PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Actuarial considerations on genetic testing

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Actuarial considerations on genetic testing

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SUMMARY

In the UK the majority of life insurers employ relatively liberal underwriting standards so that people can easily gain access to life assurance cover. Up to 95% of applicants are accepted at standard terms. If genetic testing becomes widespread then the buying habits of the public may change. Proportionately more people with a predisposition to major types of disease may take life assurance cover while people with no predisposition may take proportionately less. A model is used to show the possible effect. However, the time-scales are long and the mortality of assured people is steadily improving. The change in buying habits may result in the rate of improvement slowing down. In the whole population, the improvement in mortality is likely to continue and could improve faster if widespread genetic testing results in earlier diagnosis and treatment. Life insurers would not call for genetic tests and need not see the results of previous tests except for very large sums assured. In the UK, life insurers are unlikely to change their underwriting standards, and are extremely unlikely to bring in basic premium rating systems that give discounts on the premium or penalty points according to peoples genetic profile. The implications of widespread genetic testing on medical insurance and some health insurance covers may be more extreme.

1. INTRODUCTION

Concern is being expressed that if genetic information is released to insurance offices then, in some way, it could be used 'unfairly', and that some people would be denied insurance or would be charged excessively high premiums. On the other hand, insurance offices worry that if they are denied access to the results of genetic tests, when the proposer already knows the results, then offices may be open to widespread adverse selection and could suffer a run of large claims in the short-term and the long-term.

There are an increasing number of genetic tests which identify that a person may have a predisposition to certain diseases, such as cancer and heart disease. These tests provide no certainty that the person will develop the disease, but show that they are at an increased risk in the future. It is likely that the ability to quantify and forecast the risk will steadily improve. The risk to insurance offices is in the long-term, not the short-term. People who are likely to die in the short-term will probably already be showing symptoms of disease and heightened risk, and orthodox underwriting systems would identify them without the need for a genetic test.

The effect on insurance companies will unfold over the long-term if peoples' buying habits for life assurance change. If those who have been confirmed by genetic test to have a predisposition to disease take up assurance more readily than those with a good genetic profile (no predisposition to the main disease groups), then the mortality experience of assured lives could steadily and progressively deteriorate over the long-term.

2. LONG-TERM MORTALITY EXPERIENCE

Since the turn of the century, population mortality rates in the UK have dropped steadily. Figure 1 shows the progressive reduction in the mortality rate for males aged 50 by around 1–1.5% yr^{-1} on average. This decline is also mirrored in the mortality rates for people who are covered for life assurance. The rate for assured lives decreases similarly to population mortality and stays at *ca.* 60–70% of the population rates.

The reason for lower mortality rates for assured lives is that, generally, but not exclusively, they come from the higher socio-economic groups who have the means, the ability and the realization to follow healthy regimes, good diets, better hygiene and more comfortable lifestyles. The mortality variation according to socio-economic groups is wide, as shown by OPCS data (figure 2).

The fact that life offices only accept people who are considered to have relatively healthy lives and who have passed an underwriting test also has a bearing, though the effects of underwriting selection are relatively short-lived. The mortality of a group immediately after acceptance for assurance cover is low compared to that of people who have been assured for a long time. These long-time insured people are said to be in the ultimate period. The longer the date since the underwriting selection, the closer the mortality of the newly accepted group merges with the mortality of the long established group. For mathematical convenience, actuaries assume that the effect of selection will wear off in five years. Studies show that it continues with slight and diminishing effect for longer than that period, and in North America actuaries assume that

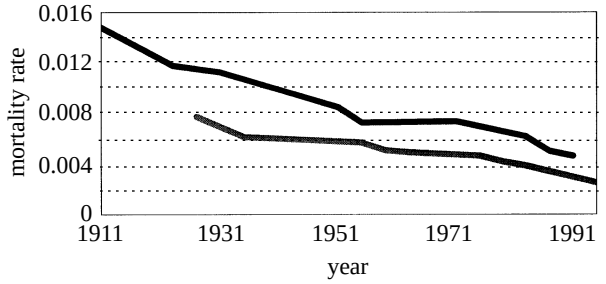

Figure 1. Mortality rates for males aged 50 years. The top line represents population mortality; the lower line represents assured lives mortality.

