

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

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Breast cancer is the most commonly diagnosed cancer worldwide. Breast cancer is also the second leading cause of cancer death among women in the United States after lung cancer with over 40,000 breast cancer deaths occurring each year.

The purpose of this research was to determine the all-cause mortality of applicants diagnosed with breast cancer currently or at some time in the past.

Life insurance applicants with reported breast 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. If there was a death from the other death source, then the SSDMF was searched to verify the death.

The study had approximately 561,000 person-years of exposure.

Actual-to-expected (A/E) mortality ratios were calculated using the Society of Actuaries 2008 Valuation Basic Table (2008VBT), select and ultimate table (age last birthday) and the 2010 US population as expected mortality ratios. Since the A/Es presented in this paper were known to be an underestimate due to the exclusion of the recent SSDMF deaths, comparative analysis of the mortality ratios was done. Since there was no smoking status information in this study, all expected bases were not smoker distinct.

Overall, the 35-44 age group had 6.3 times the relative mortality ratio than those in the 65-75 age group. The relative mortality ratio for the 35-44 age group applicants, when cancer severity was accounted for in combination with 3 or more nodes of cancer involvement, was 29.3 times that when compared to those in the 65-75 age group having localized cancer, where no nodes are involved.

The 35-44 age group applicants who were diagnosed with cancer within the last year had over 10-fold increase in relative mortality ratios compared to the 65-75 age group, who were over 10 years from diagnosis. Taking the severity of cancer along with time from diagnosis showed over a 12 times relative mortality ratio between the low rate of over 10 years from diagnosis and localized involvement to those diagnosed within the last year having 3 or more nodes with cancer.

Applicant age, time since diagnosis and cancer severity were the most significant variables to predict the relative mortality ratios.

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INTRODUCTION

Breast cancer is the most commonly diagnosed cancer worldwide. In the United States, breast cancer is the most common non-cutaneous malignancy among women, representing 4 in 10 female cancer survivors. Approximately 230,000 new cases of invasive breast cancer occur in American women each year. About 12% of women in the United States (or 1 in 8) will be diagnosed with breast cancer in their lifetime.¹⁻³ Although the vast majority of breast cancer survivors are women, approximately 2000 men are also diagnosed with breast cancer annually in the United States, and most will achieve long-term disease-free survival.^{4,5}

Breast cancer is also the second leading cause of cancer death among women in the United States after lung cancer with over 40,000 breast cancer deaths occurring each year.^{2,3,6} However, long-term survival is common after breast cancer treatment, with a 5-year survival rate of almost 90%.⁷ As a result, there are an estimated 3.1 million breast cancer survivors alive in the United States, a figure that is expected to increase significantly over the next decade.^{2,6}

Individuals who are living for decades beyond their cancer experience the normal issues and comorbidities of aging, which are often compounded by the long-term effects of having had cancer and cancer therapy. These patients are at risk for a breast cancer recurrence (which is most common in the first 5 years, but may occur even decades following treatment), a new primary breast cancer, other cancers, and short-term and long-term adverse effects of treatment.⁴

Underwriters and medical directors are frequently asked to quantify the mortality risk presented by a proposed insured who has survived an episode of breast cancer. Quantifying the mortality risk in such applicants requires knowledge of the individual's breast cancer-specific prognostic markers, including tumor stage, morphology, histologic grade, tissue markers and genomic

profile. But equally important, it requires knowledge of the mortality rates and the pattern of breast cancer mortality (ie, the time frame over which deaths from breast cancer occur).⁸⁻¹⁰

The purpose of this research was to determine the all-cause mortality of applicants diagnosed with breast 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.¹¹

The sample used for this study represented all 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 561,000 person-years of exposure and between 3510 and 5355 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.¹²

METHODOLOGY

Individuals from the United States who applied for life insurance and had been clinically diagnosed with breast cancer formed

the basis for this study. This study did not examine individuals who were suspected to have breast 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 one 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.¹³ To more accurately confirm all possible deaths, 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 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.

As in previous research by this committee, the Society of Actuaries 2008 Valuation Basic Table (VBT) select and ultimate (age last birthday), weighted composite¹⁴ was used along with the weighted 2010 US population mortality rates.¹⁵ The weights used were equal to the known gender in this cohort, which was 97.3% female and 2.7% male. The average between the mortality ratios based on the 2008VBT and the 2010 US population mortality rates is presented in this paper. The

details of the calculations used are the same as that of a previous paper published by this committee.¹⁶

The calculation of exposure was defined as the time in years from the first report of breast 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 authors were unable to derive a reliable estimate to compensate for not having the most recent 3 years of deaths from the Social Security Death Master file (SSDMF). All deaths from February 10, 2012, forward were not considered in this study if the only death source was the SSDMF. To estimate the actual mortality from the most recent 3 years, an assumption was made that the mortality ratio for the first 3 years was consistent with years 4 to 7. Since the mortality patterns of the known deaths differed over time, it was felt that no adequate estimate could be made of the missing deaths without introducing considerable bias.

Because of these missing deaths, the actual-to-expected (A/E) mortality ratios presented in this paper were an underestimate of the true A/E mortality ratios. 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 underlying A/E mortality ratio. Previous researchers pointed out this phenomenon and referred to the different conditions as mortality gradients.¹⁷ Even though A/E mortality ratios were presented in this paper, the conclusions drawn from the analyses were based on comparisons in A/E ratios relative to a baseline condition.

