

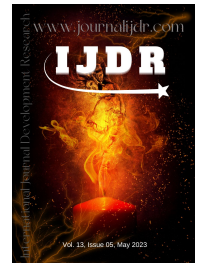


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RESEARCH ARTICLE

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HEALTH ECONOMICS ON THE COMPLEMENTARITY OF MEDICINE AND ECONOMICS

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ABSTRACT

A new positivist interface between Medicine, Economics and Psychology is termed Neuroeconomics. Also in a broader perspective Medicine and Economics need each other. Modern health technology requires so many scarce resources that economic priority rules are needed for an optimal allocation. Economics needs medical science, too, because the Neoclassical Paradigm of bounded economic rationality (BR) doesn't apply to health behavior due to an "Asymmetric Knowledge" between physician and patient. This study focuses on 5 interdisciplinary relationships:

1. Neuroeconomics explains "Asymmetric Knowledge" as rooted in risk-averse behavior
2. Cost-effectiveness Analysis (CEA) cannot stand-a-lone but is a special case of Health Technology Assessment (HTA)
3. Universal Basic Income (UBI) is a common political objective for Economics and Medicine
4. A cost-effective organization of healthcare recognizing the "Asymmetric Knowledge" must focus:
 - a) The GP is the local key coordinator
 - b) University regions are the basal functional unit of specialized healthcare
 - c) A Regional Health Council, constituted by the local municipalities, advising on continuity of care
5. Neuroeconomics identifies meditative in-depth-relaxation as complementary to physical fitness in stress-management and as such a common target for Medicine and Economics, too

Discussion focuses on the development from a special HTA to Universal Technology Assessment (UTA) integrating economic, medical and ecological factors. A development constituting a new approach to the environmental crisis.

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INTRODUCTION

Health Economics has so far developed as a subspecialty of Economics defined as the comparative analysis of alternative courses of action in terms of both their costs and consequences [Rudmik & Drummond, 2012]. The claim is that with increasing health care expenditure and limited resources, it is important for physicians to consider the economic impact of their interventions. "Willingness to pay for a Qaly" (WTA) has been advanced as an indicator for development of healthcare as a spillover from general economics [Gyrd-Hansen, 2005]. The health economic approach is to guide the prioritization of healthcare resources, simply asking a sample representative of the population about their preferences on alternative choices of healthcare. QALY represents the value of living one year in complete from 1 (perfect health) to 0 (dead) [Weinstein et al., 2009]. The quality-adjustment makes QALY a generic measure of disease burden combining quality and quantity of life actually lived. QALY is used to inform on treatment decisions, evaluate programs, and to set priorities for future programs.

However, for economic prioritization across medical interventions it's necessary to determine a standard price per QALY which Gyrd-Hansen recognizes as impossible. A later study recognizes the subjectivity of the matter proposing the feeling of well-being as an operational principle [Himmeler, 2021]. To overcome such subjectivity bias, the present approach is rooted in a transdisciplinary neuroeconomics between Economics, Medicine and Psychology. The "laboratory" model of Neuroeconomics is the "Triune Conception of Brain and Behavior" finding our brain mirrors biological evolution [MacLean, 2002]. The basal dynamics is between "Frontal Cognition" and Autonomic Limbic ambivalence ("ANS"). Neuroeconomic trials on intertemporal (Complex) and explorative choices determine the functional relationship between Frontal Cognition and ANS as curvilinear, see Figure 1 [Larsen & Satpathy, 2022]. General Risk-willingness - the ability to overcome risk-aversion - is identified as a broad parameter of economic behavior. Risk-willingness correlates with important behavioral domains: 1) Career ($r=0.61$), 2) Financial Matter ($r=0.56$), 3) Sports ($r=0.5$), 4) Health ($r=0.48$) and 5) Driving ($r=0.49$) [Dohmen et al., 2005].

