



# Risks Identification of Genetic Test Results Applied in Insurance Underwriting- A Design Thinking Analysis

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## Abstract

*In order to provide more information to help insurers do the preparation well to face the era of genetic generation, there are two goals need to be achieved for this research. The first is to identify the risks concerned by potential insurance consumers either agree to provide genetic testing results used as part of the underwriting process or not. The second is to identify the risks concerned by insurers either be allowed to use genetic testing results as an underwriting reference or not. A five-point scale attitude survey is used to collect data, then analyzed by the descriptive statistic analysis and independent t test. Furthermore, this study conducts a five-step process of design thinking that enables to come up with impactful solutions vetted by the potential customers. There are four recommendations include 1. The supervisor should invite insurer, genetic experts and consumers to get together to develop laws or regulations related to reasonable using genetic testing in insurance underwriting. 2. Insurers should design a clear and easy understand policy related to using genetic testing results in underwriting to avoid disputes and improve the acceptance of policies. 3. The supervisor not only to develop a consumer protection mechanism by revising the contemporary related statutes but also to request insurance companies to improve the employees' legal awareness of using genetic test results appropriately by providing advance on the job training program. 4. The insurance industry, by applying Blockchain tech, to establish a third-party justice and trusted unit to manage genetic testing information fairly and insurance companies could reasonably employ genetic testing information in their underwriting procedures.*

**Keywords:** Genetic testing; Insurance underwriting; Adverse selection; Design Thinking

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## 1. Introduction

### 1.1 Background

A gene is a functional segment of a DNA molecule that is the basic unit of genetic information. It affects our birth and old age, sickness and death. There are 70% of American who have implemented the genetic testing. American well-known actress Angelina Jolie successfully prevents breast cancer through preventive surgery after found herself a BRCA1/2 mutation carrier through genetic testing. The implication of this example is to do genetic testing as well as might help more people take preparation in advance.

In 2014, the Office of the Privacy Commissioner of Canada commissioned two papers by experts in actuarial science and economics, and agreed "the impact of a ban on the use of genetic test results by the life and health insurance industry would not have a significant impact on insurers or the efficient operation of insurance markets... [...]collection and use of existing genetic test results by insurance companies would not appear to be necessary for the legitimate business needs of the industry at the present time (Dobson, 2017)."

In reality, a conventional insurance company gets all the information they need from medical and family histories, which they now regularly use in their decision-making, just as they use the client's age, sex and smoking habits to set premiums. In other words, insurance underwriters seem to unnecessary refer to genetic test results while making underwriting decision or setting premiums (Jacobs, 2004).

What is genetic testing? Why can genetic testing help individuals understand their risk of disease? Genetic tests are done using a blood or spit sample and results are usually ready in a few weeks (Centers for Disease Control and Prevention, 2020). Over the past couple of years, scientific breakthroughs in the identification of genetic markers for disease. Accompanying the development of human genetic research, however, is fear of potential unintended consequences. In particular, experts repeatedly have warned that genetic information also might be used by health insurers to deny or limit access to coverage (Pollitz et al, 2007).

Right now, most consequences of genetic testing are out of sight and just below the surface of health insurance's iceberg. However, genetic testing will become gradually more pervasive in the years ahead. At the same time, the knowledge of the risk of disease associated with the results of those tests will become increasingly refined (Brody, 2002). This means the number of inherited diseases for which genetic tests are available is increasing at a rapid rate. A current policy issued across Europe and the US is whether, and if so under what circumstances, insurance companies (and/or employers) should be given access to the results of such genetic tests (Wilson, 2006). In other words, despite the rapid developments in relation to genetic information and insurance in both Europe and the United States, the question of the appropriate policy response remains an open one (Godard et al, 2003).

### **1.2 Motivation**

As mentioned in the background, genetic testing is widely used in medical diagnosis, prevention and treatment, but it also causes public anxiety, including the complex problems of social ethics and morality. In the process of life insurance underwriting, insurers are concerned if they can legally obtain genetic information related to consumer diseases then lose control of quality customers. On the other hand, consumers worried that if insurers obtain insureds' genetic information, insureds will be treated differently or be rejected at application discriminately.

Many previous essays were fascinating exploration of the financial and moral implications of the rapidly expanding world of genetic testing. The studies ask whether it makes sense to bar life insurance companies from forcing insureds to undergo genetic tests or to provide the results of genetic testing insureds obtain on their own (Rothstein, 2009). From perspective of insurance companies, they worry that applicants who know flunked genetic test results will sign up for big policies, concealing the results. On the other hand, genetic testing can provide proof that an individual does not have a genetic disorder which is helpful in getting insurance coverage (Jacobs, 2004).

