any additional amount that would be necessary to cover administrative expenses and profit are not included.

The implications of private information are illustrated as variations from a baseline scenario, shown in Panel A of Table A-1 in the Appendix. The first set of columns (A–G) in the table show the annual expected mortality experience. In year one, the pool of insureds at the beginning of the year (BOY) is 10,000. In each subsequent year, the pool size is shown to decline due to the expected mortality experience in the pool and 500 policies that are expected to lapse each year. The breakeven premium is calculated by first considering the expected death benefits that must be paid each year (shown in column H). These are discounted to present value (column I) to obtain the amount today that would be necessary to meet all expected future obligations, shown at the bottom of column I. Finally, column J shows the factor applied to each year's experience to account for the fact that: 1) premiums collected in any year will earn interest until needed to pay claims; and 2) the pool of individuals from whom premiums can be collected each year is decreasing over time. The annual level premium is calculated by dividing the present value of the total expected benefit payments per policyholder by the present value (PV) factor of 6.3849.

Columns K–N illustrate the changes to the insurer's balance of expected premiums collected minus expected benefits paid over the 10-year period, including interest that is earned on the balance each year. The values in Column N illustrate that if the insurer charges each policyholder $226.30 at the beginning of the 10-year term and charges all policyholders who remain in the pool $226.30 each year, it will accrue funds just sufficient to make all expected death benefit payments for this cohort of 10,000 insureds by the end of the 10 years.

Panels B–D of Table A-1 provide three alternative scenarios for comparison with the baseline result. The scenarios are arbitrary but are designed to illustrate how misestimation of either the mortality information (Panel B and Panel C) or lapse experience (Panel D) can affect the insurer's solvency, i.e., ability to meet the expected death benefit obligation.

First, consider that the insurer may underestimate the mortality experience of this pool of insureds. This is possible if just a small proportion of the insureds are now more likely to be substandard risks, but the insurer is not aware of this. The table shows how a difference in the probability of death of just 0.00005 in each year results in only a small change in the total number of deaths over the time period (188 to 192), but if the insurer charges only $226.30 per policyholder, it will have insufficient funds in year 10 to pay all death benefits for which it is obligated.

In Panel B, if the insurer had charged each policy holder $231 each year, it would expect to break even. While the insurer cannot change the premium for this cohort, the insurer must respond to the new mortality experience by increasing premiums for the next year's cohort, and it must do this for every policyholder since it cannot determine which policyholders are substandard. While the premium increase that is suggested in this example is small ($5 more per year), any increase in premiums has the potential to affect demand for coverage. Individuals with a greater need, i.e., higher mortality risk, will be more likely to purchase coverage while individuals with a lower need, upon receiving a higher price, may decline coverage. Thus, subsequent cohorts face increasing prices and the insurer experiences higher-than-expected mortality, leading to another price increase for the next cohort. Panel C provides an indication of how this plays out if the insurer's estimates of mortality are off to an even greater degree due to this adverse selection over time. In Panel C, where the insurer's mortality estimates are off by 20%, the insurer is insolvent by the fifth year of coverage.

The figures in Panel D illustrate what happens when the insurer overestimates the lapse rate on policies purchased by the cohort. This is possible if only a small proportion of individuals in the cohort have received genetic test results that suggest increased mortality risk, or subsequently obtain positive genetic test results after they have purchased coverage and, consequently, decide to hold onto the life insurance coverage when they may have let it lapse without this information. We might assume that the individuals more likely to keep coverage will be those who have positive genetic test results, which would, consequently, increase the mortality rates over the contract period as well. However, for simplicity, the mortality rates are not changed in this scenario, so that the effect of the change in lapse rate is isolated. The scenario suggests that the insurer is unable to meet the expected death benefit obligation in the 10^{th} year. If the insurer continues to note a reduction in lapse behavior, premiums for future cohorts will have to increase. Since the insurer cannot identify a priori which applicants are more likely to lapse, it will have to charge all applicants in subsequent cohorts a higher premium in order to ensure solvency.

