Doctoral School of Management

THESES

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A NEW METHOD FOR THE MEASUREMENT OF ACCEPTABLE HEALTH STATES

PhD dissertation

Supervisor:

Prof. Péntek Márta, PhD

Professor

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Corvinus University of Budapest
Department of Health Economics

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I. BACKGROUND

I.1. Introduction

Due to technological innovation, demographic change and the growth of income, GDP-proportional health expenditure has regained intense growth in the OECD member states after a stagnation that followed the economic crisis of 2008. Sustainable financing of healthcare became one of the key challenges of countries with developed economies. Decision-makers may need to introduce new decision-methods in order to maintain equitable and legitim allocation of resources despite the growing fiscal pressure. While in the past decades the QALY concept has been adopted by an increasing number of countries for the measurement of health outputs, its amendment has been suggested both in the measurement of individual well-being or in the measurement of societal preferences, for supporting health resource allocation decisions. Amending the QALY concept and new ways of measuring health outcomes became recently intense areas of research in the field of health economics.

The research of acceptable health states (AH) started in the Netherlands as well as at the Corvinus University of Budapest, approximately 10 years ago. The measurement of acceptable health problems, applied together with sufficientarian theory – a novel theory of justice in the field of health economics – aims to provide a transparent picture for decision-makers about the society's age and disease severity related preferences.

Wouters et al have explored a potential normative model model of applying AH in decision-making about health resource allocation . (Wouters et al., 2017) According to their conclusions, the deterioration of health with age is a natural process, that affects everyone, therefore applying AH can be a suitable point-of reference in health financing decision making. It is acceptabe morally if we do not make efforts to achieve perfect health, but we aim to maximis the number of patients achieving acceptable health states. Applying the AH principle is acceptable, if there is considerable difference between the utility of acceptable and not acceptable health states. However, we do not yet have

practically feasible measures of the acceptability threshold, as we don't know the utility differences between acceptable and not acceptable health states. My research aimed to find answer to these two questions.

I.2. Goals

My thesis has two overarching goals in the development of the AH concept, and I have tested six hypotheses in connection with the primary research goals.

1. Goal 1.: developing new measurement methods for AH, which are more accurate than previous techniques.

    1.1. *Joint evaluation of the acceptability of discrete health states*: instead of asking the acceptability of health states by dimension (separate evaluation), we evaluate the acceptability of joint health states displayed as vignettes containing different levels of the five EQ-5D dimensions, using an adaptive algorithm that selects questions based on the previous answers of respondents. In joint evaluation we aim to obtain a yes/no answers for all elements of the acceptability matrix (E-matrix). The E-matrix consists the acceptability information of 243 health states (constructed from the three levels on the five dimensions of the EQ-5D) across six ages from 30 to 80 years in 10-year intervals.

        1.1.1. *Hypothesis 1 (H_1): Using the adaptive algorithm, all elements of the E-matrix can be unequivocally determined for 90% of respondents.*

        1.1.2. *Hypothesis 2 (H_2): With joint evaluation, people consider less problems acceptable compared to separate evaluation.*

    1.2. Overall assessment of AH using the EQ VAS: the EQ VAS measures AH on a continuous scale on which 0 indicates the worst and 100 indicates the best imaginable health state.

1.2.1. Hypothesis 3 (H_3): When measured with the EQ VAS, people consider worst health states acceptable at older ages than at younger ages.

2. Goal 2.: Exploring the association of AH and happiness.

2.1. Measuring the association of the acceptability of individuals' health states and their happiness.

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2.2.2. *Hypothesis 6 (H_6): Individuals with worse subjective health consider their condition less acceptable than ones indicating better subjective health.*

II. METHODS

II.1. EQ-5D-3L

We used the modified EQ-5D-3L questionnaire for the assessment of acceptable health states. EQ-5D is the most frequently applied generic quality of life measure in health economic analyses. (Brazier et al., 2019) The EQ-5D-3L version of the instrument measures 3 problem levels (1: no problem, 2: moderate problems, 3: extreme problems) in five health dimensions (mobility, self-care, usual activities, pain/discomfort, anxiety/depression), so it describes 243 (3^5) discrete health states. Each health state is denoted by a five-digit number called EQ-5D-3L profile, which indicates the problem levels in the five dimensions. For example, the EQ-5D-3L profile "21121" denotes a health state characterised by moderate problems in the mobility and pain / discomfort dimensions. (EuroQoL Group, 1990) We may render utility values (EQ-5D-3L index) reflecting the general population's preferences to each EQ-5D-3L profile (value set). Perfect health is indicated by 1, death by 0 and worse-than-death health states by negative numbers. We use the health-related utility values to calculate the quality adjusted life years (QALYs), which are used as the standard measure of health outcomes in health economic analyses.