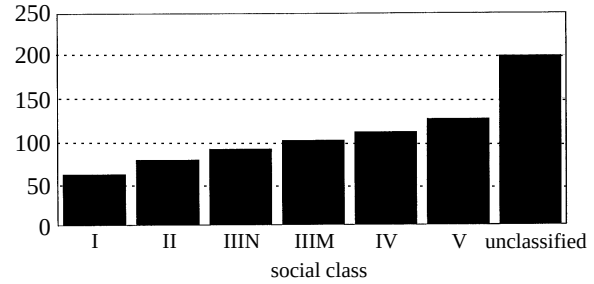

Figure 2. Standardized mortality ratio by social class (males).

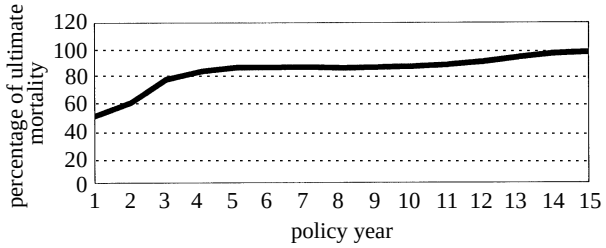

Figure 3. Progression of mortality with policy year for males aged 40 years (USA statistics).

the selection effect lasts 15 years, when it is then assumed to be of no influence (figure 3). So the effect of underwriting is relatively short-lived and people blend in the ultimate experience. The people who constitute this body of lives in the ultimate period are not all fit and healthy. At one extreme, there will be those who are superfit, who will have a very low mortality rate, through to those whose life expectation is seriously impaired, and who will experience a very heavy rate of mortality. The majority, of course, will experience mortality slightly better or worse than average.

Various models can be constructed to measure the possible pattern of the mortality rates across a group of lives all at the same age. I should emphasize that these models are purely theoretical because the detailed statistics for measuring the various subgroups are not available, except in very broad terms. One model splits the lives at any one age and in the ultimate period into six categories (table 1). At each age, the average mortality rate over all the six groups must conform with the standard mortality table. For males at age 50, around 25% are assumed to be in category 1—the superfit lives—and the remainder are allocated to fit in with a few known and observed factors. The proportion

Table 1. *A model which splits the lives at any one age and in the ultimate period into six categories*

category	type of life
1	people who are very fit (and probably know they are fit)
2	people who are in an average state of health with no particular problems (and probably consider themselves reasonably fit for their age)
3	people who are active, but who have one or two conditions that affect their health detrimentally (they probably know or suspect that their health is borderline)
4	people who have a past history of moderate ill health or a continuing condition that requires monitoring and control (they probably know that their health is not normal, but do not consider themselves very unhealthy)
5	people who have a past history of serious ill health or a prolonged condition requiring continual treatment (they probably know that they are not healthy and that they have a condition that affects life expectation)
6	people in serious ill health who would probably be considered unacceptable for any new life insurance (they would know that their life expectation could be seriously impaired)

of unfit lives in categories 3–6 is small at young ages (*ca.* 1.5%), but gradually increases with attained age to *ca.* 6–7% at 50 with less than 1% in the seriously impaired category at that age. The risk of accidental death, which is the most common cause of death for young males, is not considered in this model and can be quantified separately. The distribution at age 50 according to this model is shown in table 2.

The essential question is: what will be the long-term effect of genetic testing on this type of distribution? The worry for actuaries is that the pattern will be seriously disturbed; less of the superfit will effect assurance and proportionately more of the unfit will do so, and so the ultimate experience is worsened.

The dynamics of the changes that could be brought in via genetic testing are simple to define. There is a pattern for those taking assurance under current conditions. If we assume that genetic testing exists and is widespread, and some people are made aware that they have a predisposition to a certain disease or

Table 2. *Percentage distribution and assumed mortality rate at age 50, using the model in table 1*

category	percentage distribution in six categories	assumed mortality rate as a percentage of standard in each category
1	25%	30
2	68%	100
3	3%	170
4	2%	260
5	1%	490
6	1%	1150
	100% (total)	100 (average)

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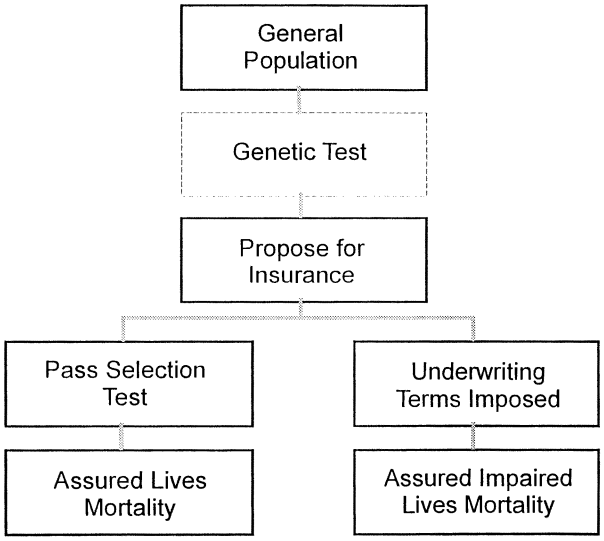

