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CURRENT OPINION

Insights from Financial Economics to Value Healthcare Investments that Reduce System-Level Risks: Example of Disease Elimination and Eradication

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Abstract

System-level risks generate volatility that can threaten the stability of public health systems and jeopardise population health. In financial terms, these risks may be systematic, arising from macroeconomic shocks, or systemic, arising from cascading failures due to interconnectedness. Interventions such as disease elimination and eradication (DEE) play a crucial role in mitigating the aggregate impact of such risks. However, conventional health economic evaluations often overlook these broader benefits realised during periods of instability, focusing instead on programme-specific risks under steady-state assumptions. Insights from financial economics can help capture this value and inform a more robust economic appraisal. This paper explores how concepts from financial economics can strengthen conventional health economic methods for evaluating programmes that reduce the aggregate impact of such system-level risks, using DEE as a primary example. It draws on asset pricing theory, macroeconomic models of rare disasters, real options analysis, and discounting practices. Key recommendations include recognising the added value of programmes that perform better during downturns due to the protection they offer against macroeconomic shocks or catastrophic events; using 'real options' thinking to manage uncertainty and preserve flexibility in long-term, high sunk cost projects; and accounting for equity considerations when setting discount rates for programmes with significant intergenerational impacts. The financial economics tools highlighted here could serve as key components of a broader analytical framework, supporting investment decisions that recognise and more accurately capture the value of investments that reduce the aggregate impact of system-level risks.

1 Introduction

Health economic analysis plays a central role in assessing the value of public health investments through the quantification of health benefits and costs [1, 2]. However, little consideration has been given to whether routinely applied economic evaluation methods appropriately capture the value of mitigating and adapting to system-level risks. These are risks that extend beyond individual interventions or programmes but can affect whole health systems and exist within broad social, financial, and economic contexts [3]. In financial economics, there is typically a greater concern for how investment opportunities, both financial and real, perform in the face of system-level risks, which can be systematic stemming from macroeconomic events (e.g., global recessions) [4] or systemic stemming from interconnectedness or dependencies within the system [5]. The latter is particularly concerning as it can enable tail events, which are extreme, rare shocks, to cascade into catastrophic crises (e.g., the 2008 financial crisis) [6].

The current health economics toolkit is arguably more tailored to quantify and determine the impact of intervention-specific risks under normal circumstances, while neglecting broader impacts on healthcare system demand and supply during periods of severe stress or resource constraints. For instance, systematic risks, such as recessions or financial crises, can strain health systems and public programmes, contributing to adverse outcomes for specific diseases, as seen in a rise in tuberculosis (TB) incidence in some European countries following the 2008 financial crisis [7]. Separately,

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Key Points for Decision Makers

Standard economic evaluations focus on intervention-specific risks in steady conditions, often neglecting the broader health system impact during system-level crises.

We draw lessons from financial economics to inform health economic methods for assessing and valuing the benefits of programmes aimed at reducing the aggregate impact of system-wide risks.

Recommendations include prioritising countercyclical health programmes for their protective value, using real options to value flexibility when making irreversible, long-term investments under uncertainty, and carefully selecting discount rates to account for intergenerational equity.

systemic vulnerabilities (like weak sanitation infrastructure) could cause a tail event (like an earthquake) to cascade into a catastrophic health crisis (as seen with the cholera epidemic in Haiti [8]). It is worth considering whether and how the benefits of certain public health interventions (like disease elimination and eradication [DEE]), which may help mitigate the consequences of such risks, can be adequately captured and valued.

In this paper, we argue that insights from financial economics can be useful in informing the economic evaluation of public health initiatives that can play a role in mitigating the aggregate impact of system-level risks. We highlight key concepts from financial theory and explore their relevance for evaluating the long-term value of interventions addressing such risks, using DEE investments as a primary example. Specifically, we draw on beta values from asset pricing models to reflect the countercyclical value, welfare cost of uncertainty from disaster risk models to reflect the insurance value, real options analysis to reflect the flexibility value, and declining discount rates to reflect the intergenerational equity value of these programmes. Finally, we present a stylised numerical example to show how incorporating these concepts can alter the estimated value of a programme relative to standard economic evaluation.

2 Lessons From Financial Economics

2.1 The Countercyclical "Hedge" Value of DEE

Health economics typically accounts for parametric uncertainty and its consequences in decision making [9, 10]. Variability of actual project outcomes, although recognised and often estimated [11], is not explicitly accounted for in routine economic evaluations. In financial economics, such project risk is divided into two types: diversifiable and non-diversifiable. Diversifiable risks, also known as idiosyncratic risks, are project-specific (e.g., cost overruns, unforeseen challenges, or failure) and are independent of the events in the wider economy [12]. Finance considers these irrelevant for valuation because investors can eliminate them through diversification. Non-diversifiable risks, on the other hand, are commonly referred to as systematic risks, and include those arising from economy-wide factors such as inflation, interest rates, or recessions [4, 13]. It is useful to distinguish between systematic and systemic risk within the broad category of non-diversifiable risks. While the terminology and distinction are not always consistent across sources, we define both as having system-wide impacts but differing in their source: systematic risks stem from macroeconomic cycles or market fluctuations, whereas systemic risks originate from failure of one entity, sector, or component, such as the collapse of a major financial institution, that triggers cascading failures across the entire system [4, 14, 15].