The numeric sum of the problem levels in the EQ-5D-3L profiles is denoted as the „misery index", (Augustovski et al., 2013) which serves as an estimate of disease severity, but it is not suitable for QALY calculations. A health-thermometer (EQ VAS) is also part of the EQ-5D questionnaire, on which respondents can indicate their current health status between the worst and best (0-100) imaginable health.

II.2. Acceptable health states (AH)

II.2.1. The history of AH measurements

Theories of justice concerned with the equitable allocation of health resources take perfect health as a reference-point and compare health losses or gains to perfect health with utility 1. The concept of AH assumes that with time, certain health problems are considered natural by people as a normal part of ageing, which may be taken into consideration when allocating scarce resources - and taken as a point of reference rather than perfect health states. (Wouters et al., 2017)

So far, three studies focused on the measurement of acceptable health (Brouwer et al., 2005, Pentek et al., 2014, Wouters et al., 2015). In all three studies, the acceptability of health problems was measured by the EQ-5D-3L questionnaire. In all three studies, the acceptability of health problems was asked in 10-year-age bands, separately by each EQ-5D-3L dimension, according to the following wording:

„Please indicate, from what age do you consider the below indicated problem levels acceptable?"

All three studies have shown, that people consider health problems increasingly acceptable with age. However, their main weakness was that they evaluated the acceptability of health problems *separately* by each dimension, while in reality problems are experienced in combination, and their *joint evaluation* is likely to affect their acceptability.

For summarizing their results, the authors constructed the following measures of AH:

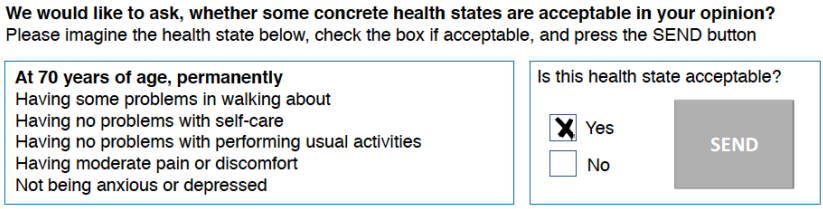
a) Aggregate Acceptable Health Curve ($AHC_{aggregate}$): the main assumption is that the health state aggregated from the problems that are acceptable separately in each dimension would also be acceptable by the respondent. The sample's $AHC_{aggregate}$ is constructed from the mean EQ-5D-3L index values of the individual $AHC_{aggregate}$ health states.

b) Worst Acceptable Health Curve (AHC_{worst}): the main assumption is that problems in each EQ-5D-3L dimension are acceptable only in the presence of perfect health in other dimensions. Since health problems in several dimensions may be indicated as acceptable in a certain age, the sample's AHC_{worst} is constructed from the lowest individual AHC_{worst} values in each age.

c) Profiles' Acceptable Health Curve ($AHC_{profiles}$): the mean age from which EQ-5D-3L profiles are considered acceptable by the sample is plotted against their EQ-5D-3L index values.

II.2.2. New methods for the measurement of AH

We developed a new method for the measurement of AH, in which problems were not introduced to respondents separately, but jointly in form of health states of combined problems as well as an age, as displayed in the figure below.



Forrás: (Zrubka, 2018b)

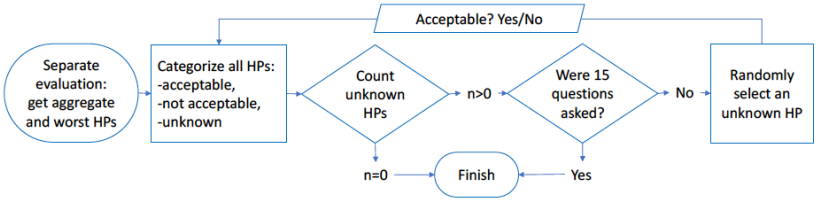
Taking the 243 EQ-5D-3L profiles in 6 ages in the 30 to 80 years range provides 1458 health states, which we denote as the acceptability matrix (*E-matrix)* hereinafter. In order to get as much information as possible from each respondent about the 1458 cells of the E-matrix, we applied an adaptive questioning algorithm. The adaptive algorithm made deductions about the acceptability of several health states based on a single answer from respondents, according to the following assumptions:

a) Each EQ-5D dimensions were treated as an ordinal variable: in case a profile was acceptable in a certain age, then we considered every profile acceptable in which the level of any problem was the same or

lower than the profile in question (better health states). In case a profile was not acceptable, then those profiles were not acceptable either, which had the same or higher level of problems in any dimension. The acceptability of profiles which had both higher and lower levels of problems compared to the evaluated profile could not be deducted without knowing the respondent's preference.

b) Health deteriorates with age in a monotonous fashion: if a health state is was acceptable in a certain age, then the same or better health states were not acceptable either in the same or younger ages. If a health state was acceptable in an age, then the same or better health states were acceptable in older ages as well.