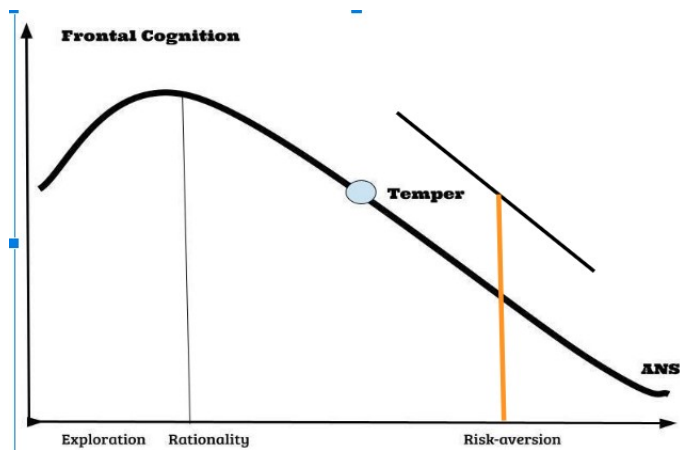


Figure 1. Model of Risk/averse health behavior

NeM shows how the complexity of healthcare decisions implies a parallel shift in Figure 1. The typical consumer rationality regarding simple consumption of daily necessities is now overloaded and consecutively replaced by the risk-averse decision pattern known from complex intertemporal choices. The consequence of “Asymmetric Knowledge” in healthcare is that individual behavior is dominated by risk-aversion instead of the kind of rationality presupposed for simple economic choices for instance regarding daily consumer necessities. Risk-aversion implies conformity to social norms, wherefore the organization of healthcare must be based on collective rather than individual responsibility. Accordingly the WTA-paradigm must be rejected as a positivist approach to health economics.

“Asymmetric Knowledge” is identified as a behavioral model in healthcare in more studies suggesting how a disparity of information between the parties of an economic transaction can cause inefficiency. This phenomenon is also known as information failure and it can usually be observed when the seller of a product or service retains more knowledge than the person who is willing to make the purchase. In relation to health care, asymmetric information relationships can occur between several parties such as providers, regulators, and patients, and the “lemons” can take the forms of avoidable, low-quality outcomes and price discrimination. In some cases, information failure can also lead to medical errors, patient dissatisfaction, and over or under treatment [Cardena & Szentkuti, 2020]. Also, the “Asymmetric knowledge” between physician and patients is emphasized [Fabes et al., 2022]. The common feature of these studies are that the “Asymmetric Knowledge” is understood as an exploitation by the seller that can be counteracted by a “buyer-beware” marketplace, where consumers can obtain all the relevant information about a product or service before they make a purchase. However, neuroeconomics explains “Asymmetric Knowledge” as rooted in mental overload of the patient which requires far stronger counteraction. The purpose of this study is to develop a multidisciplinary approach to healthcare as a positivist alternative to the WTA Paradigm.

METHODS

Application of NeM in Health Economics must face the following methodological challenges:

1. What's the guidelines on organization of healthcare?
2. How to allocate resources to a specific medical treatment?
3. What's the health economic contribution to Social Medicine?

To answer these questions the method of study is an integrative review [Snyder, 2019]. For this purpose public international databases are searched, for instance scientific standard bases as Medline, EconLib and PsychInfo. However, specific international databases such as WHO, OECD, World Bank and IMF do complement the

scientific databases well with basic demographic and socioeconomic data.