Measuring systematic risk is central to asset pricing theories in finance [16–19]. The consumption-based Capital Asset Pricing Model (CCAPM) extends the traditional market-based CAPM by incorporating consumers' intertemporal choices and consumption preferences into asset pricing by considering the wider economy beyond financial markets. In this model, expected returns on financial investments reflect the difference in marginal utility between consuming today versus saving for future consumption. A key feature of the CCAPM is its use of a consumption beta as a measure of systematic risk, which captures the correlation between the asset's realised outcomes and changes in aggregate consumption levels. A procyclical or positive beta asset moves in the same direction as the overall consumption growth. Countercyclical (or negative beta) assets, on the other hand, such as gold, move in the opposite direction to the overall consumption growth. Although systematic risk is difficult to avoid, it can be partially hedged using assets with negative betas. The lower systematic risk profile of these assets justifies the use of a lower discount rate, thereby increasing the investment's calculated net present value (NPV) [20].

This interaction between realised outcomes and the broader economy has seen relatively little consideration in health economics. A good example of investments with a negative beta or countercyclical potential could be DEE programmes. Similar to the way investors use countercyclical stocks to diversify their portfolios and potentially mitigate losses during economic downturns, DEE programmes could offer a form of risk mitigation against deteriorating population health and the consequent system strain [21]. Evidence shows that the incidence of many communicable diseases often rises during periods of economic crisis [22, 23], including neglected tropical diseases (NTDs) [24–26]. This may be because worsening health causes recessions, or because maintaining well-working healthcare systems becomes harder during economic downturns. For valuation, the direction of causation is not relevant for adjusting the discount rate; rather, the programme's value as a hedge is influenced by how its benefits, measured in disability adjusted life years (DALYs) averted or quality adjusted life years (QALYs) gained per unit cost, co-move with changes to macroeconomic growth (systematic risk). Elimination or eradication of diseases before such periods of downturn would avert worsening health outcomes when the consequences of these are particularly challenging for health systems to bear, and when the marginal utility of consumption is high. In the language of CCAPM, this countercyclical pay-off corresponds to a *negative* consumption beta.

Therefore, DEE efforts should arguably be valued more than they typically would be using more standard health economic methods. Viewing DEE programmes as countercyclical assets could also mean their financing could be drawn from climate or disaster risk frameworks, like blended finance alliances and resilience bonds, rather than traditional health aid. We recognise that programme costs may fluctuate with economic conditions, and if they are systematically higher during downturns, this could partially offset the project's hedging value. Therefore, the betas for both costs and benefits must be empirically estimated for each programme to ensure robust valuation. Currently, given that there is a lack of experience in estimating beta values for health projects, it would be useful to illustrate, with case studies, how a qualitative indication of whether projects are likely to be strongly pro- or countercyclical might be made. Also how these co-dependencies are likely to be concentrated, i.e., whether in low probability high impact events, such as catastrophic shocks or disasters [27]. This could help identify the types of programmes and conditions under which quantifying the interaction between project outcome and broader economy is likely to be important for investment decisions, as well as inform how beta could be estimated for these [27].

2.2 The Insurance-Like Value of DEE

Financial economics has long focused on understanding the impact of potential future catastrophes on the valuation of financial assets [28–30]. This focuses on large-scale national or global events that can cause a *severe* fall in consumption, gross domestic product (GDP), and wealth but allow for some degree of recovery [30]. Such catastrophes are realisations of tail risks, which are low-probability, but extremely high-impact events (e.g., a pandemic or climate shock) whose probabilities lie in 'fat-tails' of statistical distributions [31, 32]. When such a tail event occurs within a system characterised by high *systemic* risk, localised failures can cascade system-wide, amplifying the initial shock into a catastrophic crisis [33–35]. For instance, the emergence of SARS-CoV-2 in late 2019 exemplifies a tail-risk event that became a global catastrophe not only due to the virus's virulence, but also because structural weaknesses allowed failures to propagate system-wide. Localised outbreaks in Wuhan cascaded globally: overwhelmed health systems triggered care rationing [36], concentrated supply chains turned local disruptions into global shortages [37], workforce depletion strained health services [38], and limited surveillance led to blunt lockdowns that synchronised economic shocks [39]. The pandemic's cascading effects went beyond direct health impacts, driving food insecurity for 135 million additional people [40], education disruptions for 1.6 billion students [41], and economic losses estimated at $28 trillion globally (2020–2025) [42]. Although these events typically only have a low probability of occurrence, the economic and social harms experienced within them are so severe that they should have a significant ex-ante effect on programme valuation.

Recent extensions to the CCAPM [29] focus on simultaneous tail risk to both consumption and asset outcomes, and this provides important insights relevant for economic evaluation of health policies. These models suggest that projects or policies that are expected to deliver the greatest benefits within these tail events or catastrophic states are known to be particularly valuable because they occur at times when the marginal utility of consumption is very high, more so than general negative beta projects that are countercyclical within more normal economic cycles. The more systemic the downturn, the greater this value is likely to be. This is particularly true if such catastrophes last for extended periods, since, given their severity, society would be unable to adapt at the time to provide similar benefits through other means. For instance, Barro [29] shows that eliminating disaster risks yields welfare gains about 15 times greater than reducing conventional business cycle risks, as disasters impose significant costs through reduced consumption. This would be further amplified for wars, natural disasters, and epidemics if an allowance were made for direct utility losses from death, injury, and disease.

