

Department of Health Management and Health Economics

English

Faculty of Medicine

University of Oslo

Written exam 27th of May 2026, 09:00 – 13:00

HEVAL5120 – Modeling in economic evaluation I

Results will be available within three weeks on Studentweb.

The exam consists of 6 pages including this one.

Two files are attached:

Exam

HEVAL5120_template

The Excel template should be mainly used for Question 1. In addition, the template includes a sheet at the end (entitled “Question2”) which you may use to calculate responses to Question 2.

You should hand in a PDF document including your answers to the questions below, **and** the Excel file with solutions of the tasks.

The best of luck!

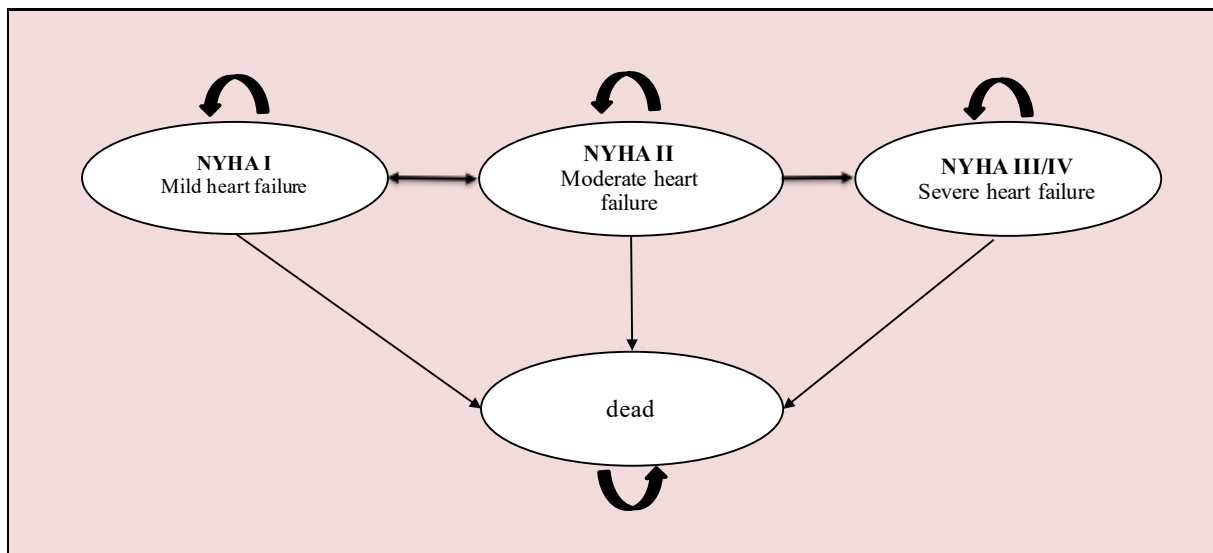
Question 1 (65%)

In this exercise, you are going to use the template **HEVAL5120_template**.

Read all the information in the template (all sheets) carefully. *Note that one sheet, entitled “Question2”, is reserved for Question 2.*

You are going to evaluate treatment options for patients diagnosed with heart failure. The disease is modelled using four health states, reflecting the New York Heart Association (NYHA) classification of heart failure: **NYHA I (Mild)**, **NYHA II (Moderate)**, **NYHA III/IV (Severe)**, and **death**.

Heart failure is a chronic condition, and the model is set up to reflect that patients can transition back and forth between the NYHA I and NYHA II health states. However, it is assumed that individuals with severe heart failure (NYHA III/IV) cannot improve their health condition (e.g., they cannot transition to NYHA II). Individuals can transition at annual cycles between the health states as depicted in the model schematic below (and included in the Excel template).



Assume that all individuals start in the NYHA I health state.

You are comparing two treatment strategies: **Standard care (SC)** and a **new medication regime (MED)**.

The relevant time horizon for your analysis is 25 years.

Model outcomes include quality-adjusted life-years (QALYs) and costs. All costs are provided in Euros (EUR).

You adopt a healthcare analytic perspective in the main analysis, for which treatment costs represent total healthcare costs. You will explore a scenario where you include productivity costs. Assume that productivity costs are related to the health state and not the treatment strategy.

In the template, all calculations for standard care have been completed and the values are included in the 'standard care' sheet. The formulas for calculation have been removed, such that you cannot copy the values in the 'Standard care' sheet to the 'MED' sheet.