RESULTS

Organization of Healthcare

The Overall Organization of an Economic Health System: The mainstream economic approach to production of complex goods as healthcare is private enterprise which is now adopted as the best way to technological progress by the far majority of the world population. This implies a preference for private health insurance companies with the necessary expertise to collaborate with suppliers of healthcare in a competitive market. The prototype of such an insurance-based health system is the USA (IHS), but most other industrialized countries find that the complexity of healthcare implying risk-averse behavior requires a better social protection of individuals towards monopolistic exploitation. Health insurance companies must accept some governmental regulation and complementary finance of universal health coverage (UHS). Whether IHS or UHS is best is demonstrated by data from OECD enabling an international comparison of national systems for healthcare. To assure a fair comparison, the primary analysis is limited to the G7 Group that all are advanced market economies. This simplifies the comparison, too, because all members of G7 but the US have UHS. UHS means typically, that the government complements rather than substitutes, IHS with tax-based finance of healthcare for the low-income groups of the population that can't afford private health insurance. Table 1 shows empirical key figures for a comparison of IHA and UHS extended with data for India and China, recognizing the global importance of these countries. UHS is 1) Far cheaper than HIS, 2) Provides better coverage, and 3) Life-expectancy, as a leading quality indicator of healthcare, is also far higher by UHS.

Which is related to stronger regulation of competition between the private insurance companies. The economy of UHS relates to the monopolization of large insurance companies and medical unions in the USA that rather suspends than promotes competition. The broader coverage of the population by UHS is rather self-evident. The comparative advantage in life-expectancy is to some extent surprising and accentuated by the finding that China in 2022 has accomplished the same life-expectancy as the USA. The overall learning regarding Covid-19 is that large developing Asian economies such as Japan, South Korea and India have overcome Covid-19 remarkably well - even in comparison with the older UHS in Europe. The comparative advantage of UHS in relation to Covid-19 relates to a more effective closing down of business activities to minimize the spread of the virus in an early stage of the pandemic before vaccines were developed. Official data on fatalities are omitted for China and put in Parenthesis for India due to under-reporting in Table. The Indian economy is still at an early stage of industrialization as the average PPP per capita is significantly above most African countries South of Sahara (Except South Africa) and a few countries in South-East Asia, but below most other countries. However, in China the Covid-19 restrictions have been so strong that the effect on economic growth appears to be stronger than in comparable countries. In 2022, the Chinese rate of economic growth is 2.7% compared to >8% in 2021 and many years before Covid-19.

An alternatively type of comparison, a Cross Country Panel analysis, shows, too, that the transition to UHS increases life expectancy (+1.3 years), and reduces under-5 mortality (-8.7%) and catastrophic health expenditure incidence (-3.3%) [O'Rourke et al., 2020]. An alternative study compares the coping with the first phase of Covid-19, in Brazil, USA and India focusing on the respective actions of the President and the Healthcare Authorities [Greer et al., 2022]. The major conclusion is that all of these 3 democracies coped relatively poorly with Covid-19 due to the arbitrariness of the president. In our analysis focusing on the healthcare system India differs from the other two representing a UHS. Also, India coped far better than the USA in accordance with our thesis.

Table 1. G7+ and Total (Public + Private) Expenses on Healthcare 2021

Country	Population (Millions)	UHS/HIS	Income per Capita (1000 PPP ²)	Total Health Exp ¹ (% of GDP)	Life-Expectancy	Covid-19 Deaths (Per mill. People)
USA	335	HIS	63	18%	77	3.340
UK	69	UHS	46	10%	80	2.905
France	66	UHS	45	11%	83	2.470
Germany	84	UHS	53	11%	81	1.925
Italy	60	UHS	42	9.5%	83	3.065
Canada	38	UHS	48	11%	82	1.275
Japan	126	UHS	41	11%	85	456
UHS in G7	443		45	10.5%	83	1.835
India	1.410	UHS ³	7	3.5%	70	(377)
China	1.450	UHS	18	5.5%	77	No data

Source: Public OECD Database and Worldometer Statistics.

Note: ¹Total Expenses = Government/compulsory + Voluntary + Private Out-of-pocket, USD/GDP.

² PPP (Purchasing Power Parities) is a better indicator for comparison than USD at exchange rates.

³ Since 2018 Ayushman Bharat covers half of the population working in small firms (<10 employees).