This insight extends to programmes such as DEE. During a catastrophic crisis, when health systems are overwhelmed and fiscal capacity is sharply reduced, routine disease control can break down, increasing the likelihood that previously contained pathogens resurface just when the system is least equipped to respond (e.g., measles surveillance and vaccination campaigns were suspended worldwide during COVID-19, leading to immediate outbreaks [43]). The unique value of DEE programmes is that they can offer protection against the compounding threat of disease re-emergence during severe economic or social crises. Even though they might not prevent all illnesses, their ability to mitigate losses in tail-risk or catastrophic states can massively, not just modestly, increase their value. In this sense, DEE can be viewed as a form of insurance policy for public health, as its benefits are concentrated where they matter most, in times of systemic stress. Society effectively pays for a guarantee to mitigate the impact of low-probability, high-impact disasters, much like Pindyck's [44] framing of greenhouse gas abatement as societal insurance against catastrophic climate risk. Positioning DEE similarly may also broaden its appeal to investors beyond the health sector, seeking systemic resilience.

Frameworks and models developed in financial economics estimate willingness-to-pay (WTP) to quantify the welfare cost of uncertainty associated with rare disasters or catastrophes [29, 30]. It estimates how much society is willing to pay for this protection, usually as a fraction of consumption or the tax burden. However, these frameworks are not designed for health contexts; in particular, they do not account for the opportunity cost (in terms of shorter-term benefits) of drawing on finite health care resources to deliver these insurance policy interventions. Willingness-to-pay for protection, therefore, should not be treated as a decision rule for investment since, in theory, it can be unlimited. As a result, it doesn't represent the true opportunity cost of choosing one intervention over another. Nonetheless, elements of their approach, such as the focus on rare disasters and the welfare cost of uncertainty, should, we believe, be considered for health economic evaluation. A practical first step is to use a risk-adjusted discount rate to capture this high "insurance" value. However, determining this rate is challenging. It would require data on whether these co-dependencies are likely to be concentrated in such tail-risk or catastrophe states, as well as plausible estimates of the probability of the occurrence of these catastrophic events, and some distribution about the impact size, both in terms of health system costs, population health effects and macroeconomic outcomes, all of which remain quite difficult to generate. A feasible way forward could be to use historical data to quantify the welfare gains associated with protection against rare but severe states, extending standard economic evaluation to capture insurance value.

2.3 The Flexibility Value of DEE

Health economic evaluation, as noted before, doesn't typically consider the variability of actual outcomes in decision making, which can only be resolved over time and not through additional evidence. Unpredictable disease dynamics and future states of the world are key factors influencing the success of long-term policies like DEE programmes, highlighting the need for considering the dynamic evolution of uncertainty in the evaluation of health programmes. Combined with significant sunk costs, designing policies that provide the flexibility to adapt and time actions based on realised outcomes could create substantial value for policymakers.

Within finance theory, real options analysis (ROA) is a well-established approach to model investments under uncertainty [45, 46], where there is some flexibility over the timing of a decision which, once taken, would be to some degree irreversible. Real options analysis explicitly recognises that retaining or creating flexibility over decision making is a desirable characteristic with economic value. This value can be derived from an option to defer (thereby avoiding sunk costs if the intervention may become unnecessary) or, conversely, from an option to invest in a manner that can create future options for decision making as uncertainty resolves. The latter can be particularly relevant in valuing DEE programmes.

Establishing DEE programmes involves irrecoverable costs, for example, in setting up early warning systems (EWS) for disease surveillance. Conventional methods are generally wary of funding such a programme, as they would treat this as a high sunk cost while the true long-term benefits of the programme remain uncertain. However, through a real options lens expenditure on EWS is better identified as a strategic "preliminary" investment that generates value by providing flexibility to respond to the evolving uncertainty based on the information gathered from the programme rather than improving our current understanding of uncertainty to commit to a full-scale, irreversible investment decision. The upfront cost of implementing an EWS can be viewed as the option premium the government pays for the right (but not the obligation) to make a future intervention decision. By allowing decision makers to optimise resource allocation in response to evolving epidemiological and economic uncertainty, EWS preserves the programme's value even during volatile periods [45–48]. Furthermore, early detection helps prevent localised outbreaks from evolving into system-wide crises that demand costly emergency response.

By explicitly valuing the strategic flexibility created by EWS (i.e., the option to stage investments, optimise their timing, and allow switching between the options of intervening and monitoring), ROA can capture the DEE programme's true worth. For example, integrated serological surveillance, like the combined lymphatic filariasis and malaria platforms emerging in Hispaniola [49], Togo [50], Malawi [51], and Papua New Guinea [52], shows how elimination and monitoring investments act as mutually reinforcing real options, delivering immediate benefits while maintaining flexibility for future shocks. This dynamic approach supports long-term healthcare planning, minimises economic and social costs, and advances long-term DEE goals. However, despite its potential, real option analysis has seen limited application in healthcare decision making beyond valuing new technologies and treatment strategies [53–56], informing antiviral drug stockpiling policy [57, 58], and guiding pandemic policies [59–61]. This indicates that while insightful, ROA should be applied with caution and probably in conjunction with other decision-making frameworks in the healthcare sector [61].

2.4 The Intergenerational Equity Value of DEE

The evaluation of policies over time is almost exclusively done by transforming future values into a present value using discounting. An important effect of discounting is that the value of spending now on policies that benefit future generations is reduced compared to spending now on policies with immediate benefits.

