Aalto-yliopisto
Perustieteiden
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Optimization of the Finnish colorectal cancer screening programme

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04.12.2019

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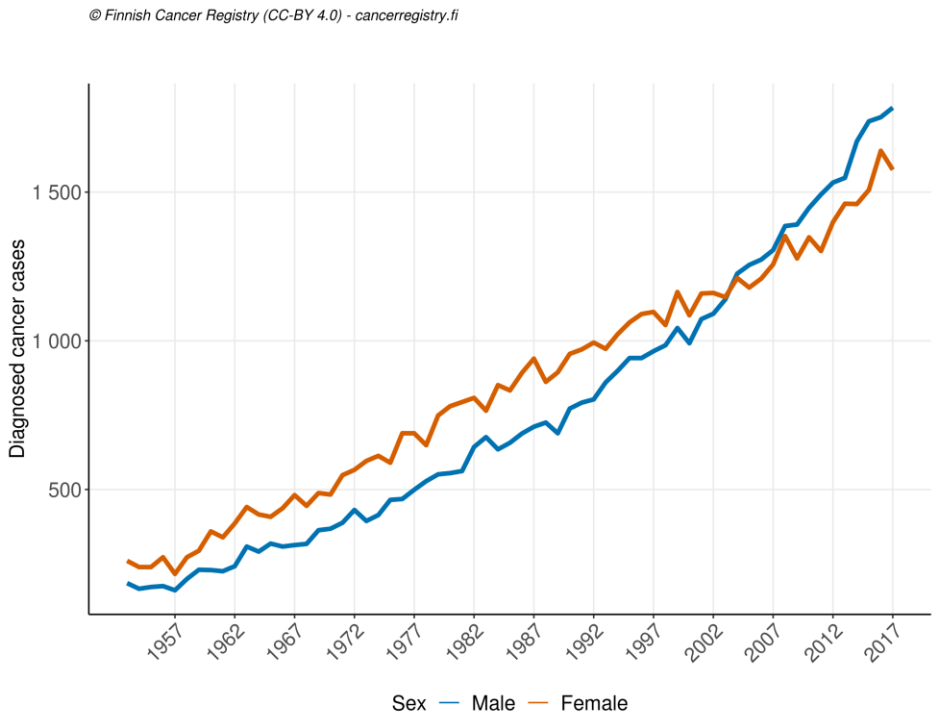
Colorectal cancer (CRC)

- The second most common cancer for males and females in Finland.
- CRC incidence and mortality rates have been rising.
  - Crucial concern in the public health of Finland.



Screening for CRC

- Improves the cost-effectiveness of healthcare delivery.
- In 2004-2016, CRC screening in Finland was based on guaiac-based fecal occult blood test (gFOBT).
  - No effect on CRC mortality has been detected.
- In April 2019, a new Finnish CRC screening programme was launched.
  - Employs fecal immunochemical test (FIT).
  - FIT is more sensitive to detect CRC, but more expensive.

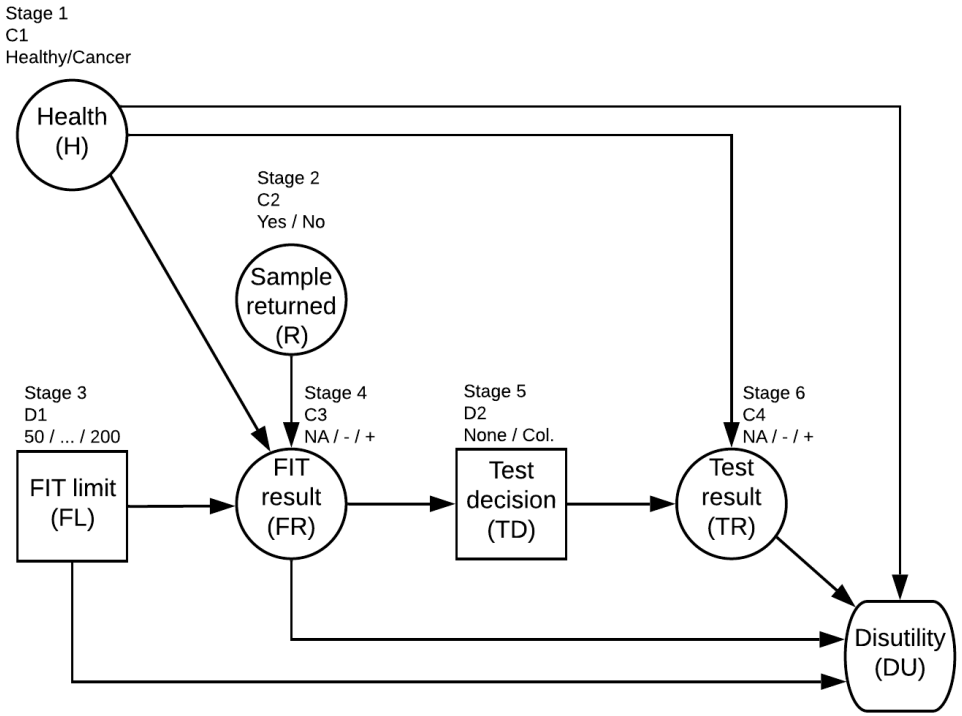
Objectives

- Build a decision model for the new Finnish CRC screening programme.

- Optimize the positivity cut-off level of the FIT using decision programming.
  - A recent framework for multi-stage decision problems with uncertainties.

Influence diagram of the screening process

- Consists of chance nodes (circles), decision nodes (squares) and a value node (rounded square).
- Dependencies between nodes are represented by directed arcs.



