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Discounting health gain: a different view

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ABSTRACT

At least since the Age of Enlightenment, good health has been a tenet for society. Healthy societies could learn better, work harder, improve their wealth, and live longer. Today societies focus on life expectancy, as we value long and healthy lives. As illustrated by the provision of COVID-19 vaccines first for the elderly, societies value life-saving actions. Paradoxically, health economic assessments conventionally devalue long-lasting health through the practice of discounting health benefits along with costs. However, health, with its intrinsic and instrumental characteristics, is not synonymous with money cash, a tradeable asset that devalues with time. If improving healthy life expectancy is a societal ambition, it seems counter-intuitive to value future health less as a result of an artificial mathematical construct when evaluating economically new medical interventions. In this paper, we investigate the application of discounting health in healthcare and consider paradoxical findings, especially in relation to disease prevention with vaccination. We argue that there is no economically sustainable argument to discount health gains, except for the benefit of the payer with a goal of spending less on life-saving products. If that is the objective for discounting health, there are other means to achieve the same goal in a more transparent and simpler way. From the long-term perspective of healthcare development, not discounting health gains would encourage research that values long-term effects. This in turn has the potential to benefit the investor, the payer, and the patient/consumer, improving the situation from multiple perspectives.

KEY POINTS FOR DECISION MAKERS

Discounting in the consumer market is applied on money flow but not on the outcome of products consumed.
Discounting in the healthcare market is applied on both the money flow and the outcome of products consumed which causes paradoxical findings especially on interventions that act on prevention.
There is no good economic rational in discounting health, except that it benefits the payer in valuing less the price of products that cause long term health benefit.
Moreover, no consumer can report the experience of a discounted health gain over time creating therefore the discounted health gain as a mathematical, artificial construction.
If the finality about discounting health gain is about getting lower prices for goods acquired by payers, other means exist that are simpler and more transparent to understand and accept for all the stakeholders involved.

Introduction

Discounting health gains, as is currently routine in health economic (HE) assessments, remains subject to many controversies [1–3]. Although there has been an evolution in the reasoning and argumentation that tries to justify the discount rate to apply, there is a lack of clear and transparent answers [4]. Moreover, the main point of discussion is whether health should be considered equivalent to money and therefore equal discount rates should be applied, or whether health should be seen as different from money and therefore discounted differently [5].

The current discussion is quite technical, conducted among experts related to the objectives of healthcare development, a fixed or flexible healthcare budget, and having data available on pure social time preference for health gain by the consumer [1]. This discussion of detailed issues is likely to lead to additional debates, in the absence of clear methods to quantify the problem.

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An economic analysis in healthcare involves the evaluation of different aspects of value [6]. One is the money value that decreases over time if nothing is done. The other is the health gain value that increases when healthy behavior results in longer life. On top of that, both money and health could be impacted by another aspect of value, the time preference expressed by the consumer looking for quality health gain now [7]. In general, a consumer prefers to receive gains immediately but likes to pay later. Health Economics (HE) brings the two elements of money and health into one value measure that captures these different aspects when evaluating the price-setting of new products and services. The result is presented as a cost per extra unit of health gain obtained with the new intervention [8]. However, it is challenging to calculate that outcome correctly when the health gain obtained and the cost spent are spread over time, because the components move in different directions. Experts have therefore put norm-settings introducing discounting rules for health gain and cost separately that should facilitate practical decisions [9]. However, countries may apply these norm-settings differently, resulting in the same product with the same indication and price being considered cost-effective and reimbursable in one country but not in another [10]. This situation raises questions from the producer/investor, the end-user (consumer/patient), the prescriber, and potentially the public or the third-party payer when challenged on why the product is offered in one country but not in its neighbor.

Let us take one step back to facilitate different, perhaps better, insights into the reasons for discounting health gain. A hypothetical-deductive methodology can be applied to answer the fundamental question of whether health gain can be discounted, a question that has not been assessed sufficiently in the past [11]. If it cannot, then it follows that discounting should not be applied to health. How can that question be answered comprehensively? In this article, we consider four points of assessment. Firstly, we identify where discounting is applied uncontroversially in the best-known and most familiar market, which is the consumption market. Then, we compare it with what is done in the healthcare market and investigate the differences. Secondly, we consider who gains and who loses with discounting of health gains in the healthcare market, and how much is the gain-loss difference between winners and losers? [12] If the difference is large, is this a fair economic deal for the stakeholders? Thirdly, we consider the properties needed for use of discounting and whether health measurement complies with those [13]. Lastly, we consider paradoxical situations that arise when using the current discounting rules on health. Does discounting health fit with a sense of reality when making appropriate economic evaluations?

We will identify the fundamentals of discounting health and compare them to methods used in general economic application. If those fundamentals are absent, we will end our evaluation with suggestions for appropriate health economic analyses that could achieve the same results as the existing methods involving discounting. These newly proposed evaluations should be clearer in their assessment, by being simpler to understand and more transparent in their application. The adoption of proposed new approaches could end the debate on discounting health, which has become too complex and controversial for those who need to apply and explain the existing method to a broad audience to support healthcare decision-making.

