increase in the mortality ratio for those over 10 years from diagnosis. Relative mortality rate was close to unity for those with localized cancer across all age groups. The mortality ratio was 2 to 4 times greater for those with cancer in 1 positive node, and much greater with 3 positive nodes. For each time-from-diagnosis category, the relative mortality ratios compared to age were highest in the 45–54 age group. The A/E mortality ratios based on the 2015VBT were consistently 3 to 4 times that of the mortality ratios based on the 2013 US population.

Conclusion. – The mortality patterns of insurance applicants with prostate cancer were similar to that observed in individuals with

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prostate cancer in the general population. Applicant age, time to diagnosis and cancer severity were the most significant variables to predict mortality.

INTRODUCTION

Prostate cancer is the second most common cancer diagnosed in men worldwide. In the United States, where prostate cancer is the most common non-cutaneous malignancy in men, approximately 12.9% of men will be diagnosed at some point during their lifetime. Currently, there are more than 3.3 million men living with the disease in the United States, representing 4 in 10 male cancer survivors. In 2016, it is estimated that 180,890 men in the United States will be diagnosed with prostate cancer and begin their journey into prostate cancer survivorship.[1,2]

Prostate cancer is also the second leading cause of cancer-related death in men in the United States with 26,120 deaths from the disease estimated to occur in 2016. However, cancer-specific survival is excellent in many patients. The median age at diagnosis is 67 years, and over 90% of men are diagnosed with local or regional disease, for which the 5-year relative survival approaches 100% but declines to 28% for those diagnosed at a distant stage. Over the past 25 years, the 5-year relative survival rate for all stages combined has increased from 83% in the late 1980s to 99% in the most recent time period (2005–2011). The 10-year and 15-year relative survival rates are 98% and 95%, respectively. These trends in survival have been attributed to a combination of early detection, increasingly effective treatment of localized and advanced disease, lead-time bias (early diagnosis falsely appears to prolong survival) and over diagnosis (due to widespread use of PSA screening).[1–4]

Screening tests for prostate cancer are often ordered by insurance companies and are commonly encountered in reviews of applicants' attending physician's statements (APS). Although prostate cancer is prevalent and may cause premature death, prostate cancer often progresses slowly, long-term survival is common after treatment and many men die of competing causes. Thus, it will be important for insurance company medical directors and underwriters to have a good understanding of prostate cancer-related mortality trends, patterns, and outcomes in the insured population.[5,6]

The purpose of this research was to determine the all-cause mortality of applicants diagnosed with prostate cancer currently or at some time in the past. The exposure period for the insurance applicants was from November 2007 to November 2014.

The data used for this study is contained in the medical impairment database operated by MIB, Group, Inc. MIB is a member cooperative data exchange formed by the North American life insurance industry in 1902. It currently is a cooperative of 430 United States and Canadian insurance companies. These member companies represent most of the underwritten life insurance activity in the United States and Canada.[7]

The sample used for this study represented all of the applicants for life insurance from MIB member companies over 7 years. This is a large sample for this type of study as it represents approximately 405,000 person-years of exposure and between 2984 and 5184 deaths, depending on the method of death record matching.

This research is done under the guidance of the Mortality Risk Analysis Committee (MRAC). This Committee is a coordinated multidisciplinary committee of actuaries, medical directors, underwriters and other roles appointed by the senior management of MIB with input from MRAC members. The Committee serves as an advisory group. Its mission is to facilitate and direct research endeavors, focusing on mortality risk relevant to insurance enterprises.[8]

METHODOLOGY

Individuals from the United States who applied for life insurance and had been clinically diagnosed with prostate cancer formed the basis for this study. This study did not examine individuals who were suspected to have prostate cancer without a record of clinical diagnosis. Canadian applicants were not considered because there was no national registry of deaths. In cases where there was more than 1 record on an individual, only the first occurrence was retained.