- a) Using deterministic analysis, complete the Markov trace for the MED strategy and estimate the half-cycle corrected and discounted total expected costs and QALYs for this strategy. Report the values.

The half-cycle corrected and discounted total expected costs were 42 844 (healthcare costs)/299 765 (societal costs) and the QALYs were 12,07. The Markov trace:

Proportion of patients in health states			
NYHAI (Mild)	NYHAI (Mod)	NYHAIII/IV (severe)	Dead
1,000	0,000	0,000	0,000
0,986	0,011	0,000	0,003
0,973	0,021	0,000	0,006
0,961	0,029	0,000	0,010
0,950	0,036	0,001	0,014
0,939	0,042	0,001	0,018
0,929	0,047	0,001	0,022
0,920	0,052	0,002	0,027
0,911	0,056	0,002	0,032
0,902	0,059	0,002	0,037
0,894	0,062	0,003	0,042
0,886	0,064	0,003	0,047
0,878	0,066	0,003	0,052
0,871	0,068	0,003	0,058
0,864	0,069	0,004	0,063
0,857	0,070	0,004	0,069
0,850	0,071	0,004	0,075
0,844	0,072	0,004	0,080
0,837	0,072	0,004	0,086
0,831	0,073	0,004	0,092
0,825	0,073	0,005	0,097
0,819	0,073	0,005	0,103
0,813	0,074	0,005	0,109
0,807	0,074	0,005	0,115
0,801	0,074	0,005	0,120

- b) Report the proportion of patients alive after 10 years (cycle 9) in both strategies (standard care and MED). Discuss the finding briefly (1-3 sentences).

Standard care: 94,2% alive

MED: 96,3% alive

+ discussion of finding

- c) Using deterministic analysis, and using the pre-filled results for standard care, and your calculations for MED, estimate the ICER of MED compared to standard care. Given a

cost-effectiveness threshold (CET) of EUR 40 000, what is your recommendations when using a healthcare perspective? What is your recommendation when using a societal perspective?

Discounted half-cycled corrected results - HEALTHCARE PERSPECTIVE			
Strategy	Cost	QALY	
Standard care	23 431	11,65	
Medication regime - MED	42 844	12,07	
Increment	19 413	0,41	
ICER		Incremental cost/QALY	
		47 044	

Discounted half-cycled corrected results - SOCIETAL PERSPECTIVE			
Strategy	Cost	QALY	
Standard care	294 416	11,65	
Medication regime - MED	299 765	12,07	
Increment	5 348	0,41	
ICER		Incremental cost/QALY	
		12 961	

MED is not cost-effective from a healthcare perspective but is cost-effective from a societal perspective.

- d) Conduct a one-way deterministic sensitivity analysis where you vary cMED_mild from 1500-3500. You may use the sheet 'One-way SA' in the template. For what values would MED be considered cost-effective from a healthcare perspective? Discuss briefly what drives these results (2-4 sentences). *Remember to save the results as values and reset your model before continuing with the next sub-question.*

cMED_Mild	Incr. Cost	Incr. QALY	ICER
1 500	1213	0,413	2939
1 750	4713	0,413	11421
2 000	8213	0,413	19902
2 250	11713	0,413	28384
2 500	15213	0,413	36866
2 750	18713	0,413	45347
3 000	22213	0,413	53829
3 250	25713	0,413	62311
3 500	29213	0,413	70793

+ explain/discuss results

- e) Conduct a two-way deterministic sensitivity analysis where you vary cMED_mild from 1500-3500 and cMED_sev from 5500-7500. You may use the sheet 'Two-way SA' in the

template. For what combinations of cMED_Mild and cMED_sev values would MED be considered cost-effective from a healthcare perspective? Discuss briefly what drives these results (2-4 sentences). *Remember to save the results as values and reset your model before continuing with the next sub-question.*

		cMED_Sev								
	47 044	5 500	5 750	6 000	6 250	6 500	6 750	7 000	7 250	7 500
	1 500	2 839	2 862	2 885	2 907	2 930	2 952	2 975	2 998	3 020
	1 750	11 321	11 344	11 366	11 389	11 412	11 434	11 457	11 479	11 502
	2 000	19 803	19 825	19 848	19 871	19 893	19 916	19 938	19 961	19 984
	2 250	28 284	28 307	28 330	28 352	28 375	28 398	28 420	28 443	28 465
	2 500	36 766	36 789	36 811	36 834	36 857	36 879	36 902	36 924	36 947
cMED_Mild	2 750	45 248	45 270	45 293	45 316	45 338	45 361	45 384	45 406	45 429
	3 000	53 730	53 752	53 775	53 797	53 820	53 843	53 865	53 888	53 911
	3 250	62 211	62 234	62 257	62 279	62 302	62 324	62 347	62 370	62 392
	3 500	70 693	70 716	70 738	70 761	70 783	70 806	70 829	70 851	70 874