Application of discounting

Money- and gain-flow

Different markets exist that can offer goods and services to be bought by payers to obtain short- or long-term gains. The best-known operational market is the consumption market, which satisfies short-term utilities of the consumer such as hunger or thirst with food or drink. The market may also satisfy, by devices producing regular outputs, sustained long-term utilities of the consumer, for example staying warm with clothes or heating infrastructure, keeping food fresh with refrigerators, or making coffee with coffee machines. The money flow and satisfaction gain of the consumer market is illustrated in Figure 1.

In the consumer world shown in Figure 1, the consumer purchases goods and services based upon a perceived value defined by the price she/he wants to pay (P). When bought, the good or service provides the consumer with satisfaction and/or wealth, and also causes a revenue flow back to the investor and/or producer. Investments (I) are made to maximize revenue or financial benefit to the investor, a process that occurs through offer and demand of the products available in the market that helps define the price-setting (discussed further below).

Healthcare is another big market in modern society. It currently represents between 12% and 18% of production capacity in high-income countries expressed as Gross Domestic Product (GDP) [14]. In this market goods and services are also offered, but under different circumstances than in the consumer market. It operates when patients request help to satisfy their impaired health utilities. The money flow and gain in the
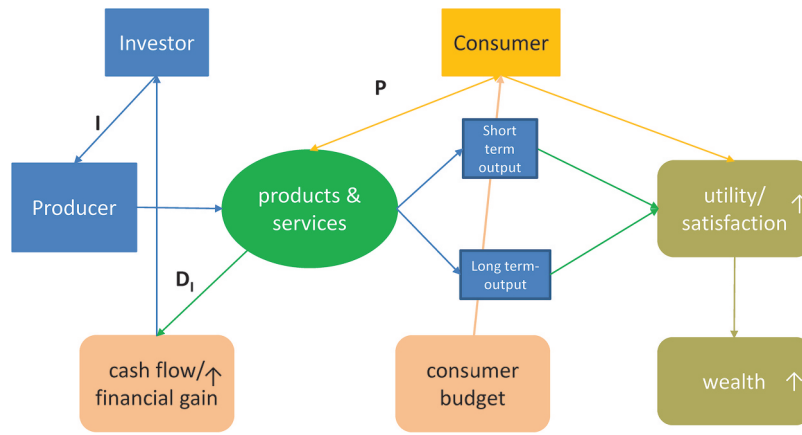
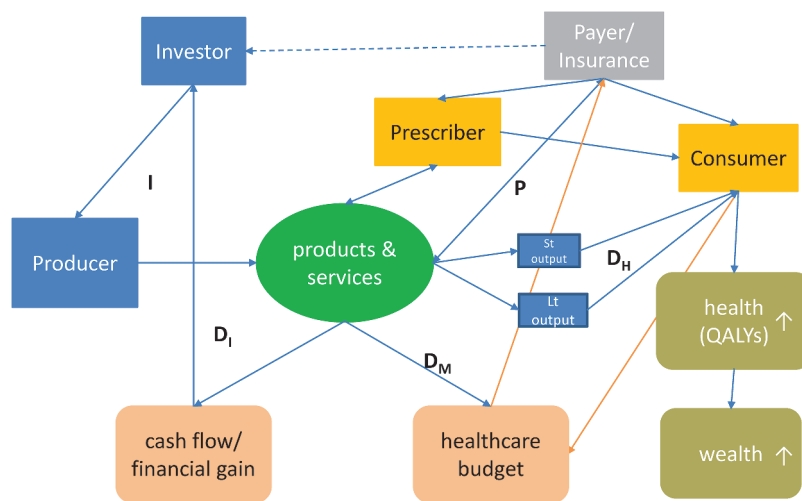**Figure 1.** Money and utility gain flow of the consumer market.

Figure 2. Money and utility gain flow of the healthcare market.

healthcare market is more complex than in the consumer market because the consumer (patient) does not operate directly in the market, but instead obtains healthcare products and services through intermediaries such as prescribers and third-party payers. That has consequences for the frequency of using the market, for price-setting of the products and services available on the market, and for the financial gain for stakeholders. But, as in the consumer market, there is also short-term satisfaction of health utilities by specific products and services to address acute situations, and long-term satisfaction of health utilities by other products and services to manage chronic health conditions and/or prevent worse health conditions (Figure 2).

However, in the healthcare market, besides the investor who introduces (new) products other important players are present, such as payers and prescribers (Figure 2). These players may have specific objectives. The payer in the healthcare market,

often public or third party, tries to control the market size and the price-setting independent of the consumer. Prescribers can be incentivized to decide what products/services to use, but more importantly the consumer does not have a free choice. Therefore, the cash-flow generated back to the investor is only marginally influenced by the consumer. Furthermore, the overall economic objective of healthcare is different and not as simple as in the consumer world. Investments in healthcare should stimulate the development of more and better health for all, rather than creating profit by selling more goods and services to improve financial returns. The latter can occur but is not the final objective in healthcare. The public payer or health authority may have several critical objectives to fulfil, including controlling the budget, improving health of all consumers, and stimulating research to increase efficiency in the system. To control the budget, the demand of the payer is to buy at

low prices goods and services that maximize quality health (the realm of health technology appraisal), with the approved price acting as a signal to the investor/producer about expected returns.