The applicant records were first searched against the Social Security Death Master File (SSDMF). Due to restrictions imposed on the SSDMF, all the deaths that were within 3 years of the date of the search could not be used for this research and were not available for the study.[9] To more accurately confirm all possible deaths, a second death source (Other Death Source, ODS) file was used that had more than 3,000 sources of death notifications. This registry was a compilation of obituaries from newspapers or funeral homes, and state vital statistics records. Deaths had to adequately match at least 1 database to be included in the study.

In the Other Data Source there were a large number of the records that did not have a date of birth, only age at death. From this, the year of birth was calculated using the age at death compared with the applicant year of birth. If the calculated year of birth matched the applicant year of birth, the case was considered a match. These deaths along with the deaths adequately matched on surname, given name and date of birth are labeled in this paper as **all deaths**. The deaths determined by adequately matching surname, given name and date of birth are called **definite deaths**.

The Society of Actuaries 2015 Valuation Basic Table (VBT) select and ultimate (age last birthday), male composite[10] was used along with the 2013 US male population mortality rates[11] to form the expected deaths for this study.

The average between the mortality ratios based on the 2015VBT and the 2013 US population mortality rates is presented in this paper. The details of the calculations are described in Appendix A.

The calculation of exposure was defined as the time in years from the first report of prostate cancer to the MIB database until November 14, 2014. If the applicant became an observed death, then the exposure was the number of years between the impairment report date and the date of death, rounded up to the next integer.

The actual-to-expected (A/E) mortality ratios presented in this paper were an underestimate of the true A/E mortality ratios. This was due to the most recent 3 years of SSDMF deaths being excluded. However, comparison of A/E ratios between the factor levels of the variables under study (eg, 1-2 nodes involved vs. localized disease) provided meaningful insights. These ratio comparisons were consistent, regardless of the actual A/E mortality ratio. Previous researchers pointed out this phenomenon and referred to the different conditions as mortality gradients.[12] Even though A/E mortality ratios were presented in this paper, the conclusions drawn from the analyses were based on comparisons of A/E ratios relative to a baseline condition.

The calculation used for the relative mortality ratios is presented in Appendix A.

The variables considered for this study were applicant age, prostate cancer severity as defined below, time since cancer diagnosis and number of cancer sites.

The groups for applicant age were:

- 45–54
- 55–64
- 65–75

Prostate cancer severity was defined as:

- Localized, no lymph nodes involved
- Metastases to 1 or 2 regional nodes
- Metastases to 3 or more regional nodes or other organs/tissues

- Other (which is a combination of: Treated by surgical operation, 2 or more cancer occurrences, and 'Under treatment not surgical')
- Unknown severity

Time since cancer diagnosis was defined as:

- 0–1 year
- 1–2 years
- 3–5 years
- 6–10 years
- Over 10 years
- Unknown

The 'number of non-prostate cancer sites' variable reflects the number of non-prostate cancer sites reported for a given individual and was categorized as:

- 0
- 1
- 2 or more

This study covered applicants between the ages of 45 and 75. When the data were aggregated, it was discovered that those applicants under 44 consisted of around 4400 person years of exposure with only 17 deaths. This resulted in many 0 death cells when the data were broken out. Also when there was a death, the expected deaths were so low that it tended to create artificially high Actual to Expected Ratios. Based on this, it was decided to exclude the under 44 cohort from the study.

RESULTS

The mortality analysis by applicant age and cancer severity is summarized in Table 1.

There were 404,870.1 person-years of exposure when all deaths are included and 407,061.8 when only definite deaths were included. Regarding exposure, 89.7 percent of the exposure was found in 55 to 75 cohort for all deaths and 89.8 percent for the definite deaths. The percentage of deaths in this age range was 95.6 for all deaths and 96.2 for the definite deaths.

Since the A/E mortality ratios were considered an underestimate of the true mortality risk, only the relationship of these ratios across the various levels of the variables in this study were compared.

