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Comparing Measurement Methods in Health State Evaluation – Case of the Burden of Tinnitus

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Abstract

The objective of this study is to compare four methods for valuing health states in their ability to reflect the burden of Tinnitus. Valuations arr elicited from 210 patients using frequently applied measurement methods: Time Tradeoff (TTO), Standard Gamble (SG) and two different versions of Visual Analog Scales (VAS). Correlation, factor and regression analysis are performed to investigate whether these valuations corresponded to impairments of Tinnitus. The standardised form of the VAS, which is assumed to correct for reference point biases, perform best. Its correlation with symptoms is highest compared to other methods. Factor analysis supports this finding. In addition, least-square regression analysis show that standardised VAS explain more of overall variance than other instruments. However, a definite judgement on the best measurement method cannot be made since the analysis was restricted to a single health state. Further research, including a broader range of health conditions, is required.

Zusammenfassung

Ziel der Untersuchung war der Vergleich vier verschiedener Methoden zur Bewertung von gesundheitsbezogener Lebensqualität, in wieweit sie die Belastung durch das Krankheitsbild Tinnitus abbilden können. 210 Patienten sind in der Untersuchung befragt worden, wobei folgende Methoden zum Einsatz kamen: Time Tradeoff (TTO), Standard Gamble (SG) und zwei verschiedene Formen der Visuellen Analogskala (VAS). Korrelations-, Faktor- und Regressionsanalyse wurden durchgeführt, um einen Vergleich von Bewertungen und Tinnitus-Einschränkungen vorzunehmen. Sechs häufig genutzte Tinnitus-Charakteristiken wurden für den Vergleich genutzt: Schlaf-, Konzentrations- und Hörprobleme, sowie die Fähigkeit, die Geräusche zu ertragen, die generelle Einschränkung und die subjektiv empfundene Lautstärke. Die standardisierte Form der VAS, die für Referenzpunkteffekte korrigieren soll, ist im Vergleich das überlegene Instrument. Die so ermittelten Bewertungen korrelieren am stärksten mit der Tinnitus-Symptomatik. Die Faktorenanalyse unterstützt dieses Ergebnis. Zudem zeigt die Regressionsanalyse, dass die Methode der standardisierten VAS den größten Teil der Gesamtvarianz erklärt. Dennoch kann dies kein abschließendes Ergebnis sein, da sich der Vergleich nur auf einen Gesundheitszustand bezieht. Weitere Untersuchungen sind notwendig, die sich auf ein größeres Spektrum von Krankheitsbildern beziehen.

JEL classification: C9, I10

Introduction*

In recent discussions about cost-effectiveness in health economics, data on mortality and medical disease-specific parameters were not seen to be sufficient to determine the effect of medical interventions.[1] Changes in perceived health status were required as well.[2] Considerable effort has been devoted to the development of health status measures to properly reflect disease-related quality of life. Individual valuation of diseases is a preference-based way to form such measures. Several procedures coexist but economic approaches as Standard Gamble (SG) and Time Tradeoff (TTO)[3] are conceptionally very different from psychological instruments[4] as Rating Scales (RS) and Visual Analog Scales (VAS). The differences in evaluation results have led to an intensive debate about which instrument is preferable, and several articles have encompassed two or more methods for comparison.[5]

Rating Scales and Visual Analog Scales are extensively used because of their simplicity. Time Tradeoff and Standard Gamble are seen to be more complicated and criticized for confronting a respondent with hypothetical situations.[6] Green et al. (2000) published a review on health state valuation techniques to appraise the current theoretical and empirical evidence. His results suggest that all techniques are practical and reliable. Significant differences do not exist for TTO, SG, and VAS. Considering the theoretical basis of the instruments, the authors conclude that choice-based methods (TTO and SG) are best placed to reflect the strength of preference for health. But descriptive validity turned out to be poor for all mentioned techniques. The theoretical framework could be responsible for deviating results.[7]

The objective of this study is not to analyse underlying assumptions but to compare valuation techniques in their ability to reflect the burden created by a given disease, in our case Tinnitus. Different aspects of validity are usually investigated.[8]

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1 Gold et al., "Identifying and Valuing Outcomes" in Gold et al. (1996).