Definitely, the advanced and developed technology of genetic test triggers a lot of problems specifically applied in the insurance underwriting. Apparently and inevitably, using genetic testing results could be not only the end of private health insurance but beyond the knowledge of insurance sector (Brody, 2002).

Should genetic information be exceptional? These questions have received occasional attention in the past, but have become more salient with the rapidly decreasing cost and increasing use of predictive genetic testing (Klitzman, Appelbaum, and Chung, 2014). According to a research of 2018 from Institute for Biotechnology and Medicine Industry in Taiwan, the penetration rate of genetic test is going to reach 100% before 2030 due to the testing cost keep going down. Without exception, insurance companies in Taiwan do not well prepare to face all kinds of questions from the using or not using genetic testing information for underwriting decision. However, to identify the risks of using or not using genetic testing results for both insurers and insureds is the most important work that could help insurance regulator and insurers to develop their strategies to deal with the problems related to genetic testing results usage.

### **1.3 Purpose**

In order to provide more information to help insurers do the preparation well to face the era of genetic generation, there are two goals need to be achieved for this research.

- 1.3.1 To identify the risks concerned by potential insurance consumers either agree to provide genetic testing results used as part of the underwriting process or not.
- 1.3.2 To identify the risks concerned by insurers either be allowed to use genetic testing results as an underwriting reference or not.
- 1.3.3 To conduct a design thinking process then generate the best treatments for the risks resulting from use or unused genetic testing results as an underwriting reference.

## **2. Literature Review**

### **2.1 Background on Medical Underwriting and Technology of Genetic Test**

Individual health insurance is medically underwritten in most insurance business. This means applicants for coverage must submit information about their current and past health status. Then, underwriters make a decision to issue or decline coverage accordingly (Pollitz et al, 2007). This traditional underwriting decision making procedures may go to change because of the technology advanced of the genetic test employed.

Genetic information contains more certainty than information traditionally gathered by insurers to investigate the existence of diseases running in the family. This may have important consequences for insurance industry (Godard et al, 2003). However, the insurance industry would like to use genetic information as just part of the (predictive) information that they should be able to use less for deciding to accept a private, voluntary application, than for setting the premium level according to the individuals' risk, and for avoiding the possibility of adverse selection (Godard et al, 2003).

Genetic tests can ascertain if a person is a carrier of a particular gene, which may determine whether the person is predisposed to a particular disease or is presymptomatic for a specific illness. On one hand, these new developments were publicly and politically acclaimed as a positive step toward a new era in pre and post medical healthcare (Morris, 2010; Riordan, 2015). But on the other hand, allowing or not allowing to use genetic testing results in underwriting processes may cause some different impacts toward insurance companies and potential insurance consumers.

## **2.2 Risks of Using or not Using Genetic Test Information in Life Insurance Underwriting**

There are different risks to insurers and insureds if insurers can use insured's genetic test information or insureds have to provide their genetic test information to insurers.

### **2.2.1 Risks of Insurers if Using Genetic Test Results in Underwriting**

The result of insured's genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting (Morris, 2010; Holbrook, 2013). Although insurers that know applicants' genetic propensities could stratify risks more accurately, conservative business decisions may lead them to overestimate risks. Risk adjustment based on genetic data could price many people out of the life insurance market (Klitzman, Appelbaum, and Chung, 2014). Experience shows that the assessment of substandard risks due to genetic information is proved fair since the observed mortality is very close to what had been expected. Requesting genetic tests from insurance applicants could then constitute another source of information for insurers. This would permit to classify individuals more accurately in various categories of risk, or to assess risk premiums more accurately (Godard et al, 2003).

In other words, the genetic testing result is more accurate and reliable compare to medical and family histories. However, the genetic testing results can be well enough served for the underwriting of life insurance? Some prior studies had different opinions. The genetic test results, merely produce a probability of developing a particular disease for one individual, are not accurate enough to be used by insurers in underwriting (Morris, 2010; Lombardo, 2018). To be more precisely, genetic test results are fallible regarding future mortality should not be used as evidence by insurers in assessing insurability or deciding the premium to be charged (Morris, 2010; Riordan, 2015). Therefore, neither the end result could be a population not taking measures to reduce their susceptibility to genetic disease due to fear of an unaffordable increase in their life insurance payments (Goh, 2017; Morris, 2010), nor national regulation cannot be developed for insurers to follow when using genetic test results and have no mechanisms to monitor further developments (Zick et al, 2005; Morris, 2010).