Cancer severity was an important factor determining mortality. The mortality ratio is slightly above unity for those with localized cancer, is 2 to 4 times greater for those with cancer in 1 node, and much greater with 3+ nodes. Age had a slight interaction with severity since older aged applicants had a lower mortality ratio than those who were younger.

The A/E mortality ratios based on the 2015VBT were consistently 3 to 4 times that of the mortality ratios based on the 2013 US population.

The mortality analysis by applicant age and time since diagnosis is presented in Tables 2.

Those applicants over 55 years old have mortality ratios slightly higher in the first year after diagnosis than the subsequent years. From year 1 onward the mortality ratio is relatively flat. The applicants 45 to 54 have the highest mortality ratios in the first year after diagnosis which steadily decrease in years 6 to 10 with a dramatic increase in the mortality ratio for those over 10 years from diagnosis. This sharp increase could be a function of the low number of expected deaths in this category.

Table 3 shows the mortality ratio analysis for cancer severity and the time since prostate cancer diagnosis.

The exposure for those 3 or more years since diagnosis was 70.4 percent of the total exposure for all deaths and 70.4 percent for the definite deaths where the time from diagnosis was known. Similarly, this scenario had 68.1 percent of all deaths and 69.5 of the definite deaths.

The mortality ratios for those applicants with 3+ nodes within the first 2 years from diagnosis were extremely high. The ratio then flattened out after 3 years from diagnosis. Those with 1 to 2 nodes involved had a high mortality ratio within the first year from

Table 1. Analysis by Applicant Age and Cancer Severity for All Deaths

Applicant Age/ Severity	Person Years of Exposure	All Deaths	Definite Deaths[a]	Expected Deaths 2015VBT[b]	Expected Deaths 2013 US[c]	Mortality Ratio Average Qx[d]	Mortality Ratio Average Popx[e]
45–54							
Localized	21,396.5	83	32	37.0	146.2	1.6	0.4
1-2 nodes	813.1	8	7	1.5	5.6	5.0	1.3
3 + nodes	327.1	7	6	0.6	2.2	10.9	3.0
Other	347.4	2	1	0.6	2.3	2.5	0.7
Unknown	18,736.2	129	67	32.0	126.2	3.1	0.8
Aggregate	41,620.3	229	113	71.7	282.5	2.4	0.6
55–64							
Localized	93,280.3	585	268	359.2	1,226.5	1.2	0.4
1-2 nodes	3,033.2	47	33	11.9	40.1	3.4	1.0
3+ nodes	1,344.5	46	31	5.0	17.5	7.7	2.2
Other	1,226.2	13	8	4.6	15.9	2.3	0.7
Unknown	77,243.6	926	552	297.7	1,020.4	2.5	0.7
Aggregate	176,127.8	1,617	892	678.4	2,320.4	1.8	0.6
65–75							
Localized	90,230.5	1,140	613	668.3	2,360.6	1.3	0.4
1-2 nodes	2,694.5	53	34	20.2	71.5	2.2	0.6
3+ nodes	1,677.1	81	63	13.0	45.9	5.5	1.6
Other	936.8	14	10	6.7	23.1	1.8	0.5
Unknown	91,583.1	2,050	1,259	690.2	2,469.6	2.4	0.7
Aggregate	187,122.0	3,338	1,979	1,398.4	4,970.7	1.9	0.6
Total							
Localized	204,907.3	1,808	913	1,064.5	3,733.3	1.3	0.4
1-2 nodes	6,540.8	108	74	33.6	117.2	2.7	0.8
3+ nodes	3,348.7	134	100	18.6	65.6	6.3	1.8
Other	2,510.4	29	19	11.9	41.3	2.0	0.6
Unknown	187,562.9	3,105	1,878	1,019.9	3,616.2	2.4	0.7
Aggregate	404,870.1	5,184	2,984	2,148.5	7,573.6	1.9	0.6

Note:
[a]The number of deaths when removing the fuzzy date of birth matches.
[b]The expected deaths based on the 2015VBT.
[c]The expected deaths based on the US 2013 population.
[d]The average of the A/E ratios using all deaths and definite deaths based on the 2015VBT.
[e]The average of the A/E ratios using all the deaths and definite deaths based on the 2013 US population.

diagnosis, then the ratio flattened out for years 1 to 10, with an increase shown for those over 10 years from diagnosis. Localized cancer mortality ratios were slightly above unity no matter how long from the diagnosis of the cancer.

