JOURNAL OF INSURANCE MEDICINE

J Insur Med 2018;47:159–171

MRAC
Mortality Risk Analysis Committee

MORTALITY

All-Cause Mortality for Life Insurance Applicants with a Family History of Coronary Artery Disease Before 60

Stephen A. Freitas, FLMI, ACS; Ross MacKenzie, MD FRCP(C), FACC, FAAIM; David N. Wylde, FSA, MAAA; Jason Von Bergen, FSA, MAAA; J. Carl Holowaty, MD; Margaret Beckman, FALU, FLMI; Steven J. Rigatti, MD; Stacy Gill

Objective.—To determine the all-cause mortality of life insurance applicants having a family history of coronary artery disease (CAD) before age 60.

Background.—Epidemiological studies have shown that a family history of premature CAD is an independent risk factor for CAD events. The strength of the association between family history and CAD is greatest with earlier age of presentation of CAD in the family member and when multiple family members are affected. Despite earlier insurance studies on this relationship, there is sparse current data on the association between family history of CAD and all-cause mortality in life insurance applicants.

Methodology.—Life insurance applicants with reported family history of Coronary Artery Disease (CAD) were extracted from data covering United States residents between October 2009 and October 2016. Information about these applicants was matched to the Social Security Death Master (SSDMF) file for deaths occurring from 2009 to 2012 and to another commercially available death source file (Other Death Source, ODS) for deaths occurring from 2009 to 2016 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). All expected bases were not smoker distinct. Confidence bands around these mortality ratios were calculated. The variables of interest were applicant age, gender, number of family members with CAD before age 60, and the presence of cardiac or cardiovascular conditions.

Results.—Overall, the mortality of applicants with family members with a history of CAD before age 60 was slightly lower than expected mortality based on the 2015 VBT. Applicants with a cardiac or cardiovascular comorbid condition had a significantly higher mortality ratio. For applicants aged 25-54 and 65-75 with cardiac comorbid conditions, the mortality ratio was 2 times that of those without a cardiac comorbid condition. For those aged 55-64 with cardiovascular comorbid conditions, the mortality ratio was 2.9 times that of those without a cardiovascular comorbid condition. Females had a slightly higher mortality ratio for all age groups, number of family members with CAD before age 60, and cardiovascular conditions.

Conclusion.—A family history of CAD before the age of 60 in an insurance applicant may be associated with increased all-cause mortality. Overall in this study, life insurance applicants had a mortality

Address of Correspondent: MIB, Inc., 50 Braintree Hill Park, Suite 400, Braintree, MA 02184-8734; SFreitas@mib.com.

Correspondent: Stephen A. Freitas, FLMI, ACS; Senior Statistician, Actuarial and Statistical Group, MIB Solutions.

Key words: Family history, premature coronary artery disease, mortality, prognosis, risk factors, insurance population.

Received: November 21, 2017

Accepted: January 11, 2018

slightly lower than the expected mortality based on the 2015 VBT. However, applicants with a positive family history and a cardiac or cardiovascular comorbid condition had a significantly higher mortality ratio.

Coronary artery disease (CAD) is a leading cause of death and disability in developed countries.[1,2] Despite subsequent improved mortality from CAD in these countries, the disease is still the most important impairment affecting life insurance practice today.

It has been known for many years that CAD aggregates in families.[3-9] Family history, as a risk factor, represents genetic, environmental, and behavioral elements, and the interactions between them.[10,11] Well-established risk factors for CAD include age, sex, smoking, hypertension, diabetes mellitus, obesity and dyslipidemia. Family history of CAD is often considered a surrogate for these traditional coronary risk factors as well as other biochemical and genetic markers.[12]

The contribution of a positive family history independent of these other risk factors has been debated, since most of the traditional risk factors are also known to aggregate in families.[3] More recently, a number of prospective studies have demonstrated that a family history of CAD is a risk factor independent of these traditional risk factors.[13-15] Although definitions vary, the strength of the association between family history and CAD is greatest with earlier age of presentation of CHD in the family member and when multiple family members are affected.