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

The variables considered for this study were applicant age, breast cancer severity as defined below, time since cancer

diagnosis and number of non-breast cancer sites.

The groups for applicant age were:

- 25 – 34
- 35 – 44
- 45 – 54
- 55 – 64
- 65 – 75

Breast 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 (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-breast cancer” reflects the number of cancer sites reported for a given individual and was categorized as:

- 0
- 1
- 2 or more

RESULTS

The mortality analysis by applicant age and cancer severity is summarized in Tables 1 and 2.

There were 559,306.3 person-years of exposure when all deaths are included and 561,224.2 when only definite deaths were included. Regarding exposure, 57.3% and 57.4% of the exposure was found in 55 to 75 cohort for all deaths and definite deaths, respectively. The percentage of deaths in this

age range was 71.2 for all deaths and 66.7 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.

Applicant age was an important factor determining mortality, since older aged applicants had a much lower mortality ratio than those who were younger. There was a steady increase in the mortality ratios going from localized (no lymph node involvement) tumors to the involvement of 3 or more nodes.

The A/E mortality ratios based on the 2008VBT were consistently slightly more than twice that of the mortality ratios based on the 2010 US population.

The mortality analysis by applicant age and time since diagnosis is presented in Tables 3 and 4.

Those applicants with the lowest mortality ratios were those who were older and had their breast cancer diagnosis much further in the past. This was true whether the 2008VBT or the 2010 US population was used as the basis for comparison. For those applicants within the first 2 years of diagnosis and among applicants 44 years old and younger, there was an increase in the mortality ratios.

Tables 5 and 6 show the mortality ratio analysis for cancer severity combined with the time since breast cancer diagnosis.

The exposure for those 3 or more years since diagnosis was 59.3% of the total exposure. Similarly, this combination accounted for 51.3% of all deaths and 48.5% of the definite deaths.

For those applicants who had localized cancer, the mortality ratios were elevated for the first 2 years since diagnosis. For those with 1-2 nodes involved and within the first 2 years of diagnosis, the mortality ratios were similar, and there was a steady decrease in the ratios as the time from diagnosis increased. For applicants with 3 or more nodes involved or regional cancer, mortality ratios were very high in the early years from diagnosis then

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

Applicant Age/Severity	Person Years of Exposure	All Deaths	Expected Deaths 2008VBT ^a	Expected Deaths 2010 US ^b	Mortality Ratio Average Qx ^c	Mortality Ratio Average Popx ^d
25-34						
Localized	1,591.3	8	0.4	1.3	17.7	5.3
1-2 nodes	674.1	9	0.2	0.6	52.6	15.6
3+ nodes	365.3	7	0.1	0.3	77.5	22.7
Other	4,016.2	1	0.9	3.0	1.1	0.3
Unknown	6,170.5	33	1.5	4.9	22.3	6.7
Aggregate	12,817.4	58	3.1	10.1	18.8	5.6
35-44						
Localized	15,465.5	38	7.5	27.5	4.4	1.2
1-2 nodes	5,656.3	41	2.7	10.0	14.3	3.9
3+ nodes	2,573.4	52	1.3	4.6	38.1	10.4
Other	8,557.2	9	3.9	14.6	1.7	0.5
Unknown	25,465.1	254	11.9	44.2	19.7	5.3
Aggregate	57,717.5	394	27.3	100.9	13.2	3.5
45-54						
Localized	56,807.8	198	59.3	218.7	2.7	0.7
1-2 nodes	16,726.8	113	17.3	63.8	5.8	1.6
3+ nodes	7,068.0	122	7.4	27.0	15.1	4.1
Other	16,150.9	37	16.0	59.8	1.7	0.4
Unknown	71,346.9	619	73.3	271.7	7.3	2.0
Aggregate	168,100.4	1,089	173.3	641.0	5.4	1.5
55-64						
Localized	71,717.2	409	173.5	553.6	1.8	0.6
1-2 nodes	16,922.1	161	40.1	128.5	3.2	1.0
3+ nodes	7,848.0	141	19.0	60.2	6.5	2.1
Other	12,182.1	55	27.9	90.1	1.4	0.5
Unknown	93,121.2	1,068	228.8	730.0	3.9	1.2
Aggregate	201,790.6	1,834	489.3	1,562.4	3.0	1.0
65-75						
Localized	42,059.4	443	271.9	762.8	1.3	0.5
1-2 nodes	7,675.4	117	47.9	135.6	2.0	0.7
3+ nodes	3,568.5	64	22.3	62.7	2.5	0.9
Other	4,496.6	64	27.6	78.0	1.7	0.6
Unknown	61,080.5	1,292	401.0	1,129.1	2.6	0.9
Aggregate	118,880.4	1,980	770.7	2,168.2	2.1	0.7
Total						
Localized	187,641.2	1,096	512.6	1,563.9	1.7	0.6
1-2 nodes	47,654.7	441	108.2	338.5	3.4	1.1
3+ nodes	21,423.2	386	50.1	154.8	6.9	2.2
Other	45,403.0	166	76.3	245.5	1.6	0.5
Unknown	257,184.2	3,266	716.5	2,179.9	3.8	1.3
Aggregate	559,306.3	5,355	1,463.7	4,482.6	3.0	1.0

Note:

^a The expected deaths based on the 2008VBT.

