THE VALUE OF IMPLEMENTATION AND THE VALUE OF INFORMATION: COMBINED AND UNEVEN DEVELOPMENT

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Abstract

Issue being addressed: In a budget constrained healthcare system the decision to invest in implementation strategies must be made alongside those regarding investment in healthcare services and further research. We present a framework that examines the value of further information and the value of implementation strategies separately but simultaneously.

Methods: We provide a measure of the maximum return to further research (expected value of perfect information) and an upper bound on the value of adopting implementation strategies (expected value of perfect implementation). This framework is demonstrated using a series of health care technologies selected from those previously considered by the UK National Institute for Clinical Excellence (NICE) including: prophylactic extraction of wisdom teeth and Zanamivir for influenza. The information used for the case studies was taken from the NICE guidance and assessment reports.

Results: In the case of wisdom teeth the value of further research is low but the value of adopting appropriate implementation strategies is substantial. In other circumstances, investment is worthwhile in both further research and implementation strategies, e.g. in the case of Zanamivir further clinical trials are worthwhile as are strategies to restrict use to high risk groups presenting within 24 hours of symptom onset.

Conclusions: Previous methods for valuing implementation strategies have confused the value of research and the value of implementation. This framework demonstrates that the value of information and the value of implementation can be examined separately but simultaneously in a single framework. This can usefully inform policy decisions about investment in healthcare services, further research and adopting implementation strategies.

1. Introduction:

In a budget constrained healthcare system there is a single 'pot' of resources from which funds must be found to provide technologies and services, to undertake research and to invest in implementation activities that attempt to change professional practice. There is an established literature concerning the use of cost-effectiveness analysis to support decisions regarding service provision [1-4]. Policy decisions regarding investment in future research and the collection of further information can be supported by value of information analysis [5-10]. A framework has been developed which can address these two separate but related activities simultaneously to ensure that investment in research is subject to the same evaluation of efficiency as investment in healthcare provision [11, 12]. However, it is less clear how to evaluate and support decisions regarding investment in strategies to change implementation. The papers that have examined interventions to change implementation have tended to concentrate on the cost-effectiveness of these policies [13-15].

This paper proposes a single, unified framework to address the problem of allocating funds between these separate but linked activities. The paper builds on the current framework, which unifies decisions concerning investment in research and service provision, to incorporate decisions regarding investment in implementation activities. The proposed framework is illustrated through the use of a series of case studies, each of which involves a technology previously considered by the National Institute for Clinical Excellence (NICE).

The paper starts with an outline of the proposed framework. Section three presents the case studies and section four presents the results of the analyses. Section five provides a discussion and some conclusions are drawn in the final section.

2. Framework

The framework that we propose involves determining the expected value of implementation strategies in a way analogous to the use of value of information analysis to determine the expected value of information.

The framework is illustrated through a simple 2 x 2 state matrix (see Table 1). The two columns represent the state of the world with regard to the level of information available about the technology, which is taken to either be perfect or current. The two rows represent the state of the world with regard to the implementation of the technology,

which is again taken to be perfect or current. The level of implementation of the technology is denoted by the proportion of the eligible patient base that receives the technology (ρ). Perfect implementation requires that $\rho = 1$ when the technology is determined as optimal (i.e. generates a positive incremental net benefit or maximises net benefit) and $\rho = 0$ otherwise. The current level of implementation can however take any value between 0 and 1 depending upon the uptake of the technology.

Each entry within the matrix represents the expected value of a decision made in that state of the world:

A. current information, current implementation;
B. perfect information, current implementation;
C. current information, perfect implementation;
D. perfect information, perfect implementation.

In each case the expected value of the decision made on the basis of a perfect state (with regard to information and/or implementation) must be at least as good as the expected value of the decision made on the basis of a current state. Hence:

$$B \geq A \qquad C \geq A \qquad D \geq C \qquad D \geq B$$

$$\therefore \quad D \geq A$$

2.1 Expected value of perfect information (EVPI)

Value of information analysis involves establishing the difference between the expected value of a decision made on the basis of the existing evidence and, following the collection of further information, the expected value of a decision made on the basis of the new evidence [16]. For the expected value of perfect information (EVPI) this difference is calculated between a position of perfect information about the technology (no uncertainty) and the current information position. Value of information analysis involves the implicit assumption that there is perfect implementation in both the current and the perfect information state. In terms of the 2 x 2 matrix, the EVPI is simply the difference between cell D and cell C.