The effect of a family history of heart disease on mortality has also been demonstrated in several life insurance industry studies carried out between 1951 and 1983. Depending on the definition of family history, mortality ratios of actual to expected deaths ranged from 1.40 to 1.88 in applicants rated as standard risks.[16-19] As a result, the occurrence of CAD in the immediate family of a life insurance applicant is of prime importance; the younger the age of occurrence the greater the significance. This applies not only to risk selection for traditional life insurance policies but also for newer versions such as critical illness insurance and decisions about preferred rates for applicants in optimal health. Thus, when applying for a life insurance policy, the applicant is asked questions about their family's medical history. Usually the questions are limited to parents and siblings who may have suffered certain diseases (including CAD) under the age of 60.

The purpose of this study was to determine the all-cause mortality of life insurance applicants who reported a family history (family history being defined as a parent or sibling) of CAD occurring under the age of 60. 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.[20]

METHODOLOGY

Data Source

The data used for this study was 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.[21]

Study Participants

The sample used for this study represented all the MIB member companies' applicants from the United States who applied for life insurance from over 7 years and had family members with coronary artery disease before the age of 60. It represents approximately 739,423 person-years of exposure and between 821 and 998 deaths, depending on the method of death record matching.

Variables

The variables considered for this study were applicant age, gender, the number of family members (family member defined as a parent or sibling) with CAD before age 60, the presence of cardiac conditions, and the presence of cardiovascular conditions.

The groups for applicant age were:

- 25 – 54
- 55 – 64
- 65 – 75

Gender was defined as:

- Female
- Male
- Unknown

Number of family members with CAD before age 60:

- One
- More than one

Presence of Cardiac Conditions was defined (as per MIB coding) as an applicant having:

- Myocardial infarction, no surgery
- Coronary artery disease or myocardial infarction, with surgery
- Cardiomyopathy

Presence of Cardiovascular Conditions was defined (as per MIB coding) as an applicant having:

- Cerebrovascular disorder, accident or insufficiency
- Peripheral vascular disease or disorder

Data Collection

The life insurance 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.[22] 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 many 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.

Statistical Methods

The Society of Actuaries 2015 Valuation Basic Table (VBT) select and ultimate (age last birthday), female, male composite was used to form the expected deaths for this study.[23] The average between the mortality ratios based on all deaths or definite deaths using the 2015VBT as an expected basis was presented in this paper.

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.

The calculation of exposure was defined as the time in years from the first report of

Table 1. Summary of Life Insurance Applicants with a Family Member with CAD Before 60

Condition	Value	Person Years Exposure	Average Deaths
Applicant Age	25 – 54	530,417.91	368.5
	55 – 64	172,416.30	370.5
	65 – 75	36,588.51	170.5
Gender	Female	113,743.29	71.0
	Male	138,237.04	142.0
	Unknown	487,442.39	696.5
Number of Family Members	One	649,847.13	754.0
	More than One	89,575.59	155.5
Presence of Cardiac Condition	None	710,761.09	801.0
	Present	28,661.63	108.5
Presence of Cardiovascular	None	732,198.01	877.5
	Present	7,224.71	32.0
Aggregate		739,422.72	909.5

Note. Average deaths was the midpoint between All Deaths and Definite Deaths.

family history of CAD before age 60 to the MIB database until October 18, 2016. 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.

Confidence bands at the 95% level are calculated on the mortality ratios, to determine if any condition examined is significantly different than any other. The method used is based on that proposed by Singer in the 5th ed of *Brackenridge's Medical Selection of Life Risks*.[24]

RESULTS

Baseline Characteristics

A summary of the study cohort is presented in Table 1.

There were 739,422.72 person-years of exposure. Regarding exposure, 71.7% of the exposure was found in the 25 to 54 age cohort, but this group only accounted for 40.5% of the deaths.

For gender, most the applicants (65.9% of person-years exposure) were of unknown gender with 15.4% female and 18.7% male. The majority with 87.9% of the applicants had only one family member with CAD. In terms of cardiac conditions, 3.9% of the applicants had a cardiac condition and 1.0% had a cardiovascular condition.

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.

Mortality Analysis by Applicant Age and Gender

The mortality analysis by applicant age and gender is summarized in Table 2.

The female mortality ratios were consistently slightly higher than the males. The differences though were not statistically significant. The mortality ratio was slightly higher for the younger aged applicants.