There has been considerable debate and ongoing discussion around discounting costs and health benefits in cost-effectiveness analysis [27, 62]. The health economics literature recommends two well-accepted approaches to inform appropriate discount rates [63]. One is using market interest rates as they represent competing investment returns and hence opportunity costs of capital. The second uses the Ramsey Equation, used widely in finance, which adds the rate of pure time preference to the product of expected consumption growth and the marginal utility of consumption (this product is sometimes called the wealth effect). These factors increase the discount rate because they indicate that future impacts are less important to intertemporal welfare. However, the Ramsey Equation can be extended to account for consumption growth uncertainty. When this is done, macroeconomic risk suggests a greater future need (because of a precautionary savings motive), decreasing the discount rate. Another possible extension to the Ramsey Equation is to incorporate project-specific risk that can either increase or decrease the discount rate, depending on whether the "beta" is positive or negative. The Ramsey equation is often used to estimate the social discount rate (SDR). In practice, most health economics guidelines recommend the use of constant discount rates of 3–6% [63]. However, suppose the time horizon of an economic evaluation is (very) long. In that case, the compounding nature of constant discounting has the effect of leaving a close to zero weight for future generations, which has been argued to be an undesirable and unfair feature of constant discounting [64, 65]. This is especially relevant in health economics when appraising policies that span multiple generations, as in DEE, that tackle infectious diseases. This has led to an interest in exploring intergenerational equity in the context of discounting in the area of healthcare [66].

The financial economics literature has sometimes used a declining social discount rate (DDR) instead of a constant discount rate [67]. Many countries, including France, the USA and the UK, have incorporated declining discount rates within official guidelines for projects exceeding 30 years' duration. From an intergenerational perspective, a discount rate that decreases over time is one of the options that could be applied to public health interventions with consequences spanning several decades, for the purpose of equity. This is especially salient for strengthening the case for investments like DEE strategies that have long-term payoffs and risk being deprioritised in short-term planning. Another justification for it could be the possibility that over long time horizons, the uncertainty of the estimated parameters (e.g., in a Ramsey equation) becomes larger, which could be reflected in lowering the rate [66].

Aligning discounting practice with broader social objectives can support organisations as they refresh long-term strategies for 2030 and beyond. This is especially relevant in current global policy dialogues on equitable health investments and Universal Health Coverage (UHC) [68]. Appropriate discounting in public investments, such as DEE, would be critical for populations in low- and middle-income countries (LMICs), given that they remain disproportionately vulnerable to the long-term implications of current policy decisions [69]. However, further investigation is needed to examine the underpinning and practical operationalisation of DDRs, alongside explicit consideration of equity issues within health economics.

3 Discussion and Conclusion

This paper discusses four key considerations for the economic appraisal of programmes that address system-level risks, illustrated by their possible implications for DEE programmes. Drawing on concepts from finance, we explore innovative ways in which these might inform decision making beyond the conventional applications of health economic methods (see Table 1). Figure 1 illustrates the implications of these considerations using a stylised numerical example (see Online Resource), providing conceptual groundwork for a more comprehensive approach to health economic evaluation. However, implementing this approach in practice will require careful reassessment of input assumptions and further methodological development to ensure rigour and consistency with established evaluation guidelines. This includes delineating the specific contribution of each concept and addressing the practical challenges that arise with applying them empirically, such as estimating beta values for health interventions, overcoming historical data scarcity to calibrate tail risk parameters, and adapting financial models for public health.

A programme's value can vary depending on how its benefits co-move with societal downturns. Investing in programmes like DEE may be more justified than currently recognised, given their likely countercyclical benefits. Accounting for the fact that such programmes are *negative*

Table 1 Summary of key financial concepts and their relevance to DEE

Financial concept	Finance definition	Relevance to DEE
Idiosyncratic risk	Diversifiable risks unique to a single project, firm or asset (e.g., operational failures, cost overruns) that are unrelated to the broader economy	Project-specific risks, e.g., cold-chain failures or sudden rise in input costs, are distinct from system-level risks and are typically managed through price negotiations or other mechanisms
Systematic risk (Beta)	Risk correlated with macroeconomic fluctuations (e.g., inflation, interest rates, recession, unemployment, or wars) that affect all projects or firms simultaneously. These cannot be diversified away	Programmes like DEE can be viewed as negative beta projects, as they can provide benefits specifically during standard economic downturns. This hedging function or countercyclicality should be reflected in their value
Tail risk	The risk of rare, high-impact events that occur in the tails of probability distributions (e.g., COVID-19). In practice, many real-world distributions exhibit "fat tails," meaning such events occur more frequently than predicted by normal models	The value of programmes like DEE increases exponentially (not just modestly) when accounting for catastrophic 'fat tail' events, as protecting against the threat of disease re-emergence during such periods of severe societal crisis may yield welfare gains far exceeding standard hedging. This "insurance" function should be reflected in their value
Systemic risk	Risk of cascading failures or collapse arising from interconnectedness within the system (e.g., high dependencies across financial institutions during the 2008 crisis). These are endogenous (originating within the system) and cannot be diversified away	The mechanism where structural weaknesses (e.g., supply chains, lack of surveillance) transform a localised tail event into a global catastrophe. The more systemic the downturn, the higher the value of programmes like DEE as insurance
Real options (method)	The value of flexibility, specifically the right, but not the obligation, to make investment decisions as uncertainty is resolved	ROA views costs of investments in programmes like DEE as an "option premium" that provides strategic flexibility to respond to the evolving epidemiological and economic uncertainty, preserving programme value during periods of instability. It also prevents localised outbreaks from cascading
Intergenerational equity (complementary)	The consideration of the long-term consequences of our choices today and their impact on future generations	Adopting declining discount rates (DDR) can be vital for evaluating programmes like DEE to account for the uncertainty of long-time horizons and the principle of intergenerational equity

COVID Coronavirus disease, *DDR* declining discount rates *DEE* disease elimination and eradication