+ explain/discuss results

- f) Prepare the model for probabilistic analysis by assigning appropriate probability distributions to the following parameters: tpMild2Mild_MED, tpMild2Mod_MED, tpMild2D_MED, uState_Mild, and cMED_Mild. Fill in the appropriate columns in the parameter sheet in Excel such that your model could run a probabilistic analysis for these parameters using VBA. Report which distributions you selected. *Note that you are only asked to set up the model for the specific parameters listed here, not all parameters in the model. You are NOT asked to run a full probabilistic analysis.*

You may need the following equations for the gamma distribution:

$$\alpha = \text{mean}^2 / \text{st.error}^2$$

$$\beta = \text{std. error}^2 / \text{mean}$$

Dirichlet for tpMild2Mild/Mod/D:

tpMild2Mild_MED	0,986	0,985	0,986	0,986	Dirichlet	1460,2	1 479	21
tpMild2Mod_MED	0,011	0,012	0,011	0,011	Dirichlet	17,3	17	1 483
tpMild2D_MED	0,003	0,003	0,003	0,003	Dirichlet	4,8	4	1 496

E.g. beta for uState_Mild:

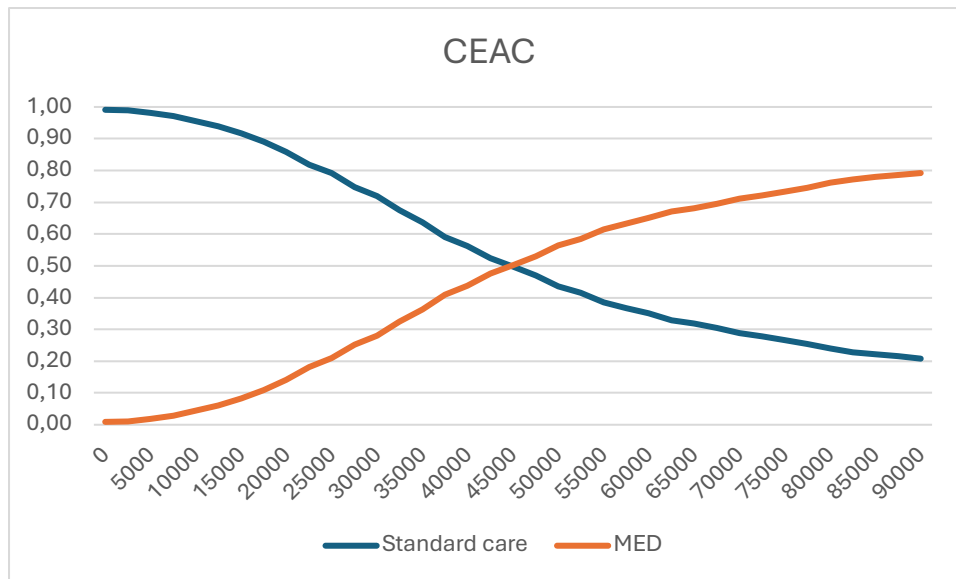
Utility weights	Value	Probabilistic	Deterministic	Standard error	Distribution	Random draw	Alpha	Beta
uState_Mild	0,82	0,82	0,82	0,820	Beta		82	18

E.g. gamma for cMED_Mild:

cMED_Mild	2 800	3 197	2 800	560	Gamma		25	112
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- g) A health economist has already run the model with probabilistic analysis (healthcare perspective) using VBA and has provided the results of the 1000 trials in the sheet PSA. Use these results and estimate the probabilistic ICER and create a CEAC. Report and interpret the findings.