Table 2. Applicant Age by Gender

Applicant Age	Gender	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
25 – 54	Female	84,487.73	38	29	38.86	0.86	0.59	1.21
	Male	97,810.87	69	55	78.43	0.79	0.61	1.01
	Unknown	348,119.31	311	235	307.49	0.89	0.78	0.99
	Aggregate	530,417.91	418	319	424.78	0.87	0.78	0.96
55 – 64	Female	23,457.60	23	19	37.09	0.57	0.35	0.87
	Male	33,385.46	55	49	96.84	0.54	0.40	0.70
	Unknown	115,573.24	326	269	368.05	0.81	0.72	0.90
	Aggregate	172,416.30	404	337	501.98	0.74	0.66	0.81
65 – 75	Female	5,797.96	17	16	20.04	0.82	0.47	1.33
	Male	7,040.71	29	27	38.05	0.74	0.49	1.06
	Unknown	23,749.84	130	122	154.44	0.82	0.67	0.96
	Aggregate	36,588.51	176	165	212.53	0.80	0.68	0.92
Total	Female	113,743.29	78	64	95.99	0.74	0.58	0.93
	Male	138,237.04	153	131	213.32	0.67	0.56	0.78
	Unknown	487,442.39	767	626	829.98	0.84	0.78	0.90
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The confidence limits are at the 95% level.

Applicant Age by Number of Family Members with CAD before Age 60

Applicant age by number of family members with CAD before age 60 is summarized on Table 3.

Most of the person-years exposure (87.9%) was found in those applicants with only one family member with CAD before age 60. There was not much appreciable difference in the mortality ratios across all the categories. The category with the best mortality ratio was 0.71 and the highest 0.96. None of these small differences were significant.

Applicant Age by the Presence of Cardiac Conditions

Table 4 has a summary of applicant age by the presence of cardiac conditions. The cardiac conditions are myocardial infarction, no surgery; coronary artery disease or myocardial infarction, with surgery; and cardiomyopathy (as per MIB coding).

Even though those applicants with a cardiac condition consisted of only 3.9% of all the person-years exposure, they had a significantly higher mortality ratio than those without this condition. Overall, the mortality ratios of the cardiac condition applicants were 1.7 times those without the condition. For ages 25-54 and 65-75, the mortality ratios for the cardiac applicants were double those of the non-cardiac group.

Applicant Age by the Presence of Cardiovascular Conditions

Applicant age by the presence of cardiovascular conditions is found on Table 5. A cardiovascular applicant was one who had a cerebrovascular disorder, accident or insufficiency or peripheral vascular disease or disorder (as per MIB coding).

Table 3. Applicant Age by Number of Family Members with CAD Before 60

Applicant Age	Number of Family Members	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
25 – 54	One	474,677.56	365	272	372.78	0.85	0.76	0.95
	More than one	55,740.35	53	47	52.00	0.96	0.71	1.27
	Aggregate	530,417.91	418	319	424.78	0.87	0.78	0.96
55 – 64	One	145,321.48	324	272	422.12	0.71	0.63	0.79
	More than one	27,094.82	80	65	79.86	0.91	0.71	1.14
	Aggregate	172,416.30	404	337	501.98	0.74	0.66	0.81
65 – 75	One	29,848.09	141	134	172.61	0.80	0.66	0.93
	More than one	6,740.42	35	31	39.92	0.83	0.57	1.16
	Aggregate	36,588.51	176	165	212.53	0.80	0.68	0.92
Total	One	649,847.13	830	678	967.51	0.78	0.72	0.83
	More than one	89,575.59	168	143	171.78	0.91	0.76	1.05
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The confidence limits are at the 95% level.

Applicants with a cardiovascular disorder only had 1% of all the person-years exposure, but overall had 2.0 times the mortality ratio as those that did not have this disorder. The difference increased for those 55 to 64 to 2.9 times the mortality ratio. Both differences were statistically significant.