Discounting

To assess the full economic value in consumer and healthcare markets, specific techniques are applied including discounting. In the consumer market, discounting adjusts future money to its current value because money changes in value over time. Money that is not consumed today may have a different value tomorrow when invested, or it may decrease in value if not invested [15,16]. The net change to today's value over time is an opportunity cost, as money could be directed into different options. The rate at which money is discounted is often based on the interest rate defined by local treasuries, but other methods of discounting exist based on time preference [17]. With discounting, investors compare net present values and the rate of return on their investment across different projects that may generate cash-flows at different times. The discounting rules allow for a fair comparison of different investment strategies, even if the returns are obtained at widely different time points.

The distinction between immediate and long-term demand/satisfaction, as shown in Figure 1, is important because short-term satisfaction is immediate and therefore does not need discounting of the utility gain obtained. With a sustained situation for satisfying long-term utilities, using products that facilitate the achievement of that objective, the same output is expected over time when the product is used. No discount is applied to the output delivered later compared with immediate output. The value is considered absolute. Examples in the consumer market include a refrigerator producing sustained low temperature over time, a coffee-machine regularly producing cups of coffee over time, or a car providing travel distance (Figure 3). Discounting here considered is about the value of future output and is different from depreciation of the asset value of products used like the car, the coffee machine, or the refrigerator over time, reflecting the fact that it will wear out and will eventually need replacing.

There is no argument for discounting the output the machines deliver over time that is consumed at different time-points. Furthermore, it is considered normal for manufacturers to give warranties that pay back if products do not deliver the same quality/quantity output over a fixed period of time. Consumers are therefore accustomed to expect the
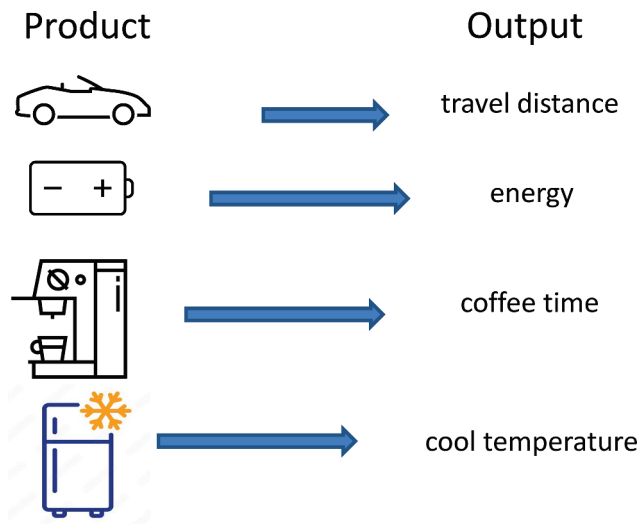

Figure 3. From product to output and value in the consumer market.

same output to be sustained for a period in the future from products bought to satisfy specific utilities, without considerations of discounting the output.

Economic evaluations in healthcare apply the same principle of discounting costs (money), but currently also discount the output of healthcare, namely the health gain [18]. HE applies a level of discounting to money that may differ from the one used in the consumer market, and the discount rate can also differ within healthcare between cost and health gain. However, money, as mentioned above, decreases in value over time, whereas (as observed for some time), health increases in value, expressed in increasing life-expectancy and in the improvement of health-related quality of life [19,20]. Norms defined in HE justify the use of discount rates depending on many factors. The most recent norms specified are sometimes difficult to apply because the quantification is not easy (discussed further below), but they may help to explain why discount rates should be different for health gain versus cost [1,3]. Discounting in HE also occurs at different places and for different purposes, compared with the consumer market (see Figures 1 and 2). The discounting of the investment (D_I (investment)) is the same in healthcare as it is in the consumer market because the objective is the same (a financial return on the investment made). However, discounting applied by the payer (D_M (money) and D_H (health)) has a different objective, which has consequences for the producer and the investor because it directly impacts the price-setting of products and services. This is something not seen in the consumer market.
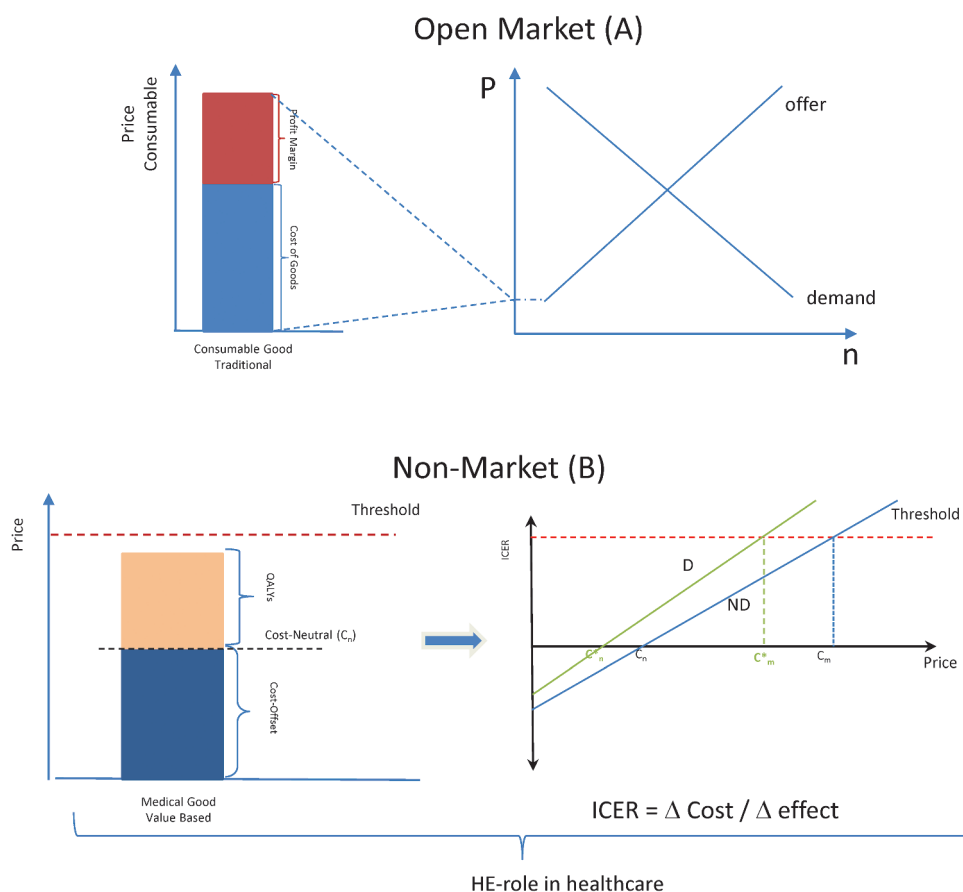
Open Market (A)