A more likely scenario, over time, is one in which the mortality experience of the pool increases (as shown in the change from Panel A to Panel B), and coverage lapses decline (as shown in the change from Panel A to Panel D). These changes lead to the so-called "death spiral" in which insurers are forced to increase rates to stay solvent; however, increasing rates continue to discourage standard risks from purchasing coverage, resulting in an increasingly larger share of substandard risks in the pool. While it is not clear how fast such a process would play out in this arena, the phenomenon suggests that eventually, premiums are so high that the insurer may attract only the highest risks, if it attracts any applicants at all.

The analysis shows that if the information obtained from a genetic test is kept private, and the results would have been relevant for underwriting, adverse selection will increase. This happens in two ways, specifically: 1) through a change in the risk profile of applicants seeking coverage; and 2) through a change in the risk profile of policyholders who keep their coverage through the policy period. With more and more genetic tests being performed, the potential for adverse selection grows, creating further complications for the market. To remain financially viable, life insurers must increase prices to account for the changing composition of the risk pool, and the increase in prices will increasingly drive the lower (or standard) risk-types out of the market as their demand for coverage responds to the price increase. Ultimately, adverse selection will affect the affordability of products, and consequently, availability is reduced as insurers are unwilling or unable to participate in the market.

The SOA Model

The SOA produced a report in 2018 (Lombardo, 2018) that considers the impact of genetic testing in life insurance. The report contains a simulation of the outcomes for the U.S. life insurance market under various assumptions about the information value of genetic tests (e.g., the prevalence and rating of certain genes), incorporating individual and insurer responses to the information.[8] The report concludes that "legislation prohibiting the use of genetic information and family history during the underwriting process has the potential to materially affect U.S. life insurance industry claims." They estimate the following impacts:

- "If only the applicant knows the result of genetic testing, but both the applicant and the insurance company know the family history at time of underwriting, the present value of new business claim costs modeled increase by 4% to 8% overall, and industry-wide claim costs could rise by as much at 3% on a present value basis.
- If the applicant alone knows the result of genetic testing and family history and the insurance company knows neither, the present value of new business claim costs modeled increases by 5% to 10% overall, and industry-wide claim costs could rise by as much at 4% on a present value basis.
- In general, estimated increases in industry-wide claims cost are low at first and increase over time. In the first 10 years, projected modeled claims increase by less than 1%. The cost increase rises quickly over the next 20 years to upwards of 5% of projected claims, as the Baseline In Force and New Business policies run off." (pp. 32-33)

The analysis by the SOA contains several assumptions, and the results are sensitive to the validity of these assumptions. While it is reasonable to assume the volume of genetic testing will increase, for example, the rate of increase and the corresponding increase in the information that may be relevant for underwriting cannot be predicted. Further, the change in demand for coverage—interest in obtaining greater amounts of life insurance coverage or elasticity of demand with respect to the changes in price—is also unclear. For this reason, the SOA study includes several sensitivity tests using different ranges of assumptions.

6. State Developments

According to the National Human Genome Research Institute (NHGRI), states have enacted or proposed more than 792 statutes pertaining to genetic information.

8. The SOA approach follows the simulation approach used by Howard (2014) for Canada, with some different assumptions.

To date, 68 statutes extend underwriting restrictions to other forms of insurance besides health insurance.[9] Many of the statutes that target life insurance operations impose limitations on life insurers' ability to require a genetic test or perform a genetic test without informed consent. A sample of current provisions (as of early 2019) that impose restrictions on life insurers is shown in Table 3 along with the statute information. No state has enacted a complete ban on the use of genetic test information for the purposes of life insurance underwriting.

7. Conclusion

In addressing the question of whether life insurers should be allowed genetic test information for the purposes of underwriting, a variety of issues must be considered, and the conclusions are not black or white. Some forms of genetic information are valuable in the underwriting process, especially test results that may be relied on by medical doctors for treatment. To the extent that test results lead to better medical care, underwriting consequences may be favorable. If the information is not allowed for underwriting, insurers will experience some degree of adverse selection, which will raise the cost of coverage for all applicants and reduce the availability of coverage.