Table 4. Applicant Age by Presence of Cardiac Conditions

Applicant Age	Presence of Cardiac Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
25 – 54	None	519,203.20	393	298	411.07	0.84	0.75	0.93
	Present	11,214.71	25	21	13.71	1.68	1.06	2.52
	Aggregate	530,417.91	418	319	424.78	0.87	0.78	0.96
55 – 64	None	159,947.99	359	300	460.69	0.72	0.64	0.79
	Present	12,468.31	45	37	41.29	0.99	0.71	1.35
	Aggregate	172,416.30	404	337	501.98	0.74	0.66	0.81
65 – 75	None	31,609.90	130	122	181.24	0.70	0.57	0.82
	Present	4,978.61	46	43	31.29	1.42	1.04	1.91
	Aggregate	36,588.51	176	165	212.53	0.80	0.68	0.92
Total	None	710,761.09	882	720	1,053.00	0.76	0.71	0.81
	Present	28,661.63	116	101	86.29	1.26	1.02	1.49
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The cardiac conditions can be one or more of the following: myocardial infarction, no surgery; coronary artery disease or myocardial infarction, with surgery; or cardiomyopathy.

Table 5. Applicant Age by Presence of Cardiovascular Conditions

Applicant Age	Presence of Cardiovascular Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
25 – 54	None	527,453.09	416	317	421.57	0.87	0.78	0.96
	Present	2,964.82	2	2	3.21	0.62	-	-
	Aggregate	530,417.91	418	319	424.78	0.87	0.78	0.96
55 – 64	None	169,429.36	384	317	492.43	0.71	0.64	0.79
	Present	2,986.94	20	20	9.55	2.09	1.28	3.24
	Aggregate	172,416.30	404	337	501.98	0.74	0.66	0.81
65 – 75	None	35,315.56	166	155	204.82	0.78	0.66	0.90
	Present	1,272.95	10	10	7.71	1.30	0.62	2.39
	Aggregate	36,588.51	176	165	212.53	0.80	0.68	0.92
Total	None	732,198.01	966	789	1,118.82	0.78	0.73	0.84
	Present	7,224.71	32	32	20.47	1.56	1.07	2.21
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The cardiovascular conditions can be one or more of the following: cerebrovascular disorder, accident or insufficiency; or peripheral vascular disease or disorder.

Gender by Number of Family Members with CAD before Age 60

Table 6 summarizes gender by number of family members with CAD before age 60. Even though the female applicants had a higher mortality ratio than the males for those with more than one family member, it was not that much higher. This could be due to the low number of deaths in these groups.

Gender and the Presence of a Cardiac Condition

Table 7 has a summary of life insurance applicants by gender and the presence of a cardiac condition. For both males and unknown gender, the presence of a cardiac condition had a dramatic effect on the mortality ratios. The mortality ratios for males were around 1.9 times for the cardiac applicants vs those applicants without a cardiac condition and 1.6 for unknown gender.

Gender and the Presence of Cardiovascular Conditions

Gender by cardiovascular conditions is summarized on Table 8. Even though applicants with cardiovascular conditions had much higher mortality ratios, the number of deaths were so small making the 95% confidence intervals very large.

Number of Family Members with CAD before 60 by Presence of Cardiac Conditions

Table 9 shows the number of family members with CAD before 60 by the presence of cardiac conditions. When there was one family member with CAD before 60, the cardiac applicants had a 1.5 times mortality ratio over those that do not have a cardiac condition. This increased to 1.9 times for those applicants having more than 1 family member with CAD before the age of 60.

Number of Family Members with CAD before 60 by Presence of Cardiovascular Conditions

Cardiovascular applicants by number of family members with CAD before 60 is summarized on Table 10. Those cardiovascular applicants with one family member with CAD before age 60 had a mortality ratio 2.0 times

Table 6. Gender by Number of Family Members with CAD before 60

Gender	Number of Family Members	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
Female	One	97,448.19	55	42	78.75	0.62	0.45	0.82
	More than one	16,295.10	23	22	17.24	1.31	0.82	1.97
	Aggregate	113,743.29	78	64	95.99	0.74	0.58	0.93
Male	One	121,377.60	127	109	180.09	0.66	0.54	0.77
	More than one	16,859.44	26	22	33.23	0.72	0.46	1.07
	Aggregate	138,237.04	153	131	213.32	0.67	0.56	0.78
Unknown	One	431,021.34	648	527	708.67	0.83	0.76	0.90
	More than one	56,421.05	119	99	121.31	0.90	0.73	1.07
	Aggregate	487,442.39	767	626	829.98	0.84	0.78	0.90
Total	One	649,847.13	830	678	967.51	0.78	0.72	0.83
	More than one	89,575.59	168	143	171.78	0.91	0.76	1.05
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

that of those who were not cardiovascular applicants. A similar result was found in those with more than one family member with CAD before 60, but the number of deaths was too small to attach any significance to this event.