Non-Market (B)

Figure 4. Comparing price-setting in the 'open' consumer (A) versus the 'non-market' healthcare world (B).

Discounting and the price-setting in the two worlds

Figure 4 considers the price (P) composition and construction in the consumer (open market) world and in the healthcare (non-market) world.

In the consumer market (Figure 4A), the price of a good mainly consists of the cost of producing the good (CoGs) plus a profit margin. Sometimes, other more value-focused cost terms are used, such as the intrinsic, instrumental, and inherent value of a product expressed in monetary units [3,21]. The size of the profit margin (the inherent value) fluctuates according to supply (surplus) and demand (shortage) until a price equilibrium is reached (right side of Figure 4A). The price proposed in the consumer market reflects the total value of a product (cost-offset and value measured), presented as a one money number paid to the investor who gets back his investment returned with a gain. The discounting applied is driven by the financial benefits the investor wishes to gain over a given timescale. There is no incentive to discount other values elsewhere in this market, such as the amount of utility satisfaction of the consumer over time, that may impact the price-setting. This is indirectly accounted for by the

offer and demand arrangement. An example from the car industry illustrates that value-setting is not discounted by the payer or the investor in the consumer market. A consumer/payer when buying a car will know the longevity of the car expressed in the number of kilometers the car can be driven during a certain (warranty) period. There is no incentive for the seller or the payer/consumer to discount that value when making a comparison with other products/cars that may influence the price-setting. The payer/seller prefers the real number and not a discounted value for the distance the car can be expected to be driven. The difference in the nominal number of kilometers that cars can be driven trouble-free is a reference that helps the consumer/payer to make a choice.

Healthcare can be described as a 'non-market' situation, in contrast to the 'open' market of the consumer world, because the demand for goods and services is not always predictable, continuous, or sustained. There is an information gap in knowledge between producers, prescribers, and consumers about the goods offered; market entrance is highly regulated, determining who can operate in

healthcare; and the price paid is not a market-value-driven, exclusively expressed in money terms. All these conditions mean that the market in healthcare operates quite differently when compared with the consumer market. Prices are not obtained through offer and demand and cost of goods plus profit margin. The method most often used to allow reimbursement by the payer at a fixed price level is the incremental cost-effectiveness analysis. The incremental cost-effectiveness ratio (ICER) must be communicated by the producer to the payer (see right side of Figure 4B). Critical elements of this analysis are the cost-offset made by the new intervention in avoiding other medical consumption and the number of quality-adjusted life-years (QALYs) gained by avoiding disease events. The calculation of those two values make the link between price-setting (C_n (cost neutral) to C_m (maximum price) in the graph) and the maximum ICER obtained under the threshold defined by the payer. Currently those QALYs gained, measuring the product impact over time (equivalent to the number of trouble-free kilometers driving in the consumer world), are subject to discounting (D_H), in addition to the D_M on the money flow when comparing products and services. This discounting of health benefits impacts the price-setting for the product or service.

Critically, as can be seen in Figures 2 and 4B, an investor in healthcare does not receive the full gain of the product invested in by means of a cash-flow, since part of the gain is retained by the consumer in the form of a health gain. The investor has no access to that 'gain' so this 'profit' cannot be further traded. This is equivalent to the consumer world where the investor has no direct access to the utility gain of consumers. However, if the demand for the product is high, the investor can propose a new price that will augment the profit in volume and margin in the consumer market. In the healthcare market the investor cannot replicate this because the market volume and maximum price are defined by the payer. Discounting in healthcare is now commonly applied to both cost and health gain (D_M and D_H), thereby reducing the investor's benefit twice, once by a reduced price (under the threshold) and again by a fixed market size (no adjustment in offer and demand). To make the healthcare world attractive for investors, an important role is played by the patent protection of products and services offered when newly introduced into the market. Investors can thereby temporarily operate as if under monopolistic conditions to gain revenues by greater volume, if their products are highly valued.

Who wins and loses with health discount?

Having described the scene for discounting in healthcare, compared with the situation in the consumer market, many complex questions on the application of discounting in healthcare arise [22]. The list has been described multiple times in the literature and has caused many debates about normative setting versus practical use of discounting for money and health gain [1,3,4,22]. Here we address different questions.