^b The expected deaths based on the US 2010 population.

^c The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^d The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

Table 2. Analysis by Applicant Age and Cancer Severity for Definite Deaths

Applicant Age/Severity	Definite Death Person Years of Exposure	Definite Deaths ^a	Expected Definite Deaths 2008VBT ^b	Expected Definite Deaths 2010 US ^c	Mortality Ratio Average Qx ^d	Mortality Ratio Average Popx ^e
25-34						
Localized	1,596.2	6	0.4	1.3	17.7	5.3
1-2 nodes	674.1	9	0.2	0.6	52.6	15.6
3 + nodes	365.3	7	0.1	0.3	77.5	22.7
Other	4,016.2	1	0.9	3.0	1.1	0.3
Unknown	6,171.4	32	1.5	4.9	22.3	6.7
Aggregate	12,823.2	55	3.1	10.1	18.8	5.6
35-44						
Localized	15,480.1	28	7.5	27.6	4.4	1.2
1-2 nodes	5,660.7	37	2.7	10.0	14.3	3.9
3 + nodes	2,593.0	45	1.3	4.7	38.1	10.4
Other	8,560.7	4	3.9	14.6	1.7	0.5
Unknown	25,504.9	217	12.0	44.2	19.7	5.3
Aggregate	57,799.4	331	27.4	101.1	13.2	3.5
45-54						
Localized	56,887.7	124	59.4	219.0	2.7	0.7
1-2 nodes	16,743.7	90	17.4	63.8	5.8	1.6
3 + nodes	7,096.4	102	7.4	27.1	15.1	4.1
Other	16,176.3	16	16.0	59.9	1.7	0.4
Unknown	71,552.5	451	73.6	272.5	7.3	2.0
Aggregate	168,456.6	783	173.8	642.3	5.4	1.5
55-64						
Localized	71,915.8	211	174.2	555.1	1.8	0.6
1-2 nodes	16,979.0	94	40.3	128.9	3.2	1.0
3 + nodes	7,890.3	107	19.2	60.6	6.5	2.1
Other	12,219.7	26	28.1	90.4	1.4	0.5
Unknown	93,543.0	701	230.4	733.2	3.9	1.2
Aggregate	202,547.8	1,139	492.2	1,568.2	3.0	1.0
65-75						
Localized	42,217.7	249	273.6	765.7	1.3	0.5
1-2 nodes	7,710.6	73	48.2	136.1	2.0	0.7
3 + nodes	3,583.0	49	22.5	62.9	2.5	0.9
Other	4,545.2	30	28.1	78.9	1.7	0.6
Unknown	61,540.7	801	406.0	1,138.0	2.6	0.9
Aggregate	119,597.2	1,202	778.4	2,181.6	2.1	0.7
Total						
Localized	188,097.5	618	515.1	1,568.7	1.7	0.6
1-2 nodes	47,768.1	303	108.8	339.4	3.4	1.1
3 + nodes	21,528.0	310	50.5	155.6	6.9	2.2
Other	45,518.1	77	77.0	246.8	1.6	0.5
Unknown	258,312.5	2,202	723.5	2,192.8	3.8	1.3
Aggregate	561,224.2	3,510	1,474.9	4,503.3	3.0	1.0

Note:

^a The number of deaths when removing the fuzzy date of birth matches.

^b Expected deaths based on the 2008VBT and removing the fuzzy date of birth matches.

^c Expected deaths based on the 2010 US population and removing the fuzzy date of birth matches.

^d The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^e The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

Table 3. Analysis by Applicant Age and Time Since Diagnosis for All Deaths

Applicant Age/Time	Person Years of Exposure	All Deaths	Expected Deaths 2008VBT ^a	Expected Deaths 2010 US ^b	Mortality Ratio Average Qx ^c	Mortality Ratio Average Popx ^d
25-34						
0-1 year	5,357.3	33	1.3	4.2	25.7	7.7
>1-2 years	2,039.1	9	0.5	1.6	18.8	5.6
3-5 years	2,766.9	12	0.7	2.2	17.5	5.2
6-10 years	1,381.4	1	0.3	1.1	3.1	0.9
Over 10 years	347.6	0	0.1	0.3	0.0	0.0
Unknown	925.1	3	0.2	0.7	13.5	4.0
Aggregate	12,817.4	58	3.1	10.1	18.8	5.6
35-44						
0-1 year	17,057.4	159	7.8	29.1	18.9	5.1
>1-2 years	7,827.4	62	3.7	13.6	15.6	4.2
3-5 years	15,048.1	82	7.2	26.4	10.2	2.8
6-10 years	10,569.5	48	5.1	18.8	8.4	2.3
Over 10 years	3,203.7	7	1.6	5.9	4.4	1.2
Unknown	4,011.4	36	1.9	7.1	17.2	4.6
Aggregate	57,717.5	394	27.3	100.9	13.2	3.6
45-54						
0-1 year	34,339.0	316	34.1	127.7	8.2	2.2
>1-2 years	16,932.0	151	16.8	62.7	7.7	2.1
3-5 years	42,369.0	260	43.3	159.6	5.2	1.4
6-10 years	39,552.6	164	41.9	153.5	3.2	0.9
Over 10 years	19,378.0	87	20.8	76.7	3.5	0.9
Unknown	15,529.8	111	16.4	60.8	5.8	1.6
Aggregate	168,100.4	1,089	173.3	641.0	5.4	1.5
55-64						
0-1 year	34,620.5	426	82.5	266.9	4.4	1.4
>1-2 years	14,159.4	152	34.3	109.0	3.7	1.2
3-5 years	39,519.4	357	95.1	302.4	2.9	0.9
6-10 years	46,429.3	327	112.1	355.3	2.3	0.7
Over 10 years	40,167.6	304	98.7	315.9	2.4	0.8
Unknown	26,894.4	268	66.6	212.9	3.3	1.0
Aggregate	201,790.6	1,834	489.3	1,562.4	3.0	1.0
65-75						
0-1 year	18,555.9	375	116.9	333.1	2.6	0.9
>1-2 years	7,397.4	130	47.6	133.8	2.2	0.8
3-5 years	20,373.5	341	131.7	369.2	2.1	0.8
6-10 years	22,472.2	343	146.1	406.7	1.8	0.7
Over 10 years	28,133.9	414	181.4	514.5	1.8	0.7
Unknown	21,947.5	377	147.0	410.9	2.0	0.7
Aggregate	118,880.4	1,980	770.7	2,168.2	2.1	0.7