The performance of adaptive questioning was tested via computer simulation on the $AHC_{aggregate}$ profiles from a sample of 9260 respondents obtained in a previous study. After separate evaluation, health states with unknown acceptability were chosen randomly, and their acceptability was determined randomly with p=0.5 probability as yes or no according to the following process:



According to the simulation, with 15 randomly selected questions the acceptability of the 1458 health states could be fully determined for 90% of the subjects. The overall proportion of unknown states was 0.4%, which result was only minimally improved by further questions. Keeping the effort required from participants when completing the evaluation task reasonable, we decided to apply a modul of 15 questions during the joint evaluation exercise.

For summarizing results of the joint evaluation exercise, we created the Joint Acceptable Health Curve (AHC_{joint}). We rendered he EQ-5D-3L index (UK-TTO value set) to all health states that were considered acceptable after the

joint evaluation, and for each age, we selected the health state with lowest EQ-5D-3L index value as the individual AHC_{joint},, and from the average of individual values, we constructed the sample $AHC_{joint.}$

The other new method for measuring AH was the modified EQ VAS, on which our subjects indicated between the best (100) and worst (0) imaginable health the level of health that they considered still acceptable in the six age groups. The acceptable VAS expresses the level of acceptable health with a single numeric value. From the averages of individual acceptable VAS values, we constructed the VAS Acceptable Health Curve (AHC_{vas}).

II.2.3. Data collection

In early 2018, we performed a cross-sectional survey via personal interviews among 200 members of the Hungarian general population selected by convenience sampling. Subjects provided written consent, and data were collected anonymously. The research plan was approved by the Ethical Committee of the National Research Council (ETT-TUKEB) under the identifier: 5111-2-2018/EKU.

We collected the following information via an electronic questionnaire:

a) Participant information and consent
b) Separate evaluation of acceptable health problems
c) Joint evaluation of acceptable health states
d) Persons imagined during the evaluation of acceptable health

Furthermore, we applied a paper-pencil questionnaire for recording the self-evaluated health of subjects via the EQ VAS and acceptable health in age groups from 30 to 80 years in 10-year-intervals via the modified EQ VAS. We also recorded the health status of respondents via the EQ-5D-3L questionnaire (EuroQoL Group, 1990) We analysed separately moderate and severe problems by each dimension, and also created an „any problem" category by counting moderate and severe problems together. In a separate variable, we recorded if respondents indicated any problems in any of the dimensions. We also recorded the health state utilities (EQ-5D-3L index values) for each individual.

For describing the socio-demographic status of respondents, we recorded the following data: age (and age group), gender, family status (married: married or lives in domestic partnership, vs. not married: single, divorced or widowed), education (tertiary: university of college degree, other: primary or secondary education), employment (employed: full or part-time, not employed: pensioner, student, housemaker), household income per capita. Based on data from the Central Statistical Office of Hungary, (KSH, 2015) we grouped respondents in the first two quintiles as having high income and ones in the remaining three quintiles as having low income.

We described the lifestyle of respondents with behaviours associated with health risks: overweight (body mass index (BMI) >25) (Garrow, 1981)), smoking (at any quantity) (Schane et al., 2010)), excessive alcohol intake (men: >14 drinks / week or >4 drinks / occasion, women >7 drinks / week, or >3 drinks/occasion (NIAAA)), lack of exercise ((<150 minutes light exercise / week (WHO)).

Furthermore, we asked questions potentially related to health attitudes: expected life span (own lifespan estimated by the respondent), life span of close relatives (<75 years, >=75 years), informal caregiver status (ones who have provided care for free for at least 6 weeks for relatives or close friends), as well as the use of healthcare services during the 3 months preceding the interview.