In summary, we interpret this extra study as a consolidation of the thesis that the type of healthcare system in democracies does express the national culture in a better way than the ad hoc president.

Internal Organization of UHS: "The Five C's" to consider organizing healthcare have been listed as Cost, Coverage, Consistency, Complexity, and chronic illness. Out of these, the best overall combination of cost and coverage is identified above as UHS. Complexity, Chronical care and Consistency within UHS are considered as follows:

The core Function of Complex Healthcare: The core of public healthcare is general medical practitioners (GP) to provide a comprehensive range of services and care to the local population. This includes for instance vaccination; screenings; prevention, control and management of noncommunicable and communicable diseases; care and services that promote, maintain and improve maternal, newborn, child and adolescent health; and mental health and sexual and reproductive health. In many years any physician serving in the community could serve as GP. Since the 1950s GP has developed as a medical specialty of its own focusing on the "Family GP" as part of the local municipality, but well-educated in the hospital sector, too. A Norwegian study concludes that "Length of GP-patient relationship is significantly associated with lower use of out-of-hour services, fewer acute hospital admissions, and lower mortality" [Sandvik et al., 2022]. A key figure is the number of registered patients per GP. A simple guideline is based on 70 appointments per week per 1000 patients per GP. Supposing a GP has 20 appointments per day 5 days a week the optimal number of registered patients per GP is 1500. The complex specialization of modern healthcare implies that regions with a university hospital are a basal geographical coordination unit that typically requires a population base of at least 1 million people due to the many specialties that must be represented at a university hospital. However, a region with 1 million inhabitants does often have a series of local hospitals with a varying number of specialties depending on local historical conditions. Health economic research shows neither large or small hospitals are optimal [Ankjær-Jensen, 2005]. In all, 2.5 beds per 1000 inhabitants is probably enough in future healthcare. A high priority for a university region must be to assure an effective structure of coordinated specialties in the region as a whole.

Two major variants of the Organization of Hospitals: Within insurance-based UHS hospitals are mostly privatized in a mix of Profit and Not-for-profit institutions and the hospital structure is formed by competition. In Northern Europe, for instance Scandinavia and the UK are the hospitals owned and financed by the state which creates a special need for coordination and rationalization of the hospital structure. By the Danish Municipality Reform 2007 this need for coordination of hospital resources was delegated to an independent third body of administrative coordinating in addition to the existing bodies of national and municipal administrations. In the light of 15+ years of experience, the Danish model has contributed markedly to an average rise of hospital productivity of 2% per year until Covid-19.

This remarkable result is partly due to implementation of a marginal privatization of the otherwise public owned healthcare by application of New Public Management (NPM) [Hood, 1991] although it didn't work the same way in the UK [Hood & Dixon, 2015]. Some critical learnings appear from the Danish Municipality Reform:

- The original idea of the reform was to strengthen the influence of the regional population on the development of healthcare, but this target is not confirmed as the population interest in the direct elections to the Regional Hospital Councils is very low compared to the interest in the national as well as municipal levels of politics. This lack of interest is to be expected, too, from the understanding of "Asymmetric Knowledge" presented in Figure 1.
- The municipal level is critical to better population influence for chronics that need follow-up on discharged chronics from the hospitals, but this is not strongly accommodated in the present organization. The rising life-expectancy implies that an increasing share of elderly people suffer from chronic diseases such as diabetes, cardiovascular conditions and COPD. Chronic diseases often require a multifaceted collaboration on rehabilitation between hospital, domicile of the patient and paramedical practitioner groups as nurses in the municipalities. Such collaboration across hospitals, domicile and municipality is already important and does grow fast as reflected in the growing international interest in integrated homecare (IHC), for instance [Larsen, 2012].
- A special learning for health economists is that strict focus on Formula 2 over a long period can affect the psychological factors in Formula 1, too. Health economic management must be complemented by specific evidence-based standards on for instance the minimal staffing of hospital wards.