State insurance regulators need to strike a balance between insurers' need for accurate underwriting information and the concerns of the medical community and consumers. Some form of compromise may be possible, such that a complete ban would not be imposed on the use of genetic testing information. Table 4 shows a new subsection to Florida s. 627.4301 that was proposed in an amendment to Senate Bill 258, filed April 5, 2019. The amendment would restrict the use of genetic test information without imposing a complete ban. Item (3)(c) puts the burden on life insurers to justify underwriting decisions with objective statistical evidence related to actual or anticipated loss experience, and thus allows for, and even encourages, further study on the statistical accuracy of this information for underwriting. A complete ban would necessarily complicate insurers' ability to perform statistical analysis of genetics information and the impact on mortality experience.

The discussion and analysis in this paper emphasize the problems for life insurers when individuals have private information about their mortality. The financial consequence—a need to maintain solvency in order to meet obligatory death benefit payments—is significant and sizable. Restrictions may be necessary to placate concerns from consumers and the medical community, but a well-functioning life insurance market requires that insurers be allowed access to information that is material in providing financially viable life insurance products.

9. Roughly 29 state bills failed or died in committee; several other bills, including those proposed in Florida, are still under consideration.

Table 3:
State Provisions Affecting Genetic Testing in Life Insurance Products

Provision	State (statute)
Information about a genetic condition may not be used for underwriting or ratemaking of life and disability insurance policies unless supported by the applicant's medical condition, medical history, and either claims experience or actuarial projections.	Arizona §20-448
Life and disability insurers may not discriminate based solely on the fact that the person to be insured carries a gene that may be associated with disability in that person or the person's offspring, but which causes no adverse effects in the carrier, including, but not limited to, Tay-Sachs trait, sickle cell trait, thalassemia trait and X-linked hemophilia trait.	California §10140
Policies may only limit benefits otherwise payable if loss is caused or contributed to by the presence or absence of genetic characteristics if the insurer imposes limitations for other medical conditions that present an increased risk.	California §10146
Insurers may not refuse to issue or deliver any policy of life insurance or disability insurance that affords certain services and benefits or impose a higher premium rate or charge for those policies solely because the person to be insured has the sickle-cell trait.	Florida F §626.9706 et seq.
Life, disability income or long-term care (LTC) insurers also may not provide for rates or any other aspect of coverage that is not reasonably related to the risk involved.	Kansas §40-2259
Life, credit life, disability, LTC, accidental injury, specified disease, hospital indemnity or credit accident insurers, or an annuity may not discriminate unfairly, which includes the use of genetic test results in a manner that is not reasonably related to anticipated claims experience.	Maine 24A §6981
Unless there is actuarial justification, an insurer may not refuse to insure or make or allow a differential in ratings, premium payments or dividends in connection with life insurance and annuity contracts because the applicant or policyholder has the sickle-cell trait, thalassemia-minor trait, hemoglobin C trait, Tay-Sachs trait or a genetic trait that is harmless in itself.	Maryland §27-208
An insurer, agent or broker authorized to issue life insurance policies, policies against disability from injury or disease, or policies for LTC may not practice unfair discrimination because of the results of a genetic test or the provision of genetic information or require an applicant to undergo a genetic test as a condition of issuance or renewal of a policy. Unfair discrimination involves discriminatory practices against persons unless such action is based on reliable information relating to the insured's mortality or morbidity and based on sound actuarial principles or actual or reasonably anticipated claim experience. These insurers may ask if an applicant has taken a genetic test.	Massachusetts MGL 175 §1081, §180E
The rejection of an application or the determining of rates, terms or conditions of a life or disability insurance contract is permissible if the applicant's medical condition and history, as well as either claims experience or actuarial projections, establish that substantial differences in claims are likely to result from the genetic condition.	Montana §33-18-206
Discrimination by an insurer against a person or his/her family member based on genetic analysis, genetic information or genetic propensity is prohibited. Life, disability income or long-term care insurance (LTCI) are exempt if use is based on sound actuarial principles or related to actual or reasonably anticipated experience.	New Mexico §24-21-1 et seq.
No insurance company may refuse to issue or deliver any policy of life insurance solely by reason of the fact that the person to be insured possesses sickle cell trait or hemoglobin C trait. A policy also may not carry a higher premium rate or charge by reason of the fact that the person to be insured possesses these traits.	North Carolina §58-58-25
The genetic information of a person's blood relative may not be used to reject, deny, limit, cancel, refuse to renew, increase the rates of, affect the terms and conditions of, or otherwise affect any policy of insurance.	Oregon §746.135
It is an unfair method of competition or unfair and deceptive act or practice to make or permit any unfair discrimination against any individual by conditioning insurance rates, the provision or renewal of insurance coverage, or other conditions of insurance based on the results of genetic testing where there is not a relationship between the information and the cost of the insurance risk that the insurer would assume by insuring the proposed insured.	Vermont VSA 8 §4724