We also recorded happiness on a 0-10 point numeric scale, which is one of the simplest and most frequently used measure of subjective wellbeing. (Veenhoven, 2009, Veenhoven, 2012)

II.2.4. Statistical methods and hypothesis testing

We analysed the dataset by descriptive methods as well as econometric models using the Stata 14 statistical software package. The methods used for testing the six hypotheses are described below:

H_1: *With adaptive testing we can determine the acceptability of all cells of the E-matrix in 90% of subjects.* During the preparatory simulation, we managed to determine the acceptability of all health states in 90% of the 9260

individuals, from whom $AHC_{aggregate}$ curves were available. We expected the same results from the interviews conducted with real respondents. We tested the hypothesis using the 95% exact binomial confidence interval. The expected value was π_0=0,9, π_1 is the proportion of respondents, for whom the acceptability can be determined for all cells of the E-matrix.
We tested the following hypotheses:

H_0: $\pi_1=0,9$

H_{alt}: $\pi_1\neq0,9$

Our H_1 hypothesis can be accepted in case H_0 is accepted.

H_2: *When assessed via joint evaluation, people consider fewer problems acceptable compared to separate evaluation.* Due to the non-normal distribution of the data, we tested the hypothesis by comparing median values of the $AHC_{aggregate}$ from separate evaluation ($M_{aggregate}$) and AHC_{joint} from joint evaluation (M_{joint}) via the sign test, using $p=0.05$ significance level. Median values of the curves at all ages were tested jointly.

H_0: $M_{aggregate}=M_{joint}$

H_{alt}: $M_{aggregate}<M_{joint}$

H_2 can be accepted if H_0 is rejected and H_{alt} is accepted.

H_3: *When measured with the EQ VAS, people consider worse health states acceptable in older ages than in younger ages.* Due to the high inter-individual variance of the level as well as slope of AHC_{vas}, we tested the hypothesis using the following multi-level regression model:

$$AHC_{vas_{ik}} = \alpha + \beta age_{AHS_{ik}} + \gamma X_i + \delta age_{AHS_{ik}} * X_i + \mu_i + \tau_i * age_{AHS_{ik}} + \varepsilon_{ik},$$

where age_{AHSik} denotes age k, when respondent i evaluates acceptable health. We centred age_{AHS} at 30 years, therefore the intercept denoted with α represented the mean AHC_{vas} at age_{AHS} 30. The individual variation of the level of AHC_{vas} is denoted by μ, while β indicates the acceptable deterioration rate of health (ADR), and τ indicates the individual component of ADR. The vector X_i indicates the explanatory variables of individual respondent characteristics, the γ and δ coefficients denote the effect of individual explanatory variables on the level and slope of AHC_{vas}, respectively. Individual variance of the level and slope are denoted by μ and τ respectively,

which were modelled as random effects. We evaluated H_3 based on the parameter value of β:

H_0: $\beta=0$

H_{alt}: $\beta<0$

H_3 can be accepted if H_0 is rejected and H_{alt} is accepted.

When evaluating the association of AH and happiness, the question was whether respondents considered their own health acceptable or not. Therefore, we created two new variables, and coined two new terms:

a) *"Relative health"* is the difference between the self-rated health of respondents and the level of acceptable health indicated for his/her own age group (e.g. age_{AHS} 40 for a respondent from the 35-44 age group), measured on EQ VAS.

b) In *"acceptable health status",* respondents' own health status was evaluated as better than what they considered acceptable for their own age. In the "*not acceptable health status"* group, the own health of respondents was evaluated as worse than what they considered acceptable for their own age.

H_4: *In acceptable health status, the level of subjective health influences happiness to a smaller extent than in not acceptable health status.* We tested this hypothesis with the following multivariable regression model:

$$h = \alpha + \beta na + \gamma eqvas + \delta na * eqvas + \mu age + \theta age * eqvas + \boldsymbol{\lambda} X + \varepsilon$$

where h denotes happiness, α is the intercept, *na* denotes the binary variable of acceptable health with value of 1 if the individual is in not acceptable health status, and 0 if the individual has acceptable health status; *eqvas* is the individuals' self-rated health score on the EQ VAS, *age* is respondents' age centred at 18 years and X is the vector of other explanatory variables. We evaluated H_4 based on the parameter value of δ:

H_0: $\delta=0$

H_{alt}: $\delta>0$

H_4 can be accepted if H_0 is rejected and H_{alt} is accepted.

H_5: *Older individuals are more likely to consider their health acceptable than younger ones.* ***H_6:*** *Individuals with more severe conditions consider their health less acceptable than healthier ones.* We tested H_5 and H_6 hypotheses using the following logistic regression model:

$$logit_{pA} = \alpha + \beta age + \gamma eqvas + \delta X + \varepsilon$$

where $logit_{pA} = log(p_A/(1-p_A))$, p_A is the probability that an individual considers his/her health state acceptable, *age* is the age of respondents centred at 18 years, *eqvas* is the self-rated current health of respondents measured on the EQ VAS scale. We tested the H_5 hypothesis based on the parameter value of β:

H_0: $\beta=0$

H_{alt}: $\beta>0$

H_5 can be accepted if H_0 is rejected and H_{alt} is accepted.