Danish experiences indicate that the better regional organization of healthcare within UHS is that the municipalities in each university hospital region form a Regional Health Council (RHC) because they have a primary financial interest in the best possible revalidation of chronic patients by IHC after discharge. Also, hospitals have a financial interest in IHC because it shortens the hospital stay with very costly bed days. In summary, public hospitals should be financed in accordance with patient activities and research obligations by direct approbation from the national Government. RHC should be constituted by political representatives appointed by the local municipalities and financed by a national approbation to the national association of municipalities. The primary role of RHC should be guidance on the best hospital structure and IHC in their region. To achieve such a target each RHC must have a health economic planning section, but not direct economic responsibility for hospital management.

Allocation of Resources to Specific Medical Treatment: Healthcare differs from general market-based economy in the way that a Health Technology Assessment (HTA) is not a sub-discipline of Economics, but an interdisciplinary discipline between Medicine, Economics and

Psychology, that synthesizes both quantitative and qualitative information related to the use of a health technology [O'Rourke et al., 2020]. Examples of HTA include medicinal products, medical equipment for diagnostic and treatment, and prevention methods, see for instance HTA of Integrated Home Care (IHC) [Larsen, 2012]. In practice a HTA includes three steps:

1. The assessment begins with preceding considerations in order to determine whether it is relevant for an institution at a given point in time to carry out the assessment. This involves mainly assessment of the maturity of the technology and the organization planning to use it. If the technology is not matured without tests, then pilot studies must be carried out to mature the technology before a multidisciplinary study is initiated.
2. After the preceding considerations, the multidisciplinary assessment is carried out in order to describe and assess the different outcomes of the application. This involves assessment of the following seven domains:

- Domain 1: Health problem and characteristics of the application
- Domain 2: Safety
- Domain 3: Clinical effectiveness
- Domain 4: Patient perspectives
- Domain 5: Economic aspects
- Domain 6: Organizational aspects
- Domain 7: Socio-cultural, ethical and legal aspects

The functional criteria of HTA (Domain 3-6) are specified in Formula 1 as an operation of the economic thesis of Utilitarianism [Mill, 1863]. Psychological aspects are considered online with finance by qualitative interviews of both patients and staff and that's a novelty compared to monodisciplinary economic analysis.

Formula 1 on HTA: $U_{QALY} = F(M_c * P_c | Q_{Pat,Pers})$

U =Utility of healthcare as indicated in QALY (=Quality adjusted living years) [Weinstein, 2009]

M_c =Cost of materials; P_c =Cost of personnel

$Q_{Pat,Pers}$ =Psychological effects on either or both Patients (Pat) and Staff (Pers) as identified by personal interviews

The complex utility function of healthcare (Formula 1) makes it nearly impossible to assure an optimal use of health resources in a specialized healthcare system with thousands of different outcomes aiming for an UHS. In such a case, a group of coordinating specialists in Formula 1 and not at least operation of the concept of QALY is absolutely necessary. So, the primary role of health economists in healthcare is to guide decision-makers on Formula 1. Fortunately, extensive research in Qalys is available for a broad spectrum of health interventions. This simplifies the health-economic task to the accounting of the costs in a Cost-effectiveness Analysis (CEA) as stated in Formula 2. Within healthcare CEA and CUA, cost-utility analysis are synonym terms.

Formula 2 on Cost Effectiveness: $CE = (M_c + P_c) / QALY$

In the most simple case, CEA is done directly on alternative medical diagnostic procedures without changing the QALY, for instance treating or preventing pelvic inflammatory disease by a test as outlined in the example. To facilitate CEA a global health registry (GH CEA) is established with support from the Bill and Melinda Gates Foundation [Global Health, 2023]. The GH CEA is a free database that compiles research literature on the economic value of global health interventions. The inclusion criterion for contributing articles is contingent on its application of the "cost-per-DALY-averted" metric, which measures the cost-effectiveness of an intervention. DALY is a special way of calculating QALY focusing on life-expectancies corrected for disability. The GH CEA Registry is a repository of all peer-reviewed cost-per-DALY studies stratified by methods, cost-per-DALY ratios, and disability weights published since the 1990s.