DISCUSSION

This life insurance-based population study focuses on all-cause mortality for insurance applicants who had a family member (family member defined as parent or sibling) with

Table 7. Gender by Presence of Cardiac Conditions

Gender	Presence of Cardiac Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
Female	None	111,860.19	74	61	92.44	0.73	0.57	0.93
	Present	1,883.10	4	3	3.55	0.99	0.23	2.68
	Aggregate	113,743.29	78	64	95.99	0.74	0.58	0.93
Male	None	129,590.43	122	104	188.38	0.60	0.49	0.71
	Present	8,646.61	31	27	24.94	1.16	0.78	1.67
	Aggregate	138,237.04	153	131	213.32	0.67	0.56	0.78
Unknown	None	469,310.47	686	555	772.18	0.80	0.74	0.87
	Present	18,131.92	81	71	57.80	1.31	1.04	1.65
	Aggregate	487,442.39	767	626	829.98	0.84	0.78	0.90
Total	None	710,761.09	882	720	1,053.00	0.76	0.71	0.81
	Present	28,661.63	116	101	86.29	1.26	1.02	1.49
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The cardiac conditions can be one or more of the following: myocardial infarction, no surgery; coronary artery disease or myocardial infarction, with surgery; or cardiomyopathy.

Table 8. Gender by Presence of Cardiovascular Conditions

Gender	Presence of Cardiovascular Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
Female	None	112,565.92	74	60	93.95	0.71	0.55	0.91
	Present	1,177.37	4	4	2.04	1.96	0.54	5.00
	Aggregate	113,743.29	78	64	95.99	0.74	0.58	0.93
Male	None	136,710.68	150	128	209.03	0.66	0.55	0.78
	Present	1,526.36	3	3	4.29	0.70	0.14	2.05
	Aggregate	138,237.04	153	131	213.32	0.67	0.56	0.78
Unknown	None	482,921.41	742	601	815.84	0.82	0.76	0.89
	Present	4,520.98	25	25	14.14	1.77	1.15	2.61
	Aggregate	487,442.39	767	626	829.98	0.84	0.78	0.90
Total	None	732,198.01	966	789	1,118.82	0.78	0.73	0.84
	Present	7,224.71	32	32	20.47	1.56	1.07	2.21
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The cardiovascular conditions can be one or more of the following: cerebrovascular disorder, accident or insufficiency; or peripheral vascular disease or disorder.

coronary artery disease before age 60. The main results of the study indicate that even though there were conditions where mortality ratios were different, overall mortality of applicants with family members with a history of CAD before age 60 was slightly lower than expected mortality based on the 2015 VBT.

Most of the person-years of exposure (87.9%) was found in applicants with only 1 family member with CAD before age 60. Female mortality ratios were consistently higher than those of males, but the differences were not statistically significant. Mortality ratios were slightly higher for younger aged

Table 9. Number of Family Members with CAD before 60 by Presence of Cardiac Conditions

Number of Family Members	Presence of Cardiac Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
One	None	629,068.78	753	611	905.27	0.75	0.70	0.81
	Present	20,778.35	77	67	62.24	1.16	0.91	1.46
	Aggregate	649,847.13	830	678	967.51	0.78	0.72	0.83
More than one	None	81,692.31	129	109	147.73	0.81	0.66	0.95
	Present	7,883.28	39	34	24.05	1.52	1.06	2.10
	Aggregate	89,575.59	168	143	171.78	0.91	0.76	1.05
Total	None	710,761.09	882	720	1,053.00	0.76	0.71	0.81
	Present	28,661.63	116	101	86.29	1.26	1.02	1.49
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The cardiac conditions can be one or more of the following: myocardial infarction, no surgery; coronary artery disease or myocardial infarction, with surgery; or cardiomyopathy.