showed a steady decrease as the time from diagnosis increased. Applicants with over 10 years since diagnosis and 3 or more nodes still had a relatively high mortality ratio as compared to those with fewer than 3 nodes involved.

Tables 7 and 8 summarize the mortality analysis by the number of non-breast cancer sites. These tables show that there was an increase in the mortality ratios as the number of non-breast cancer sites increased. If the number of non-breast cancer sites was 0, the

Table 3. Continued

Applicant Age/Time	Person Years of Exposure	All Deaths	Expected Deaths 2008VBT ^a	Expected Deaths 2010 US ^b	Mortality Ratio Average Qx ^c	Mortality Ratio Average Popx ^d
Total						
0-1 year	109,930.1	1,309	242.6	761.0	4.6	1.5
>1-2 years	48,355.3	504	102.9	320.7	4.2	1.3
3-5 years	120,076.9	1,052	278.0	859.8	3.1	1.0
6-10 years	120,405.0	883	305.5	935.4	2.3	0.8
Over 10 years	91,230.8	812	302.6	913.3	2.2	0.7
Unknown	69,308.2	795	232.1	692.4	2.8	0.9
Aggregate	559,306.3	5,355	1,463.7	4,482.6	3.0	1.0

Note:

^a The expected deaths based on the 2008VBT.

^b The expected deaths based on the US 2010 population.

^c The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^d The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

applicant had only breast cancer. If there were 1 or more sites, the applicant had cancer diagnosed in more than one part of their body.

Table 9 compares the relative mortality ratios using all deaths and the 2008VBT expected deaths for various applicant age and severity combinations to that of a 65-75 age group applicant having only localized cancer.

The applicants with 3 or more nodes or regional cancer involvement exhibited the highest relative mortality ratios. The younger cohorts had the highest relative mortality (eg, an applicant in the 25-34 age group with 3+ or more nodes, had 59.6 times the relative mortality of the baseline). Within the localized tumor cohort, the 55-64 age group had 1.4 times the baseline mortality ratio, the 45-54 age group had 2.1 times, and the 35-44 age group had 3.4 times. For those with 1-2 nodes involved, the applicants in the 35-44 age group had a mortality ratio 11.0 times the baseline, and those in the 45-54 age group had a mortality ratio 4.5 times the baseline.

Table 10 shows the relative mortality ratios with the 65-75 age group with over 10 years from breast cancer diagnosis as the baseline.

The relative mortality ratios increased as the cohort got younger. The range of the relative mortality ratios were 1.0 to 1.4 for applicants in the 65-75 age group; 1.3 to 2.4 for 55-64 age group; 1.8 to 4.6 for 45-54 age group; 2.4 to 10.5 in the 35-44 age group; and 1.7 to 14.3 in the 25-34 age group. For the most part, the smallest relative mortality ratios were for those with a longer time since breast cancer diagnosis.

Table 11 shows the relative mortality ratios for breast cancer severity and time from diagnosis compared to applicants that had localized cancer diagnosed over 10 years ago.

The younger applicants with more severe cancer had the largest relative mortality ratios compared to the baseline. The localized breast cancer relative mortality ratios were very close to unity for all times from diagnosis. The largest relative mortality ratio was in the group with 3 or more involved nodes, ranging from 1.8 to 12.1 times the baseline.