Table 4 summarizes the mortality analysis by the number non-prostate cancer sites.

If the number of sites is 0, the applicant had only prostate cancer. If there were 1 or more sites, the applicant had cancer diagnosed in more than 1 part of their body.

This table shows that there was an increase in the mortality ratios as the number of non-prostate cancer sites increased.

Table 5 compares the relative mortality ratios using all deaths and the 2015VBT expected deaths for various applicant age and severity combination to that of a 65-75 age group applicant having only localized cancer.

Table 2. Analysis by Applicant Age and Time Since Diagnosis for All Deaths

Applicant Age/Time	Person Years of Exposure	All Deaths	Definite Deaths[a]	Expected Deaths 2015VBT[b]	Expected Deaths 2013 US[c]	Mortality Ratio Average Qx[d]	Mortality Ratio Average Popx[e]
45–54							
0-1 year	10,284.6	74	48	17.5	69.0	3.5	0.9
>1-2 years	8,181.1	44	19	14.1	55.5	2.2	0.6
3–5 years	14,188.1	72	33	24.6	97.1	2.1	0.5
6–10 years	6,418.4	22	3	11.3	44.2	1.1	0.3
Over 10 years	1,232.5	9	5	2.0	8.0	3.5	0.9
Unknown	1,315.6	8	5	2.2	8.7	3.0	0.8
Aggregate	41,620.3	229	113	71.7	282.5	2.4	0.6
55–64							
0-1 year	28,788.0	312	187	108.7	371.5	2.3	0.7
>1-2 years	25,837.1	237	132	98.2	335.5	1.8	0.6
3–5 years	60,659.3	487	258	232.3	794.7	1.6	0.5
6–10 years	44,075.8	391	206	173.6	590.5	1.8	0.5
Over 10 years	10,981.6	99	54	43.0	150.6	1.8	0.6
Unknown	5,786.0	91	55	22.6	77.6	3.2	1.0
Aggregate	176,127.8	1,617	892	678.4	2,320.4	1.8	0.6
65–75							
0-1 year	20,707.3	437	274	150.4	530.6	2.4	0.7
>1-2 years	20,922.1	364	215	154.6	541.9	1.9	0.6
3–5 years	54,539.9	923	532	400.8	1,420.5	1.8	0.5
6–10 years	53,913.4	878	518	409.2	1,443.4	1.7	0.5
Over 10 years	26,945.1	465	262	205.8	754.2	1.8	0.5
Unknown	10,094.2	271	178	77.6	280.1	2.9	0.8
Aggregate	187,122.0	3,338	1,979	1,398.4	4,970.7	1.9	0.6
Total							
0-1 year	59,779.9	823	509	276.6	971.1	2.4	0.7
>1-2 years	54,940.3	645	366	266.9	932.9	1.9	0.6
3–5 years	129,387.3	1,482	823	657.7	2,312.3	1.8	0.5
6–10 years	104,407.6	1,291	727	594.1	2,078.1	1.7	0.5
Over 10 years	39,159.2	573	321	250.8	912.8	1.8	0.5
Unknown	17,195.8	370	238	102.4	366.4	3.0	0.8
Aggregate	404,870.1	5,184	2,984	2,148.5	7,573.6	1.9	0.6

Note:
[a]The number of deaths when removing the fuzzy date of birth matches.
[b]The expected deaths based on the 2015VBT.
[c]The expected deaths based on the US 2013 population.
[d]The average of the A/E ratios using all deaths and definite deaths based on the 2015VBT.
[e]The average of the A/E ratios using all the deaths and definite deaths based on the 2013 US population.