### **2.2.2 Risks of Insureds if Using Genetic Test Results in Underwriting**

In fact, genetic testing results used in underwriting processes may trigger some risks to insureds as well. Budden, Morris, and Riordan had similar view points and concluded that genetic test results are far too limited and unreliable to be used as an evidence basis from which to make underwriting decisions (Budden, 1999; Morris, 2010; Riordan, 2015). Given this opinion, insureds are open to the risk of being "unfair" discriminated against and being "punished" by life insurance companies if they are permitted to use genetic test results.

Even though genetic testing result is a scientific evidence, it could be misapplied in the insurance underwriting. Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged (Zick et al, 2005; Morris, 2010). Besides misapplying the genetic testing result, an insurance company may create a questionable and rushed policy that are neither well thought through nor suitable for managing the potentially harmful consequences of life insurers using genetic testing to underwrite applicants (Morris, 2010; Lombardo, 2018). In order to purchase an insurance policy, insureds are all forced to take a genetic test. However, to collect a blood sample when takes genetic test which may cause physical harm (Morris, 2010). Furthermore, in many cases, the revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being (Bolger, 2000; Morris, 2010). Without any doubt, the privacy issues are concerned by many stakeholders including policyholder's families, relations and future generations. Life insurance companies may use the result of a genetic test of an individual to underwrite insurance policies for members of that individual's families or relations (Rez and Macdonald, 2004; Morris, 2010). Moreover, the genetic testing result could just right affect future generations and counteracting an individual's right to privacy (Morris, 2010).

Insurers and insureds will suffer various risks if insurers cannot use insured's genetic test information or insureds have no necessary to provide their genetic test information to insurers.

**2.2.3 Risks of Insurers If Not Using Genetic Test Results in Underwriting**

If insurers do not take genetic test results into account in their underwriting processes, the result may be an increased susceptibility adverse selection (Goh, 2017; Dobson, 2017; Morris, 2010; Budden, 1999; Rrez and Macdonald, 2004). The Actuarial Standards Board defines adverse selection as "the actions of individuals, acting for themselves or for others, who are motivated directly or indirectly to take financial advantage of the risk classification system."(Actuarial Standards Board, Actuarial Standard of Practice no. 12 Concerning Risk Classification, section). For example, if people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance policies to preserve wealth for surviving family members. If insurers are unaware of who might be engaging in this behavior, they would be unable to adjust their actuarial calculations and could face economic losses. If genetic tests become more accurate, this will result in an increased number of individuals taking tests, insurers will find it increasingly difficult to quantify the increased risk as result of being denied knowledge of applicants’ genetic test results (Morris, 2010).

**2.2.4 Risks of Insureds If Not Using Genetic Test Results in Underwriting**

If insurers are not permitted to use genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts. Insurers argue that they will therefore be compelled to raise insurance premiums (Bombard and Lemmens, 2010). It may not be possible for the insurer to maintain profitability as a lower premium. Insurers may charge an individual with a higher than standard risk grade (Morris, 2010; Holbrook, 2013; Brody, 2002). This is because the principle of utmost good faith collapses if an applicant does not provide the result of a previously taken genetic test.

**3. Methodology**

**3.1 Sampling Method**

Because the population of this study is the people who are eligible to apply life insurance and the employees of all life insurance companies in Taiwan. However, due to the limitation of research time and funding, it may be difficult to apply random sampling. Therefore, this study adopted quota sampling, one type of non-probability sampling method to choose the respondents. That is, according to a certain attribute or characteristic of the survey object, all individuals in the population were divided into several classes or layers, and then sampled in each layer. The proportion of each layer/class in the sample was the same as their proportion in the population, but the samples of each layer were not chosen randomly.

**3.2 Sample Size**

The sample size calculation formula for sampling in this study is

$$n = \left[ \frac{Z_{\alpha} \sigma}{e} \right]^2$$

Among them,  $\sigma$  is unknown, so the sample standard deviation  $s$  is substituted, and  $s$  is estimated to be  $[5-(-5)] / 4 = 2.5$  according to The Range Rule. Under the 95% confidence level, it is 1.96. This study also set the error  $e$  of the average estimate not to exceed 0.5. Therefore  $n = [1.96 * 2.5/0.5] * [1.96 * 2.5 / 0.5] = 96.04$ . That is to say, with a confidence level of 95% and an error of no more than 0.5, the sample size that must be achieved in this study is 96.4, so the number of questionnaires to be distributed in this study were be about 100 for the public and the insurance industry. The question items in the questionnaire were designed based on the results of the summary and collation of the content of the literature. They have the appropriateness of the measurement content and therefore have the validity of the content. Furthermore, the reliability Cronbach’s Alpha value of the questionnaire measured by the pilot test is 0.702, which has reached the acceptable standard (Hair et al, 2016).