Table 4. Analysis by Applicant Age and Time Since Diagnosis for Definite Deaths

Applicant Age/Time	Definite Death Person Years of Exposure	Definite Deaths ^a	Expected Definite Deaths 2008VBT ^b	Expected Definite Deaths 2010 US ^c	Mortality Ratio Average Qx ^d	Mortality Ratio Average Popx ^e
25-34						
0-1 year	5,361.2	31	1.3	4.2	25.7	7.7
>1-2 years	2,039.1	9	0.5	1.6	18.8	5.6
3-5 years	2,768.8	11	0.7	2.2	17.5	5.2
6-10 years	1,381.4	1	0.3	1.1	3.1	0.9
Over 10 years	347.6	0	0.1	0.3	0.0	0.0
Unknown	925.1	3	0.2	0.7	13.5	4.0
Aggregate	12,823.2	55	3.1	10.1	18.8	5.6
35-44						
0-1 year	17,077.0	138	7.8	29.2	18.9	5.1
>1-2 years	7,848.2	53	3.7	13.6	15.6	4.2
3-5 years	15,062.2	64	7.2	26.4	10.2	2.8
6-10 years	10,588.2	39	5.2	18.9	8.4	2.3
Over 10 years	3,203.7	7	1.6	5.9	4.4	1.2
Unknown	4,020.1	30	1.9	7.1	17.2	4.6
Aggregate	57,799.4	331	27.4	101.1	13.2	3.6
45-54						
0-1 year	34,425.8	244	34.3	128.0	8.2	2.2
>1-2 years	16,986.4	107	16.9	62.9	7.7	2.1
3-5 years	42,449.0	187	43.3	159.9	5.2	1.4
6-10 years	39,613.8	108	42.0	153.7	3.2	0.9
Over 10 years	19,424.0	57	20.8	76.9	3.5	0.9
Unknown	15,557.6	80	16.5	60.9	5.8	1.6
Aggregate	168,456.6	783	173.8	642.3	5.4	1.5
55-64						
0-1 year	34,767.6	297	83.1	268.1	4.4	1.4
>1-2 years	14,209.3	103	34.5	109.4	3.7	1.2
3-5 years	39,676.9	202	95.7	303.5	2.9	0.9
6-10 years	46,611.4	183	112.5	356.6	2.3	0.7
Over 10 years	40,287.6	179	99.1	316.8	2.4	0.8
Unknown	26,995.0	175	67.0	213.8	3.3	1.0
Aggregate	202,547.8	1,139	492.2	1,568.2	3.0	1.0
65-75						
0-1 year	18,696.4	231	118.3	335.6	2.6	0.9
>1-2 years	7,449.5	81	48.2	134.7	2.2	0.8
3-5 years	20,493.8	214	113.0	371.4	2.1	0.8
6-10 years	22,604.3	199	147.5	409.1	1.8	0.7
Over 10 years	28,269.4	253	182.9	517.3	1.8	0.7
Unknown	22,083.8	224	148.5	413.5	2.0	0.7
Aggregate	119,597.2	1,202	778.4	2,181.6	2.1	0.7

DISCUSSION

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

Table 4. Continued

Applicant Age/Time	Definite Death Person Years of Exposure	Definite Deaths ^a	Expected Definite Deaths 2008VBT ^b	Expected Definite Deaths 2010 US ^c	Mortality Ratio Average Qx ^d	Mortality Ratio Average Popx ^e
Total						
0-1 year	110,328.0	941	244.8	765.1	4.6	1.5
>1-2 years	48,532.5	353	103.8	322.2	4.2	1.3
3-5 years	120,450.7	678	279.9	863.4	3.1	1.0
6-10 years	120,799.1	530	307.8	939.4	2.3	0.8
Over 10 years	91,532.3	496	304.5	917.2	2.2	0.7
Unknown	69,581.6	512	234.1	696.0	2.8	0.9
Aggregate	561,224.2	3,510	1,474.9	4,503.3	3.0	1.0

Note:

^a The number of deaths when removing the fuzzy date of birth matches.

^b Expected deaths based on the 2008VBT and removing the fuzzy date of birth matches.

^c Expected deaths based on the 2010 US population and removing the fuzzy date of birth matches.

^d The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^e The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

cohort. Therefore, the mortality ratios presented in this paper were lower than the true mortality ratio.

The statistic used to rate the breast cancer mortality severity was the relative mortality ratio based on a “benchmark” standard. For the most part the baseline condition chosen for those comparisons were those conditions having the lowest mortality ratio (Appendix A).

The relative mortality ratio for the younger applicants was extremely high, suggesting that the disease in the younger population when discovered was much more severe or suggest a different form of the disease. Even when taking severity into account, the localized breast cancer applicants that were in the 35-44 age group had 3.4 times the relative mortality ratio as the localized 65-75 age group applicants. As the cancer became more severe, these relative ratios dramatically increased.

To see how the cohort of insurance applicants compares 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.^{6,18,19}

The percentage of deaths by age group in the US population from 2009 to 2013 was:¹⁸

- 8.0% for age group 35-44
- 22.4% for age group 45-54
- 35.3% for age group 55-64
- 34.3% for age group 65-74

The corresponding percentage of deaths for the 35 to 75 age cohort in this paper were:

All Deaths

- 7.4% for age group 35-44
- 20.6% for age group 45-54
- 34.6% for age group 55-64
- 37.4% for age group 65-75

Definite Deaths

- 9.6% for age group 35-44
- 22.7% for age group 45-54
- 33.0% for age group 55-64
- 34.8% for age group 65-75