Table 10. Number of Family Members with CAD before 60 by Presence of Cardiovascular Conditions

Number of Family Members	Presence of Cardiovascular Conditions	Person Years Exposure	All Deaths	Definite Deaths	Expected 2015 VBT	Mortality Ratio Qx	Lower Bound	Upper Bound
One	None	644,198.39	805	653	951.63	0.77	0.71	0.82
	Present	5,648.74	25	25	15.88	1.57	1.02	2.32
	Aggregate	649,847.13	830	678	967.51	0.78	0.72	0.83
More than one	None	87,999.62	161	136	167.19	0.89	0.75	1.03
	Present	1,575.97	7	7	4.59	1.53	0.61	3.14
	Aggregate	89,575.59	168	143	171.78	0.91	0.76	1.05
Total	None	732,198.01	966	789	1,118.82	0.78	0.73	0.84
	Present	7,224.71	32	32	20.47	1.56	1.07	2.21
	Aggregate	739,422.72	998	821	1,139.29	0.80	0.75	0.85

Note. The cardiovascular conditions can be one or more of the following: cerebrovascular disorder, accident or insufficiency; or peripheral vascular disease or disorder.

applicants. Applicants with cardiac conditions (as defined by MIB coding) had a significantly higher mortality ratio (overall 1.7), but this added risk factor was infrequent in the study population (3.9% of all the person-years of exposure). Similarly, applicants with cardiovascular disorders (as defined by MIB coding) had significantly higher mortality ratios (overall 2.0) but, again the prevalence of this additional risk factor was low (1% of all person-years of exposure). Having more than 1 family member with CAD before age 60 further increased the mortality ratios to 1.7 in those applicants with cardiac conditions (as defined by MIB coding).

Assessing the family medical history of a life insurance applicant has been a traditional risk assessment tool for many years. The effect of a family history of heart disease on mortality had previously been demonstrated in several life insurance industry studies carried out between 1951 and 1983. In the insurance industry's *1951 Impairment Study*, the bulk of experience was in the standard risk section which consisted of 11,600 insured lives, all of whom had a history of 2 or more deaths in the immediate family from cardiovascular-renal diseases under the age of 60. The mortality ratio of actual to expected deaths was 1.4.[17] This experience was confirmed with almost identical figures in the industry's *Build and Blood Pressure Study* in 1959.[18] Further confirmation of the importance of a family history of cardiovascular disease (two or more cases of cardiovascular disease among natural parents and siblings under age 60) came in the 1983 *Medical Impairment Study*.[19] The results of the study showed a surprisingly high mortality ratio of 1.88 in the standard classification and those in the slightly rated category also showed excessive mortality at 2.26. The breakdown by sex for the standard risk category indicated that women had considerably lower mortality than men (1.27 vs 1.88). Comparison of the current study with these earlier industry studies is problematic given the difference in family history definitions and data sources.

The definition of what constitutes a family history of CAD has also been variable in clinical studies.[25] However, there is general agreement that the occurrence of CAD in a first-degree relative (ie, parent or sibling) prior to age 55 (males) or 65 (females) denotes a significant family history. The importance of family history has been confirmed in several large cohort studies (Physician's Health Study[12], Women's Health Study[12], Reykjavik Cohort Study[3], Framingham Offspring Study,[14]

INTERHEART Study,[26] Cooper Center Longitudinal Study,[27] Danish national population database[28]) that collectively followed over 163,000 patients, and all showed that a positive family history is associated with greater risk of CAD when compared with participants without a family history of CAD.[29]

From an insurance perspective, many of the family history studies are relatively short term in duration. Of interest is the Cooper Center Longitudinal Study, which recently reported on the association of family history of premature CAD (defined as an event before 50 years of age) and mortality. After adjusting for traditional risk factors, the investigators observed a persistent association between premature family history and both CAD and cardiovascular disease (CVD) mortality across short-term (0–10 years), intermediate-term (>10–20 years), and long-term (>20 years) follow-up (1.41, 1.59 and 1.46, respectfully) They also observed that premature family history was associated with a 50% increase in the lifetime risk for both CVD and CAD mortality, approaching that of a major CAD risk factor.[27]