Figure 4. Dynamics of assurance buying habits.

diseases, then the picture of the dynamics for those who have had a genetic test has one extra step (figure 4). The part of the diagram that is least understood is the link from 'General Population' to 'Propose for Insurance'. Why do people effect assurance? Is it peace of mind, security for the family, recognition of the risk, because they are made to do so for mortgage protection, or simply because a persuasive salesman calls? Since the overall percentage of people in the UK covered for life assurance protection policies (as opposed to pensions and investment contracts) is only around 30% of the total population, it is clear that there is the scope for significant shifts in the portfolio of assured lives which could lead to significant changes in the assured lives mortality over time.

How does the news that a person has a predisposition to a disease change their willingness to take life assurance? Probably they are more inclined to take it, especially if they get standard terms for life assurance. If they have no special predisposition and already consider themselves superfit, surely they will be inclined to take less assurance? However, people's buying habits are influenced by a whole range of factors and, though the knowledge of one's own genetic background is unlikely to be decisive in making clear cut decisions of yes or no to buying assurance, it must be of some significant influence. But we have little knowledge, as yet, of the motivating factors to buy life assurance, and it is pure guesswork to try to calculate the changes in behaviour after genetic testing. This part of the dynamic equation is just not measurable at this stage.

However, what we can do is to look at some possible scenarios on a 'what if?' basis. Suppose buying habits change so that the portfolio of lives covered for assurance changes, so that ultimately there are less superfit lives (the superfit with a good genetic profile take less assurance) and their place is taken by more lives with a predisposition in the long-term to certain diseases. These lives could be assumed to have mortality equivalent to the current average experience of people in categories 3–6. The arithmetic based on

Table 3. *The increase in ultimate mortality for people who once passed the selection test and are now in the ultimate period*

(Deaths from accidents are excluded.)

percentage of superfit lives lost (i.e. percentage of impaired lives gain)	percentage increase in ultimate mortality
10 (or total 2.5 of total pool)	8%
20 (or total 5 of total pool)	16%
30 (or total 7.5 of total pool)	24%
40 (or total 10 of total pool)	32%
50 (or total 12.5 of total pool)	40%

the theoretical model shows that the overall mortality of the pool would increase as shown in table 3. The figures relate to people who once passed the selection test and are now in the ultimate period—deaths from accidents are excluded. Are these figures alarming for actuaries in life offices? In my opinion, they are not for a number of factors.

First, we need to consider the time-scales. It will be many years before genetic testing and screening of the whole population will take place, if ever. In the intervening period, population mortality (and assured lives mortality) will probably continue to reduce by 1–1.5% each year, due to improvements in lifestyles, changes in habits, improved diagnosis and advances in medicine, quite apart from advances in genetic science. Any adverse trend caused by a change in buying habits of genetically tested proposers will be countered to some extent or completely balanced by general improvements in mortality.

Second, we should not overlook the fact that genetic testing will reveal to people that they have a predisposition to disease—changes in habits and unhealthy lifestyles could be encouraged at an early stage. Other preventive medicine could be undertaken, the onset of disease would be diagnosed earlier and medical treatment started. Even though it may be many years before genetic therapies and cures are fully established, earlier diagnosis and standard modern treatment should lead to further substantial reductions. My conclusion is that the advent of genetic testing will lead to further improvements in population mortality and could accelerate the existing improving trends.