Table 5. Analysis by Cancer Severity and Time Since Diagnosis for All Deaths

Cancer Severity/ Time	Person Years of Exposure	All Deaths	Expected Deaths 2008VBT ^a	Expected Deaths 2010 US ^b	Mortality Ratio Average Qx ^c	Mortality Ratio Average Popx ^d
0-1 year						
Localized	27,588.0	193	72.6	223.9	2.1	0.7
1-2 nodes	5,533.9	82	11.9	37.9	5.9	1.9
3+ nodes	2,738.5	113	6.0	18.4	18.2	5.8
Other	13,828.5	36	17.7	59.2	1.4	0.4
Unknown	60,241.3	885	134.4	421.6	5.7	1.8
Aggregate	109,930.2	1,309	242.6	761.0	4.6	1.5
>1-2 years						
Localized	16,031.0	109	37.8	117.3	2.3	0.8
1-2 nodes	3,682.1	50	7.2	22.7	5.9	1.9
3+ nodes	1,349.7	34	2.5	8.0	12.2	3.8
Other	5,877.0	16	8.4	27.2	1.4	0.4
Unknown	21,415.5	295	47.0	145.4	5.4	1.7
Aggregate	48,355.3	504	102.9	320.6	4.2	1.3
3-5 years						
Localized	46,122.6	258	112.7	347.1	1.7	0.6
1-2 nodes	12,530.0	110	25.0	78.6	3.8	1.2
3+ nodes	4,949.5	90	10.0	31.3	8.1	2.6
Other	10,702.0	40	18.1	58.0	1.6	0.5
Unknown	45,772.8	554	112.2	344.7	4.1	1.3
Aggregate	120,076.9	1,052	278.0	859.7	3.1	1.0
6-10 years						
Localized	50,211.3	224	130.6	398.8	1.3	0.4
1-2 nodes	14,349.1	99	31.0	97.9	2.6	0.8
3+ nodes	6,292.4	70	14.1	43.3	4.3	1.4
Other	6,895.6	33	13.9	43.6	1.8	0.6
Unknown	42,656.7	457	115.9	351.8	3.2	1.1
Aggregate	120,405.1	883	305.5	935.4	2.3	0.8
Over 10 yrs						
Localized	28,044.7	164	89.9	272.7	1.5	0.5
1-2 nodes	7,077.5	56	19.9	61.3	2.2	0.7
3+ nodes	4,104.0	37	11.7	36.0	2.7	0.9
Other	3,429.4	21	8.0	25.4	2.1	0.7
Unknown	48,575.1	534	173.1	518.0	2.5	0.8
Aggregate	91,230.7	812	302.6	913.4	2.2	0.7
Unknown						
Localized	19,643.7	148	69.0	204.3	1.7	0.6
1-2 nodes	4,482.1	44	13.2	40.0	2.8	0.9
3+ nodes	1,989.0	42	5.8	17.9	6.2	2.0
Other	4,670.5	20	10.2	32.1	1.3	0.4
Unknown	38,522.8	541	133.9	398.2	3.3	1.1
Aggregate	69,308.1	795	232.1	692.5	2.8	0.9

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

The 5-year survival rates by cancer severity were approximately 99% for localized breast

cancer; approximately 85% for regional breast cancer; and approximately 25% for distant cancer. Using the localized 5-year survival rates as a basis, the regional breast cancer mortality was 1.2 times more than localized

Table 5. Continued

Cancer Severity/ Time	Person Years of Exposure	All Deaths	Expected Deaths 2008VBT ^a	Expected Deaths 2010 US ^b	Mortality Ratio Average Qx ^c	Mortality Ratio Average Popx ^d
Total						
Localized	187,641.3	1,096	512.6	1,564.1	1.7	0.5
1-2 nodes	47,654.7	441	108.2	338.4	3.4	1.1
3+ nodes	21,423.1	386	50.1	154.9	6.9	2.2
Other	45,403.0	166	76.3	245.5	1.6	0.5
Unknown	257,184.2	3,266	716.5	2,179.7	3.8	1.3
Aggregate	559,306.3	5,355	1,463.7	4,482.6	3.0	1.0

Note:

^a The expected deaths based on the 2008VBT.

^b The expected deaths based on the US 2010 population.

^c The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^d The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

breast cancer and distant cancer was 4.0 times that of localized breast cancer.^{6,18} Using 1-2 nodes as described in this paper for regional, and 3 or more nodes for distant, the cumulative 5-year mortality relative ratios from localized were 2.5 times for 1-2 nodes and 5.4 times for 3 or more nodes.

The percentage of cases of breast cancer by severity in the US general population was 61.0% localized, 31% regional, 6% distant and 2% unstaged from 2006 to 2012.^{18,19} The percentages for 2015 were 60% localized, 33% regional, 5% distant and 2% unstaged. The percentage of cases in this study where the severity of breast cancer was known was 73% localized; 19% for 1-2 nodes; and 8% for 3 or more nodes.

Time from breast cancer diagnosis in combination with MIB applicant age showed a strong association. For each time-from-diagnosis, the relative mortality ratios by age steadily increased as the age groups got younger. The increase from the oldest to the 35-44 age group over the baseline condition of 65-75 age group and over 10 years since diagnosis was 2.4 for those over 10 years from diagnosis; 4.7 times for 6-10 years; 5.7 for 3-5 years since diagnosis; 8.7 times for the 1-2

years; and 10.5 times for the most recently diagnosed breast cancer cases.