Answering the question

The question of who wins and who loses, when implementing new normative rules in the economics of healthcare, is not often asked, but a response will help to better understand the consequences of the application of the rules, and an additional question relates to the size of the loss or gain between the stakeholders.

It is clear from Figure 4B that the party gaining with the introduction of discounting health gain is the payer (discounting of health gain results in a lower QALY benefit accumulated over time, and therefore a lower price as shown by the green line), while the investors/producers are the losers. Surprisingly, consumers could be indifferent in this assessment, since they do not pay the full price of the goods, cannot choose, and will never experience any difference between a discounted or an undiscounted health gain. The consumers' statement about time preference is used as the argument to impose discounting on health gains. However, as forced consumers, when they need healthcare help, they must have paid annual contributions that may provide a diagnostic and treatment option for their complaints. They have not much of a real preference to express and are likely to be more interested in knowing the absolute QALY benefit to be expected (equivalent to the number of trouble-free kilometers to be expected from the car) rather than a discounted gain that will never be directly experienced.

To maximize the gain, the payer will promote equal discounting for cost and health effect. To reduce the loss, the investor/producer will prefer higher differential discounting. The difference in gain and loss for the two groups concerned is best illustrated with a simple example, in which three elements in the ICER equation are varied to demonstrate the relative impact on the price-setting (Figure 5). The example assesses scenarios with no discount to an equal discount of 3.5% on both cost and effect, with an intermediate situation of a differential discount of 1.5% for health and 3.5% for
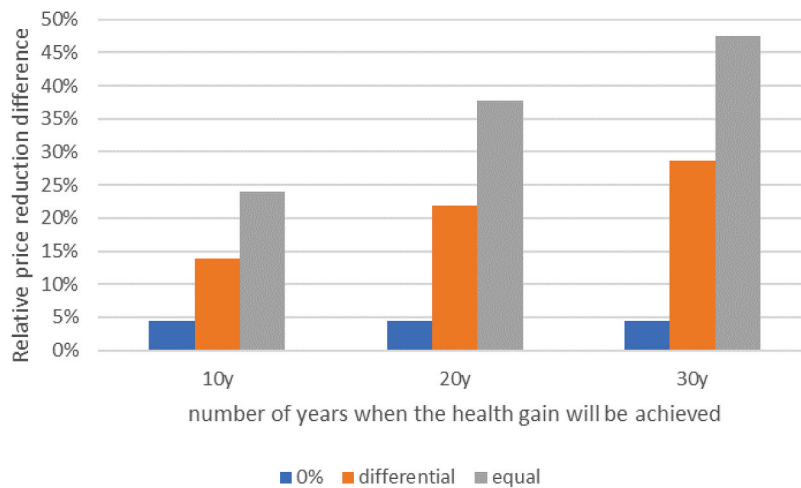
Figure 5. Difference in relative price reduction as a function of health discount and timing of the QALY gain.

cost. To simplify the assessment, the accumulated QALY gain in absolute terms is 4 QALYs, which can occur accumulated after 10, 20, or 30 years. The cost-difference between the existing and the new intervention is selected so that the current treatment requires an undiscounted cost of 10,000€/year over 10 years, while the new intervention reduces that annual cost to 5,000€/year but with an extra first-year cost that reaches the threshold of 50,000€/QALY:

$$\frac{\Delta Cost}{\Delta Effect} = \frac{200,000€}{4QALYs} = 50,000€/QALY$$

Applying discounting to the health gain has a striking impact on the price-setting of products, creating a large imbalance between those who gain and those who lose, especially if the health gain happens later in time – up to > 45% price reduction with equal discounting when the gain happens 30 years in the future. It is not clear that the real intent of the convention for discounting health gain was to dramatically reduce the price of goods and services for a health gain obtained later in time. While interventions that increase health gain both immediately and over time are of obvious value, the approach of discounting health gains at the same rate as costs has the effect of penalizing the intervention that may create higher and longer health gain over time. The convention therefore does not create the right economic incentive to encourage research to improve long-term health gains. It may rather have the opposite effect of discouraging improvements in health gain obtained too late.

Experts have imposed discounting rules on health gain because of the time preferences of the consumer receiving the intervention and the uncertainty surrounding an unclear long-term health future. However, historical evaluation of healthcare

development gives information about how to maximize health gains, reducing the perception of the future as uncertain [23]. What drove the thinking of discounting health gain is that historically economic evaluation in healthcare began with cost-benefit analyses, which were the initial method of economic evaluation in the public domain [24], where all items (resource use and benefit) were expressed in monetary terms. Therefore, health gain translated into money terms through a willingness-to-pay assessment could be evaluated as if it were money. However, there is a weakness in this reasoning. The non-healthcare focused cost-benefit analysis applied to building new roads or new water-works expressed the societal benefit in monetary terms related to increased production, increased social (market) activities, and increased welfare indices (less cost spent on healthcare), which were tangible items that could easily be expressed in acceptable and verifiable monetary terms. This step is not taken in the economics of healthcare. Experts consider health gain, on which a monetary value estimate is placed based on questionnaire surveys of individuals [25]. More appropriate economic analyses for healthcare should be to consider the best integration of a person recovered from sickness following treatment (or not having become sick at all due to a preventive intervention) and resuming or continuing normal activity, rather than settling for a quality-adjusted health gain as an endpoint that captures only part of the gain to be measured at the societal and economic functional level [26]. The objective of healthcare could be limited to a health-focused view, but a better economic analysis would compare apples with apples, rather than the current approach of combining money and health gain into one equation when they do not have the same attributes (discussed further below) [4,11,15,17,27].