The information provided by research is a public good, as such the societal value of research should be calculated across the population of future patients for whom this decision is relevant. It is this population EVPI that provides a measure of the maximum return to further research, providing a necessary condition for determining whether

further research is potentially worthwhile, assuming that provision is perfectly dictated by the expected value of the decision.

2.2 'Realisable' EVPI

Given that implementation may not be perfect, decision-makers may also be interested to know the expected value of research that is realisable without actively undertaking strategies to change implementation. In the 2 x 2 matrix this is simply the difference between cell B and cell A. Under the assumption that implementation is only influenced as a result of direct implementation strategies (i.e. there is no relationship between information and implementation) information alone has no value and the 'realisable' EVPI will be zero.

2.3 Expected value of perfect implementation (EVPImp)

In much the same way as with EVPI, determining the expected value of perfect implementation involves determining the difference in the expected value of a decision when it is implemented perfectly (ρ is either zero or 1) and the expected value of a decision when implementation is at its current level. The population EVPImp gives a measure of the maximum return to strategies to change implementation and provides a necessary condition for determining whether such strategies are potentially worthwhile. Where the current level of implementation is 'perfect' there will be no value in strategies to change implementation.

The calculation of the EVPImp can be based on either information position to provide the expected value of perfect implementation with or without perfect information. In terms of the 2 x 2 matrix, the EVPImp based upon the current level of information is simply the difference between cell C and cell A. The EVPImp based upon perfect information is simply the difference between cell D and cell B in the matrix.

2.4 Expected value of 'perfection' - EVP

Finally, a comparison of the difference in the expected value of the decision made in the perfect state, with respect to information and implementation, and that made in the current state provides the decision-maker with the expected value of 'perfection' in terms of information and implementation. The population EVP provides a measure of the maximum return to resources expended on research and implementation strategies. In terms of the 2 x 2 matrix, the EVP is simply the difference between cell D and cell A.

3. Case studies

The framework will be illustrated through the use of 3 case studies, which were selected from those recently considered by NICE [17-19]. For each of the case studies a simple, stylised decision model was constructed and populated with parameter estimates that were publicly available in either the assessment reports or guidance documents. In each case the estimates of effectiveness were based on the reported meta analysis of the RCT evidence, but other key inputs, such as cost, baseline risks, health state utilities and/or other relevant epidemiological variables were based on other sources (observational studies and in some cases informed judgement). The population size and the estimate of the current level of implementation were also taken from public sources (where possible this was the assessment reports and guidance documents).

These case studies were created as part of a pilot project to assess the applicability of Bayesian value of information analysis to the NICE assessment process [20]. It should be stressed that the case studies are used here purely as a vehicle to demonstrate the proposed framework. Table 2 contains details of the 3 case studies.

4. Results

Table 3 contains the main results for the analyses of each of the case studies including the incremental cost-effectiveness ratio associated with each technology and the expected value of perfect information, perfect implementation and 'perfection' in £ millions for the estimated population. The results for each case study, including the individual elements of the 2 x 2 matrix, are detailed below. All values are based on a maximum acceptable ratio (λ) of £30,000 per QALY.

4.1 Orlistat

The analysis indicates that the incremental cost-effectiveness ratio associated with Orlistat is £21,267 per QALY (Table 3). Table 4 details the individual elements of the 2 x 2 matrix. The expected value of the decision made purely on the basis of current information is estimated to be £163. With a current implementation level (ρ) of 0.504 the 'realisable' expected value of the decision made on the basis of current information is reduced to £82. The expected value of the decision made on the basis of perfect information is £187. Thus, the expected value of perfect information is £24 per decision, whilst the expected value of implementation is £81 per decision and the expected value of 'perfection' is £105. Under the assumption that the proportion of implementation does not change on the basis of information alone, the 'realisable' expected value of the

decision made on the basis of perfect information remains at only £82. Hence, the 'realisable' EVPI is zero. Given an estimated population of just over 83,000 (over 8 years) these translate into an EVPI of £2 million, an EVPImp of £6.8 million and an EVP of £8.7 million.