The applicants with 3 or more nodes or regional cancer involvement exhibited the highest relative mortality. The younger cohorts had the highest relative mortality (e.g., an applicant in the 45–54 age group with 3 or more nodes, had 8.4 times the relative mortality of the baseline). Within the localized tumor cohort, the 55–64 age group had 0.9 times the baseline and the 45–54 age group had 1.2 times the baseline. For those with 1-2 nodes involved, the applicants in the 45–54 age group had relative mortality 3.8 times the baseline, those in the 55–64 age group had relative mortality 2.6 times the baseline and

Table 3. Analysis by Cancer Severity and Time Since Diagnosis for All Deaths

Cancer Severity/ Time	Person Years of Exposure	All Deaths	Definite Deaths[a]	Expected Deaths 2015VBT[b]	Expected Deaths 2013 US[c]	Mortality Ratio Average Qx[d]	Mortality Ratio Average Popx[e]
0-1 year							
Localized	23,755.3	204	106	112.2	393.7	1.4	0.4
1-2 nodes	990.1	33	27	4.8	17.0	6.2	1.8
3+ nodes	623.0	51	44	3.0	11.2	15.6	4.2
Other	667.0	3	1	2.8	9.8	0.8	0.2
Unknown	33,744.5	532	331	153.8	539.4	2.8	0.8
Aggregate	59,779.9	823	509	276.6	971.1	2.4	0.7
>1-2 years							
Localized	32,308.6	269	137	155.2	542.8	1.3	0.4
1-2 nodes	1,164.9	15	8	5.4	18.8	2.2	0.6
3+ nodes	470.7	26	18	2.4	8.6	9.2	2.6
Other	355.7	4	2	1.7	5.8	1.8	0.5
Unknown	20,640.4	331	201	102.2	356.9	2.6	0.8
Aggregate	54,940.3	645	366	266.9	932.9	1.9	0.6
3-5 years							
Localized	78,260.3	657	335	390.8	1,373.5	1.4	0.4
1-2 nodes	2,448.9	30	20	12.3	42.8	2.0	0.6
3+ nodes	1,145.6	32	17	6.3	21.5	3.9	1.2
Other	778.7	13	9	3.5	12.2	3.2	0.9
Unknown	46,753.8	750	442	244.8	862.3	2.5	0.7
Aggregate	129,387.3	1,482	823	657.7	2,312.3	1.8	0.5
6-10 yrs							
Localized	55,899.2	527	260	313.0	1,089.1	1.3	0.4
1-2 nodes	1,447.9	20	11	8.2	28.2	1.9	0.6
3+ nodes	692.5	17	14	4.2	14.7	3.7	1.1
Other	403.9	6	4	1.9	6.7	2.6	0.8
Unknown	45,964.1	721	438	266.8	939.4	2.2	0.7
Aggregate	104,407.6	1,291	727	594.1	2,078.1	1.7	0.5
Over10years							
Localized	13,386.3	136	69	85.2	306.3	1.2	0.3
1-2 nodes	401.8	8	6	2.4	8.6	2.9	0.8
3+ nodes	345.9	7	7	2.2	8.0	3.1	0.9
Other	218.6	2	2	1.6	5.3	1.3	0.4
Unknown	24,806.6	420	237	159.4	584.6	2.1	0.6
Aggregate	39,159.2	573	321	250.8	912.8	1.8	0.5
Unknown							
Localized	1,297.6	15	6	8.1	27.9	1.3	0.4
1-2 nodes	87.2	2	2	0.5	1.8	4.0	1.1
3+ nodes	71.0	1	0	0.5	1.6	1.0	0.3
Other	86.5	1	1	0.4	1.5	2.5	0.7
Unknown	15,653.5	351	229	92.9	333.6	3.1	0.9
Aggregate	17,195.8	370	238	102.4	366.4	3.0	0.8
Total							
Localized	204,907.3	1,808	913	1,064.5	3,733.3	1.3	0.4
1-2 nodes	6,540.8	108	74	33.6	117.2	2.7	0.8
3 + nodes	3,348.7	134	100	18.6	65.6	6.3	1.8
Other	2,510.4	29	19	11.9	41.3	2.0	0.6
Unknown	187,562.9	3,105	1,878	1,019.9	3,616.2	2.4	0.7
Aggregate	404,870.1	5,184	2,984	2,148.5	7,573.6	1.9	0.6