Relative mortality ratios were dramatic when comparing time from diagnosis to the number of cancer nodes. The ratios for those with 3 or more nodes was very large, especially for those 5 years and under from the time of diagnosis (5.4 to 12.1 times the baseline). The 1-2 nodes with cancer also had relative mortality ratios from 1.5 times the baseline for over 10 years since diagnosis to 3.9 times for those diagnosed within the last year before application. The localized cancer applicants were consistently at or below 1.5 times the baseline no matter the time from diagnosis.

The number of non-breast cancer sites had an impact on the relative mortality ratios. The overall relative ratio was 4.1 times those with 2 or more sites compared to those with breast cancer being the only cancer.

CONCLUSION

This paper was an all-cause mortality study of insurance applicants who were diagnosed with breast cancer. The mortality patterns of

Table 6. Analysis by Cancer Severity and Time Since Diagnosis for Definite Deaths

Cancer Severity/ Time	Definite Death Person Years of Exposure	Definite Deaths ^a	Expected Definite Deaths 2008VBT ^b	Expected Definite Deaths 2010 US ^c	Mortality Ratio Average Qx ^d	Mortality Ratio Average Popx ^e
0-1 year						
Localized	27,655.9	117	73.1	224.6	2.1	0.7
1-2 nodes	5,545.3	60	12.0	38.0	5.9	1.9
3+ nodes	2,762.2	99	5.8	18.5	18.2	5.8
Other	13,850.2	14	17.9	59.5	1.4	0.4
Unknown	60,514.7	651	136.0	424.4	5.7	1.8
Aggregate	110,328.3	941	244.8	765.0	4.6	1.5
>1-2 years						
Localized	16,081.0	69	38.1	117.7	2.3	0.8
1-2 nodes	3,696.1	36	7.3	22.9	5.9	1.9
3+ nodes	1,356.8	27	2.5	8.1	12.2	3.8
Other	5,900.0	8	8.4	27.4	1.4	0.4
Unknown	21,498.6	213	47.5	146.1	5.4	1.7
Aggregate	48,532.5	353	103.8	322.2	4.2	1.3
3-5 years						
Localized	46,231.3	132	113.1	348.1	1.7	0.6
1-2 nodes	12,548.8	82	25.1	78.8	3.8	1.2
3+ nodes	4,973.1	74	10.1	31.5	8.1	2.6
Other	10,732.7	18	18.3	58.3	1.6	0.5
Unknown	45,964.8	372	113.3	346.8	4.1	1.3
Aggregate	120,450.7	678	279.9	863.5	3.1	1.0
6-10 yrs						
Localized	50,328.1	114	131.2	400.1	1.3	0.4
1-2 nodes	14,392.3	62	31.3	98.2	2.6	0.8
3+ nodes	6,319.2	52	14.3	43.5	4.3	1.4
Other	6,912.6	17	14.0	43.8	1.8	0.6
Unknown	42,846.8	285	117.0	353.8	3.2	1.1
Aggregate	120,799.0	530	307.8	939.4	2.3	0.8
Over10 years						
Localized	28,105.2	98	90.2	273.3	1.5	0.5
1-2 nodes	7,093.8	33	19.9	61.4	2.2	0.7
3+ nodes	4,114.4	27	11.8	36.0	2.7	0.9
Other	3,434.3	13	8.0	25.4	2.1	0.7
Unknown	48,784.5	325	174.6	521.1	2.5	0.8
Aggregate	91,532.2	496	304.5	917.2	2.2	0.7
Unknown						
Localized	19,695.9	88	69.4	205.0	1.7	0.6
1-2 nodes	4,491.9	30	13.2	40.1	2.8	0.9
3+ nodes	2,002.2	31	6.0	18.1	6.2	2.0
Other	4,688.4	7	10.4	32.3	1.3	0.4
Unknown	38,703.1	356	135.1	400.5	3.3	1.1
Aggregate	69,581.5	512	234.1	696.0	2.8	0.9
Total						
Localized	188,097.4	618	515.1	1,568.8	1.7	0.5
1-2 nodes	47,768.2	303	108.8	339.4	3.4	1.1
3+ nodes	21,527.9	310	50.5	155.7	6.9	2.2
Other	45,518.2	77	77.0	246.7	1.6	0.5
Unknown	258,312.5	2,202	723.5	2,192.7	3.8	1.3

Table 6. Continued

Cancer Severity/ Time	Definite Death Person Years of Exposure	Definite Deaths ^a	Expected Definite Deaths 2008VBT ^b	Expected Definite Deaths 2010 US ^c	Mortality Ratio Average Qx ^d	Mortality Ratio Average Popx ^e
Aggregate	561,224.2	3,510	1,474.9	4,503.3	3.0	1.0

Note:

^a The number of deaths when removing the fuzzy date of birth matches.

^b Expected deaths based on the 2008VBT and removing the fuzzy date of birth matches.

^c Expected deaths based on the 2010 US population and removing the fuzzy date of birth matches.

^d The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^e The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

insurance applicants with breast cancer was 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 changes in mortality.

APPENDIX A

Process Used to Calculate Relative Mortality Ratios

The US 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 re-

cent deaths. If the recent death is discovered from another death registry, then the SSMDF can be used to verify the information for that death.¹³

The applicant records were first searched against the Social Security Death Master File (SSDMF). To more accurately confirm all possible deaths, 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 1 database to be included in the study.