Sensitivity analysis – the maximum acceptable ratio (λ)

Figure 1 illustrates the relationship between the value of the maximum acceptable ratio (λ) and the population values for EVPI, EVP Imp and EVP. The EVPI increases with the maximum acceptable ratio up to the value of the ICER (£21,267), and then falls as the ratio increases beyond this point. For values of λ up to the ICER, the error probability (reflected by the CEAC – not shown) and the value of the consequences of an error are both increasing with λ. Hence the EVPI must increase. Beyond this point, the error probability falls whilst the value of the consequences continues to rise as the maximum acceptable ratio increases. In this particular case the fall in the error probability outweighs the rise in the value of the consequences and EVPI falls.

The EVPImp has the inverse relationship with the maximum acceptable ratio - falling as the ratio increases up to the value of the ICER and increasing as the ratio increases beyond the ICER. As the maximum acceptable ratio increases the INB associated with Orlistat increases from negative to positive. At the point where the maximum acceptable ratio is equal to the ICER, the INB associated with Orlistat is zero and the decision-maker is indifferent about whether or not to adopt the technology. Strategies to change implementation will have no value at this point. When the maximum acceptable ratio is below the ICER, the optimal decision is not to provide Orlistat (perfect level of implementation is zero). If the current level of implementation exceeds zero, strategies to change implementation *away* from Orlistat will have value (positive EVPImp). The value of such strategies will fall as the maximum acceptable ratio increases towards the ICER and the negative impact of the current implementation falls (INB rises towards zero). When the maximum acceptable ratio is above the ICER, the optimal decision is to provide Orlistat (perfect level of implementation is 1). If the current level of implementation is less than 1, strategies to change implementation *toward* Orlistat will have value (positive EVPImp). The value of such strategies will rise as the maximum acceptable ratio increases beyond the ICER and the negative impact of the current implementation increases (INB rises).

In this case the EVP has a similar relationship with the value of the maximum acceptable ratio as the EVPImp, albeit smoother, reflecting the dominating effect of the EVPImp.

Sensitivity analysis – the level of current implementation

Figure 2 examines the impact that the level of current implementation has on the expected values, for a maximum acceptable ratio of £30,000 per QALY. At this value of λ, the optimal level of implementation (ρ) is 1 (Orlistat is the optimal decision based on expected values). As the level of current implementation increases from 0 to 1 a larger proportion of patients are already receiving Orlistat and hence strategies to change implementation will have less value. The EVPI is constant irrespective of the level of current implementation as the calculation is made on the assumption of perfect implementation. The EVP falls as the proportion of current implementation rises over the range from 0 to 1.

If the maximum acceptable ratio were taken to be £20,000, the optimal level of implementation would be 0 and the expected value of implementation would rise along with the level of current implementation.

Sensitivity analysis – the post-information level of current implementation

The analysis makes the assumption that information alone does not impact on the level of implementation hence the expected value of perfect information achievable without implementation policies ('realisable' EVPI) is 0. However, it is likely that the provision of information would alter the level of implementation. Figure 3 illustrates how the value of the 'realisable' EVPI is impacted by relaxing this assumption and allowing the level of implementation to change on the basis of information alone (post-information). The figure is shown for a maximum acceptable ratio of £30,000 per QALY. At this value of λ, the optimal level of implementation is 1 (Orlistat is the optimal decision based on expected values). Hence, the value of the 'realisable' EVPI increases as the level of post-information implementation increases from 0 to 1. At a post-information level of 1 (perfect implementation) the 'realisable' EVPI equals the EVPI. The 'realisable' EVPI is 0 when the post-information level of implementation equals the current level (0.503). For values of post-information implementation below the current level, information has reduced implementation away from the desired level (information has had a negative impact upon implementation) and the 'realisable' EVPI is negative. For values of post-information implementation above the current level, information has increased implementation in the desired direction (positive impact) and the 'realisable' EVPI is

positive. The EVPI, EVPImp and EVP are all constant irrespective of the post information implementation level because they are calculated with respect to the proportion of current implementation and/or the value of perfect implementation.