Investigators with the Malmo Preventive Project in Sweden have reported on the predictive power of parental family history of CVD before age 75 years for offspring cardiovascular morbidity and mortality, adjusted for individual social and biological risk factors at screening. The overall relative risk of mortality for a cardiovascular event was 1.51. If the father had a CAD event, then the son's relative risk was 1.22 and the daughter 1.20. If the mother had the CAD event, then the son's relative risk was 1.51 and the daughter 0.87. The female cardiovascular mortality ratio in this study was 2.45 with those with no event at 0.83 or a 2.45 increase in the ratio. The male cardiovascular mortality ratio was 1.17 with those with no event at 0.76 or a 1.54 increase.[30]

Strengths and Limitations

The strength of this study lies in the fact that it is an insurance industry population-based study and that the family history and relationships were collected from a nationwide life insurance database. Several limitations of this study should be acknowledged. The definition of family history of CAD in our study was based on the coding requirements for the MIB database. This requirement did not allow verification of the accuracy and reliability of applicant's self-reported family history. Generally, individuals more accurately identify healthy family members as being healthy and are less accurate in correctly identifying family members with specific diseases.[25,29]

The individuals in the MIB database are a unique cohort of life insurance applicants. Life insurance applicants are generally held to be in a higher socio-economic class with access to better health care and living conditions and generally make healthier lifestyle choices. Similarly, they are believed to invest more in prevention, resulting in their experiencing lower mortality rates than those of the general population for the same age and gender groups. In addition, life insurance companies' underwriting process (detailed health questions plus medical exam and/or fluid collection) tends to select risks that are generally in much better health than the average individual in the US population.

Most of the literature presents relative risk statistics with a basis population that does not have a family history of CAD. This study does not have that type of comparison. The comparisons made were the difference of those having cardiac or cardiovascular conditions vs those that do not.

Due to the ambiguity in some of the information used to match the death records, the mortality ratios have been presented using the average value from all deaths and definite deaths. 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. We were unable to estimate the effect that missing the most recent SSDMF deaths had on this cohort. However, comparison of A/E ratios between the factor levels of the variables under study (eg,

age at application vs gender) 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[31].

CONCLUSION

Family history of CAD before the age of 60 in an insurance applicant may be associated with increased all-cause mortality. Overall in this study, life insurance applicants had a mortality slightly lower than the expected mortality based on the 2015 VBT. However, applicants with a positive family history and a cardiac or cardiovascular comorbid condition had a significantly higher mortality ratio.

