Genetic Testing, Insurance Underwriting and Adverse Selection

Pradip Tapadar

University of Kent

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Agenda

1. Introduction
2. Risk aversion
3. Adverse selection
4. A Simple Two-state Model
5. Critical Illness Insurance Example
6. References
Background

- Multifactorial disorders: Cancer, Cardiovascular disease.
- The UK Biobank project:
  - Over 500,000 recruited from England, Scotland and Wales.
  - Age-range 40-69: Follow-up period 30 years.
  - DNA extraction from blood sample as and when required.

“The main aim of the study is to collect data to enable the investigation of the separate and combined effects of genetic and environmental factors (including lifestyle, physiological and environmental exposures) on the risk of common multifactorial disorders of adult life.”
Genetics and Insurance Regulations

- Insurance underwriting and setting premium rates.
- Information asymmetry and adverse selection.
- Genetic risk, environmental risk and insurance.
- Insurance regulatory developments in the UK:
  - 1997: HGAC asks Government to impose a moratorium.
  - 1999: GAIC formed to scrutinise use of genetic tests.
  - 2000: GAIC approves use of genetic tests for HD for life insurance contracts over £500,000.
  - 2001: ABI withdraws all applications – agrees a 5-year moratorium.

Q: Taking economic and epidemiological issues into account, under what circumstances is adverse selection likely to occur with sufficient force to be problematic?
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Consider an individual with:

- initial wealth: $W$;
- exposed to an adverse risk with probability $q$;
- on adverse event would incur a loss: $L$;
- utility function $U(w)$, which is:
  - an increasing function of wealth;
  - with decreasing marginal utility.
Utility function

\[
U(W) = U(W - L)
\]

Risk aversion Utility function

Genetics and Insurance

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Expected utility of a gamble

\[ U(W) = qU(W-L) + (1-q)U(W) \]

where
- \( U(W) \) is the utility of wealth \( W \)
- \( U(W-L) \) is the utility of wealth \( W-L \)
- \( q \) is the probability of gaining \( W-L \)
- \( 1-q \) is the probability of losing \( W-L \)
A risk-averse individual with insurance

\[ U(W) \]

\[ U(W-qL) \]

Fair premium

\[ qL \]
Comparing insurance against a gamble

Wealth

Utility

\[ U(W) \]

\[ U(W - qL) \]

Preference for insurance

\[ qU(W - L) + (1 - q)U(W) \]

Risk aversion

Comparing insurance against a gamble
Tolerance for a higher than fair premium

Utility

\[ U(W) = qU(W - L) + (1 - q)U(W) \]

Tolerance limit

Extra premium \( \Delta \)

Fair premium \( qL \)

Wealth

\[ W - L \]
\[ W - (qL + \Delta) \]
\[ W - qL \]
\[ W \]
Adverse selection

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Uniform premium for all strata

Suppose:
- There are two risk groups.
- Low-risk group’s risk of adverse event \( q_0 \).
- High-risk group’s risk of adverse event \( q_1 \).

Suppose further:
- The insurer is not allowed access to private information, and
- is forced to charge the same average premium, \( \bar{q} \), for both groups.

**Q:** Assuming that the insurance purchasers are aware of their own risk, under what circumstances will the low-risk individuals stop purchasing insurance, triggering adverse selection?
Within tolerance limits – no adverse selection

\[ q_0 U(W - L) + (1 - q_0) U(W) \]

Utility

\[ U(W - L) \]

Wealth

\[ W - L \]

\[ W - \bar{q} \times L \]

\[ W \]

Extra premium

Fair premium

Average premium

\[ \Delta \]

\[ q_0 L \]

\[ \bar{q} \times L \]
Outside tolerance limits – adverse selection

Utility

\[ U(W) = q_0 U(W - L) + (1 - q_0) U(W) \]

Average premium

\[ q \times L \]

Extra

\[ \Delta \]

Fair

\[ q_0 L \]

W - \( q \times L \)
A Simple Two-state Model

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The Model

Model assumptions:

- Insured event represented by transition from state A to state B.
- Two risk groups with different transition intensities $\lambda$.
- Relative risk: $k = \frac{\lambda_1}{\lambda_0} \Rightarrow q_1 = 1 - (1 - q_0)^k$.
- Proportion of population in each risk-group is known.

The threshold relative risk, above which adverse selection takes place, can now be analysed.
A Simple Two-state Model

Threshold relative risk

50% in low-risk group

$q_0 = 0.5$

$q_0 = 0.1$
Threshold relative risk

Threshold relative risk

$q_0 = 0.5$

$q_0 = 0.1$

90% in low-risk group

Loss ratio (\(L/W\))
Immunity from Adverse Selection

The population proportions above which the low-risk group will buy insurance at the average premium regardless of the relative risk:

\[
q_0 = 0.1
\]

\[
q_0 = 0.5
\]
Observations

- For low loss ratios, even small relative risks cause people to opt against insurance.
- At high loss ratios, threshold relative risk increases.
- A sufficiently high proportion of low risk individuals ensures that adverse selection never occurs whatever the relative risk.
- Higher risk-aversion $\Rightarrow$ Higher threshold relative risk.

Conclusions

Adverse selection in the 2-state insurance model does not appear unless:

- purchasers insure a small proportion of wealth;
- the elevated risks implied by genetic information are implausibly high;
- the size of the low-risk stratum is unrealistically small.
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A Critical Illness Insurance Model

State 1 Healthy

\[ \lambda_{12}(x) \rightarrow \text{State 2 Heart Attack} \]

\[ \lambda_{13}(x) \rightarrow \text{State 3 Cancer} \]

\[ \lambda_{14}(x) \rightarrow \text{State 4 Stroke} \]

\[ \lambda_{15}(x) \rightarrow \text{State 5 Other CI} \]

\[ \lambda_{16}(x) \rightarrow \text{State 6 Dead} \]
Heart Attack Rates as a % of Total CI Rates

- Male
- Female

Age (years):
0 10 20 30 40 50 60 70 80

Ratio:
0 0.2 0.4 0.6 0.8 1
Summary

Observations

- Critical illnesses other than heart attacks creates a minimum premium;
- ... and dilutes the impact of genetic risk on heart attack.
- The threshold relative risks are much higher for males than females.
- Adverse selection appears to be possible only for smaller losses and extremely low levels of risk aversion.
- Adverse selection does not appear at all at realistic risk-aversion levels.

Conclusions

The results suggest that in circumstances that are plausibly realistic, private genetic information relating to risks only available to consumers does not lead to adverse selection.