Probabilistic ICER = 44 617



+interpretation

- h) Consider a situation where a new treatment became available, named Combi, which is a combination of MED and lifestyle interventions. This treatment reduces the risk of death with 20% for patients in health state NYHA III/IV (severe), compared with MED alone. Explain which parameter in your model this treatment effect would impact (parameter name), and how. What would be the parameter value for this transition probability in your model, if you were asked to model Combi? You may use the sheet ‘Question1h and i – Combi’ to perform calculations. *Note that you are NOT asked to incorporate this in your model, you should only calculate the new parameter value.*

It would impact tp_{Sev2D_MED} and reduce by 20%, such that the new value is 0,152. In consequence, this would also impact $tp_{Sev2Sev}$ since these two parameters need to sum to 1.

- i) Assume now that a health economist has estimated the expected discounted total costs and QALYs for Combi, which corresponds to EUR 43 270 and 12,537 QALYs. Repeat your ICER calculation using deterministic results (from sub-question c) by considering all three alternatives simultaneously (standard care, MED and Combi). Which treatment is considered cost-effective given a CET of 40,000? You may use the sheet ‘Question1h and i – Combi’ to perform calculations. *Note that you should calculate the ICERs using the total cost and QALYs for each treatment strategy; there is no need to calculate a new trace for Combi.*

Strategy	Cost	Incr costs	QALY	Incr QALY	ICER
Standard care	23 431,39		11,654		
Medication regime - MED	42 844,22	19 412,83	12,067	0,413	47 044
Combi	43 270,00	425,78	12,537	0,470	906
Recalculate Combi vs Standard care because MED is weakly dominated:		19 838,61		0,88	22 473

Combi is cost-effective, MED is weakly dominated.

Question 2 (15%)

In this exercise, you may use the sheet 'Question2' in the template **HEVAL5120_template**.
You are asked to perform some calculations for certain parts of a decision tree model, without developing and completing the decision tree model.

You are working on developing a decision tree model comparing two screening tests, Test A and Test B, which can be used to detect COPD. You find a study showing that the prevalence of COPD in a high-risk population is 10,5%. Test A has a sensitivity of 91% and a specificity of 73%.

- a) How many will test positive using Test A? Among those testing positive, how many have COPD?

Probability of testing positive with test A = 33,7%

Among those testing positive, 28,3% will have COPD.

- b) One strategy in your decision tree model is to use Test A. In this strategy, one branch ends with a true positive case. What is the path probability for this branch given the prevalence, sensitivity and specificity for Test A?

The path probability of a true positive case is 9,6%.

- c) Assume that Test A costs EUR 50 and that treatment costs EUR 400. What is the expected cost for the particular branch specified in sub-question b)?

Using the path probability in b) and a cost of 50+400 EUR, the expected cost at this branch is EUR 43.

- d) Assume that you identified that Test A is cost-effective compared to Test B. If you were a decision maker, describe briefly (maximum 6 sentences) two other considerations that you would evaluate prior to making a decision, alongside the cost-effectiveness results.

Discuss two other considerations than cost-effectiveness, e.g. harm-benefit tradeoffs, aspects of the tests, ethical considerations etc.

Question 3 (20%)

Partitioned survival models are based on estimations of progression free survival (PFS) and overall survival (OS) from clinical trials. A typical challenge in these trials is censoring.

- a) Explain censoring and challenges (6-10 sentences).

Define censoring + discuss the need to adjust for whether people experienced the event and time spent in the study + discuss reasons for not having full observation time (e.g., drop-out, selection bias)

- b) A general issue with health economic modeling relates to structural uncertainty. Provide at least two examples of structural uncertainty in modeling in general (for example, you may refer to the paper by Henkel et al on gestational diabetes screening, but it can also be other examples) and related to partitioned survival models specifically.

Define structural uncertainty in general + examples of structural uncertainty for modeling in general and for PSM specifically. For PSM, there may be several candidates for a good specification of the survival model, and different models is a structural assumption.

- c) Below you have information on survival data for a given treatment. Based on the information below you should be able to choose the optimal specification. Which survival model would you choose? Explain and discuss.

Discuss what is observed from the all different figures/tables (descriptive findings) and tradeoffs when evaluating. Summarize and discuss how several candidates may be relevant (gen gamma, log normal and log logistic are candidates when comparing the plots and AIC).

