The Actuarial Profession
making financial sense of the future

Health and care conference 2010
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Understanding medical tests and how to use them

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What is a medical test?

- **Definition:** A **medical test** is a kind of medical procedure performed to detect, diagnose, or evaluate disease, disease processes, susceptibility, and determine a course of treatment
  - Screening
  - Diagnostic
  - Evaluation

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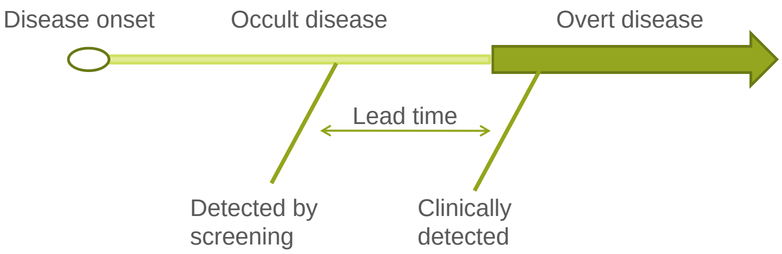
What is screening ?

- **Screening** is a strategy used in a population to detect a disease in individuals without any signs or symptoms of that disease
- The intention is to identify disease early, thus enabling earlier intervention to reduce mortality and suffering from a disease



Screening starts before birth…..

	Screening-Test	Disease
Unborn	Nuchal fold	Down-Syndrome
Newborn	Heel stick test Hearing test	Metabolic disorders Congenital deafness
Nursling	Ultrasound of hip	Hip dysplasia
Female > 20 years	PAP-smear	Cervical cancer
Female > 40-50 years	Mammogram	Breast cancer
Male > 50 years	PSA-test	Prostate cancer
> 55 years	Colonoscopy	Colon cancer
?	Resting/Exercise-ECG	Coronary artery disease
?	Carotid intima thickness	Arteriosclerosis/Stroke
?	Blood tests	Kidney disease, diabetes, liver diseases
Under evaluation	Cardiac CT scan Biomarkers Thoracic CT scan	Coronary artery disease Heart failure, Alzheimer Lung cancer

Screening tests in U/W – an example

- 35 years old female applicant; broker → £ 5 m life cover
- Ht :1.65cm Wt: 65kg, non-smoker, no family history
- No history of any significant disease, no cardiovascular risk factors

- As a result of the non-medical life limits, the following tests are required:
  - APS
  - MER (BP, pulse, full physical exam => heart, lungs, abdomen etc.)
  - ECG
  - Exercise-ECG
  - Fasting blood sugar or HbA1c
  - Erythrocyte sedimentation rate
  - Lipids (Fasting Cholesterol, Trigs, HDL, LDL)
  - Liver function tests (GGT, AST, ALT etc.)
  - Kidney function tests (creatinine, BUN)
  - Urine analysis (hematuria, proteinuria etc.)
  - HIV-test
  - sometimes CXR, Hepatitis B/C-serology, new biomarkers etc.

Screening tests in U/W

- Companies spend enormous resources on blood profiles, the attending physician's statement (APS), stress-tests etc. to determine every disease or diagnosis that can be attached to the applicant now or in the future
- But why do companies spend so many efforts in screening tests ?
  - risk control: the more money is at risk the more screening tests are applied

But are they right ?

How to approach screening test results ?

- Most people think, the test result is the most important information:
  - A test result can be positive for the target condition = disease is present
  - A test result can be negative for the target condition = disease is not present
- This sounds quite logic and most U/W's trust that approach

→Unfortunately, this costs the insurance industry a lot of money…

Possible results of a screening test

	Disease +	Disease -
Test +	**A** True positive	**B** False positive
Test -	**C** False negative	**D** True negative

Parameters of quality

Sensitivity	Percentage of diseased persons who get a positive test „How many diseased applicants can we detect by the test?“
Specificity	Percentage of healthy persons who get a negative test „How many healthy applicants will falsly be classified as diseased by the test“ (1 – specificity)

Sensitivity and Specificity

	Disease **+**	Disease **-**
Test **+**	**100**	**10**
Test **-**	**10**	**100**
	110	**110**

Sensitivity = $\frac{100}{110}$ = 91%   Specificity = $\frac{100}{110}$ = 91%

Sensitivity and Specificity

	Disease **+**	Disease **-**
Test **+**	**A** True positive	**B** False positive
Test **-**	**C** False negative	**D** True negative

Sensitivity = $\frac{A}{A+C}$

Specificity = $\frac{D}{B+D}$

How to remember – Sensitivity and Specificity

- **Sensitivity:** „I know my applicant has the impairment. What is the chance that the test result will show that my applicant actually has the impairment?"
- **Specificity:** „I know my applicant does not have the impairment. What is the chance that the test result will show that my applicant does not have the impairment?"