We tested the H_6 hypothesis based on the parameter value of γ:

H_0: $\gamma=0$

H_{alt}: $\gamma>0$

H_6 can be accepted if H_0 is rejected and H_{alt} is accepted.

III. RESULTS

III.1. Sample characteristics

The survey was completed by 200 respondents. Mean age was 43,3 years (±SD: 17,3 years). The main socio-demographic characteristics of our respondents are summarized in the following table.

Variable	Category	N	%
Age (n=200)	18-24	24	12,00
	25-34	54	27,00
	35-44	32	16,00
	45-54	43	21,50
	55-64	20	10,00
	65-74	16	8,00
	75+	11	5,50
Gender (n=189)	Male	79	41,80
	Female	110	58,20
Education (n=199)	Primary	9	4,52
	Secondary	73	36,68
	Tertiary	117	58,79
Household income per capita (n=194)	≤ 52 th HUF	5	2,51
	53-74 th HUF	12	6,03
	75-94 th HUF	27	13,57
	95-128 th HUF	35	17,59
	≥ 129 th HUF	120	60,30

Percentages were calculated from the number of respondents with available data

Based on the EQ-5D-3L dimensions, 44% of respondents indicated the presence of any health problems. Severe problems were reported by 4,5% of respondents. The mean level of happiness was 7,3 (±SD: 2,0), with level 8 reported most frequently.

For 32 of the 200 respondents, data indicating self-rated health or acceptable health were missing, therefore we analysed the association of AH and happiness on a sample of 168 individuals. On average, respondents scored the level of their own health 1,95 points lower (±SD: 13,732), than the health they considered acceptable for their age. From the sample 88 respondents

considered (52.4%) their own health as better, while 80 (47,6%) as worse than acceptable for their age.

III.2. Measuring AH

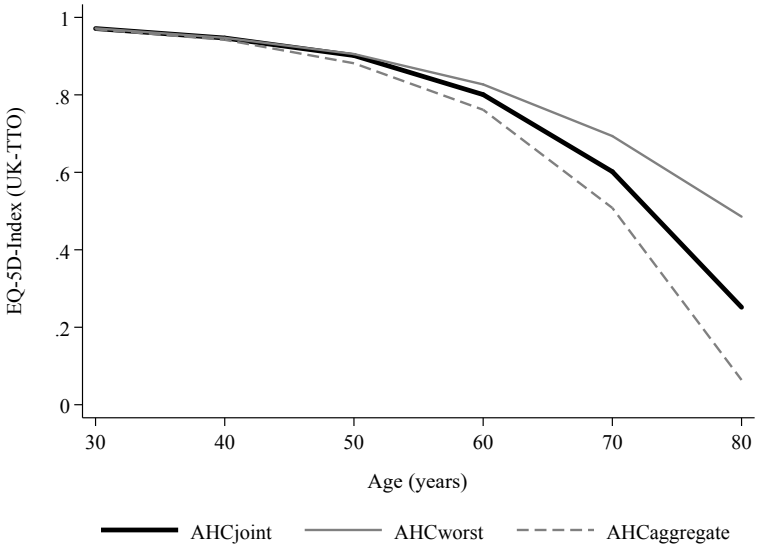
III.2.1. Efficiency of adaptive testing (H_1)

We evaluated the acceptability of 1458 discrete health states for each of the 200 respondents. Altogether we collected 291600 data points. After separate evaluation, 91,7% of health states were not acceptable, 1,3% were acceptable and for 7,1% the acceptability was unknown. During joint evaluation, the algorithm asked on average 11,09 questions from each respondent. For 43,5% of respondents, (n=87) 15 or fewer questions were sufficient to evaluate the acceptability of all health states of their *E-matrix* in question.

The first hypothesis (H_1) of the research was that the acceptability of all health states could be fully determined for 90% of individuals. In case of 200 respondents, the 95% exact binomial confidence interval for the 90% acceptability rate falls between 85,0-93,8%. Our results fell below the lower 95% CI limit, outside the expected range. Therefore, we did not accept our H_1 hypothesis: the efficiency of adaptive testing was inferior compared to our expectations.

III.2.2. Acceptability of health states by joint evaluation (H_2)

The $AHC_{aggregate}$ of separate evaluation and AHC_{joint} of joint evaluation are compared in the following graph.