Source: Author's search of statutes in the Genome Statutes and Legislation Database at *www.Genome.gov*, Aug. 20, 2019.

Table 4:
Amended Language – Restrictions on the Use of Genetic Information

(3) RESTRICTIONS ON THE USE OF GENETIC INFORMATION BY LIFE INSURERS, LONG-TERM CARE INSURERS, AND DISABILITY INCOME INSURERS. (a) A life insurer, long-term care insurer, or disability income insurer may not: 1. Require an applicant to take a genetic test; 2. Collect an applicant's genetic information or genetic test results without the applicant's authorization; or 3. Consider the results of a genetic test that is designed to share information with an individual concerning the applicant's race, ethnicity, or national origin and that is not related to an applicant's medical condition or future health risk. (b) A life insurer, long-term care insurer, or disability income insurer may only consider genetic test results included in an individual's medical record if the tests have been reviewed and confirmed by the individual's physician and the insurer complies with paragraph (c). (c) A life insurer, long-term care insurer, or disability income insurer may not cancel, limit, or deny coverage, or establish differentials in premium rates, based on genetic information unless such action is based on objective statistical evidence related to actual or anticipated loss experience that is relevant to an individual's life expectancy or health. A life insurer, long-term care insurer, or disability income insurer shall document the rationale for such action and provide the documentation to the office upon request. (d) Genetic information, including genetic test results, is nonpublic, private health information and is subject to the privacy protections under ss. 626.9651 and 760.40. (e) This subsection does not relieve the obligation of a life insurer, long-term care insurer, or disability income insurer to comply with ss. 626.9706 and 626.9707. (f) This subsection does not apply to health insurers. (g) This subsection applies to policies entered into or renewed on or after January 1, 2020.

Appendix Table A-1:
Effects of Misestimation of Mortality or Lapse Rates in Level Premium Term Coverage

PANEL A: Baseline

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Year	**Age**	**P(Death)**	**# BOY**	**# Deaths**	**# Lapses**	**# EOY**	**Claims Payments**	**PV of Payments**	**PV Factor**	**Beginning Balance**	**Premiums Collected**	**Interest**	**Ending Balance**
1	40	0.00179	10000	17.9022	500	9482	$1,790,218.99	$1,704,970.46	1.00000		$2,262,969.65	$113,148.48	$585,899.15
2	41	0.00191	9482	18.1031	500	8964	$1,810,310.40	$1,642,004.90	0.90306	$585,899.15	$2,145,769.96	$136,583.46	$1,057,942.16
3	42	0.00204	8964	18.3105	500	8446	$1,831,045.63	$1,581,726.06	0.81306	$1,057,942.16	$2,028,524.80	$154,323.35	$1,409,744.67
4	43	0.00219	8446	18.5056	500	7927	$1,850,560.85	$1,522,460.99	0.72957	$1,409,744.67	$1,911,232.71	$166,048.87	$1,636,465.41
5	44	0.00236	7927	18.7052	500	7408	$1,870,522.39	$1,465,603.24	0.65217	$1,636,465.41	$1,793,896.47	$171,518.09	$1,731,357.58
6	45	0.00254	7408	18.8239	500	6890	$1,882,392.20	$1,404,670.05	0.58047	$1,731,357.58	$1,676,515.05	$170,393.63	$1,695,874.06
7	46	0.00275	6890	18.9594	500	6371	$1,895,937.54	$1,347,407.41	0.51412	$1,695,874.06	$1,559,106.77	$162,749.04	$1,521,792.33
8	47	0.00302	6371	19.2268	500	5851	$1,922,676.16	$1,301,342.91	0.45275	$1,521,792.33	$1,441,667.84	$148,173.01	$1,188,957.01
9	48	0.00335	5851	19.5794	500	5332	$1,957,935.39	$1,262,102.61	0.39605	$1,188,957.01	$1,324,168.40	$125,656.27	$680,846.29
10	49	0.00372	5332	19.8181	500	4812	$1,981,807.23	$1,216,657.72	0.34370	$680,846.29	$1,206,589.17	$94,371.77	$0.00
								$14,448,946.34	6.3849				
								$226.30					