This study distributed consumer and Insurance Company Faculty questionnaires (see Table 2 and Table 4) based on the gender ratio of Taiwanese’s population (see table 1) and the gender ratio of the employment population of three major insurance companies (see Table 3) in Taiwan in 2020 separately.

Unit: 1000				
Years Gender	15-24	25-44	45-64	<65
Male	523 (7.89)	3296 (49.71)	2607 (39.32)	205 (3.09)
Female	466 (8.77)	2932 (55.18)	1831 (34.47)	85 (1.60)

**Table 1. The Gender Ratio of Taiwanese’s population in 2020**

Years Gender	15-24	25-44	45-64	<65	total
Male	4	28	22	2	56
Female	4	24	15	1	44
Total	8	52	37	3	100

**Table 2. Questionnaire Distribution (Consumer)**

Company	Number	Percentage (%)
Fubon Life Insurance Co., Ltd.	41174	26.20
Cathay Life Insurance Company, Ltd.	83820	53.33
Nan Shan Life Insurance Company, Ltd.	32152	20.46

**Table 3. The Employee Number of Three Major Insurance Companies**

Company	Number	percentage (%)
Fubon Life Insurance Co., Ltd.	26	26
Cathay Life Insurance Company, Ltd.	53	53
Nan Shan Life Insurance Company, Ltd	21	21
total	100	100

**Table 4. Questionnaire Distribution (Insurance Company Faculty)**

**3.3 Method of Data Analysis**

Since the questionnaire is used to collect data and it is a five-point scale attitude survey, the collected data was analyzed by the descriptive statistic analysis and independent t test, then, provided more information to help insurance companies do the preparation well to face the era of genetic generation.

**3.4 Method of Risks Treatments**

More industries than ever are taking a consumer-centric approach to evolve their existing products and generating new ideas to serve their customers better. This study tried to employ design thinking methodology to take a closer look at what are risks of genetic test results applied in insurance underwriting and what are creative suggestions for life insurers.

Design thinking is a process for creative problem-solving. Rather than a one-shoe-fits-all mindset, it encourages a holistic view where uncertainty and ambiguity are welcomed and embraced as to consider all sides of a problem. A design mindset can be applied to any life situation, and it aids in considering the bigger picture and informatively acting accordingly. Insurance is a part of service industry and absolutely is a customer-centric financial business. Therefore, through empathy for customers, consumers, or clients, insurers are able to create products and services that truly help insureds and even protect or recover their damage or losses. The Design thinking method exactly is steeped in a deep belief that the end-user should be at the heart of all marketing decision-making in an insurance company.

This study, after risks identifying risks of genetic test results applied in insurance underwriting, will conduct the five-step process of design thinking that enables insurers to come up with impactful solutions to real problems that are vetted by the potential customers they intend to serve before they’ve even been built.

The 5-Step Design Thinking Process to build impactful suggestions to insurance companies (Interaction Design Foundation, 2020; Simon, 1996; Waloszek, 2012).

**3.4.1 Empathize**

The first stage of the design process is to understand the perspective of the target customers to identify and address the problem at hand. This allows the decision maker to objectively consider all possibilities about the customers and their needs. By employing typical activities include observations, qualitative interviews, or immersions, the decision maker can step into user’s shoes so can feel and experience customers’ concerns.

**3.4.2 Define**

This step is to define the problem statement clearly. The resulting problem statement gathered together in the first step should be captured in human-centered terms rather than focused on business goals. The typical activities are to group and cluster ideas together until find the prevailing or most prominent themes and to know the most significant or most impactful issues that you want to consider as you move forward.

**3.4.3 Ideate**

After collecting as many ideas as possible at the start, the design thinking team can investigate and test them. In other words, the ideation stage marks the transition from identifying problems to exploring solutions. Before this

step, each process remains separate from each other. It's time to generate ideas and move into the evaluation phase. The ideation phase is usually a very creative and freeing phase for a team because they have permission to think of out-of-the-box ideas before deciding what they are going to prototype

### 3.4.4 Prototype

By trial and error, this stage can identify which of the possible solutions can best solve the identified problems. This typically will include scaled-down versions of the products or systems in question so you can present and get feedback from the potential customers they are intended to serve.