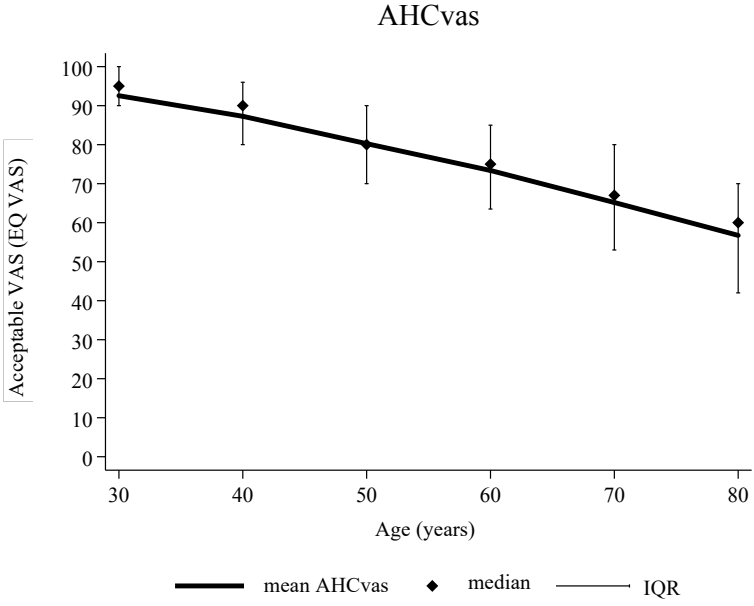
The second hypothesis (H_2) was that by joint evaluation people considered fewer health problems acceptable when compared to separate evaluation, meaning that median values of $AHC_{aggregate}$ are lower than those of the AHC_{joint}. The results of the sign test of the differences of medians ($M_{aggregate}$, M_{joint}) were summarized in the next table.

M_{joint}-$M_{aggregate}$	Outcome (N)	Expected (N)
>0	148	74
<0	0	74
=0	52	0
Total	200	200

If $M_{joint} > M_{aggregate}$, the exact binomial probability of the result (M_{joint}-$M_{aggregate}$ >0, N=148) is p<0,001, therefore we rejected the null-hypothesis (H_0: $M_{aggregate}=M_{joint}$) and accepted the alternative hypothesis (H_{alt}: $M_{aggregate}<M_{joint}$). *So, we could accept H_2: with joint evaluation people consider fewer health problems acceptable than with separate evaluation.*

III.2.3. Measuring AH with the adapted EQ VAS instrument (H_3)

We had acceptable VAS data from 196 respondents in at least one age. The acceptable VAS curve (*AHC_{vas}*) is shown in the graph below.



We analysed the *AHC_{vas}* via multilevel regression. Results are summarized in the table on the following page. In the baseline model (M1) the intercepts and slopes of individual *AHC_{vas}* curves differed significantly. *AHC_{vas}* showed on average 7,2 points decline in every 10 years. *(β_{ageAH}*=-0,723, p<0,001). *Since in all further models including explanatory variables the β_{ageAH} was significant and negative, we accepted H_3: people consider worse health states acceptable in older ages compared to younger ages.*

		M1	M5
1st level parameters	Intercept	93,87***	96,71***
	age_{AH}	-0,723***	-0,734***
2nd level parameters: intercept	Respondents age: 18-34		-4,636***
	Respondents age: 65+		2,673
	Female gender		0,686
	Tertiary education		-0,856
	Self-rated health (EQ VAS) [i]		0,271***
	High risk alcohol consumption		0,047
	Smoking		2,553*
	Lack of exercise		0,305
	Body mass index > 25		3,501***
	Persons imagined: own and others		-2,825*
	Persons imagined: others		-2,640*
	Closest relatives' life span >75years		-3,061**
	Informal caregiver		-1,123
2nd level parameters: slope	Respondents age: 18-34		0,104*
	Respondents age: 65+		-0,018
	Female gender		0,002
	Tertiary education		0,012
	Self-rated health (EQ VAS) [i]		0,007***
	High risk alcohol consumption		0,143*
	Smoking		-0,042
	Lack of exercise		-0,140***
	Body mass index > 25		0,070
	Persons imagined: own and others		-0,034
	Persons imagined: others		-0,142**
	Closest relatives' life span >75years		0,007
	Informal caregiver		0,166***
Random effects parameters	Variance (age_{AH})	0,117***	0,0912***
	Variance (Intercept)	75,483***	52,875***
	Covariance (Intercept, age_{AH})	0,041	-0,283
	AIC	7657,35	7352,86
	Observations (N)	1145	1109
	Number of respondents	194	188

*** p<0,01, ** p<0,05, * p<0,1

i: Self-rated health was measured on the EQ VAS scale and centred to the sample mean.