If the maximum acceptable ratio were taken to be £20,000, the optimal level of implementation would be 0 and the 'realisable' EVPI would have the inverse relationship with the post-information level. That is 'realisable' EVPI would fall as the level of post-information implementation increases from 0 to 1. In this circumstance, the 'realisable' EVPI would reach a maximum (equal to EVPI) when the level of post-information implementation is 0.

4.2 Zanamivir

The analysis indicates that the incremental cost-effectiveness ratio associated with Zanamivir is £22,739 per QALY (Table 3). Table 5 details the individual elements of the 2 x 2 matrix. The expected value of the decision made on the basis of current information is £7. With a current implementation level (ρ) of 0.0034 the 'realisable' expected value of the decision made on the basis of current information is reduced to £0.02. The expected value of the decision made on the basis of perfect information is £14. Thus, the expected value of perfect information is £6 per decision, whilst the expected value of implementation is £7 per decision and the expected value of 'perfection' is £14. Given an estimated population of approximately 895,000 (over 8 years) these translate into an EVPI of £5.6 million, an EVPImp of £6.6 million and an EVP of £12.1 million.

Sensitivity analysis – the maximum acceptable ratio (λ)

Figure 4 illustrates the relationship between the value of the maximum acceptable ratio (λ) and the population values for EVPI, EVP Imp and EVP. These relationships are similar to those illustrated for Orlistat (Figure 1) with EVPI and EVPImp moving in different directions as the maximum acceptable ratio increases beyond the ICER. For values of the maximum acceptable ratio (λ) below the ICER, the EVPImp is negligible. This is due to the proximity of the current level of implementation (0.0034) to the perfect level (0) for this range of the maximum acceptable ratio.

4.3 Wisdom teeth

The analysis shows that a policy of prophylactic extraction of wisdom teeth is dominated by a policy of no prophylactic extraction (Table 3) with very little uncertainty surrounding

the decision (not shown). Table 6 details the individual elements of the 2 x 2 matrix. The expected value of the decision made on the basis of current information is £99. With a current implementation proportion (ρ) of 0.02 the 'realisable' expected value of the decision made on the basis of current information is reduced to £20. The expected value of the decision made on the basis of perfect information is £99. Thus, the expected value of perfect information is zero, whilst the expected value of implementation is £79 per decision and the expected value of 'perfection' is £79. Given an estimated population of approximately 57,336 (over 6 years) these translate into an EVPImp and an EVP of £4.5 million.

The relationship (not shown) between the value of the maximum acceptable ratio and the population values for EVP Imp and EVP are similar to those illustrated for Orlistat and Zanamivir (Figures 1 and 4). Both the EVPImp and EVP increase as the maximum acceptable ratio increases. The EVPI remains negligible over the entire range of the maximum acceptable ratio (λ).

5. Discussion

The results of the case studies show that the value of funding further research and strategies for changing implementation will differ between technologies. In the case of Orlistat there is more value associated with strategies to change implementation (EVPImp is £6.8m) than there is associated with further research (EVPI is £2m) although both are potentially worthwhile. With Zanamivir the value associated with further research (EVPI is £5.6m) is equivalent to the value associated with strategies to change implementation (EVPImp is £6.6m) again both are potentially worthwhile. However, in the case of prophylactic extraction of wisdom teeth the value of further research is negligible whilst the value of strategies to change implementation is substantial (EVPImp is £4.5m). In this case funding efforts should be focused upon implementation policies.

The case studies identify several key factors that will affect the value of EVPI, EVPImp and EVP. These factors include:

i) level of the maximum acceptable ratio (λ) – the calculations of the EVPI, EVPImp and EVP all crucially depend upon the value of the maximum acceptable ratio (see Figures 1 and 4). Where the maximum acceptable ratio is close to the ICER, the EVPI is maximised but the EVPImp is minimised.

ii) uncertainty surrounding the adoption decision – the uncertainty surrounding the decision impacts upon the EVPI. Where there is very little uncertainty

surrounding the decision (e.g. prophylactic extraction of wisdom teeth) the EVPI is neglible (not shown).

iii) current level of implementation – the level of current implementation impacts upon the EVPImp and the EVP. Where the current level is close to the perfect level the EVPImp is negligible e.g. when the maximum acceptable ratio was taken to be £20,000 the EVPImp for Zanamivir was negligible (£0.01).