For the assured lives mortality, which is lower than population mortality, the outlook is less clear. On one hand genetic testing is likely to encourage a trend towards improving mortality, but on the other hand the proportion of superfit people with no predisposition to disease may take less assurance, and those who have a predisposition to disease will take assurance more readily. This could result in an adverse trend unfolding in the future. My own view is that assured lives mortality will continue to decline in the short-term and may stabilize or improve less rapidly if widespread genetic testing is established. This very tentative conclusion is based on three assumptions: that, (i) underwriting practice is largely unchanged from the present; (ii) there are no large amounts of adverse selection by people who know they have a poor genetic pattern and who take very high sums assured; and (iii)

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Table 4. *MRFIT study of the interrelation of smoking, serum cholesterol and systolic blood pressure in age-adjusted CHD mortality per 10000 person years, by serum cholesterol and systolic blood pressure quintiles*

(J. Stamler (1992)—the MRFIT study was a 12-year follow-up study of 342815 non-smoking men, free of heart attack and diabetes.)

serum cholesterol (mmol l^{-1})	systolic pressure (mmHg)			
	< 118	118–124	125–131	132–141
< 4.7	3.09	3.72	5.13	5.35
4.7–5.2	4.39	5.79	8.35	7.66
5.2–5.7	5.20	6.08	8.56	10.72
5.7–6.3	6.34	9.37	8.66	12.21

the pool of lives is not disturbed by some people being tempted away to other pools that offer discounts to the superfit or who have good genetic profiles. If these assumptions are not solid, then there could be adverse selection against the pool of lives, and mortality could show some increase.

I would like to consider the underwriting of large sums assured and then consider if discounts can be given to superfit lives with good genetic profiles. The highest amount of life assurance cover on any one individual in the UK is *ca.* £40 million. Would any underwriter accept a new £40 million assurance policy if the proposer knew his genetic profile, but the underwriter did not? I do not think any office, reinsurance office or any combination of them would do so—it would be too speculative. The views would probably be the same at £1 million—a claim of this amount is very painful for a life office, even if it is not a disaster. Would genetic information be required by underwriters, if the proposer knew his profile, at £500000 or even £50000?

Currently, life offices require the results of genetic tests, if they are known to the proposer, for any level of sum assured proposed, but I query if this is feasible if a substantial proportion of the population have genetic tests. Underwriting aims to include the majority of people in the standard rate category, to achieve this simply and economically for the office, and in a way that is acceptable to the proposer without deterring him from completing the proposal. Practice varies between insurance offices, but typically around 65–70% of proposers are accepted on the information on the proposal form. On the balance of 30–35%, a report from the person's medical attendant would be obtained, and only around 5–10% of all applicants would be required to attend a medical examination additionally. The medical examination is similar to a simple health check and only if something is revealed at the examination or disclosed by the proposer is further detailed information requested.

The aim is to make the process simple—complicated tests are avoided. For example, an automatic test for serum cholesterol is rarely requested by life offices, even though there is a very high degree of extra mortality risk with a combination of serum cholesterol and raised blood pressure (greatly accentuated in smokers). Table 4, from the MRFIT investigation in the USA, is well known to underwriters—other examples of combinations of impairments associated with exceptionally high mortality are also known.

Table 5. *Typical medical examination limits of life offices*

age of proposer	sum assured limit (£)
up to 40	300000
40–49	200000
50–54	125000
55–59	75000
60–64	25000

The mortality rate due to coronary heart disease (CHD)—the most common cause of death—varies from one to four for the extremes of table 4 and yet all the subgroups in the table would easily qualify for standard terms under current underwriting practice. Underwriters rarely ask for serum cholesterol levels. As underwriters are prepared now to use a selection process that does not require special tests for these combinations of impairments (even for very large cases), then they are unlikely to request genetic information for ordinary-sized life assurance cases (even if genetic testing becomes widespread or if tests are as simple to obtain as blood pressure reading or serum cholesterol levels).

The underwriter would then probably want to ask for genetic information when either an existing medical impairment was revealed and if the case exceeded a certain size limit. Perhaps a convenient limit would be the sum assured, when the underwriter would automatically require a medical examination. Genetic test results would only be requested by a life office if a test had already been performed—life offices have agreed not to initiate genetic tests for insurance purposes. The size limit when a life office automatically calls for a medical examination varies from office to office and depends on many factors, such as type of policies sold, target market, methods of trading, and size of the office. Typical size limit values are shown in table 5. Thus, if no existing medical impairment was present at the proposal stage, then the percentage of cases where an underwriter would request any information on a previous genetic test would be very small. For an office that specialized in relatively large-sized cases this would be below 5%, and would probably be much lower for other offices.

However, the general suggestion put forward is that, if genetic information on previous tests was treated as other medical information (with the same safeguards), and only requested on large cases that exceed a certain size (such as automatic medical examination limits), then it would only be requested in a very few cases. These cases would normally be well in excess of the normal life assurance cover requirements of the average person.