Evolution in the application of rules

The practicality of the way the discount rate applied to health gains is calculated is not well understood. It is only well captured by a few who understand what is meant and the way it is proposed [5]. To demonstrate the current complexity in calculating the discount rates in healthcare, Appendix 1 lists the many different variables encountered in the equations defined in published papers discussing discounting in healthcare [27–29]. The premise of current analysis is that societies spend more on healthcare in absolute terms as income increases, and because the value of health increases over time a high value is attached to 'good' health as life expectancy increases (healthy ageing). However, in relative terms we may spend less because of diminishing marginal utility (more spending does not guarantee more equivalent utility increase especially at an older age). It follows that a QALY value should not remain fixed over time but should be adjusted. This statement is a rejection of the Weinstein & Stason consistency argument for claiming equal discounting for cost and health gain [9]. Following the latest proposal of Claxton et al., to select the right discounting values for money and health gain requires first identifying the intention of the healthcare development of interest to the authorities (overall broader welfare gain or mainly health gain); whether the healthcare business operates within a fixed or flexible annual budget, set for optimality; whether there are restrictions on extra healthcare spending when there is a flexible budget; and finally determining social time preference rates for consumption and for health consumption in particular [4]. The Ramsey formula is frequently used to start calculating the discount rates, using social time preference rates, elasticity of the marginal utility, and the growth rate of per capita consumption as variables in the equation [30]. However, there is a problem in defining the precise rate to apply for health gain (growth rate of value of health?) [31]. An additional issue is whether any given set of rules will be maintained over time. If the rules to be applied frequently change because of new insights and arguments, it becomes very difficult to compare economic evaluation results across periods. This can lead to controversial statements about price-setting of products that may change dramatically and too often over time, which is not attractive to investors for durable investments. There may also be a question about the intent of the norm-setting: is it to obtain an accurate health economic evaluation, or is it that some players in the market desire a favorable result? Fortunately, sensitivity analysis should still indicate the reference situation of applying no discount, as that may allow for a more straightforward comparison that is better understood by all stakeholders.

Properties and attributes

The last question is whether the QALY health measure has the right properties to allow discounting to be applied equivalent to discounting money. The properties should be the same for each, especially if they are to be combined into one evaluation formula such as the ICER calculation. If they do not have the same attributes, one may be preferentially adjusted over the other to reach certain goals in the economic assessment, because it may be easier to adjust one versus the other. This cannot be the best approach. Health and money are not value measures that work in the same way and the same direction. The forces that affect their volatility over time are very different. Money can be put temporarily aside as needed, instantaneously stopping or changing some investment action if and when the money owner wishes [32]. This cannot be done easily with health within a healthcare environment. Moreover, health is bound to specific time criteria that cannot be adapted or changed. One constraint relates to the age at which the health gain appears, linked with mortality delayed. This gain will always be larger in children and shorter in elderly populations. There is no similar perspective with money, which has no fixed endpoints in its value settings (see the cryptocurrencies for an extreme example). The economic value of health gain as a function of age is also subject to whether the individual can still be productive, as being productive could be considered a source of added value for society. Therefore, factors other than health quantification expressed by the quality time lived are of value in an economic assessment. Also, the value of money changes because of factors such as inflation, exchange rates, and global market economic impulses. A consequence of this is, because health measurement is finite in its value gain while money is not, it becomes more interesting to experiment with changes in cost than in QALYs to obtain better ICER measurements under the threshold, as shown previously [8].

Who is ultimately interested in having the QALY gain discounted, showing smaller incremental health benefits in economic evaluations than in reality? Only the payer, who can claim that the health benefit is less pronounced with discounting and that therefore the price of the new intervention should be less. The investor prefers higher prices because this generates more cash flow, and the consumer would prefer to see the real benefit, to understand what to expect from an intervention. Is therefore the evaluation proposed by the payer fair when the payer is not the one who benefits most from the intervention and the devaluation of health gain promotes lower-priced

interventions? Moreover, the perspective of improving healthcare development by increasing cost-efficiency in the long-term requires the long-term events to receive the correct importance and weight in the analysis, so that investors see a real benefit in moving towards long-term benefits with product development. This should also be a priority for the payer and the patient alike. There is also the issue of deprioritizing future generations by applying discounting, because less weight is given to future effects [22]. Finally, when not discounting health but only discounting cost, we may fall into the trap of the argument used by Keeler and Cretin about their statement paradox, that with no health discounting, the economic assessment of prevention always looks better by delaying the initiative [33]. We are in favor of the argument expressed by Menzel against this statement, that this paradox is in reality an effect of the calculation construction, because this delay is never applied in real-life [34]. Postponing an intervention such as vaccination is of no real benefit overall, rather the opposite (for example, the situation with COVID-19 in 2020/21 COVID, where health authorities scrambled to get everyone vaccinated).