Figure 1. Cumulative hazard – based on observed data from the trial

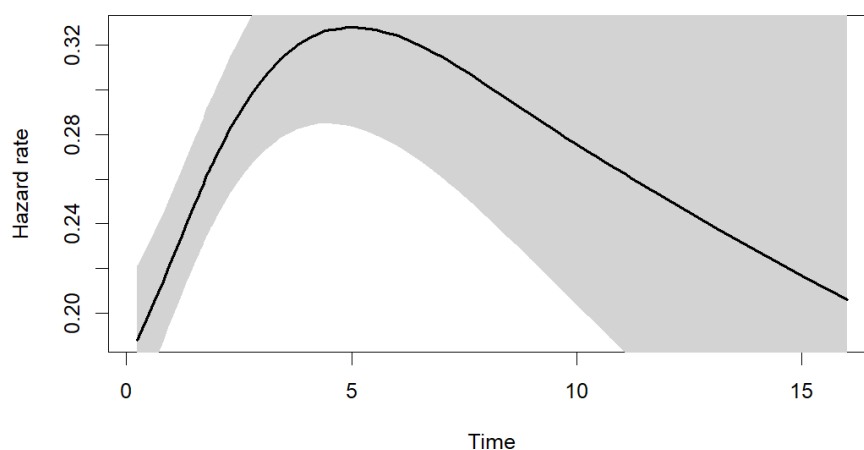


Table 1. Overview AIC according to distributions/regressions

Regression	AIC
Exponential	1994.41
Weibull	1922.50

Log-normal	1793.64
Gompertz	1987.61
Generalized gamma	1764.95
Log-logistic	1799.55

Figure 2. Estimated cumulative hazard for 6 parametric specifications

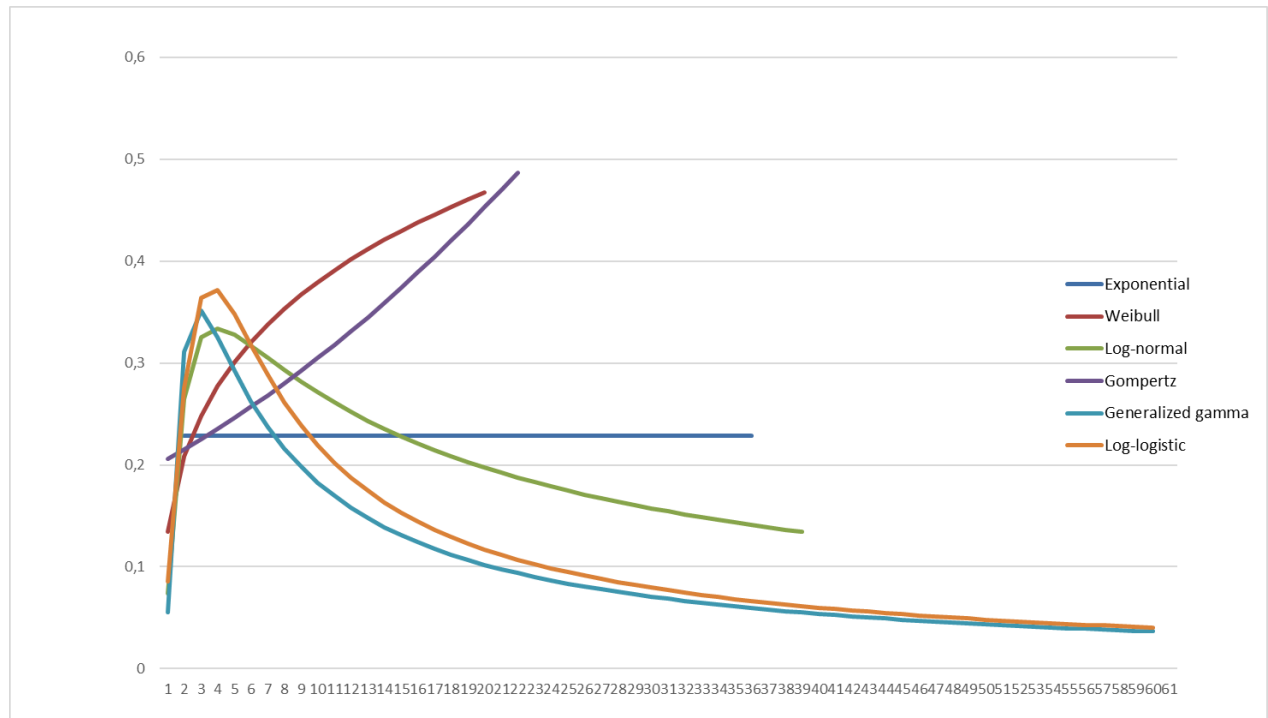


Figure 3. Extrapolated survival curves (Kaplan Meier and 6 parametric specifications):