iv) level of expected incremental net benefits – the level of the expected INB impacts on the EVPImp. Where the INB are small the EVPImp is small e.g. the INB associated with Zanamivir were less than those associated with Orlistat (£7.33 compared to £80.99) thus the value of implementation strategies (at the decision level) was lower for Zanamivir.

v) size of population – the size of the population has a direct impact on the values at the population level. Where the population is large the values will be large e.g. the decision level values for EVPI and EVPImp were lower for Zanamivir than Orlistat (£6.22 and £7.33 compared with £23.85 and £80.99 respectively) but the societal values associated with Zanamivir are substantially higher due to the size of the estimated population of benefit (895k compared to 83k).

Thus, decisions on how to allocate funds between healthcare, research and implementation strategies will depend crucially upon these factors. As a result, policies regarding the collection of further information and the funding of strategies to improve implementation may well differ between technologies.

This paper introduces a simple unified framework for assessing the value of implementation and the value of information in order to address decisions concerning healthcare funding allocations. There are a number of issues that require further examination. These include:

i) incorporating the relationship between information and the current level of implementation. The case studies were all modelled under the assumption that the level of current implementation was unaffected by information alone, thus ‘realisable’ EVPI was zero. However, it is likely that the provision of information would alter the level of implementation and it would be useful to be able to incorporate this within the framework. Figure 3 shows the results of a sensitivity analysis where this assumption was relaxed and the level of implementation was allowed to change post-information.

ii) incorporating uncertainty about the current level of implementation. The case studies were all modelled under the assumption that the current level of implementation was fixed and known. Incorporating some degree of uncertainty around the current level of implementation would allow the calculation of the expected value of information about the level of implementation.

iii) the development of a sufficient condition. Currently the existing framework focuses on a maximum approach, with the EVPImp providing an assessment of the maximum value of strategies to change implementation in the same way that EVPI provides an assessment of the maximum value for further research. Both concepts provide only a *necessary* rather than a *sufficient* condition for the investment of funds in research or implementation. In order to provide a sufficient condition for investment in implementation strategies it is necessary to examine the value of strategies that improve implementation (rather than make it perfect). The calculation of the expected value of imperfect implementation (EVIImp) will involve determining the change in implementation levels resulting from specific implementation strategies, and calculating the expected value of those changes. The concept is similar to that of the expected value of sample information used to determine the value of information available from specific research.

6. Conclusions

In a budget constrained healthcare system, decisions regarding investment in implementation strategies must be made alongside those regarding investment in healthcare services and further research. We present a simple, unified framework that examines the value of information and the value of implementation simultaneously in order to inform policy decisions about allocation of funds.

	Information	
Implementation	**Current**	**Perfect**
Current	A	B
Perfect	C	D

Table 1: **2 x 2 matrix for determining the expected value of perfect information, expected value of perfect implementation and expected value of perfection**

Technology	**Orlistat** Obesity	**Zanamivir** Influenza	**Wisdom teeth** Prophylatic extraction of wisdom teeth
Publication	No 22	No 15	No 1
Guidance	Adopt for BMI>30 Must lose 5% at 3 months and 10% at 6 months	Adopt for high risk when influenza is circulating	Reject
Evidence	RCTs, n>1500 2 CEA	RCTs, n>1250 4 CEA	1 RCT, n<300 4 CEA
Estimate of ICER	£10,400 - £46,000 per QALY	£5,000 - £28,000 per QALY	Dominated
Population	Inc 11,000	End 97,000 Epi 497,000	Inc 11,000
Review	02/04	06/02	03/03

Table 2: **Case studies**

	ICER	ρ	Pop^n	EVPI	EVP Imp	Perfection
Orlistat	£21,267	0.504	83,406	£2.0 m	£6.8 m	£8.7 m
Zanamivir	£22,739	0.0034	895,204	£5.6 m	£6.6 m	£12.1 m
Wisdom teeth	Dominates	0.20	57,336	£0.0	£4.5 m	£4.5 m

Table 3: **Expected value of perfect information, expected value of perfect implementation and expected value of perfection**