The goal is to start with a low-fidelity version of the intended solution and improve it over time based on feedback. The prototype should be a realistic representation of the solution that gains an understanding of what works and doesn't work. It is changed and updated based on feedback from the Test phase in an iterative cycle.

### 3.4.5 Test

All of the work and information come together to test the product in the final stage. But this is still an interactive stage have to hear from potential customers again by showing them the prototype to get feedback on whether or not it solves their problem. The goal of this step is to see what real people think about the idea and allow for all details to be flushed out and refined to create the best solution possible.

## 4. Data Analysis Result

According to the data collected from the consumers' questionnaire, there are 49 respondents married and 51 unmarried. Fifty-seven respondents have read reports or literatures related to the genetic testing. However, 43 respondents have not read reports or literatures regarding the genetic testing. Moreover, according to the collected data from the questionnaire of insurance company faculty, there are 62 employees who have read reports or materials related to genetic testing in the past. But only 38 employees have not read reports or materials related to genetic testing.

According to the Table 5, the attitude of all consumer respondents tends to agree that eight question items are all risky. Three of question items, such as "Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged" (mean = 3.83); "the revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being" (mean = 3.65); "the genetic testing result could just right affect future generations and counteracting an individual's right to privacy" (mean = 3.81), however, obtained higher risk attitude tendency.

Question Items	Number	Min	Max	Mean	Standard Deviation
1. The result of insured's genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	100	1	5	3.37	.981
2. Since relevant laws and regulations have not yet been established, there is no government supervision and management when insurance companies use genetic testing information.	100	1	5	3.42	1.046
3. Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged	100	1	5	3.83	1.006
4. The revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being	100	2	5	3.65	.869
5. To collect a blood sample when takes genetic test which may cause physical harm	100	1	5	3.34	1.037
6. The genetic testing result could just right affect future generations and counteracting an individual's right to privacy	100	2	5	3.81	.800
7. If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	100	1	5	3.26	.895
8. If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	100	1	5	3.24	1.036
9. The attitude toward insurance company use genetic test results in underwriting	100	1	2	1.55	.055
10. effective N (completely excluded)	100				

Table 5. The Descriptive Statistics of Consumers' Attitude Tendency

Question Items	attitude toward	number	mean	Standard deviation	standard error of the mean
1. The result of insured’s genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	1	45	3.91	.633	.094
	2	55	2.93	.997	.134
2. Since relevant laws and regulations have not yet been established, there is no government supervision and management when insurance companies use genetic testing information.	1	45	3.31	1.083	.162
	2	55	3.51	1.016	.137
3. Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged	1	45	3.67	1.022	.152
	2	55	3.96	.981	.132
4. The revelation of knowledge about future ill health may have a significant negative impact upon a person’s psychological well being	1	45	3.36	.857	.128
	2	55	3.89	.809	.109
5. To collect a blood sample when takes genetic test which may cause physical harm	1	45	3.16	1.147	.171
	2	55	3.49	.920	.124
6. The genetic testing result could just right affect future generations and counteracting an individual’s right to privacy	1	45	3.51	.869	.130
	2	55	4.05	.650	.088
7. If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	1	45	3.51	.843	.126
	2	55	3.05	.891	.120
8. If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	1	45	3.56	.867	.129
	2	55	2.98	1.097	.148

**Table 6. The Descriptive Statistics of Consumer Attitude Tendency Between Agree and Disagree**

Question Items	Homogeneity of variance Levene test		T test		
	F	p-value	t	df	p-value
1. The result of insured’s genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	12.079	.001	5.736	98	.000
4. The revelation of knowledge about future ill health may have a significant negative impact upon a person’s psychological well being	3.200	.077	-3.205	98	.002
6. The genetic testing result could just right affect future generations and counteracting an individual’s right to privacy	13.893	.000	-3.473	79.878	.001
7. If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	.427	.515	2.612	98	.010
8. If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	1.611	.207	2.853	98	.005

**Table 7. Independent t Test of the Attitude Tendency Between the Consumers Who Agree and Disagree to Use Genetic Test Result in Underwriting**

This study also compared the attitude tendency between the consumers who agree to use genetic test results in underwriting and those of disagree to use genetic test results in underwriting (see Table 6). Base on the analysis results (see Table 7), especially to the question items such as “The result of insured’s genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting” (t = 5.988 with a p-value of 0.00); “the revelation of knowledge about future ill health may have a significant negative impact upon a person’s psychological well being” (t = -3.205 with a p-value of 0.002); “the genetic testing result could just right affect future generations and counteracting an individual’s right to privacy” (t = -3.473 with a p-value of 0.001); “if people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members” (t = 2.612 with a p-value of 0.010); “If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts” (t=2.853 with a p-value of 0.005), show the significant attitude tendency difference between attendees agree to use genetic test results in underwriting and those disagree to use genetic test results in underwriting. Moreover, the risk level of attitude tendency toward those five question items, for the attendees disagree to use genetic test results in underwriting, are all higher than those of agree to use genetic test results in underwriting.