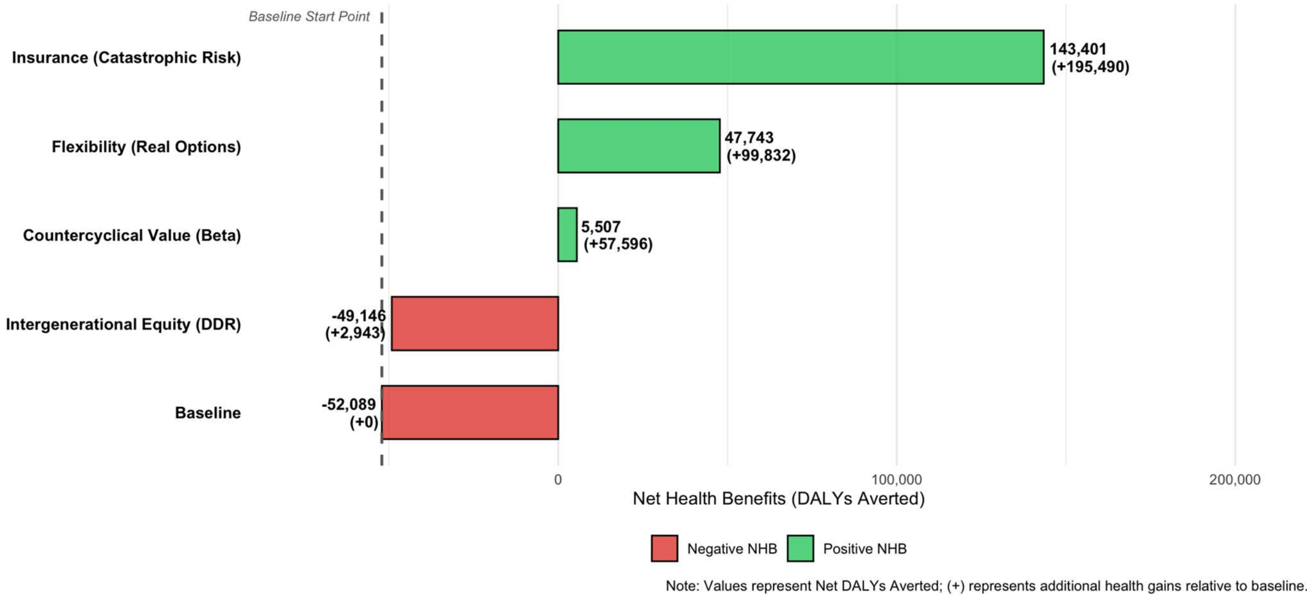

Fig. 1 Impact of system-level risk considerations on programme value. The graph reports NHB, expressed as net DALYs averted. Net health benefit is calculated as DALYs averted minus costs (US$) divided by the cost-effectiveness threshold, thereby converting costs into equivalent health units and allowing benefits and costs to be compared on a common scale. The baseline scenario evaluates a national leishmaniasis elimination programme over a 30-year horizon using standard cost effectiveness analysis, with costs and benefits discounted at a constant social discount rate of 3.5% and a threshold of $200 per DALY averted. The value of a DALY is assumed to remain constant over time. Additional scenarios extend the baseline to account for (i) countercyclicality, by applying a risk-adjusted discount rate to health benefits ($\beta = -0.2$, illustrative) while programme costs are discounted at the risk-free rate; (ii) insurance, by valuing additional welfare gains in low-probability, high-impact crisis states; (iii) flexibility, by modelling early warning systems as a real option enabling state-contingent intervention, that resolves idiosyncratic epidemiological risk at Year 1, while systematic risk remains over the remaining time horizon; and (iv) intergenerational equity, by applying a stepwise declining discount rate that falls by 0.5 percentage points every 10 years, placing greater weight on long-run health benefits. These extensions are illustrative and intended to show how estimated programme value changes when additional considerations for system-level risks are made. In all cases, we observe an improvement over the baseline. Please note these results reflect the standalone value of a single intervention. In practise, however, net benefits should account for joint production of value and shared exposure to systemic risks across the broader health-system portfolio, particularly where multiple interventions provide comparable or similar benefits. In future, more sophisticated and rigorous empirical methods must be developed to estimate these values for specific contexts. See Online Resource for more details on each scenario, their assumptions and calculations. The figure has been created using R. *DALYs* disability adjusted life years, *DDR*s declining discount rates, *NHB* net health benefits

beta likely enhances the attractiveness of investing in them. An extreme example of this countercyclicality is the potential for DEE programmes to reduce ill-health during societal shocks. Even if catastrophic social outcomes are rare, the possibility of them coinciding with the re-emergence of nearly eliminated diseases not only further strengthens the economic argument for prioritising DEE but also makes them a valuable insurance policy for public health. Such arguments underpin much of the economic case for investing in climate change prevention measures, which are much harder to justify based on non-catastrophic outcomes.

Another critical challenge in evaluating long-term policies like DEE is their high irrecoverable costs, irreversible consequences and uncertain payoffs, which could potentially affect the realisation of their expected impacts in real-world settings. This likely necessitates appraisal methods that in some way preserve policy flexibility, enabling decision makers to adapt effectively to evolving uncertainty. The real options approach may offer valuable insights into how and when to take such actions in programmes like DEE, optimising both timing and adaptability. Finally, to accurately assess the value of programmes with long time horizons and significant intergenerational impacts, the choice of discount rate is crucial. Many government guidelines, including the UK's Green Book, advocate for low and declining rates over time. It may be worth considering the underpinnings of this approach for policies with long-term and irreversible impacts.