Example of CEA on Preventive testing for Pelvic Inflammatory Disease

USD	
10.000 women were tested for sexually transmitted diseases with a net cost of	23.844
The treatment of 10.6 cases of pelvic inflammatory disease (PID) were avoided, saving	13.033

Net savings per PID case averted by preventive testing (10.811/10.6)	1.020
=====	

Source: US Center for Disease Control and Prevention (CDC).

3. An assessment should also be made of the transfer of the results to other settings or countries.

Social Medicine

Universal Basic Income (UBI): A special interface between Economics and Medicine is social medicine that recommends Universal Basic Income (UBI) towards inequality of health, see Infobox [Haagh & Rohregger, 2019]. In general terms UBI is a public subsidy to all adults equal to the baseline of relative poverty and independent of all other personal income, wealth, and relations to the labor market. Also, Nobel Prize Laureates such as Milton, Meade, Samuelson, Simon, Solow, Tinbergen and Tobin recommend UBI for redistribution of income. Mainstream (university) economists have so far questioned the benefits of UBI, because a free income to all citizens is expected to reduce work motivation and consecutively the labor supply and finally economic growth. So, in the long-term society may be worse off with UBI. The contra-argument is that the insecurity of income among low-income on top of the restriction of consumption weakens general health in a way that turns inequality in health a serious social problem. To evaluate these alternatives a Finnish sample-based pilot-study of the dynamic effects of UBI was recently conducted. The sample included about 2000 participants among social clients in the age span 23-59 years. A statistical control group comprised 5.000 other social clients. The participants received a free, monthly subsidy of 650 USD in two years. The total budget of the project was 20 million EUR. The Finnish UBI-sample shows no negative effect on labor supply [Kela, 2019] which is online with an extensive review from the International Monetary Fund (IMF), too. A calculation model on UBI based on Danish conditions is elaborated [Larsen & Satpathy, 2022]. A special variant of CEA, termed Distributive CEA, focuses on inequality of health in the way that the CE-Ratio is calculated for patients from different levels of the income hierarchy.

Info Box on Health Impact of Basic Income

Individual Level

Improves mental health, supports Intrinsic motivation, sense of Security/control and empowerment

Systemic Society Level

Generates a foundation for a comprehensive economic security system, senses of belonging, security in society, inclusion and social participation, and accountability, build/rebuild universal welfare state. A field experiment with Guaranteed Annual Income in Canada demonstrates 8.5 % decline in the hospitalization rate between 1974-1978 whereof mental health is a major component

Policy Level

Lowers public costs linked with poverty/insecurity to the health sector, supporting preventative health interventions, impact more direct but not confined to the lower part of the gradient only (proportional and universal effect)

Limitations

Effects are conditional on other change in the policy environment (fiscal capability/political preferences, economic policy)

Stress-management: WHO warns about an epidemic stress load [Markus et al., 2012]. The primary neurological advice for better mental health is self-control or *stamina* based on physical fitness [Oaten & Cheng, 2006]. However, job-related stress is a growing threat where also “soft” mental aspects require extra attention! In 2020, Depression was the second leading cause of world disability and 2030 Depression is expected to be the largest burden of disease. This line of development is investigated in a recent Danish statistical enquiry [Ottosen et al., 2022] where early personal signs of stress among youngsters are identified as 1) Lack of time for self-actualization and 2) Increased career expectations. A backside of post-industrial economies that offer great possibilities for everyone. No simple general solution seems available, whereas the second-best social solution presented below, is an option specific to those with a mental surplus to start with improvement of their own capacity. NeM guides stress-management as illustrated in Figure 2 where meditation affects a deep relaxation movement from the Temper circle towards Origo.