Question Items	gender	number	mean	Standard deviation
1. The result of insured's genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	1	56	3.39	1.021
	2	44	3.34	.939
2. Since relevant laws and regulations have not yet been established, there is no government supervision and management when insurance companies use genetic testing information.	1	56	3.52	1.027
	2	44	3.30	1.069
3. Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged	1	56	3.96	.914
	2	44	3.66	1.098
4. The revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being	1	56	3.73	.884
	2	44	3.55	.848
5. To collect a blood sample when takes genetic test which may cause physical harm	1	56	3.38	1.121
	2	44	3.30	.930
6. The genetic testing result could just right affect future generations and counteracting an individual's right to privacy	1	56	3.88	.833
	2	44	3.73	.758
7. If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	1	56	3.36	.923
	2	44	3.14	.852
8. If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	1	56	3.38	1.037
	2	44	3.07	1.021

**Table 8. The Descriptive Statistics of Consumers' Attitude Tendency Between Male and Female**

In addition, this study compared the attitude tendency between male respondents and female respondents (see Table 8). According to the t test results, there is no statistical evidence to prove that male respondents have higher risk level of attitude tendency toward all question items, although male respondents have higher risk attitude tendency toward all question items than those of female respondents.

Question Items	Number	Minimum	Max	Mean	Standard Deviation
1.The result of insured's genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	100	2	5	3.74	.799
2.Since relevant laws and regulations have not yet been established, there is no government supervision and management when insurance companies use genetic testing information.	100	1	5	3.43	.913
3.Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged	100	1	5	3.75	.957
4.The revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being	100	1	5	3.61	.863
5.To collect a blood sample when takes genetic test which may cause physical harm	100	1	5	3.44	.988
6.The genetic testing result could just right affect future generations and counteracting an individual's right to privacy	100	1	5	3.64	.938
7.If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	100	1	5	3.59	.877
8.If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	100	1	5	3.42	1.046
9.The attitude toward insurance company use genetic test results in underwriting	100	1	2	1.37	.485

**Table 9. The Descriptive Statistics of Insurance Faculty Participants' Attitude Tendency**

According to the analysis results (see Table 9), the attitude of all insurance faculty participants tend to agree that eight question items are all risky. Five of question items, such as "the result of insured's genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting" (mean:3.74); "Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged"(mean:3.75); "the revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being" (mean:3.61; "the genetic testing result could just right affect future generations and counteracting an individual's right to privacy" (mean:3.64); "if people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members." (mean:3.59), however, obtained higher risk attitude tendency.

Question Items	Attitude toward	number	mean	Standard deviation
1.The result of insured’s genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	1	63	3.98	.707
	2	37	3.32	.784
2.Since relevant laws and regulations have not yet been established, there is no government supervision and management when insurance companies use genetic testing information.	1	63	3.49	.914
	2	37	3.32	.915
3.Insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged	1	63	3.83	.871
	2	37	3.62	1.089
4.The revelation of knowledge about future ill health may have a significant negative impact upon a person’s psychological well being	1	63	3.68	.800
	2	37	3.49	.961
5.To collect a blood sample when takes genetic test which may cause physical harm	1	63	3.51	.965
	2	37	3.32	1.029
6.The genetic testing result could just right affect future generations and counteracting an individual’s right to privacy	1	63	3.68	.947
	2	37	3.57	.929
7.If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	1	63	3.81	.840
	2	37	3.22	.821
8.If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	1	63	3.68	.964
	2	37	2.97	1.040

**Table 10. The Descriptive Statistics of Insurance Faculty Participant’s Attitude Tendency Between Agree and Disagree**

Question Items	Homogeneity of variance Levene test		T test		
	F	p-value	t	df	p-value
1. The result of insured’s genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting	4.314	.040	4.213	69.426	.000
7. If people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members.	.077	.782	3.439	98	.001
8. If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts.	.000	.994	3.450	98	.001

**Table 11. Independent t Test of Attitude Tendency Between the Insurance Faculty Respondents Who Agree and Disagree to Use Genetic Test Result in Underwriting**