The authors attempted to estimate the recent deaths from only the SSDMF, but were

Table 7. Analysis by Number of Non-Breast Cancer Sites for All Deaths

Number of non-Breast Cancer Sites	Person Years of Exposure	All Deaths	Expected Deaths 2008VBT ^a	Expected Deaths 2010 US ^b	Mortality Ratio Average Qx ^c	Mortality Ratio Average Popx ^d
0	527,045.7	4,862	1,358.5	4,166.8	2.9	1.0
1	30,230.8	455	98.3	295.2	3.9	1.3
2+	2,029.8	38	6.8	20.6	4.9	1.6
Total	559,306.3	5,355	1,463.6	4,482.6	3.0	1.0

Note:

^a The expected deaths based on the 2008VBT.

^b The expected deaths based on the US 2010 population.

^c The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^d The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

Table 8. Analysis by Number of Non-Breast Cancer Sites for Definite Deaths

Number of non-Breast Cancer Sites	Definite Death Person Years of Exposure	Definite Deaths ^a	Expected Definite Deaths 2008VBT ^b	Expected Definite Deaths 2010 US ^c	Mortality Ratio Average Qx ^d	Mortality Ratio Average Popx ^e
0	528,822.1	3,159	1,368.7	4,185.7	2.9	1.0
1	30,369.4	321	99.2	296.9	3.9	1.3
2+	2,032.7	30	6.9	20.7	4.9	1.6
Total	561,224.2	3,510	1,474.8	4,503.3	3.0	1.0

Note:

^a The number of deaths when removing the fuzzy date of birth matches.

^b Expected deaths based on the 2008VBT and removing the fuzzy date of birth matches.

^c Expected deaths based on the 2010 US population and removing the fuzzy date of birth matches.

^d The average of the A/E ratios using all deaths and definite deaths based on the 2008VBT.

^e The average of the A/E ratios using all the deaths and definite deaths based on the 2010 US population.

unable to derive a reliable method without introducing considerable bias. Therefore, any deaths that could have been identified only on the SSDMF after February 10, 2012, were never used.

Table 9. Relative Mortality Ratios from the 65-75 Localized Condition

Severity/ Applicant Age	Mortality Ratio Average Qx	Relative Mortality Ratio
Localized		
25-34	17.7	13.6
35-44	4.4	3.4
45-54	2.7	2.1
55-64	1.8	1.4
65-75 (baseline)	1.3	1.0
1-2 nodes		
25-34	52.6	40.5
35-44	14.3	11.0
45-54	5.8	4.5
55-64	3.2	2.5
65-75	2.0	1.5
3+ nodes		
25-34	77.5	59.6
35-44	38.1	29.3
45-54	15.1	11.6
55-64	6.5	5.0
65-75	2.5	1.9

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 35-44 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 the ratio comparisons were consistent, regardless of the actual ratio. They called this phenomenon mortality gradients.¹⁷

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 1.

The 3 baseline conditions chosen were:

- 1) 65-75 age group with localized nodal involvement (Table 9)
- 2) 65-75 age group being diagnosed with breast cancer over 10 years ago (Table 10)

Table 10. Relative Mortality Ratios from the 65-75 Over 10 Years Condition

Time Since Diagnosis/Age	Mortality Ratio Average Qx	Relative Mortality Ratio
0–1 year		
25–34	25.7	14.3
35–44	18.9	10.5
45–54	8.2	4.6
55–64	4.4	2.4
65–75	2.6	1.4
>1–2 years		
25–34	18.8	10.4
35–44	15.6	8.7
45–54	7.7	4.3
55–64	3.7	2.1
65–75	2.2	1.2
3–5 years		
25–34	17.5	9.7
35–44	10.2	5.7
45–54	5.2	2.9
55–64	2.9	1.6
65–75	2.1	1.2
6–10 years		
25–34	3.1	1.7
35–44	8.4	4.7
44–54	3.2	1.8
54–64	2.3	1.3
65–75	1.8	1.0
Over 10 years		
25–34	0.0	0.0
35–44	4.4	2.4
45–54	3.5	1.9
55–64	2.4	1.3
65–75 (baseline)	1.8	1.0

3) Cases with local nodal involvement being diagnosed over 10 years ago (Table 11)

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 5.2 to 1.8 ($5.2/1.8 = 2.9$). Similarly, the 12.1 relative mortality ratio seen for 2 or more nodes along with 0–1 year since diagnosis was calculated by taking the 18.2 from the 1.5, to get 12.1.

Table 11. Relative Mortality Ratios from the Localized to Over 10 Years Condition

Time Since Diagnosis /Severity	Mortality Ratio Average Qx	Relative Mortality Ratio
0–1 year		
Localized	2.1	1.4
1–2 nodes	5.9	3.9
3+ nodes	18.2	12.1
>1–2 years		
Localized	2.3	1.5
1–2 nodes	5.9	3.9
3+ nodes	12.2	8.1
3–5 years		
Localized	1.7	1.1
1–2 nodes	3.8	2.5
3+ nodes	8.1	5.4
6–10 years		
Localized	1.3	0.9
1–2 nodes	2.6	1.7
3+ nodes	4.3	2.9
Over 10 years		
Localized (baseline)	1.5	1.0
1–2 nodes	2.2	1.5
3+ nodes	2.7	1.8

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