Our aim here is not to make the case for investments in DEE but instead to reflect upon the uses of conventional methods and identify areas for possible strengthening of economic evaluation methods. Given limited resources and the urgency of many healthcare needs, many countries prioritise reactive responses over long-term proactive measures. This reflects a fundamental difference in how opportunity costs are considered in healthcare versus finance.

While financial economics focus on quantifiable returns, healthcare decisions involve a complex trade-off between addressing immediate needs and investing in prevention to mitigate the risk of future, potentially catastrophic disasters. This trade-off, and how to effectively evaluate it, warrants further investigation. Looking ahead, it may be highly beneficial to develop a broader analytical framework that guides investment decisions for DEE and other social policies related to system-level risks more generally. Since the benefits of such policies are a public good [70], decision makers require more sophisticated tools than are currently available, to make sound, long-term investment decisions on society's behalf. The methods discussed in this paper, including real options, insights from asset pricing theories, and approaches to valuing disaster risk reduction, can be viewed as specific applications of a wider framework.

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Declarations

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Code availability Not applicable.

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References

1. Drummond MF, Sculpher MJ, Claxton K, Stoddart GL, Torrance GW. Methods for the economic evaluation of health care programmes. Oxford: Oxford University Press; 2015.
2. Turner HC, Archer RA, Downey LE, Isaranuwatchai W, Chalkidou K, Jit M, et al. An introduction to the main types of economic evaluations used for informing priority setting and resource allocation in healthcare: key features, uses, and limitations. Front Public Health. 2021. https://doi.org/10.3389/fpubh.2021.722927.
3. Renn O. New challenges for risk analysis: systemic risks. J Risk Res. 2021;24:127–33. https://doi.org/10.1080/13669877.2020.1779787.
4. Hansen LP. Challenges in identifying and measuring systemic risk. Risk topography: systemic risk and macro modeling [Internet]. University of Chicago Press; 2013 [cited 2025 Nov 17]. p. 15–30. https://www.nber.org/books-and-chapters/risk-topography-systemic-risk-and-macro-modeling/challenges-identifying-and-measuring-systemic-risk. Accessed 17 Nov 2025.
5. Helbing D. Globally networked risks and how to respond. Nature. 2013;497:51–9. https://doi.org/10.1038/nature12047.
6. Haldane AG, May RM. Systemic risk in banking ecosystems. Nature. 2011;469:351–5. https://doi.org/10.1038/nature09659.
7. Karanikolos M, Mladovsky P, Cylus J, Thomson S, Basu S, Stuckler D, et al. Financial crisis, austerity, and health in Europe. Lancet. 2013;381:1323–31. https://doi.org/10.1016/S0140-6736(13)60102-6.
8. Alied M, Salam A, Sediqi SM, Kwaah PA, Tran L, Huy NT. Disaster after disaster: the outbreak of infectious diseases in Pakistan in the wake of 2022 floods. Ann Med Surg (Lond). 2024;86:891–8. https://doi.org/10.1097/MS9.0000000000001597.
9. Briggs AH, Gray AM. Handling uncertainty when performing economic evaluation of healthcare interventions. Health Technol Assess. 1999;3:1–134.
10. Claxton K, Fenwick E, Sculpher MJ. Decision-making with uncertainty: the value of information. In: Jones AM, editor. The Elgar companion to health economics, 2nd edition [Internet]. Edward Elgar Publishing; 2012 [cited 2025 Mar 26]. https://doi.org/10.4337/9780857938138.00069.
11. Briggs A, Sculpher M. An introduction to Markov modelling for economic evaluation. Pharmacoeconomics. 1998;13:397–409. https://doi.org/10.2165/00019053-199813040-00003.
12. Campbell JY, Lettau M, Malkiel BG, Xu Y. Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk. J Financ. 2001;56:1–43. https://doi.org/10.1111/0022-1082.00318.
13. Garcia-Jorcano L, Sanchis-Marco L. Systemic-systematic risk in financial system: a dynamic ranking based on expectiles. Int Rev Econ Financ. 2021;75:330–65. https://doi.org/10.1016/j.iref.2021.04.001.
14. Choi SJ, Kim K, Park S. Is systemic risk systematic? Evidence from the U.S. stock markets. Int J Financ Econ. 2020;25:642–63. https://doi.org/10.1002/ijfe.1772.
15. Schwarcz SL. Systemic risk. Geo LJ. 2008;97:193.
16. Sharpe WF. Capital asset prices: a theory of market equilibrium under conditions of risk. J Financ. 1964;19:425–42. https://doi.org/10.1111/j.1540-6261.1964.tb02865.x.
17. Lucas RE. Asset prices in an exchange economy. Econometrica. 1978;46:1429–45. https://doi.org/10.2307/1913837.
18. Breeden DT. An intertemporal asset pricing model with stochastic consumption and investment opportunities. J Financ Econ. 1979;7:265–96. https://doi.org/10.1016/0304-405X(79)90016-3.