Sensitivity and Specificity are <u>properties of the test</u> you are using

Changing the population tested

	Disease +	Disease -
Test +	**100**	**100**
Test -	**10**	**1000**
	110	**1100**

Sensitivity = $\frac{100}{110}$ = 91%

Specificity = $\frac{1000}{1100}$ = 91%

Prevalence

Prevalence	Number of applicants per 100 000 population who have the disease at a given time Often depends on factors like age, gender, region, race, income ... Is also characterised as „ **pretest – probability** “

Derived parameters

Positive predictive value (PPV)	Percentage of persons with a positive test result who in fact have the disease "If the patient has a positive test, how likely is he/she to have the disease?" Formula: **True positive test results / all positive test results**
Negative predictive value (NPV)	Percentage of persons with a negative test who in fact are healthy "If the patient has a negative test, how likely is he/she actually healthy?" Formula: **True negative test results / all negative test result**

Positive predictive and negative predictive value

	Disease **+**	Disease **-**
Test **+**	**A** True positive	**B** False positive
Test **-**	**C** False negative	**D** True negative

$$PPV = \frac{A}{A+B}$$

$$NPV = \frac{D}{C+D}$$

How to remember – PPV and NPV

- **PPV:** „I got a positive test result. What is the chance that my applicant actually has the disease? "
- **NPV:** „I got a negative test result. What is the chance that my applicant actually does not have the disease?"

➔ PPV and NPV are properties of both the test you are using and the population you are testing

PPV and NPV

	Disease **+**	Disease **-**
Test **+**	**100** A	**10** B
Test **-**	**10** C	**100** D
	110	110

$$\text{PPV} = \frac{A}{A+B} = 91\%$$

$$\text{NPV} = \frac{D}{C+D} = 91\%$$

$$\text{Sensitivity} = \frac{100}{110} = 91\% \qquad \text{Specificity} = \frac{100}{110} = 91\%$$

Changing the population tested….

	Disease +	Disease -
Test +	**100** A	**100** B
Test -	**10** C	**1000** D
	110	1100

PPV = $\frac{A}{A+B}$ = 50%

NPV = $\frac{D}{C+D}$ = 99%

Sensitivity = $\frac{100}{110}$ = 91%

Specificity = $\frac{1000}{1100}$ = 91%

Effects of prevalence

Sensitivity=95% **Specificity=95%**

Population´s prevalence		Predicitive value of a positive test
0,1%	→	1,9%
1,0%	→	16,1%
2,0%	→	27,9%
5,0%	→	50%
50%	→	95%

What is the problem of incorrect test results……

	Disease **+**	Disease **-**
Test **+**	✓ True positive	**Lost money** ! False positive
Test **-**	**Future claims** ! False negative	✓ True negative

Why do I lose money with the false positives ?

- Need for costly and time consuming confirmatory tests
- Slows down the U/W process significantly
- Applicant may receive a risk loading or is even declined for insurance cover
- Bad reputation for insurance company and migration of applicants to competitors

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Examples

Age	Nonanginal pain		Atypical angina		Typical angina	
	Men	Women	Men	Women	Men	Women
30-39	4	2	34	12	76	26
40-49	13	3	51	22	87	55
50-59	20	7	65	31	93	73
60-69	27	14	72	51	94	86

Amount of ST depression	Sensitivity, percent	Specificity, percent
0.5 mm	80	60
1.0 mm	60	90
2.0 mm	20	98

Exercise – ECG

Prevalence 1% Sensitivity 60% Specificity 90%

	Disease +	Disease -
Test +	**6** True positive	**99** False positive
Test -	**4** False negative	**891** True negative
	10	990

$$PPV = \frac{A}{A+B} = \frac{6}{105} = 6\%$$

$$NPV = \frac{D}{C+D} = \frac{891}{895} = 99{,}5\%$$

PPV: 12/111 = **6%** → False positive rate: **94%**

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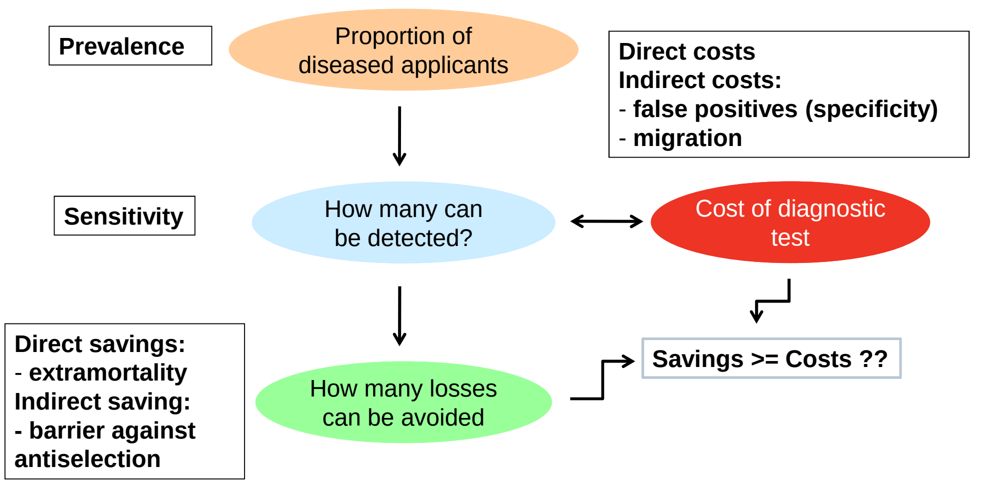
Solutions
- general aspect -