This study also compared the attitude tendency between the insurance faculty attendees who agree to use genetic test results in underwriting and those of disagree to use genetic test results in underwriting (see Table 10). Base on the analysis results (Table 11), especially to the question items such as “the result of insured’s genetic testing generally can provide insurers a more accurate and reliable source of hereditary information for underwriting” (t=4.213 with a p-value of 0.00); ” if people know that they are at higher risk of dying from cancer at an early age, then they might be inclined to purchase life insurance to preserve wealth for surviving family members” (t=3.439with a p-value of 0.001); ” If insurers are not allowed to genetic test results in underwriting, then they are concerned that they will experience a higher overall rate of death and higher payouts”; (t=3.450 with a p-value of 0.001), show the significant attitude tendency differences between insurance faculty attendees agree to use genetic test results in underwriting and those disagree to use genetic test results in underwriting. Moreover, the risk level of attitude tendency toward those two question items, for the insurance faculty attendees disagree to use genetic test results in underwriting, are all higher than those of agree to use genetic test results in underwriting.

Attitude Toward Using Genetic Test Results as an Underwriting Reference	Respondents		
	Consumers	Insurance Faculty	Total
Agree count	45	63	108
(% within respondents)	(45%)	(63%)	(54%)
Disagree count	55	37	92
(% within respondents)	(55%)	(37%)	(46%)
Total	100	100	100
	(100%)	(100%)	(100%)

**Table 12. The Cross Table Analysis of Attitude Tendency Toward Using Genetic Test Results in Underwriting Between the Insurance Faculty and Consumers**

Finally, the cross table analysis employed by this study shows that 45% of consumer agree genetic test results can be used as an underwriting reference and 55% of consumers disagree. Meanwhile, 63% of insurers agree genetic test results can be used as an underwriting reference and 37% of insurers disagree (see Table 12).

## 5. Conclusions

According to the research findings, this research has five conclusions.

5.1 Both consumers and insurance faculty worry that insurance companies may adopt unjustified caution when insurers using genetic information or misinterpret genetic information resulting in an individual being overcharged. This will lead to increase annual premiums to consumers, and the revelation of knowledge about future ill health may have a significant negative impact upon a person's psychological well being, even affect future generations and counteracting an individual's right to privacy. In other words, both consumer and Insurance faculty concern the issues of inappropriately referring and invasion of privacy if insurers employ genetic information to make their underwriting decision.

5.2 Most of consumers agree that the genetic test results are accurate. Due to learn the bad health information from genetic test results, consumers might be inclined to purchase more life insurance to preserve wealth for surviving family members. Because of increasing in adverse selection, insurers will charge applicants higher premiums inevitably. On the contrary, undoubtedly, insurance faculty have much more concern to insurers suffer from adverse selection if genetic test results cannot be used as an underwriting reference.

5.3 Both the insurance faculty and consumers agree that the result of insured's genetic testing generally can provide insurers more accurate and reliable source for making underwriting decision. However, this does not mean that consumers ignore the issues of inappropriately referring and invasion of privacy while the genetic testing results be used as an underwriting reference.

5.4 The number of consumers who disagree to use genetic test results in underwriting is more than those of insurance faculty. In other words, insurance faculty have more positive attitude tendency toward using genetic testing results as an underwriting reference. On the contrary, consumers hesitated over insurers using genetic test results for underwriting decision making.

## 6. Recommend Treatments by Design Thinking Processes

After conducting 5 steps design thinking processes, this study gains some suggestions from perspectives of stakeholders to insurers and supervisors. The suggestions are as followings.

6.1 Information Technology (IT) is getting more and more advanced. This IT improvement bring about the public's concerning the privacy. This study suggests the supervisor invite insurer, genetic medicine experts and consumer representatives to get together to develop laws or regulations related to reasonable using genetic testing in insurance underwriting. The developed law can not only perfectly protect the right of consumer but also strictly regulates the insurance industry to avoid disputes from ambiguous of regulations.

6.2 Most of insurance transaction disputes come from information asymmetry. This implies insurer should pay more attention to design a clear and easy understand policy related to using genetic testing results in underwriting to avoid disputes and improve the acceptance of policies.

6.3 In order to protect the rights and interests of consumers strictly, this study recommends the supervisor not only to develop a consumer protection mechanism by revising the contemporary related statutes but also to request insurance companies to improve the employees' legal awareness of using genetic test results appropriately by providing advance on the job training program.

6.4 Finally, this study also suggests the insurance industry, by applying Blockchain tech, to establish a third-party justice and trusted unit to manage genetic testing information fairly and insurance companies could reasonably employ genetic testing information in their underwriting procedures.