Note:
[a]The number of deaths when removing the fuzzy date of birth matches.
[b]The expected deaths based on the 2015VBT.
[c]The expected deaths based on the US 2013 population.
[d]The average of the A/E ratios using all deaths and definite deaths based on the 2015VBT.
[e]The average of the A/E ratios using all the deaths and definite deaths based on the 2013 US population.

Table 4. Analysis by Number of Non-Prostate Cancer Sites for All Deaths

Number of non- Prostate Cancer Sites	Person Years of Exposure	All Deaths	Definite Deaths[a]	Expected Deaths 2015VBT[b]	Expected Deaths 2013 US[c]	Mortality Ratio Average Qx[d]	Mortality Ratio Average Popx[e]
0	375,796.6	4,672	2,649	1,980.2	6,972.3	1.8	0.6
1	27,026.0	469	306	155.6	556.2	2.5	0.7
2 +	2,047.5	43	29	12.7	45.1	2.9	0.8
Total	404,870.1	5,184	2,984	2,148.5	7,573.6	1.9	0.6

[a]The number of deaths when removing the fuzzy date of birth matches.
[b]The expected deaths based on the 2015 VBT.
[c]The expected deaths based on the US 2013 population.
[d]The average of the A/E ratios using all deaths and definite deaths based on the 2015 VBT.
[e]The average of the A/E ratios using all the deaths and definite deaths based on the 2013 US population.

the 65–75 age group had relative mortality 1.7 times that of the baseline.

Table 6 shows the relative mortality ratios of the 65–75 age group with over 10 years from prostate cancer diagnosis compared to the baseline.

Note that the relative mortality ratios are at or below unity for those applicants 6 to 10 years from diagnosis. The only conditions where the relative mortality ratios are greater than unity are those applicants 45–54 within the first year and over 10 years from diagnosis. All the other conditions have a relative mortality ratio close to the baseline.

Table 7 shows the relative mortality ratios for prostate cancer severity and time from diagnosis compared to the applicant that has localized cancer diagnosed over 10 years ago.

The relative mortality ratios for the younger and more severe cancer applicants had the greatest relative mortality ratios compared to the baseline. The localized prostate cancer relative mortality ratio was very close to unity for all times from diagnosis. The largest relative mortality ratio was in the 3 or more nodes category, which had cancer mortality ratio comparisons ranging from 2.6 to 13.0.

DISCUSSION

This paper addresses all-cause mortality study for insurance applicants who were

Table 5. Relative Mortality Ratios Compared to the 65–75 Localized Condition

Applicant Age	Severity	Mortality Ratio Average Qx	Relative Mortality Ratio
45–54	Localized	1.6	1.2
55–64	Localized	1.2	0.9
65–75 (baseline)	Localized	1.3	1.0
45–54	1–2 nodes	5.0	3.8
55–64	1–2 nodes	3.4	2.6
65–75	1–2 nodes	2.2	1.7
45–54	3 + nodes	10.9	8.4
55–64	3 + nodes	7.7	5.9
65–75	3 + nodes	5.5	4.2