The vaccine prevention paradox

The difficulties in applying a meaningful time-discounting rule to clinical health benefit [35,36], can be illustrated using vaccines and their duration of protection. Consider multiple vaccines for the same disease, as is currently the case for COVID-19, and the discounting of health gain. The vaccine providing the longest duration of protection would have its health gain decreased the most, because discounting of health gain is greatest at times further into the future. The paradox of discounting means that vaccines are penalized when the protection lasts longer. Rather than longer protection conferring a better price, the discounting of clinical health benefit over time ensures that longer protection is valued less. Under such circumstances the investor and producer could be perversely incentivized to develop vaccines requiring regular booster doses rather than longer protection. When discounting health effects, the additional future gain with one long-term effective dose receives a lower present value than multiple booster doses. With vaccines the reporting of the absolute QALY gain for each vaccination would be fair and transparent. Moreover, the consumer will personally experience the undiscounted clinical benefit. Discounting future health gain artificially reduces possible differences between vaccines that provide benefits over different timescales without a clear incentive for doing so.

If disease prevention is successful, the normal situation remains unchanged as no infection will occur. So the question becomes: should discounting be applied to the normal situation when nothing happens and everything remains the same? Accepting that discounting is applied in order to trade the value of a benefit, this is a challenge with prevention. The value difference obtained by prevention is estimated by comparing against a group in whom prevention is absent. With treatment, value is created because the individual is already sick and therefore is below the normal level of health. With prevention, the starting health level is normal, and it should remain normal over time after vaccination. The individual receiving the vaccination is not a patient but a healthy person; a vaccine does not treat the consequence of the infection, it prevents the infection from occurring. The gain in life-years saved is thus a statistical construct based on the lower frequency of disease events after the risk reduction provided by effective vaccination. The risk reduction should not be discounted over the period of protection, unless the risk reduction effect decreases over time. If the protection does decrease over time, the benefit is greater and more valuable closer to the point of vaccination. Rather than discounting health benefit, such differences can be accounted for by considering a vaccine with or without an immune waning process.

The individual may be conscious of the value of the vaccine when first vaccinated, but after a while may become and remain quite indifferent because normally nothing should happen if the vaccine works well. Receiving the measles vaccine when being young does not create lasting moments of happiness during the remaining lifetime because of protection against measles. The individual consumer is indifferent to the benefit because it is not directly experienced, as nothing happens when encountering the infection, although the consumer may perhaps be pleased when seeing information about the difference between a condition with and without the vaccine. The value of prevention is context-related across the period it is effective and has especially societal benefit that mainly the payer and the politician may claim as important benefits. The longer the prevention lasts, the more consequences are avoided and the higher the value that should be considered.

Valuing correctly the benefit of a vaccine becomes more complex when it is known that the measured real benefit occurs years after vaccination, but the vaccination must be taken early to obtain that benefit. Consider, for example, vaccination to prevent Human Papilloma Virus (HPV)-related cancers [37]. It is a vaccine given to young adults to prevent the development of

cervical cancer years later. It could be argued whether money spent on actions other than vaccination may increase health or welfare sooner than with the vaccine, and that benefits occurring later should be valued less compared with benefits that could be obtained earlier. However, the fact that the HPV vaccine provides a substantial benefit later, and if vaccination is delayed the risk increases, should also be highly valued. Much depends on the context considered. Take a hypothetical intervention at birth that would avoid cardiovascular disease aged 40 years; many people would opt in and highly value the early intervention! It would be ridiculous to discount the benefit occurring 40 years after vaccination at a rate that means the potential benefit may disappear due to discounting.

The decision for vaccination is often taken by decision-makers evaluating the value of vaccination at a higher, population, level, rather than at an individual level. The benefit to society can be greater than the sum of the individual benefits [38]. The longer the duration of a vaccine, the faster the control of the disease spread. Society accrues greater benefits over time the more widely the vaccine is adopted. A society today without smallpox has a much higher value than the counterfactual where smallpox is still circulating. So, why discount the benefits of protection over time, when it creates substantial added value to all with time? This differs for treatment, where the latter will never be able to reach a condition of disease control leading to elimination. Finally, how can an authority motivate people to accept more prevention, when in the economic analysis done on the new intervention the potential health gain may disappear over time by applying discounting?

Alternative approaches

From the previous paragraphs it appears that discounting should not be applied to health gain, expressed as QALYs, especially in the domain of medical prevention, as it is not appropriate in its concept and application [39]. However, the objective of healthcare development is to obtain quality health for all using a cost-efficient approach that cannot rely on the known consumer market rules of offer and demand to define the price-setting of goods and services. Are there alternative economic assessment approaches available to help define the price-setting of goods and services in healthcare, that are more transparent than current methods of discounted ICER calculations? Such approaches should be easy to apply, understandable, verifiable, and they should give the right balance between maximizing health gain for all (by which economic development and welfare improvement remains durable and sustainable) and constraints of budget and logistics, giving equal priority to short- and long-term gain for research investments, and supporting societal acceptance by payers, patients, investors, producers, and politicians.