Solutions

- Increasing sensitivity and specificity is just possible by the use of either more costly and time-consuming or more dangerous diagnostic tests ⇒ not reasonable
- The only possible solution is:
  - use the correct test (in terms of costs and accuracy) in
  - the right group of applicants (pre-test probability) for
  - a target condition that is relevant for your losses with
  - the optimal sum threshold (cost-benefit-analysis)

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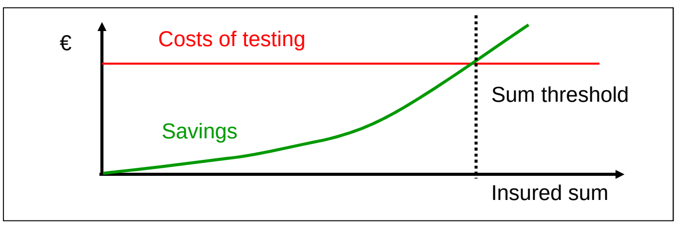
Protective value study

- Calculation to quantify the real value of a screening device
- Value of information as result of protection from future loss
- Basic requirement: savings > costs
- Savings increase with insured sum => sum threshold (savings=costs)



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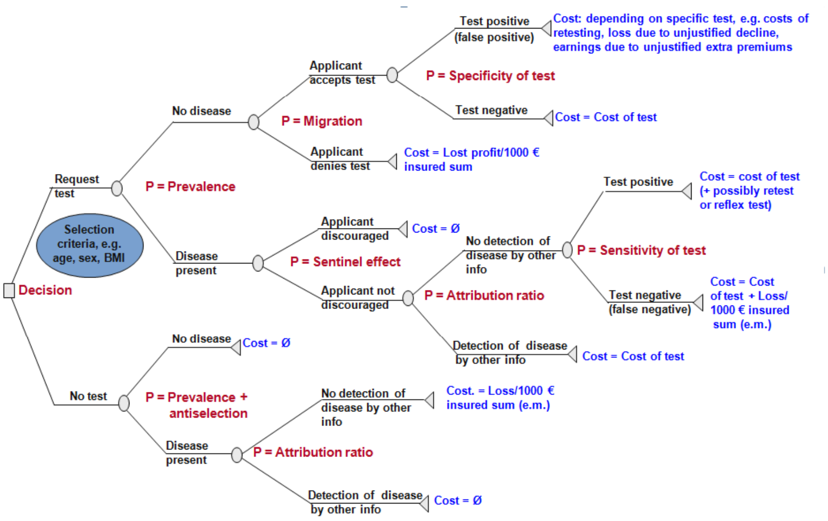
Decision tree prototype for cost benefit analysis

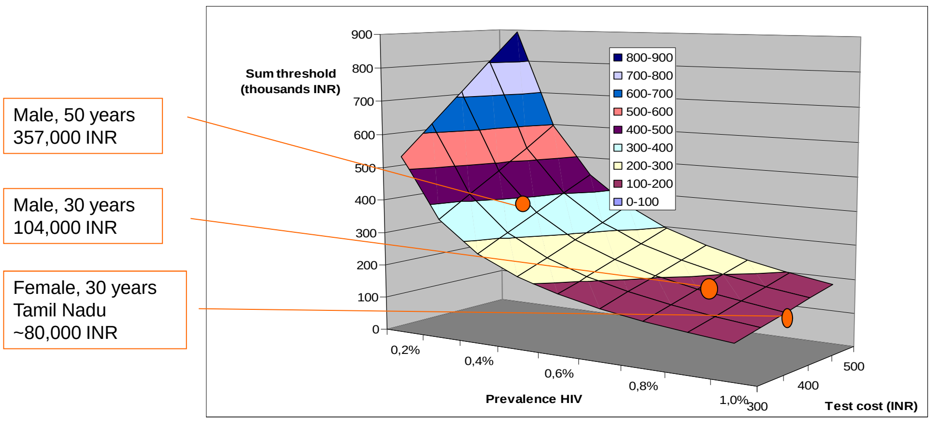


Cost-benefit analysis: HIV-Screening Test in India

Prevalence of HIV:

- Male, 30 years = 0.8 % Male, 50 years = 0.35 %, Female from Tamil Nadu, 30 years = 1 %

Mean cost of HIV test: 400 INR
Sensitivity: ~99%
Mortality loss: ~45%



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Thank you very much for your attention!!