REFERENCES

1. Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart Disease and Stroke Statistics - 2017 Update: A Report from the American Heart Association. *Circulation*. 2017;135:e146-e603. Epub 2017 Jan 25.
2. Nichols M, Townsend N, Scarborough P, Rayner M. Cardiovascular disease in Europe 2014: epidemiological update. *Eur Heart J*. 2014;35:2950-2959.
3. Andresdottir MB, Sigurdsson G, Sigvaldason H, Gudnason V. Fifteen percent of myocardial infarctions and coronary revascularizations explained by family history unrelated to conventional risk factors - The Reykjavik Cohort Study. *Eur Heart J*. 2002;23:1655-1663.
4. Phillips RL, Lilienfeld AM, Diamond EL, Kagan A. Frequency of coronary heart disease and cerebrovascular accidents in parents and sons of coronary heart disease index cases and controls. *Am J Epidemiol*. 1974;100:87-100.
5. Sholtz RI, Rosenman RH, Brand RJ. The relationship of reported parental history to the incidence of coronary heart disease in the Western Collaborative Group Study. *Am J Epidemiol*. 1975;102:350-356.
6. Barrett-Connor E, Khaw K-T. Family history of heart attack as an independent predictor of death due to cardiovascular disease. *Circulation*. 1984;69:1065-1069.
7. Friedlander Y, Kark JD, Stein Y. Family history of myocardial infarction as an independent risk factor for coronary heart disease. *Br Heart J*. 1985;53:382-387.
8. Schildkraut JM, Myers RH, Cupples LA, et al. Coronary risk associated with age and sex of parental heart disease in the Framingham Study. *Am J Cardiol*. 1989;64:555-559.
9. Colditz GA, Rimm EB, Giovannucci E, et al. A prospective study of parental history of myocardial infarction and coronary artery disease in men. *Am J Cardiol*. 1991;67:933-938.
10. McCusker ME, Yoon PW, Gwinn M, et al. Family history of heart disease and cardiovascular disease risk-reducing behaviors. *Genetics in Medicine*. 2004;6:153-158.
11. Yoon PW, Scheuner MT, Peterson-Oehlke KL, et al. Can family history be used as a tool for public health and preventive medicine. *Genet Med*. 2002;4:304-310.
12. Sesso HD, Lee IM, Gaziano JM, et al. Maternal and Paternal History of Myocardial Infarction and Risk of Cardiovascular Disease in Men and Women. *Circulation*. 2001;104:393-398.
13. Sivapalaratnam S, Boekholdt SM, Trip MD, et al. Family history of premature coronary heart disease and risk prediction in the EPIC-Norfolk prospective population study. *Heart*. 2010;96:1985-1989.
14. Lloyd-Jones DM, Nam BH, D'Agostino RB Sr, et al. Parental cardiovascular disease as a risk factor for cardiovascular disease in middle-aged adults: a prospective study of parents and offspring. *JAMA*. 2004;291:2204-2211.
15. Murabito JM, Pencina MJ, Nam BH, et al. Sibling cardiovascular disease as a risk factor for cardiovascular disease in middle-aged adults. *JAMA*. 2005;294:3117-3123.
16. Brackenridge RDC. Cardiovascular disorders. In: *Brackenridge RDC ed. Medical Selection of Life Risks*. 2nd ed. New York, NY: The Nature Press; 1985:262-263.
17. *1951 Impairment Study*. New York, NY: Society of Actuaries; 1954.
18. *Build and Blood Pressure Study 1979*. New York, NY: Association of Life Insurance Medical Directors of America/Society of Actuaries; 1959.
19. Woodman HA. 1983 Medical Impairment Study: provisional results. *J Insur Med*. 1983;14:8-23.
20. Accessed at: www.mibgroup.com/riskanalytics/industrystudies.html
21. Accessed at: www.mib.com
22. *Federal Register*. 2014;79:78314-78324. Accessed at: http://www.gpo.gov/fdsys/pkg/FR-2014-12-30/html/2014-30199.htm.
23. 2015 Composite Mortality Table based on the Society of Actuaries 2015 Valuation Basic Table for Male and Female Non Smokers and Smokers, Age Last Birthday.
24. Singer RB. The application of life table methodology to risk appraisal. In: Brackenridge RDC,

Croxson RS, and MacKenzie R, eds. *Brackenridge's Medical Selection of Life Risks*. 5th ed. New York, NY: Palgrave Macmillan; 2006:66-67.
25. Berg AO, Baird MA, Botkin JR, et al. National Institutes of Health State-of-the-Science Conference Statement: Family History and Improving Health. *Ann Intern Med*. 2009;151:872-877.
26. Chow CK, Islam S, Bautista L, et al. Parental history and myocardial infarction risk across the world: the INTERHEART Study. *J Am Coll Cardiol*. 2011;57:619-627.
27. Bachmann JM, Willis BL, Ayers CR, et al. Association between family history and coronary heart disease death across long-term follow-up in men: the Cooper Center Longitudinal Study. *Circulation*. 2012;125:3092-3098.
28. Nielsen M, Andersson C, Gerds TA, et al. Familial clustering of myocardial infarction in first-degree relatives: a nationwide study. *Eur Heart J*. 2013;34:1198-1203.
29. Wilson PWF. Overview of established risk factors for cardiovascular disease. In: *UpToDate*, Post TW (Ed), UpToDate, Waltham, MA. Accessed on: November 30, 2015.
30. Nilsson PM, Nilsson A, Berglund G. Family burden of cardiovascular mortality: risk implications for offspring in a national register linkage study based upon the Malmo Preventive Project. *J Internal Med*. 2004;255:229-235.
31. Warren, JR, Milesi C, Humphries M, Grodsky E. Do inferences about mortality rates and gradients vary by source of mortality information? Paper presented at: Population Association of America; May 2015; San Diego, CA.