Source: (Zrubka et al., 2019)

In the full model (M5) acceptable health problems (the level and/or slope of AHC_{vas}) were significantly influenced by respondents' age, self-rated health, lifestyle, and the way they imagined the reference person when evaluating the acceptability of health problems, as well as close relatives' life-span, and their informal caregiver status.

III.2.4. The association of AH and happiness (H_4)

We evaluated the association between AH and happiness in a linear regression model built in gradual steps, by continuously checking model specification and assumptions. Main results are summarized in the table below.

Interpretation of M10: if an individual has acceptable health status, then self-rated health does not influence the level of happiness. Based on the coefficients of the model, we could accept H_4, since the δ parameter denoting the interaction of subjective health and acceptable health in explaining happiness was significant and positive ($p<0,05$). However, after excluding outliers based on Cook's D, leverage, dfbeta, and standardized residuals and extremes of happiness, the coefficients did not remain significant. The results were not significant even after excluding 3 cases with the highest leverage values. *Therefore, H_4 could not be accepted with certainty.*

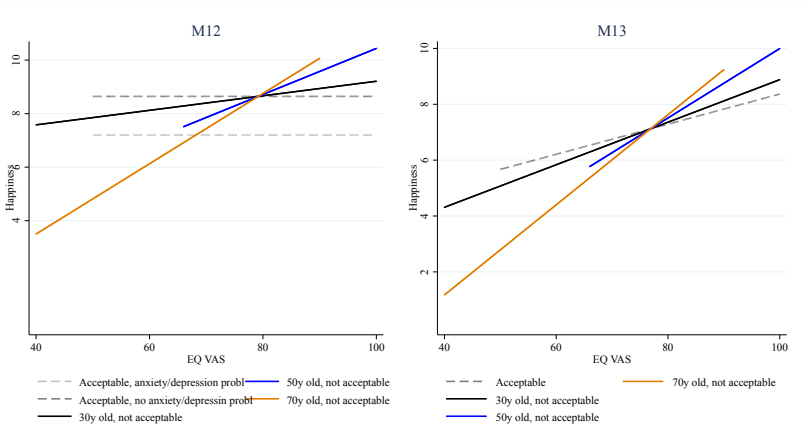
	M10	**M12**	**M13**
Not acceptable	-3,969*		
Not acceptable * Age		-0,179**	-0,142
Age (centred at 18 years)	-0,066		
EQ VAS (0-100)	-0,010		0,054**
Age*EQ VAS	0,001		
Not acceptable*EQ VAS	0,049*		
Not acceptable* EQ VAS * Age		0,002**	0,002**
High income	-0,953**	-0,789*	
Usual activities	-1,279*	-1,716**	
Anxiety / depression	-1,271**	-1,446**	
Intercept	8,698**	8,644**	2,973**
F	14,63	22,156	27,487
p	<0,001	<0,001	<0,001
R^2	0,427	0,409	0,336
Adjusted R^2	0,398	0,391	0,324

* p<0,05, ** p<0,01

The interpretation of M12: in acceptable health states, self-rated health does not influence happiness, while in not acceptable health states, health influences happiness to a smaller extent in younger respondents, while to a much greater extent in older ones. Furthermore, happiness is significantly

influenced by household income, and the level of problems in the anxiety / depression and usual activities dimensions.

Since the last three variables are important determinants of health, in M13 they were exchanged for self-rated health, the effect of which thus became significant on happiness. The interpretation of M13: in acceptable health the improvement of health affects happiness only to a moderate extent, while in not acceptable health the effect of self-rated health on happiness is the greater the older the individual is. The model was homoscedastic (Breusch-Pagan test), its specification was acceptable (Ramsey-RESET test), but the effect of acceptable health did not remain significant after the exclusion of the 3 observations with the highest leverage values, therefore the measurement should be repeated on a larger sample. The graph below illustrates the association between health and happiness, based on the parameters of M12 and M13. Lines were drawn in the EQ VAS ranges measured in the sample.



III.2.5. The association between AH and lifestyle (H_5, H_6)

The table below summarizes the results of the logistic regression analysis (M14). The acceptability of the health status of respondents was influenced

significantly by age, self-rated health, overweight and smoking status. Acceptable health status was denoted by the value of 1, while not acceptable health status was denoted by the value of 0. The interpretation of results is the following: *the older individuals were or the better their self-rated health was, the greater the chance was that they considered their own health state acceptable. Based on this result we could accept H_5 and H_6.*