PANEL B: Probability of death underestimated by 0.00005

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Year	**Age**	**P(Death)**	**# BOY**	**# Deaths**	**# Lapses**	**# EOY**	**Claims Payments**	**PV of Payments**	**PV Factor**	**Beginning Balance**	**Premiums Collected**	**Interest**	**Ending Balance**
1	40	0.00184	10000	18.4022	500	9482	$1,840,218.99	$1,752,589.51	1.00000		$2,262,969.65	$113,148.48	$535,899.15
2	41	0.00196	9482	18.5762	500	8963	$1,857,622.93	$1,684,918.76	0.90301	$535,899.15	$2,145,656.81	$134,077.80	$958,010.82
3	42	0.00209	8963	18.7566	500	8444	$1,875,661.96	$1,620,267.32	0.81297	$958,010.82	$2,028,304.58	$149,315.77	$1,259,969.21
4	43	0.00224	8444	18.9247	500	7925	$1,892,471.19	$1,556,940.73	0.72945	$1,259,969.21	$1,910,911.53	$158,544.04	$1,436,953.60
5	44	0.00241	7925	19.0972	500	7406	$1,909,715.30	$1,496,311.91	0.65202	$1,436,953.60	$1,793,480.44	$161,521.70	$1,482,240.45
6	45	0.00259	7406	19.1886	500	6887	$1,918,856.73	$1,431,880.43	0.58030	$1,482,240.45	$1,676,010.33	$157,912.54	$1,397,306.59
7	46	0.00280	6887	19.2966	500	6368	$1,929,658.71	$1,371,372.42	0.51392	$1,397,306.59	$1,558,519.54	$147,791.31	$1,173,958.72
8	47	0.00307	6368	19.5363	500	5848	$1,953,630.02	$1,322,293.70	0.45254	$1,173,958.72	$1,441,004.30	$130,748.15	$792,081.15
9	48	0.00340	5848	19.8609	500	5328	$1,986,091.80	$1,280,252.48	0.39583	$792,081.15	$1,323,434.81	$105,775.80	$235,199.95
10	49	0.00377	5328	20.0714	500	4808	$2,007,139.46	$1,232,209.52	0.34347	$235,199.95	$1,205,791.86	$72,049.59	($494,098.06)
								$14,749,036.78	6.3835				
								$231.00					