2 Schöffski (2000), Schulenburg and Greiner (2000).

3 Sackett and Torrance (1978).

4 Krabbe et al. (1997).

5 For example Read et al. (1984), Hornberger et al. (1992), Bass et al. (1994).

6 Drummond (1987).

7 Bleichrodt and Johannesson (1996), Gafni (1995), Johannesson et al. (1994), Miyamoto and Eraker (1985), Verhoef et al. (1994)

8 Krabbe et al. (1997).

Content-validity asks, "is the method really measuring what it intends to measure?" Only if valuation methods represent individual expressions of health-state preferences, a meaningful interpretation of results is possible. However, this depends in most cases on subjective judgements.[9] In addition, convergent-validity as a special form of construct-validity examines equivalence and comparability of methods. This is beyond the scope of this paper. Our interest lies in differences of measurement methods rather than theoretical convergence.

Finally, criterion-validity applies one method as 'golden standard' and compares its results to the performances of other methods. Unfortunately, the lack of any reference unit of measurement impedes the application of this approach as well. To tackle the issue, the question has been investigated by comparing ratings of disease-specific symptoms with results of TTO, SG, and VAS. Patients' subjective evaluation of the induced impairment is supposed to correlate with aggregate quality of life measures. For example, VAS has shown strong correlation to pain or clinical symptoms as measured by the Sickness Impact Profile or Arthritis Impact Measurement Scale.[10]

Accordingly, this paper asks which of the valuation methods correlates most with a few common symptoms of the disease Tinnitus? It is assumed that an instrument better reflects overall quality of life if it is related closer to any secondary symptom of Tinnitus. In addition, underlying dimensions of influencing variables and score variance of the valuation techniques are examined. It is assumed that the more score variance these symptoms explain, the better the analysed method reflects relevant aspects of disease-related quality of life.

Methods and Measurement

The disease – Tinnitus

We use Tinnitus as a case study because it is a wide-spread chronic impairment. The first symptom of Tinnitus is commonly known as "sounds in the head". Graham covers its characteristic feature:[11] "Tinnitus may be defined [further] as a sensation of sound for which there is no source of vibration outside the individual." This impairment is common in industrial societies. Between 35% and 45% of all adults over 17 years experience ear noises at least once in their life. About one out of ten has to cope with these sounds

9 Bortz and Döring (1995).

10 Kaplan et al. (1993) and Rutten et al. (1995).

11 Graham (1965), p. 4.

daily.[12] All socio-economic groups are afflicted although the prevalence is highest among unemployed people.[13] However, a typical Tinnitus personality does not exist.[14] The appearance of secondary symptoms is the main problem of Tinnitus. Affected people can suffer sleeping disorders (57%), have difficulties understanding conversations properly (38%), are depressive or desperate (36%).[15] Resulting stress can aggravate the situation and end up in a "Circulus Vitiosus".[16]

To reflect the induced impairment, several questions refer to these secondary symptoms in the questionnaire as shown in the appendix (Table A-1). Sleeping, hearing, and concentration problems, patients' ability to cope and the degree of impairment in their social environment are measured on a five-point rating scale. According to Rohrmann (1978)[17] its five levels – 1) never, 2) seldom, 3) sometimes, 4) often, and 5) always – are perceived as equidistant. Subjective loudness of sounds is measured on a visual analog scale. These Tinnitus characteristics are explicitly stated by Goebel (1994) as mainly relevant. In addition, some demographic variables as age, gender, marital status, number of school years, and occupation are surveyed at the end of the questionnaire-based interview.

Description of valuation methods

Standard Gamble:[18] The Standard Gamble method is an iterative process where fictional decision pairs are compared until indifference is reached. The choice is between life in a less than perfect health state, in our case with Tinnitus, and a hypothetical procedure that leaves the participant with two possible outcomes: either complete cure of Tinnitus with probability (p) for the rest of his life or immediate death with probability ($1 - p$). (The related question in the questionnaire in Table A-1 asks for minimum survival probability.) The level of p that determines participants' point of indifference is taken as the individual utility score of the impairment. The interviewer offers different p-values which the participant can either accept or refuse. Starting with 100 percent survival probability figures are successively lowered as described in the appendix (see Table A-2).[19]

12 Feldmann (1998).
13 Feldmann (1998).
14 Goebel (1995).
15 Goebel (1994).
16 Goebel (1995), p. 181.
17 Cited in Schnell et al. (1993).
18 Torrance (1986).
19 Bosch and Hunink (1996) used a similar flowchart for their interviews.

Time Tradeoff:[20] The Time Tradeoff procedure is also an iterative paired comparison of fictitious states. Participants trade off survival time for health. They are asked the maximum number of years they would be willing to give up in order to free themselves of symptoms of a disease. (The related question in the questionnaire in Table A-1 assumes that a drug can have that effect.) Point of indifference is reached by varying the duration spent disease-free (x). The ratio between disease-free (x) and actual life span (Y) determines a value between 0 and 1. This ratio is assumed to define the individual health-related quality of life of that condition.