Logistic regression (the acceptability of own health status)	**M14**
Age (years)	.083**
EQ VAS	.054*
Female gender	.393
Marrier	-.139
Emplyed	-.024
Has a diploma	-.510
High income	-.065
Overweight	-1,491**
Smoker	-1,311*
High-risk alcohol consumption	.680
Lack of exercise	-.546
Expected life-span	-.027
Relatives life-span	.052
Informal caregiver	-.517
Have used health services in the past 3 months	-.703
Mobility problems	.538
Self-care problems	.236
Problems with usual activities	.553
Pain / discomfort	-.817
Anxiety / depression	.359
Intercept	2,107*
LR $Chi^2_{(20)}$	62,91
p	<0,001

* p<0,05, ** p<0,01

III.2.6. Conclusions, areas of further research

In search of potential solutions for the sustainability challenges of healthcare financing, my PhD thesis summarizes the research about acceptable health - a new health measurement method reflecting societal priorities concerning age and disease severity - and its association with happiness.

Based on the cross-sectional, non-representative study conducted in the Hungarian population, the following conclusions could be drawn:

a) People consider health problems increasingly acceptable with age
b) Mild health problems are more acceptable than more severe ones
c) AH can be measured more precisely using the joint evaluation method, than with separate evaluation. Joint evaluation is feasible in practice and provides reasonably accurate measures about the acceptability of health states.
d) EQ VAS is a convenient method to measure acceptable health
e) Acceptable health from the individual's perspective reflects similar priorities than from the society's perspective.

Before the adoption of the AH principle in real practice, the reliability of its method needs to be further developed. During joint evaluation we did not evaluate the consistency of responses, therefore the adaptive algorithm needs to be amended with self-control questions. Without control questions, random answers and answers reflecting real preferences cannot be separated.

It is also important to clarify the concept of AH during the evaluation exercise in order to decrease potential errors arising from respondents' misunderstanding or misinterpretation of the evaluation task.

Furthermore, it is important to prove the basic assumption that in acceptable health status a unit health gain has lower utility (or smaller increase of wellbeing) than in not acceptable health status. Our findings concerning the association of AH and happiness are in line with this assumption. However, in our research acceptable health states were measured indirectly, and our results were influenced by a small number of outliers, therefore our measurement needs to be repeated on a sufficiently powered representative sample of the general population, by the direct evaluation of the acceptability

of individuals' health status, as well as using more specific validated measures of health-related utility and subjective well-being.

Finally, in addition to determining the *E-matrix* from the society's perspective on AH, we consider important to measure the E-matrix from the individuals' perspective as well, in order to verify the assumption that maximising health states that are considered acceptable from the society's perspective simultaneously result in the maximisation of individual wellbeing.

IV. PRACTICAL APPLICATIONS

In case of valid and reliable measurement, AH-based indicators can be incorporated in the health financing decision-process. Using the *E-matrix*, from already existing EQ-5D-3L data, the time spent in acceptable health states can be modelled via similar techniques that are used in QALY based estimates, and can be expressed in a single numerical value.

a) Indicators that maximise time spent in acceptable health states support decisions based on utilitarian and sufficientarian theories of justice.
a) QALY gains in acceptable and not acceptable health states can be separated. Maximising health gains in non-acceptable health states support decisions based on sufficientarian and egalitarian theories of justice.

Altogether, decision-makers could be informed about the society's preferences regarding age and severity of disease in a transparent manner, which could contribute to legitimate and fair decision-making under scarcity of resources. (Daniels, 2000, Daniels and Sabin, 1997) As suggested by Wouters and colleagues, (Wouters et al., 2017) initially the "soft" incorporation of AH into decision-making could be the feasible method, since we lack financing thresholds or other objective criteria about how AH could be incorporated in the decision-making process. However, in deliberative multi-criteria decision-making AH could serve as an input of societal preferences about age and disease severity, which is measured by a consistent and transparent methodology. (Thokala et al., 2016, Marsh et al., 2016) A further application of AH-based measures determine the acceptability of health according to different dimensions than those of the EQ-5D-3L. This way the age-related acceptability of certain health states could be quantified based on disease-specific criteria (e.g. sensory functions, sexuality, cognition, appearance), criteria concerning a broader concept of wellbeing (e.g. social relationships, autonomy, positive affect), or concerning the impact on one's environment (e.g. the quality of life of informal caregivers). However, before practical application, gaining more in-depth understanding of the viewpoints

of all stakeholders of the health financing decision-making process is warranted, in order to further develop the concept of AH according to the needs of its potential users.

Despite its potential areas for further improvements, the measurement of acceptable health states is a promising new method, which could provide new directions for health outcomes research with international relevance.

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VI. OWN PUBLICATIONS WITH RELEVANCE TO THE THESIS

The total impact factor of own papers with relevance to the thesis: 19,318

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