ρ = 0.504	**Information**	
Implementation	**Current**	**Perfect**
Current	£82	£82
Perfect	£163	£187

Table 4: **Framework matrix for Orlistat**

ρ = 0.0034	**Information**	
Implementation	**Current**	**Perfect**
Current	£0.02	£0.02
Perfect	£7	£14

Table 5: **Framework matrix for Zanamivir**

ρ = 0.20	**Information**	
Implementation	**Current**	**Perfect**
Current	£20	£20
Perfect	£99	£99

Table 6: **Framework matrix for Wisdom teeth**

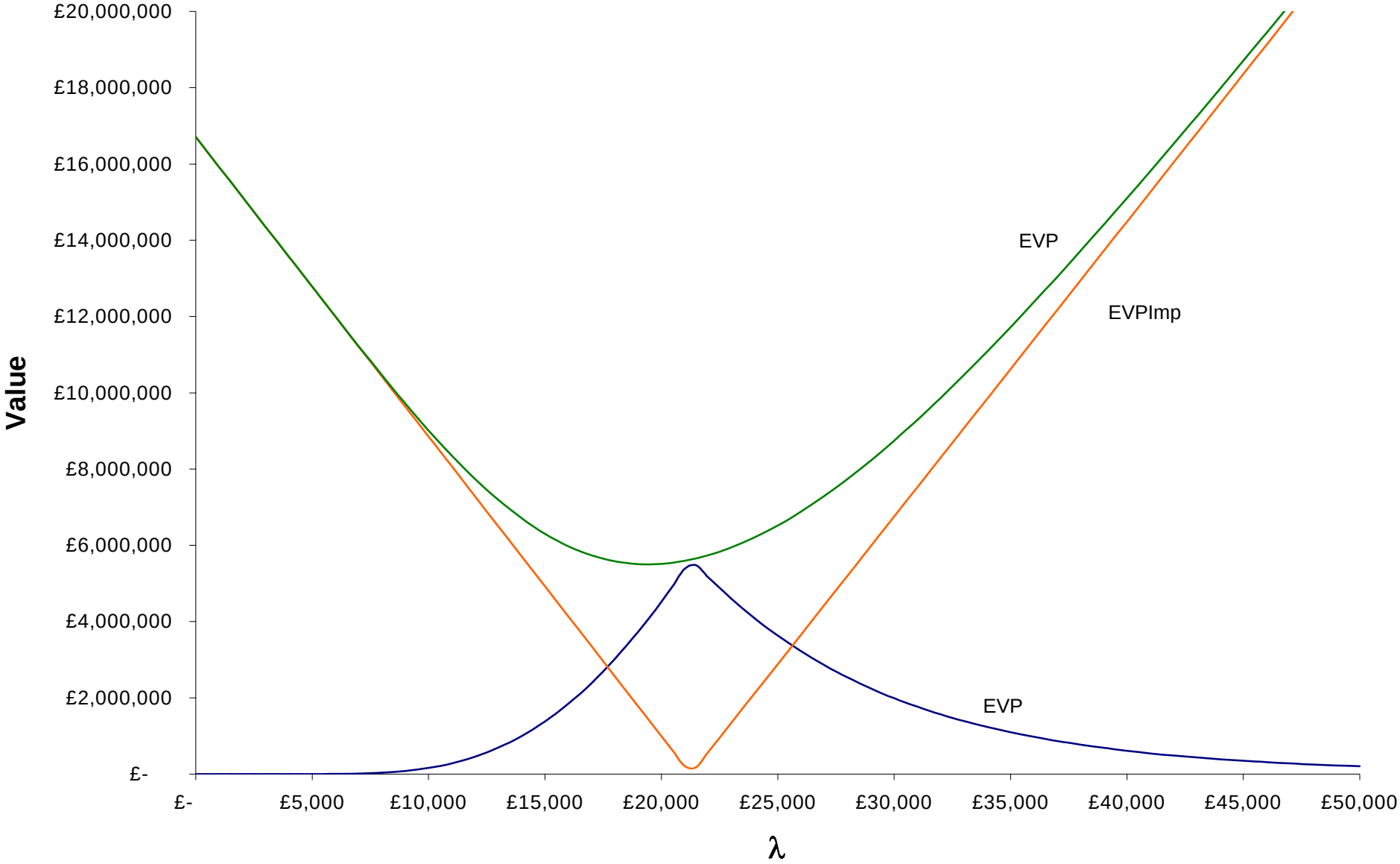

Figure 1: Expected value of information, implementation and 'perfection' for Orlistat