In order to define individual life expectancy all participants are asked how old they guess to become. The difference between individual life expectancy and actual age is the actual life span (Y) and can be defined as remaining life expectancy. This procedure allows for the avoidance of reference point biases when considering life years.[21] The interviewer offers different x-values which the participant can either accept or refuse. At the beginning of the iterative questioning process and starting with remaining life expectancy, x is lowered in successive 10 year steps until the respondent refuses the offer (see Table A-2).

Visual Analog Scale: Visual Analog Scales are preference-based measures that are extensively used in psychology. Participants are asked to place a mark on a line somewhere between two anchor states,[22] i.e. for our purpose, health with Tinnitus on a scale between 'worst imaginable health state' and 'best imaginable health state'. However, Sutherland et al. (1983) stressed that health states are strongly influenced by the context in which the measurement tool occurs. To measure the pure impact of Tinnitus on the individual life of participants, life without Tinnitus can be taken as reference point instead of optimal health. Hence, respondents are asked to state on the same scale how good or bad they suppose their health to be without Tinnitus to correct for individual reference points. We refer to the method as 'standardised VAS' as a second version of health state valuation. The standardisation is given by one minus the difference of health scores with and without Tinnitus. This procedure is not unproblematic. In general, Visual Analog Scales are assumed to have interval scale level,[23] i.e. they are unique up to a linear transformation. If this assumption does not hold and Visual Analog Scales reflect only ordinal preferences, the meaningful subtraction of two VAS scores is misleading. However, since other authors assume Visual Analog Scales to have

20 Torrance (1986).

21 Verhoef et al. (1994).

22 Kaplan (1995).

23 Torrance et al. (2001).

even ratio scale property,[24] we felt encouraged to define standardised VAS in the proposed manner.

Analysis

To analyse validity, three different statistical methods are used. Each correlation of symptoms and methods is analysed in detail. If one method documents a stronger relationship to all symptoms compared to other techniques, it is hypothesized that this method better reflects the impairment of this specific disease. The second statistic, regression analysis, is supposed to specify this connection. It assumes linear relationships between dependent and independent variables.[25] In our context, Tinnitus characteristics are taken as explaining, independent variables which are supposed to influence answers on health valuation questions. The more variance is explained, the more the analysed technique reflects associated Tinnitus burden.

Finally, factor analysis allows classifying independent groups of variables. A factor is a hypothetical construct that causes correlation in a specified group of variables. As such, factor analysis is applied to decide which variables contain similar information and which contain distinct information.[26] It helps to determine the dimension of influencing underlying impact variables. It is hoped that the specific structure of symptom variables and elicitation methods allows insight in the dimension of methods. The best scenario is that Tinnitus characteristics and certain methods correlate strongly with one factor. It is argued that other influences undermine the usefulness of those methods which are connected to a second or even third factor.

Results

Demographic data

210 patients were interviewed between September and December 2000, 110 women and 100 men between 16 and 85 years old with an average age of 53,8 years. Patients were met at four different places in Berlin: 21 at the Tinnitus-League, a self-help association; 21 at the Heinrich-Heine-Hospital, a hospital with a focus on psychosomatic conditions; 63 at the ear, nose, and throat department of the Charité, the hospital connected to the Humboldt-University; and 105 patients of Dr. Berndt, a leading expert in Tinnitus treatment.

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24 For example Price et al. (1983), Haig et al. (1986).

25 Bortz (1999).

26 Bortz (1999).

Out of 210 participants 10 said that they could not answer Standard Gamble questions or refused to do so. Sixteen of the participants gave no answers to life expectancy and Time Tradeoff questions. One participant did not finish the interview.

Table 1

Demographics of Tinnitus patients in the sample

		Tinnitus patients ($N = 210$)	
Demographics		number	column percent
Gender	male	100	47.6
	female	110	52.4
Marital status	married	146	69.5
	single	24	11.4
	widowed	14	6.7
	divorced / separated	26	12.4
Years of school attendance	less than 10 years of school	109	54.3
	more than 10 years of school	101	45.7
Occupation	student	1	0.5
	worker	17	8.1
	civil servant	10	4.8
	employee	70	33.3
	self-employed	9	4.3
	housewife	3	1.4
	pensioner	79	37.6
	unemployed	14	6.7
	other	7	3.3

Correlation

Correlation coefficients are analysed in Table 2. Four possible measurement methods for health-related preferences are compared how strongly they correlate with mentioned Tinnitus characteristics. Besides one exception (Time Tradeoff – hearing problems), all correlation coefficients (Pearson) are significant at a level of 0.01, i.e. the probability to wrongly assume a connection between two variables is less than one percent. Standard Gamble shows consistently the lowest correlation coefficients. Visual Analog Scale and Time Tradeoff are approximately on equal terms but standar-

Table 2

Correlation coefficients of Tinnitus characteristics and measurement methods.