19. Ross SA. The arbitrage theory of capital asset pricing. Handbook of the fundamentals of financial decision making [Internet]. World Scientific; 2012 [cited 2025 Mar 26]. p. 11–30. https://doi.org/10.1142/9789814417358_0001.
20. Cochrane JH. Asset pricing: revised edition. Princeton: Princeton University Press; 2009.
21. Rechel B, Suhrcke M, Tsolova S, Suk JE, Desai M, McKee M, et al. Economic crisis and communicable disease control in Europe: a scoping study among national experts. Health Policy. 2011;103:168–75. https://doi.org/10.1016/j.healthpol.2011.06.013.
22. Suhrcke M, Stuckler D, Suk JE, Desai M, Senek M, McKee M, et al. The impact of economic crises on communicable disease transmission and control: a systematic review of the evidence. PLoS ONE. 2011;6:e20724. https://doi.org/10.1371/journal.pone.0020724.
23. Bonovas S, Nikolopoulos G. High-burden epidemics in Greece in the era of economic crisis. Early signs of a public health tragedy. J Prev Med Hyg. 2012;53:169–71. https://doi.org/10.15167/2421-4248/jpmh2012.53.3.340.
24. Magalhães AR, Codeço CT, Svenning J-C, Escobar LE, Van de Vuurst P, Gonçalves-Souza T. Neglected tropical diseases risk correlates with poverty and early ecosystem destruction. Infect Dis Poverty. 2023;12:32. https://doi.org/10.1186/s40249-023-01084-1.
25. Butala CB, Cave RNR, Fyfe J, Coleman PG, Yang G-J, Welburn SC. Impact of COVID-19 on the neglected tropical diseases: a scoping review. Infect Dis Poverty. 2024;13:55. https://doi.org/10.1186/s40249-024-01223-2.
26. Immurana M, Kisseih KG, Abdullahi I, Azuug M, Manyeh AK, Mohammed A, et al. The effects of selected neglected tropical diseases on economic performance at the macrolevel in Africa. BMC Infect Dis. 2024;24:462. https://doi.org/10.1186/s12879-024-09302-3.
27. Claxton K, Asaria M, Chansa C, Jamison J, Lomas J, Ochalek J, et al. Accounting for timing when assessing health-related policies. J Benefit-Cost Anal. 2019;10:73–105. https://doi.org/10.1017/bca.2018.29.
28. Barro RJ. Rare disasters and asset markets in the twentieth century*. Q J Econ. 2006;121:823–66. https://doi.org/10.1162/qjec.121.3.823.
29. Barro RJ. Rare disasters, asset prices, and welfare costs. Am Econ Rev. 2009;99:243–64. https://doi.org/10.1257/aer.99.1.243.
30. Pindyck RS, Wang N. The economic and policy consequences of catastrophes. Am Econ J Econ Pol. 2013;5:306–39. https://doi.org/10.1257/pol.5.4.306.
31. Cirillo P, Taleb NN. Tail risk of contagious diseases. Nat Phys. 2020;16:606–13. https://doi.org/10.1038/s41567-020-0921-x.
32. Weitzman ML. Fat-tailed uncertainty in the economics of catastrophic climate change. Rev Environ Econ Policy. 2011;5:275–92. https://doi.org/10.1093/reep/rer006.
33. Goldin I, Mariathasan M. The butterfly defect: how globalization creates systemic risks, and what to do about it. Third printing and first paperback printing. Princeton, Oxford: Princeton University Press; 2016.
34. Arnscheidt CW, Beard SJ, Hobson T, Ingram P, Kemp L, Mani L, et al. Systemic contributions to global catastrophic risk. Glob Sustain. 2025;8:e19. https://doi.org/10.1017/sus.2025.20.
35. Centeno MA, Nag M, Patterson TS, Shaver A, Windawi AJ. The emergence of global systemic risk. Annu Rev Sociol. 2015;41:65–85. https://doi.org/10.1146/annurev-soc-073014-112317.
36. Melaku T, Zeynudin A, Suleman S. Ethical challenges and dilemmas in the rationing of health commodities and provision of high-risk clinical services during COVID-19 pandemic in Ethiopia: the experiences of frontline health workers. Philos Ethics Humanit Med. 2023;18:6. https://doi.org/10.1186/s13010-023-00136-6.
37. Guan D, Wang D, Hallegatte S, Davis SJ, Huo J, Li S, et al. Global supply-chain effects of COVID-19 control measures. Nat Hum Behav. 2020;4:577–87. https://doi.org/10.1038/s41562-020-0896-8.
38. Mehta S, Machado F, Kwizera A, Papazian L, Moss M, Azoulay É, et al. COVID-19: a heavy toll on health-care workers. Lancet Respir Med. 2021;9:226–8. https://doi.org/10.1016/S2213-2600(21)00068-0.
39. World Bank. Global economic prospects, June 2020. Washington, D.C: The World Bank; 2020. https://doi.org/10.1596/978-1-4648-1553-9.
40. United Nation. The impact of COVID-19 on food security and nutrition [Internet]. 2020. https://unsdg.un.org/sites/default/files/2020-06/SG-Policy-Brief-on-COVID-Impact-on-Food-Security.pdf.
41. United Nations. Education during COVID-19 and beyond [Internet]. 2020. https://unsdg.un.org/sites/default/files/2020-08/sg_policy_brief_covid-19_and_education_august_2020.pdf.
42. Gopinath G. A long, uneven and uncertain ascent [Internet]. 2020. https://www.imf.org/en/blogs/articles/2020/10/13/blog-a-long-uneven-and-uncertain-ascent.
43. eClinicalMedicine. Concerning global rise in measles cases. eClinicalMedicine. 2024;68:102502. https://doi.org/10.1016/j.eclinm.2024.102502.
44. Pindyck RS. Pricing carbon when we don't know the right price. Regulation. 2013;36:43–6.
45. Dixit AK, Pindyck RS. Investment under uncertainty. Princeton: Princeton University Press; 1994.
46. Trigeorgis L. Real options: managerial flexibility and strategy in resource allocation. Cambridge: MIT Press; 1996.
47. McDonald R, Siegel D. The value of waiting to invest. Q J Econ. 1986;101:707–27. https://doi.org/10.2307/1884175.
48. Li Y. Essays on real options and tail risks [Internet]. University of Bristol; 2023. https://research-information.bris.ac.uk/ws/portalfiles/portal/354095229/Final_Copy_2023_01_24_Li_Y_PhD.pdf.
49. Carter Centre. 2023 Hispaniola Initiative Program review Dominican-Republic and Haiti [Internet]. 2024. https://www.cartercenter.org/resources/pdfs/news/health_publications/hispaniola/2023-hispaniola-initiative-program-review-dominican-republic-and-haiti.pdf.
50. Dorkenoo MA, Bronzan R, Yehadji D, Tchalim M, Yakpa K, Etassoli S, et al. Surveillance for lymphatic filariasis after stopping mass drug administration in endemic districts of Togo, 2010–2015. Parasit Vectors. 2018;11:244. https://doi.org/10.1186/s13071-018-2843-3.
51. Msyamboza K, Ngwira B, Banda R, Mkwanda S, Brabin B. Sentinel surveillance of lymphatic filariasis, schistosomiasis, soil transmitted helminths and malaria in rural southern Malawi. Malawi Med J. 2010;22:12–4. https://doi.org/10.4314/mmj.v22i1.55901.
52. Asia Pacific Leaders Malaria Alliance, Papua New Guinea Institute of Medical Research. Integration for joint elimination of malaria and lymphatic filariasis [Internet]. 2024. https://glideae.org/wp-content/uploads/2025/07/Thematic-Feature.pdf.
53. Palmer S, Smith PC. Incorporating option values into the economic evaluation of health care technologies. J Health Econ. 2000;19:755–66. https://doi.org/10.1016/S0167-6296(00)00048-5.
54. Driffield T, Smith PC. A real options approach to watchful waiting: theory and an illustration. Med Decis Mak. 2007;27:178–88. https://doi.org/10.1177/0272989X06297390.
55. Bregantini D, Schmitt LHM, Thijssen JJJ. A Bayesian changepoint detection approach to the economic evaluation of risky projects: an application to healthcare technology assessment. J R Stat Soc Ser A Stat Soc. 2024;187:454–76. https://doi.org/10.1093/jrsssa/qnad129.