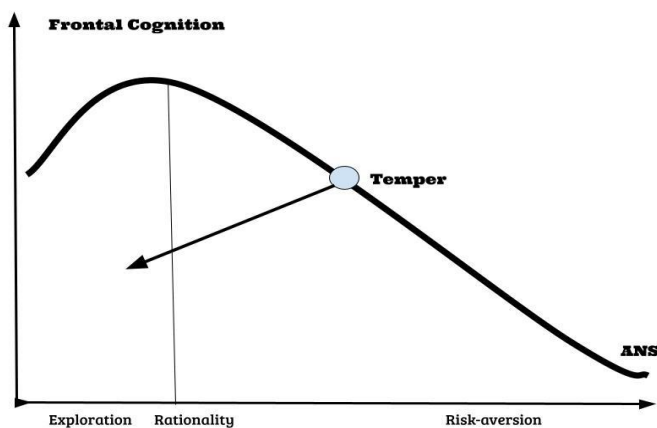


Figure 2. Action Mechanism of Meditative In-depth-relaxation

Such release of conscious blocking reveals relaxation as a fourth neurodynamic factor complements basal reward-seeking, fear responses and cognition. This extra aspect of meditation is especially confirmed in a series of studies labeled “Developing the Interoceptive Attention” [Farb et al., 2015]. Modern mantra-meditation is practiced in a relaxed sitting position for instance on a simple chair in a quiet place where thoughts are dissolved by a mantra. Such homeostatic in-depth-relaxation shows subjectively slow breathing and objectively low galvanic skin conductance. Analogue results are reproduced in subsequent studies, for instance at Harvard [Benson & Klipper, 1975]. A HTA of Meditation, Awarded “Book of the Year 2007” by IIAS, summarize the following long-term effects of regular mantra meditation [Larsen, 2007]:

- A significant decline in the stress hormone (plasma cortisol) characterizing a more relaxed pattern of behavior
- A meta-analysis finds that regular relaxation exercises complement physical fitness as health activity dissolves stress and anxiety
- A 14-year, pre and post intervention study retrospectively assessed government payments to physicians for treating the TM and comparison groups. TM reduced payments to physicians between 5 % and 13 % annually relative to comparison subjects over 6 years. Randomized study is recommended

A neuroeconomic guideline for deliberate restructure of cognition from the level of Origo is reinforcement of the Working Memory (WM) [Baddeley, 2010]. Key training tools are:

- Dialogue with yourself by open questions on the interpretation of your experiences
- Expand your vocabulary with diversified studies and communication

- Become sufficiently competent in mathematics to develop functional models
- Develop your practical competence rehearsing again and again scenarios where ambitions become better and better linked to situations, issues and persons

DISCUSSION

Health economists must master both the skills directly embedded in Formula 1 and skills ranging from a broad outlook on issues of organization and Stress-management. However, beyond such specific disciplinary skills Medicine is also committed to an ethical standard. The four pillars of medical ethics are Beneficence, Non-maleficence, Autonomy and Justice [Medical Portal, 2023]. These four principles represent a framework for analyzing the best action to take in a given situation. The medical operation, for instance of Beneficence implies acceptance, too, of the basic economic Utilitarianism [Mill, 1863]. In the case, where a physician due to scarcity of resources must choose between curing one very ill patient or 4 moderately ill patients, he must choose to cure 4. Can health economics accept medical ethics, which implies an absolute commitment to strive for the common best? A common ethical platform between general economics and Medicine requires that the special concept of HTA in Formula 1-2 extends to an universal technology assessment (UTA) including the negative side-effects of financial growth. For instance, the Greenhouse effect and Epidemic job-related stress must be included in standard economic evaluation. The full integration of Medicine, Economics, Psychology and Ecology constitutes a new interdisciplinary platform. Such development is facilitated by the globalized character of Ecology. The medical focus on the individual patient makes Medicine very complex with thousands of different interventions to be separately assessed. In comparison, the globally interrelated Ecosystem has a few key parameters, for instance the Greenhouse effect, pollution of earth and water as well as a shrinking Biodiversity. Fortunately, international organizations such as WHO and UNDP have already published studies that enable a preliminary QALY-assessment of both the benefits of market-based growth and the damages to mental health and Ecosystem. Formula 3 formalizes the concept of UTA as operated in Formula 4 as a framework for a preliminary operation.