		Tinnitus characteristics					
Methods		Sleeping problems	Concentration problems	General impairment	Ability to cope	Hearing problems	Subjective loudness
Visual Analog Scale	corr. coef.	–.449	–.427	–.425	–.547	–.283	–.438
	significance	.000	.000	.000	.000	.000	.000
	number	208	208	208	208	207	205
Standard Gamble	corr. coef.	–.270	–.275	–.315	–.382	–.250	–.346
	significance	.000	.000	.000	.000	.000	.000
	number	200	200	200	200	199	197
Time Tradeoff	corr. coef.	–.349	–.393	–.433	–.543	–.170	–.347
	significance	.000	.000	.000	.000	.018	.000
	number	194	194	194	194	193	191
Standardised VAS	corr. coef.	–.411	–.496	–.609	–.692	–.399	–.572
	significance	.000	.000	.000	.000	.000	.000
	number	206	206	206	206	205	203

dised VAS performs best. Only 'sleeping problems' correlate slightly stronger with ordinary Visual Analog Scale. Standardised VAS has also the "highest" single correlation coefficient: −0.692 for the item 'ability to cope'.

Regression analysis

A regression analysis indicates how much of overall variance of methods is explained by Tinnitus characteristics: sleeping, concentration, and hearing problems, answers to general impairment, ability to cope and subjective loudness. Again, over 50% are explained by the characteristics for standardised VAS. That is considerably more than for ordinary Visual Analog Scale and Time Tradeoff by about 30 percent. Standard Gamble scored the least with under 20 percent as can be seen in Table 3.

Table 3

Explained variance of measurement methods by six Tinnitus characteristics.

Methods	corrected R^2
Visual Analog Scale	0.335
Standard Gamble	0.157
Time Tradeoff	0.298
Standardised VAS	0.539

Factor analysis

By means of a factor analysis two factors could be extracted. The first factor loads highest with Tinnitus characteristics and measurement values associated with Visual Analog Scales. The correlation of Tinnitus symptoms and Visual Analog Scales with the second factor is far less substantial. On the other side, Time Tradeoff and Standard Gamble correlate considerably with both factors. Standard Gamble is connected even closer to the second compared to the first factor with a correlation coefficient of 0.644. The second factor explains 10% of overall variance compared to 50% for the first factor. Time Tradeoff and Standard Gamble obviously display a second influence that does not correlate closely with Tinnitus-related symptoms. On the other hand, Visual Analog Scale and especially standardised VAS are closely related to the general perception of Tinnitus given the high correlation coefficients of 'ability to cope' or 'general impairment' that load equally high on the first factor as these measurement

methods. Although no rotation of factors has been performed to allow easier interpretation of what these factors might explain,[27] the present structure allows hypothesizing that standardised VAS is best suited to reflect the Tinnitus-related burden. Since Time Tradeoff and Standard Gamble include considerations of length of life, attitudes towards this attribute might be covered by the second factor.

Table 4

Factor analysis of Tinnitus characteristics and measurement methods

Symptoms and elicitation methods	Factor 1	Factor 2
Ability to cope	0.868	0.037
Standardised VAS	–0.837	–0.015
General impairment	0.774	0.207
Concentration problems	0.736	0.227
Subjective loudness	0.719	0.121
Visual Analog Scale	–0.700	–0.029
Sleeping problems	0.638	0.025
Hearing problems	0.572	0.431
Time Tradeoff	–0.655	0.566
Standard Gamble	–0.561	0.644

Discussion

The aim of this paper is to compare four elicitation methods in their ability to reflect the burden of Tinnitus. The Tinnitus characteristics sleeplessness, subjective loudness or ability to cope correlate most with standardised VAS (Visual Analog Scales). The multiple correlation coefficient of regression analysis delivered similar results: Tinnitus characteristics explain most of the variance of observations derived by this method. The explaining power for other techniques is lower. Finally, factor analysis bundle all characteristics and standardised VAS into one factor and Time Tradeoff and Standard Gamble into another. If the characteristics are mainly relevant in explaining the degree affected people suffer from Tinnitus, standardised VAS is most appropriate to reflect the induced impairment. It is difficult to say which of the six variables is most important in explaining the degree of suffering.

[27] Brosius (1998).