56. de Mello-Sampayo F. The timing and probability of treatment switch under cost uncertainty: an application to patients with gastrointestinal stromal tumor. Value Health. 2014;17:215–22. https://doi.org/10.1016/j.jval.2013.12.008.
57. Attema AE, Lugnér AK, Feenstra TL. Investment in antiviral drugs: a real options approach. Health Econ. 2010;19:1240–54. https://doi.org/10.1002/hec.1549.
58. Park H. A real option analysis for stochastic disease control and vaccine stockpile policy: an application to H1N1 in Korea. Econ Model. 2016;53:187–94. https://doi.org/10.1016/j.econmod.2015.12.005.
59. Pike J, Bogich T, Elwood S, Finnoff DC, Daszak P. Economic optimization of a global strategy to address the pandemic threat. Proc Natl Acad Sci USA. 2014;111:18519–23. https://doi.org/10.1073/pnas.1412661112.
60. Huberts NFD, Thijssen JJJ. Optimal timing of non-pharmaceutical interventions during an epidemic. Eur J Oper Res. 2023;305:1366–89. https://doi.org/10.1016/j.ejor.2022.06.034.
61. de Mello-Sampayo F. Strategic flexibility in healthcare: an exploration of real options. J Econ Stud. 2024;51:177–99. https://doi.org/10.1108/JES-10-2023-0605.
62. Claxton K, Paulden M, Gravelle H, Brouwer W, Culyer AJ. Discounting and decision making in the economic evaluation of health-care technologies. Health Econ. 2011;20:2–15. https://doi.org/10.1002/hec.1612.
63. Cohen JT. It is time to reconsider the 3% discount rate. Value Health. 2024;27:578–84. https://doi.org/10.1016/j.jval.2024.03.001.
64. Tinghög G. Discounting, preferences, and paternalism in cost-effectiveness analysis. Health Care Anal. 2012;20:297–318. https://doi.org/10.1007/s10728-011-0188-6.
65. Jit M, Mibei W. Discounting in the evaluation of the cost-effectiveness of a vaccination programme: a critical review. Vaccine. 2015;33:3788–94. https://doi.org/10.1016/j.vaccine.2015.06.084.
66. Attema AE, Brouwer WBF, Claxton K. Discounting in economic evaluations. Pharmacoeconomics. 2018;36:745–58. https://doi.org/10.1007/s40273-018-0672-z.
67. Cropper ML, Freeman MC, Groom B, Pizer WA. Declining discount rates. Am Econ Rev. 2014;104:538–43. https://doi.org/10.1257/aer.104.5.538.
68. Barron GC, Koonin J, Akselrod S, Fogstad H, Karema C, Ditiu L, et al. Universal health coverage is a matter of equity, rights, and justice. Lancet Glob Health. 2023;11:e1335–6. https://doi.org/10.1016/S2214-109X(23)00317-0. (**Elsevier;**).
69. Cochi SL, Dowdle WR, editors. Disease eradication in the 21st century: implications for global health. Cambridge: MIT Press; 2011.
70. Geoffard P-Y, Philipson T. Disease eradication: private versus public vaccination. Am Econ Rev. 1997;87:222–30.

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