Optimizing the screening process

- The disutilities (value node) are approximate additional costs caused by false diagnoses during screening.
- Goal is to find a cut-off level that minimizes expected disutilities.
- The optimization performed separately for males and females of different ages.
- Implementation in Julia.

Results

- An average increase (34 752,20€) in the treatment costs, if CRC is not detected, was used.
- It is optimal to screen all groups.

Group		Optimal decision strategy		Expected disutility
Sex	Age	Level[a]	Col.[b]	
Male	50	200	Yes	39.02
	60	75	Yes	102.12
	62	50	Yes	121.51
	64	50	Yes	145.85
	66	50	Yes	173.48
	74	50	Yes	324.27
Female	50	200	Yes	43.80
	60	75	Yes	101.74
	62	50	Yes	117.73
	64	50	Yes	136.48
	66	50	Yes	156.07
	74	50	Yes	270.23

[a] 'Level' refers to the optimal FIT cut-off level.
[b] 'Col.' means colonoscopy.

Sensitivity analysis

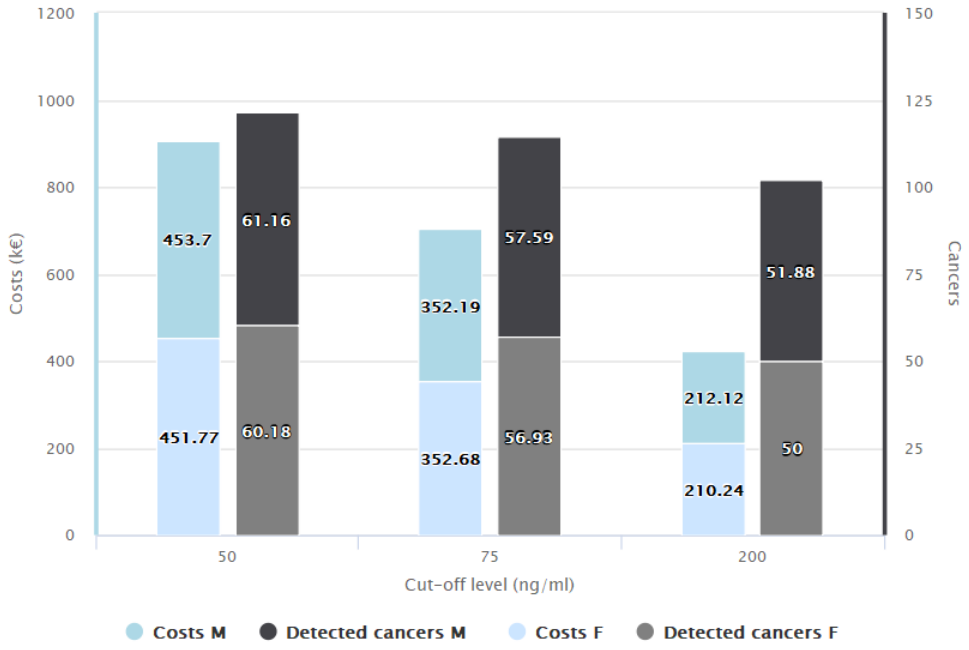
- Lower (4 522,38€) and upper bounds (38 318,85€) for the increases in the treatment costs were used.
- It is still optimal to screen the target group.
- The optimal cut-off level seems to be either 50 *ng/ml* or 75 *ng/ml*.

Group		Optimal decisions and expected disutility					
Sex	Age	Lowest cost			Highest cost		
		Level	Col.	Disutility	Level	Col.	Disutility
Male	50	-[a]	**No**	8.22	200	Yes	42.48
	60	**200**	Yes	18.63	**50**	Yes	110.87
	62	**200**	Yes	21.66	50	Yes	132.20
	64	**200**	Yes	25.48	50	Yes	159.04
	66	**200**	Yes	29.82	50	Yes	189.50
	74	**200**	Yes	53.47	50	Yes	355.74
Female	50	-[a]	**No**	9.38	200	Yes	47.74
	60	**200**	Yes	18.57	**50**	Yes	110.47
	62	**200**	Yes	21.07	50	Yes	128.04
	64	**200**	Yes	24.01	50	Yes	148.71
	66	**200**	Yes	27.09	50	Yes	170.31
	74	**200**	Yes	44.99	50	Yes	296.16

[a] Means that the chosen cut-off level does not affect the result.

Simulating the screening process (1/2)

- Simulation for 60-year-old males and females.
  - Total costs and detected cancers/adenomas were calculated.
- With lower cut-off levels, it is more costly to detect cancers.



Simulating the screening process (2/2)

- All the costs are less than the estimated increase in the treatment costs (34 752,20€).
- The optimal cut-off level is 50 *ng/ml* for all people aged 60-to-74 years.

Change in the cut-off level	Sex	Cost (€/cancer)
From 200 ng/ml to 75 ng/ml	Males	24530.65
	Females	20554.11
	Combined	22350.47
From 75 ng/ml to 50 ng/ml	Males	28434.17
	Females	30489.23
	Combined	28826.98

Conclusions

- In Finland, CRC screening can be targeted for 60-to-74-year-olds.
- The optimal cut-off level is as low as the colonoscopy capacities allow.
  - With unlimited capacity 50 ng/ml.
- The optimal screening decisions were identical for males and females.

Future work

- Data from the new programme should be updated to the model once it is available.
- Multiple objectives could be used to address the inaccuracy of the disutility function.
- Possible variations in costs and detected cancers should be considered.

The most relevant resources

- Finnish Cancer Registry (https://cancerregistry.fi/)
- A. Salo, J. Andelmin, and F. Oliveira. Decision programming for multi-stage optimization under uncertainty. *arXiv preprint arXiv:1910.09196*, 2019.