Panel C: Probability of death underestimated by 20 percent

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Year	**Age**	**P(Death)**	**# BOY**	**# Deaths**	**# Lapses**	**# EOY**	**Claims Payments**	**PV of Payments**	**PV Factor**	**Beginning Balance**	**Premiums Collected**	**Interest**	**Ending Balance**
1	40	0.00215	10000	21.4826	500	9479	$2,148,262.78	$2,045,964.56	1.00000		$2,262,969.65	$113,148.48	$227,855.35
2	41	0.00229	9479	21.7155	500	8957	$2,171,552.19	$1,969,661.85	0.90272	$227,855.35	$2,144,959.71	$118,640.75	$319,903.62
3	42	0.00245	8957	21.9549	500	8435	$2,195,491.64	$1,896,548.22	0.81241	$319,903.62	$2,026,897.07	$117,340.03	$268,649.09
4	43	0.00263	8435	22.1782	500	7913	$2,217,823.50	$1,824,608.88	0.72863	$268,649.09	$1,908,780.26	$108,871.47	$68,477.32
5	44	0.00283	7913	22.4052	500	7390	$2,240,518.29	$1,755,504.71	0.65098	$68,477.32	$1,790,612.91	$92,954.51	($288,473.55)
6	45	0.00305	7390	22.5332	500	6868	$2,253,318.38	$1,681,460.87	0.57905	($288,473.55)	$1,672,394.20	$69,196.03	($800,201.69)
7	46	0.00330	6868	22.6789	500	6345	$2,267,886.82	$1,611,744.82	0.51248	($800,201.69)	$1,554,146.53	$37,697.24	($1,476,244.74)
8	47	0.00362	6345	22.9793	500	5822	$2,297,926.09	$1,555,326.83	0.45093	($1,476,244.74)	$1,435,865.89	($2,018.94)	($2,340,323.88)
9	48	0.00402	5822	23.3772	500	5299	$2,337,721.12	$1,506,915.88	0.39406	($2,340,323.88)	$1,317,517.27	($51,140.33)	($3,411,668.06)
10	49	0.00446	5299	23.6337	500	4775	$2,363,365.45	$1,450,901.37	0.34156	($3,411,668.06)	$1,199,078.59	($110,629.47)	($4,686,581.39)
								$17,298,637.99	6.3728				
								$270.93					

Panel D: Lapse Rate overestimated

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Year	**Age**	**P(Death)**	**# BOY**	**# Deaths**	**# Lapses**	**# EOY**	**Claims Payments**	**PV of Payments**	**PV Factor**	**Beginning Balance**	**Premiums Collected**	**Interest**	**Ending Balance**
1	40	0.00179	10000	17.9022	200	9782	$1,790,218.99	$1,704,970.46	1.00000		$2,262,969.65	$113,148.48	$585,899.15
2	41	0.00191	9782	18.6759	200	9563	$1,867,586.03	$1,693,955.58	0.93163	$585,899.15	$2,213,659.04	$139,977.91	$1,071,950.07
3	42	0.00204	9563	19.5349	200	9344	$1,953,488.65	$1,687,496.94	0.86743	$1,071,950.07	$2,164,173.36	$161,806.17	$1,444,440.95
4	43	0.00219	9344	20.4737	200	9123	$2,047,368.93	$1,684,375.49	0.80716	$1,444,440.95	$2,114,493.28	$177,946.71	$1,689,512.01
5	44	0.00236	9123	21.5279	200	8902	$2,152,789.76	$1,686,767.11	0.75059	$1,689,512.01	$2,064,600.76	$187,705.64	$1,789,028.65
6	45	0.00254	8902	22.6185	200	8679	$2,261,847.87	$1,687,825.71	0.69749	$1,789,028.65	$2,014,469.67	$190,174.92	$1,731,825.36
7	46	0.00275	8679	23.8842	200	8455	$2,388,415.86	$1,697,402.56	0.64766	$1,731,825.36	$1,964,091.78	$184,795.86	$1,492,297.14
8	47	0.00302	8455	25.5184	200	8230	$2,551,837.04	$1,727,183.75	0.60091	$1,492,297.14	$1,913,427.47	$170,286.23	$1,024,173.80
9	48	0.00335	8230	27.5376	200	8002	$2,753,762.94	$1,775,100.14	0.55703	$1,024,173.80	$1,862,393.35	$144,328.36	$277,132.57
10	49	0.00372	8002	29.7438	200	7773	$2,974,383.76	$1,826,013.61	0.51584	$277,132.57	$1,810,902.28	$104,401.74	($781,947.16)
								$17,171,091.36	7.3757				
								$268.93					

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