Table 6. Relative Mortality Ratios Compared to the 65-75 Over 10 Years Condition

Applicant Age	Time Since Diagnosis	Mortality Ratio Average Qx	Relative Mortality Ratio
45–54	0–1 year	3.5	1.9
55–64	0–1 year	2.3	1.3
65–75	0–1 year	2.4	1.3
45–54	>1–2 years	2.2	1.2
55–64	>1–2 years	1.8	1.0
65–75	>1–2 years	1.9	1.1
45–54	3–5 years	2.1	1.2
55–64	3–5 years	1.6	0.9
65–75	3–5 years	1.8	1.0
44–54	6–10 years	1.1	0.6
55–64	6–10 years	1.8	1.0
65–75	6–10 years	1.7	0.9
45–54	Over 10 years	3.5	1.9
55–64	Over 10 years	1.8	1.0
65–75 (baseline)	Over 10 years	1.8	1.0

diagnosed with prostate cancer. Due to the ambiguity in some of the information used to match the death records, the mortality ratios were presented using the average value from all deaths and definite deaths. We were unable to estimate the effect that missing the most recent SSDMF deaths had on this cohort. Therefore, the mortality ratios presented

Table 7. Relative Mortality Ratios for Severity and Time Since Diagnosis Compared to Localized Diagnosed Over 10 Years Ago

Severity	Time Since Diagnosis	Mortality Ratio Average Qx	Relative Mortality Ratio
Localized	0–1 year	1.4	1.2
1–2 nodes	0–1 year	6.2	5.2
3 + nodes	0–1 year	15.6	13.0
Localized	>1–2 years	1.3	1.1
1–2 nodes	>1–2 years	2.2	1.8
3 + nodes	>1–2 years	9.2	7.7
Localized	3–5 years	1.4	1.2
1–2 nodes	3–5 years	2.0	1.7
3 + nodes	3–5 years	3.9	3.3
Localized	6–10 years	1.3	1.1
1–2 nodes	6–10 years	1.9	1.6
3 + nodes	6–10 years	3.7	3.1
Localized (baseline)	Over 10 years	1.2	1.0
1–2 nodes	Over 10 years	2.9	2.4
3 + nodes	Over 10 years	3.1	2.6

in this paper were lower than the true mortality ratio.

The comparison of the A/E ratios between the factor levels of the variables under study (e.g. 1-2 nodes involved vs. localized disease) provided meaningful insights. These relative ratio comparisons were consistent, regardless of the underlying A/E morality ratios. Previous researchers pointed out this phenomenon and referred to the different conditions as mortality gradients.[12]

The statistic used to assess the prostate cancer mortality severity was the relative mortality ratio based on a "benchmark" standard. For the most part, the baseline condition chosen for those comparisons was the condition having the lowest mortality ratio.

The relative mortality ratio for the younger applicants was extremely high, suggesting that the disease in the younger population was much more severe. If there was nodal involvement the relative mortality was between 3.8 and 8.4 of the baseline. Using person-years exposure, 10.3 percent of the prostate cancer applicants were in the 45–54 age group. This was consistent with the US Population exposure.[13]

To see how the cohort of insurance applicants compared to the general population, a comparison of the percentage of deaths by applicant age, along with the percent of cases and death rate differential by cancer severity was done.[14] The percentage of deaths by age group in the United States population from 2009 to 2013 was:

- 1.6% for age group 45–54;
- 9.0% for age group 55–64;
- 20.8% for age group 65–74.[14]

Among those 45 to 74, this translates into:

- 5.1% for age group 45–54
- 28.7% for age group 55 - 64
- 66.2% for age group 65-74

The corresponding percentage of all deaths for the 45 to 74 age cohort in this paper were:

- 4.4% for age group 45–54
- 31.1% for age group 55–64
- 64.4% for age group 65–75

For definite deaths:

- 3.8% for age group 45–54
- 29.9% for age group 55–64
- 66.3% for age group 65–75.

This shows that the mortality patterns by age are similar in the insurance applicant and US population.

The percentage of cases of prostate cancer by severity in the US general population from 2006-2012 was 80% localized, 12% regional, 4% distant and 4% unstaged.[14] The percentages for 2015 were 81% localized, 12% regional, 5% distant and 2% unstaged.[14] The percentage of cases in this study where the severity of prostate cancer was known was 50.6% localized; 1.6% for 1-2 nodes; and 0.8% for 3 or more nodes.