## Works Cited

- Bolger, A. (2000). Insurers win backing on genetic test for risk of hereditary illness, *Financial Times*, London: UK, 13 Oct 2000.
- Bombard, Y. and Lemmens, T. (2010). Insurance and Genetic Information. In: *Encyclopedia of Life Sciences (ELS)*, John Wiley & Sons, Ltd: Chichester.
- Brody, W. R. (2002). A Brave New Insurance, *Wall Street Journal, Eastern edition*, 20: A. 14. New York.
- Budden, R. (1999). Insurers tighten genetic testing guidelines, *Financial Times*, London, 09 Aug 1999.
- Centers for Disease Control and Prevention (2020). Genomics & Precision Health, 2020, [https://www.cdc.gov/genomics/gtesting/genetic\\_testing.htm](https://www.cdc.gov/genomics/gtesting/genetic_testing.htm). Accessed 27 Aug. 2020.
- Dobson, S. (2017). Genetic testing put to the test, *Canadian HR Reporter*, 30 (6), pp. 1- 8.
- Godard, B. S., Raeburn, M. P., Bobrow, M., Farndon, P., and Ayme, S. (2003). Genetic information and testing in insurance and employment: technical, social and ethical issues, *European Journal of Human Genetics*, 11 (Supplement 2), pp. S123-S142.
- Goh, J. (2017). Genetic testing could lead to life insurance discrimination, *Money Management*, Chatswood: Sydney, 26 Oct 2017.
- Hair, J. F., Celsi, M., Money, A., Samouel, P., and Page, M. (2016). *The Essentials of Business Research Method*, 3rd Edition, 2016 Faculty Bookshelf.2., <http://digitalcommons.kennesaw.edu/facbooks2016/2>. Accessed 22 Feb. 2020.
- Holbrook, E. (2013). What genetic testing means for life insurers, *National Underwriter Life & Health*, Erlanger: KY, 01 Sep 2013.
- Interaction Design Foundation (2020), *Design Thinking - The Beginner's Guide*, <https://www.interaction-design.org/courses/design-thinking-the-beginner-s-guide>. Accessed 3 May. 2020.
- Jacobs, P. (2004). Genetic Tests Find New Risk: Insurance, *Knight Ridder Tribune Business News*, Washington. 28 Apr. 2004.
- Klitzman, R., Appelbaum, P. S., and Chung, W. (2014). Should Life Insurers Have Access to Genetic Test Results, *Journal of the American Medical Association*, 312 (18), pp. 1855 - 1856.
- Lombardo, M. (2018). The Impact of Genetic Testing on Life Insurance Mortality, *The Society of Actuaries*, Schaumburg: Illinois.
- Morris, L. A. (2010). Life insurance and genetic tests: Risks for insurers and society, *Health, Risk & Society*, 12 (3), pp. 251 - 270.
- Pollitz, K., Peshkin, B. N., Bangit, E., Lucia, K. (2007). Genetic Discrimination in Health Insurance: Current Legal Protections and Industry Practices, *Inquiry – Excellus Health Plan*, 44 (3), p. 350.
- Riordan, P. (2015). Warning of genetic tests for health cover, *The Australian Financial Review*, Melbourne: Australia.
- Rothstein, M. A. (2009). Genetics and Life Insurance: Medical Underwriting and Social Policy, *The MIT Press*, Cambridge: MA.
- Rrez, C. G. and Macdonald, A. (2004). Huntington's Disease, Critical Illness Insurance and Life Insurance, *Scandinavian Actuarial Journal*, 4, pp. 279 - 313.
- Simon, H. (1996), *The Sciences of the Artificial* (3rd Edition), [https://monoskop.org/images/9/9c/Simon\\_Herbert\\_A\\_The\\_Sciences\\_of\\_the\\_Artificial\\_3rd\\_ed.pdf](https://monoskop.org/images/9/9c/Simon_Herbert_A_The_Sciences_of_the_Artificial_3rd_ed.pdf). Accessed 13 July. 2020.
- Waloszek, G. (2012), *Introduction to Design Thinking*, 2012: <https://experience.sap.com/skillup/introduction-to-design-thinking/>. Accessed 13 April. 2020.
- Wilson, D. (2006). Acquisition and disclosure of genetic information under alternative policy regimes: an economic analysis, *Health Economics, Policy and Law*, 1, pp. 263-276.
- Zick, C. D., Mathews, C. J., Roberts, J. S., and Cook-Deegan, R. (2005). Genetic Testing for Alzheimer's Disease and Its Impact On Insurance Purchasing Behavior, *Health Affairs*, 24 (2), pp. 483 - 490.