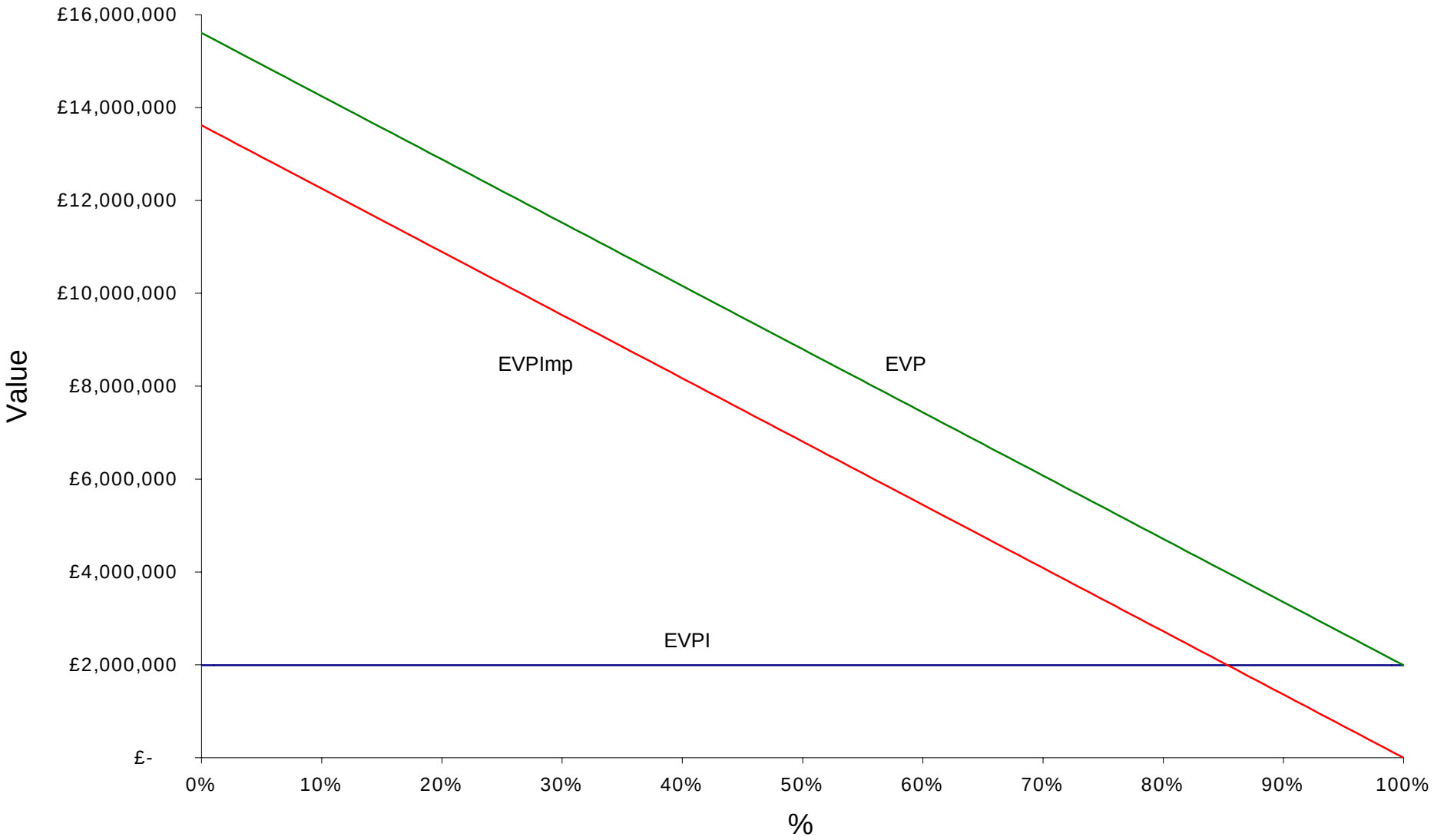

Figure 2: Sensitivity analysis on current implementation proportion - Orlistat