Time from prostate cancer diagnosis and applicant age were correlated. For each time-from-diagnosis category, the relative mortality ratios compared to age were higher for the 45–54 age group with the 55–64 and 65–75 age groups having basically the same relative mortality pattern.

Relative mortality ratios were dramatic when comparing time from diagnosis to the number of cancer nodes. The relative mortality ratios for those with 3 or more nodes were very large, especially for those 5 years and under from the time of diagnosis (1.1 to 13.0 times the baseline). Those with 1-2 involved nodes had a relative mortality ratio from 1.6 times to 5.2 times the baseline for 6–10 years since diagnosis or diagnosed within the last year before application, respectively. The applicants with a history of localized cancer were consistently at or below 1.2 times the baseline no matter the time from diagnosis.

The number of cancer sites had an impact on the relative mortality ratios. The overall relative mortality ratio was 1.6 times those with 2 or more non prostate cancer sites

compared to those with prostate cancer being the only cancer.

CONCLUSION

This paper was an all-cause mortality study of insurance applicants who were diagnosed with prostate cancer. The mortality patterns of insurance applicants with prostate cancer were similar to that observed in individuals with breast cancer in the general population. Applicant age, time to diagnosis and cancer severity were the most significant variables to predict relative mortality ratios.

APPENDIX A

Process Used to Calculate Relative Mortality Ratios

The federal government imposed restrictions on the use of the Social Security Death Master File (SSDMF). The restriction is that the deaths within the first 3 years from accessing the registry cannot be used for research purposes. These are referred to as recent deaths. If the recent death is discovered from another death registry, then the SSMDF can be used to verify the information for that death.[9]

The applicant records were first searched against the Social Security Death Master File (SSDMF). To confirm all possible deaths more accurately, a second death source (Other Death Source, ODS) file was used that had more than 3000 sources of death notifications. This registry was a compilation of obituaries from newspapers, funeral homes, and state vital statistics records. Deaths had to adequately match at least one database to be included in the study.

The authors attempted to estimate the recent deaths from only the SSDMF, but were unable to derive a reliable method without introducing considerable bias. Therefore, any death that could have been identified only on the SSDMF after February 12, 2012, was not used.

As a result, the actual-to-expected (A/E) mortality ratios presented in this paper were an underestimate of the true A/E mortality ratios. Previous researchers discovered that even though the actual mortality ratio may not be accurate, the relative mortality ratios over various comparisons (eg, comparing the mortality ratio of the 0-1 year from diagnosis and being in the 45–54 age group from that of the cases being diagnosed over 10 years ago and being in the 65–75 age group) can provide meaningful insight. These researchers found that the ratio comparisons were consistent, regardless of the actual ratio. They called this phenomenon mortality gradients.[12]

In this paper, the mortality gradients were determined by first establishing a baseline condition, then comparing the A/E mortality of each of the other conditions to that baseline. The baseline condition chosen was the condition with the lowest A/E mortality ratio. This made it so that most conditions would have a gradient or relative mortality ratio in excess of one. The 3 baseline conditions chosen were:

1) The 65–75 age group with localized nodal involvement (Table 5)
2) The 65–75 age group being diagnosed with breast cancer over 10 years ago (Table 6)
3) Cases with local nodal involvement being diagnosed over 10 years ago (Table 7)

The relative mortality ratio was a simple ratio. For example, the relative mortality ratio for those 3 to 5 years from diagnosis and aged 45–54 years compared to the baseline was the mortality ratio qx of 2.1 to 1.8 ($2.1/1.8 = 1.2$). Similarly, the 8.4 relative mortality ratio seen for 3 + nodes along with 0-1 year since diagnosis was calculated by taking the 10.9 from the 1.3, to get 8.4.

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