Different techniques/methods of economic assessments exist and have been routinely applied in domains other than healthcare, such as constrained optimization, fiscal evaluations with modified Social Accounting Matrix evaluations, and/or the more complete societal cost-benefit analysis that assesses the health gain in terms
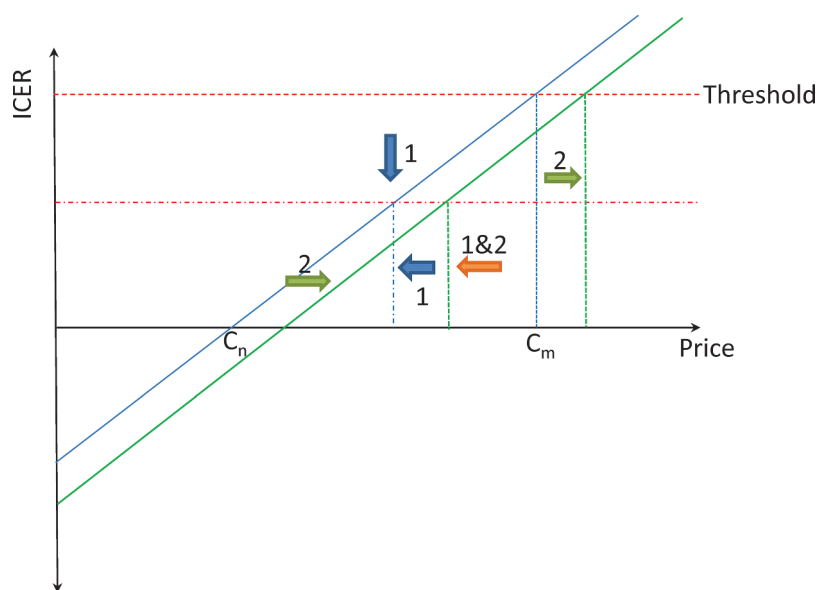

Figure 6. Changing other items (threshold (1) and cost (2)) to review price-setting in healthcare.

of measurable social economic gains such as productivity, healthcare cost, and market activities [40]. These approaches exist but need greater impetus for regular implementation in healthcare evaluations, which is perhaps missing currently for reasons of history, training, and education. If, however, economic analysis remains fixed on ICER calculations, it should shift now to an approach without discounting health gain. In Figure 6 we illustrate alternative approaches to control price-setting of goods and services in healthcare. It is a matter of finding the right balance between threshold selection (1), cost-offset calculation (extended or not) (2), while using a QALY that is undiscounted. This should facilitate the transparency of the calculations compared with current methods, together with an improved focus on the effects desired among all the stakeholders involved.

Conclusion

In this article we have examined and discussed many reasons why health gain should not be discounted in health economic analyses, especially for preventive interventions. The beneficiary of the health gain (patient/consumer) neither decides on nor pays for the intervention. The payer has mechanisms to ensure lower prices without the need to discount health, and furthermore the discounting of health does not meet the initial intended purpose of trading value. For a transparent view for all stakeholders involved in introducing new medical interventions, when determining health benefit now and in the future, health gain should not be discounted. In the realm of vaccination, benefits accrue to society over time, particularly if vaccination results in the elimination of an infection. As illustrated in the current COVID-19 epidemic, the value of a vaccine may be perceived as most critical and important when an infection outbreak occurs. When the risk of an infectious disease is minimal, the value of a vaccine to an individual person is perceived as lower or even negative. However, this is the point when the value of a vaccine to society is at its highest, as the infection is now controlled, therefore it is at this time particularly that no discount should be applied. As a society, we value maximizing life-expectancy and do not devalue gains with increasing age, quite the reverse. It seems therefore quite perverse in HE analysis to discount future health effects synonymously with costs.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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Appendix

Variables: all used in the assessment of discounting health gain [1,4–64110412741294141414142]. Often no precise method is described for how each measure is calculated. This is particularly true for the value measurement of 'pure time preference' that appears to be critical in healthcare evaluation.

Formulas: the Ramsey equation for estimating discount based on time preference and the definition of differential discounting.

Variable name	Measurement method	Code
National income		I_n
Life expectancy		L
(health) opportunity cost	money that could have been spent for other purposes (on health in particular)	C_o
Differential discount	Different discount on health gain and money	r_d
Equal discount	Same discount on health gain and money	r_e
Discount rate of money		r_m
Discount rate of health		r_h
Diminishing marginal return of investment	variable rate adjustment factor of the gain in function of the level of investment	
Difference between health, well-being, well-fair		
Value of health	life years expressed in money terms	v_c
Growth rate in value of health	money increase for the monetized life years	g_v
Growth rate in money/consumption	growth in welfare/income	g_c
Growth rate of the marginal cost-effectiveness (=threshold)		g_k
Expected growth in life expectancy	life years increase per year	g_L
Marginal cost-effectiveness of current spending		k_t
Change in value of health	difference in discount rate of money versus health	v_h
Time preference for health	?	ρ_h
Time preference for consumption	?	ρ_c
Social time preference	?	$s\rho$
Pure time preference	?	$p\rho$
Elasticity of marginal utility (of income or life expectancy)	relative change in utility per time unit	ε_x
Diminishing/decreasing marginal utility score related to expected growth in life expectancy	?	dU_L
Diminishing/decreasing marginal utility score related to healthcare spending of income	?	dU_C
Marginal productivity of healthcare spending	health opportunity cost	dC_h
Consumption value of health	money spent on health	v_c
Endogenous and exogenous budgets of healthcare		$B_{en};B_{ex}$
Uncertainty about the future		
Formula		
Rasmey formula	$r_x = \rho_x + \varepsilon_x g_x$	
Differential discount	$r_c = r_h + g_k$	