Formula 3 on UTA:

$$U = F(\text{Materials} * \text{Personnel} * \text{Ecosystem}) \text{ in QALY}$$

For practical assessment of the overall effect on the Ecosystem by Mankind the parameters operate as follows:

Formula 4:

$$\text{Effectiveness of Mankind} = \text{Growth}_{\text{Qaly}} + \text{Personnel}_{\text{Qaly}} + \text{Eco}_{\text{Qaly}}$$

1. Use of materials is operated as the expected annual growth rate of the aggregated global GDP which relate to QALY in the way that the growth rate relates significantly to average life-expectancy [UNDP, 2003]
2. Dysfunction effect on persons is operated as the costs of stress which are set-off in growth rate
3. Direct effect on the Ecosystem is operated as QALY related to fatalities of environmental diseases according to WHO

Conclusion

The overall result of the UTA is determined as the net QALY-effect of the factors 1-3.

Tenets for a Preliminary Operation of UTA

Ad 1. Market-based Economic Growth: The most probable rate of real long-term economic growth is 2% p.a. [OECD, 2022]. A study shows the relation between economic growth and growth in life-

expectancy is strongly significant logarithmic relation ($R^2=0.62$) [UNDP, 2005]. This implies the average annual growth in Life-expectancy is about 2 months. With a global population of 8 billion, the growth effect amounts to 1.300 million QALY p.a.

Ad 2. Burden of Stress: Stress is an epidemic job-related disease burden [Markus et al., 2012]. The costs of workplace stress consist of

- 1) Absence days from work, 2) Hospital admissions, 3) Early retirements and 4) GP Consultations.

In USA, A workplace survey estimates the costs of Workplace stress to 500 billion USD or 2% of GDP [MHA, 2017]. An estimate for stress costs in Europe with a broader definition of stress reaches an even higher cost level [EU-OSHA, 2014]. As the most probable estimate of stress costs is 2% p.a., the net QALY of 2% economic growth is today about Zero.

Ad 3. QALY of the Global Effect on the Ecosystem: - A study estimates fatal environmental diagnoses to 600 million QALY in 2012 [Prüss-Ustün et al., 2012].

Indications from a Preliminary UTA: Climate research has identified a critical threshold of no return with an atmospheric concentration of $CO_2 > 450$ ppm [Solomon et al., 2008]. In 2023, the level is 420 ppm and rising by 2-3 ppm p.a. Already, the negative effects on stress and the environment outbalance the QALY from liberal economic growth and in 10-15 years we may reach the critical threshold of 450 ppm CO_2 in the atmosphere with irreversible consequences.

Global Scenario by Fulfillment of the Paris Agreement 2015: The concentration of CO_2 starts to decline before reaching the critical limit of 450 ppm and the atmospheric CO_2 dips below 400 ppm and the global temperature increases $< 1.5^\circ C$ in the long term without serious long-term damages to the Ecosystem.

Global Scenario when the Paris Agreement fails and CO_2 rises beyond 450 ppm: Global Temperature rises $> 3^\circ C$ with an irreversible negative environmental effect and a state of long-term negative growth appears with the most probable scenario of a persistent economic depression like the 1930es and a strong potential conflict between countries in the rich North and the poor South. It is strongly recommended that health economists, medicine and climate science collaborate on the elaboration of UTA as a visible argument in the public discussion of environmental protection.

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