The question remains whether the most important aspects of Tinnitus are covered by six variables which mainly measure secondary symptoms. That is a question of validity of these variables. Is it possible that, for example, the Standard Gamble and Time Tradeoff method include aspects that should be necessarily included but which are not asked separately in the questionnaire? In that case, utility-based approaches might be more appropriate. An additional explanation for high correlation figures is the similarity of evaluation technique and assessment of Tinnitus symptoms. Visual Analog Scales and Rating Scales are psychometric techniques. Participants in an evaluation might be tempted to indicate similar answers to express consistency. Biased results are the consequence.

It is necessary to note: what applies to Tinnitus does not necessarily hold for other health states. Future analysis has to show whether standardised VAS is indeed better at reflecting health-related quality of life. But as far as evidence could be gathered in this paper, standardised VAS is most appropriate in representing Tinnitus-related quality of life.

Appendix

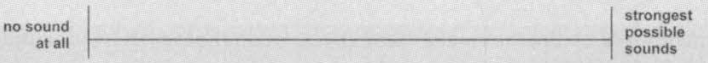
Table A-1: The Questionnaire

- How long do you have already Tinnitus? ☐ years.
- How long have you already been treated for Tinnitus? ☐ years.

	never	seldom	sometimes	often	always
• Do you have sleeping problems?	☐	☐	☐	☐	☐
• Do you have concentration problems?	☐	☐	☐	☐	☐
• Does Tinnitus impair you in your job, among your friends or in the family?	☐	☐	☐	☐	☐
• Do you have the feeling not to be able to cope with your daily life because of Tinnitus ?	☐	☐	☐	☐	☐
• Do you have problems to follow conversations because of Tinnitus ?	☐	☐	☐	☐	☐
	never	seldom	sometimes	often	always

Table A-1 – Continued

- On the first scale, we ask you to indicate **how strong or weak is your Tinnitus today**, in your opinion.



- On the second scale, we ask you to indicate, **how good or bad is your own health with Tinnitus today**, in your opinion.

- On the third scale, we ask you to indicate, **how good or bad were your own health without Tinnitus today** in your opinion

- On the fourth scale, we ask you to indicate, **how happy or unhappy you are today**, in your opinion.

- What do you think? **How old do you guess to become?** ☐ years old.

Assume there is a medicine available that removes any signs of Tinitus but has an impact on life expectancy.

- **What should be resulting life expectancy at least in order to let you take the medicine?**

☐ years.

Table A-1 – Continued

Assume there is an operation available that removes any signs of Tinnitus but life risks are involved.

- **What should be the survival probability at least in order to let you undergo such an operation?**

  ☐ percent.

- **How old are you?** ☐ years old.

- **Your gender:** m ☐ f ☐

- **Your marital status:** single ☐ widow ☐
  living separated / divorced ☐
  in partnership / married ☐

- **Your educational level:**

  less than ten years of school ☐ more than ten years of school ☐

- **Occupation:**

worker	☐	civil servant	☐	employee	☐
self employed	☐	spouse	☐	unemployed	☐
pensioner/ retired	☐	student	☐	other	☐

Table A-2: Time Tradeoff Flowchart for the Interviewer

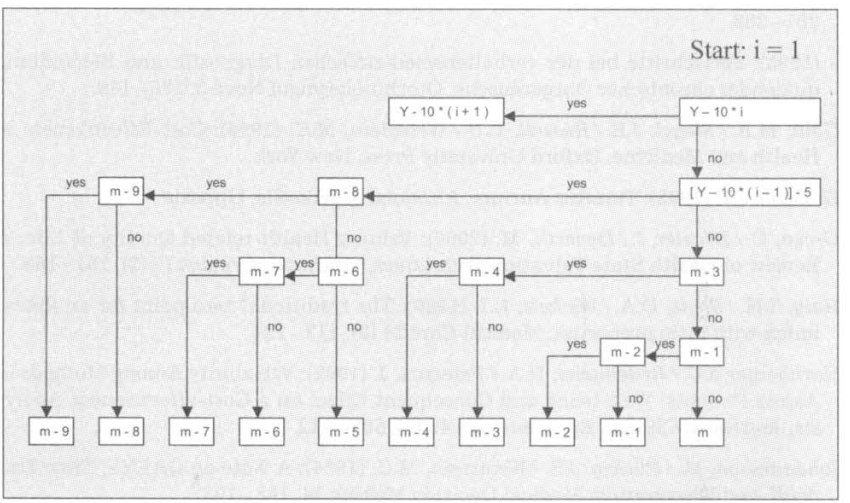
Legend:

Y = individual remaining life expectancy

i = number of steps Y is lowered by 10.

$m = Y - 10 * (i - 1)$

(For Standard Gamble, Y needs to be replaced by 100%.)



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