Adverse selection is always a threat to the stability of an insurance pool—there are well known examples where serious losses were suffered and which were caused by lack of underwriting control. Underwriters would need to be vigilant that the amount of cover

granted was reasonable compared to the proposer's income and financial status. They would also wish to ensure that an applicant is not effecting simultaneously a number of separate proposals to different offices. The insurance office's need is not for more and more genetic tests—it is for a limited number of genetic tests and much tighter financial underwriting.

3. SPECIAL TERMS FOR THE SUPERFIT

One view that has been put forward is that the group of people who are superfit and who also have a good genetic profile will decline to take or maintain their life assurance policies, or insurers would be forced to give them large discounts if they are to be persuaded to take life assurance. As discussed earlier, this could lead in time to a worsening of the mortality experience from the lives left in the pool, and higher premiums.

Apart from age, until recent years insurance pools were only differentiated by sex—separate rates were charged for males and females. In the recent past, rates have been differentiated also by smoking. More recently, several insurers have brought in rating bases that recognize a range of rating factors, such as (i) income level; (ii) social class; (iii) region within UK; (iv) family history; and (v) height and weight. Reductions or additions are made to the standard table according to favourable or unfavourable features. Within the tables for males, the variation in the final terms can vary from 60% of standard (all favourable features) to 167.5% (all unfavourable features).

In this type of rating structure, all the rating factors for an individual can be established easily without any detailed medical investigation. The system could be extended further (for large cases where medical information is obtained automatically) to include factors such as blood pressure reading, cholesterol level, etc. Determining the premium basis for these complex methods of rating is difficult. Though this concept of preferred rating is widespread in the USA, only a handful of offices employ the system in the UK, with most offices preferring to write business without subdividing the portfolio into numerous sections. Furthermore, there is as yet no strong demand from consumers or insurance agents for this approach.

In theory, it would be possible to include the genetic profile into this type of rating structure. However, in practice it will be many years before sufficiently good information is available for rating purposes. It is extremely unlikely that actuaries will attempt to include genetic testing. As most offices choose not to adjust their standard premium scales for readily measurable factors, and no office adjusts standard premium scales for medical factors, they are most unlikely to use the results of genetic tests in rating formulae, where the results are difficult to interpret and no statistics exist. The fear of the Parliamentary Health Committee that the lives with the better genetic profiles will be weaned away from the insurance pool, so that only a very heavily rated remainder is left, appears unfounded.

It is as well to point out that the concept of insurance pooling does not demand that all members are included in the pool and are all charged the same premium. The concept is better explained as 'all proposers should have access to insurance, and each should pay an equitable premium to reflect the risk'. What constitutes an equitable premium to reflect the risk may well change, both in the short-term and over the long-term as insurers, proposers, and society in general modify their views on what is equity. The view has changed with time. At one stage society considered it equitable to charge the same rate, irrespective of the sex of the proposer or smoking habit. These days, society in general, with some exceptions, considers it equitable to charge females lower rates than males, and non-smokers lower rates than smokers. It is impossible now to forecast the views on equity for future generations or our own generation, i.e. 10 or 20 years ahead, when genetic testing may be commonplace. Will there be a demand from consumers with a good genetic profile for low rates? Will there be a reluctance for them to subsidize the remainder? It is unlikely that we will know the answer within 20 years. In the meantime, there are unlikely to be any sudden changes in rating methods.

4. CONCLUSIONS

I realize, in conclusion, that I have not put forward any new ideas or any definite answers. However, I hope I have given views that will contribute to the debate. The following are points I would like to emphasize. First, genetic science and widespread genetic testing are likely to improve the mortality of the general population, i.e. the mortality rate may decline faster. However, for insurance pools the future experience is less clear—especially if people's buying habits for life assurance change. Assured lives mortality may improve slower than the general population figures and, without the necessary underwriting safeguards, it could increase. Second, if genetic information is treated as medical information, then underwriters are likely to call for results of existing tests only rarely and then only for large cases. Third, including genetic testing in preferred lives rating schemes is theoretically possible but highly improbable.

This paper only relates to life assurance policies—the effect on other classes of business, such as medical fees insurance or critical illness insurance, could be more severe. The views put forward in this note are the personal views of the author and do not purport to represent those of his office or of the industry. Finally, I would emphasize that the way individuals, underwriters and society in general view genetic tests, and how the results are used, is currently ill-informed. Almost certainly it will change, as people become familiar with the concepts, and if testing becomes widespread. We would not serve society well if we drew up rigid frameworks now that might hinder delivery of worthwhile services to the community in the years ahead.

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