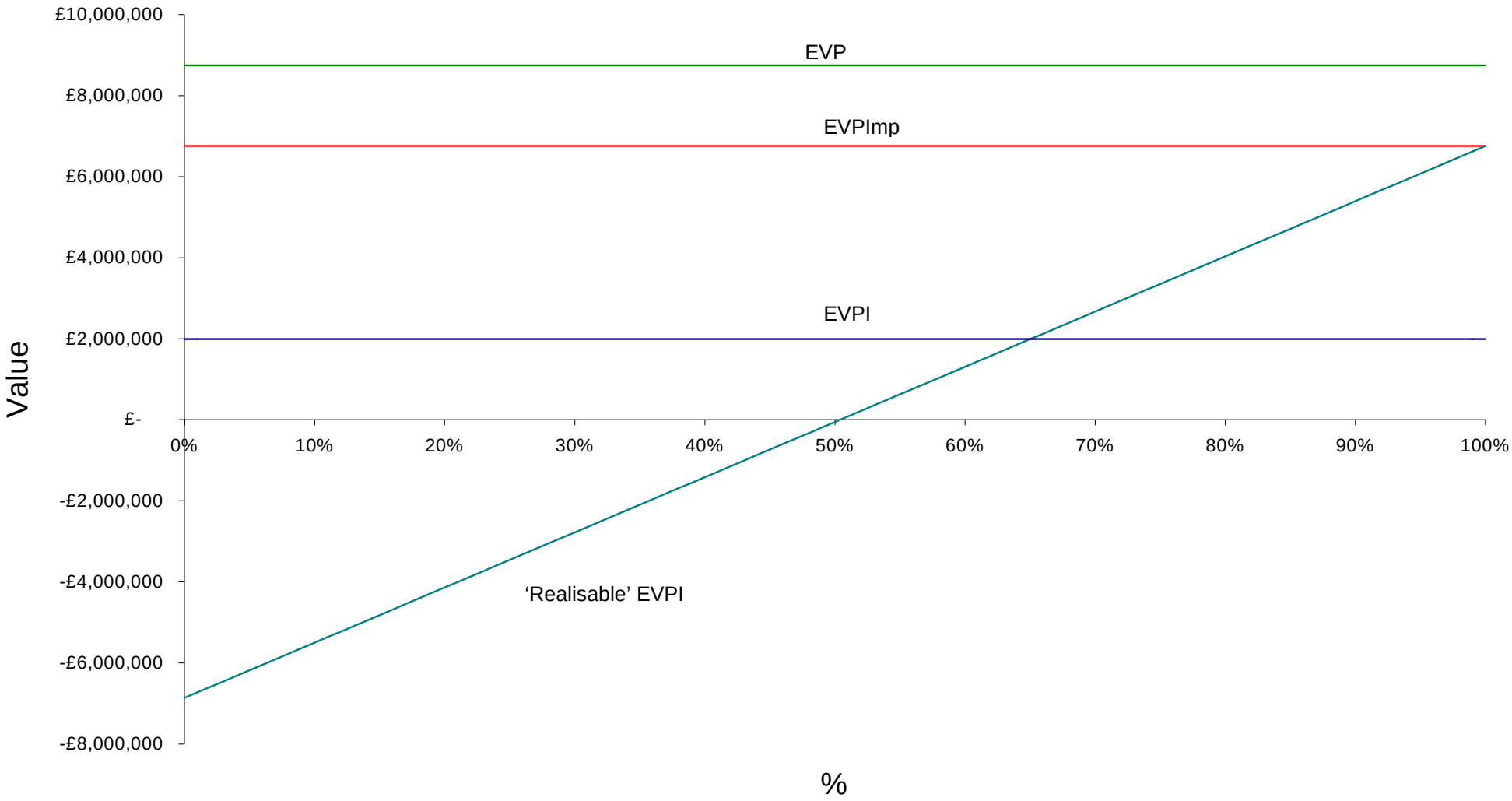

Figure 3: Sensitivity analysis on post information implementation proportion - Orlistat

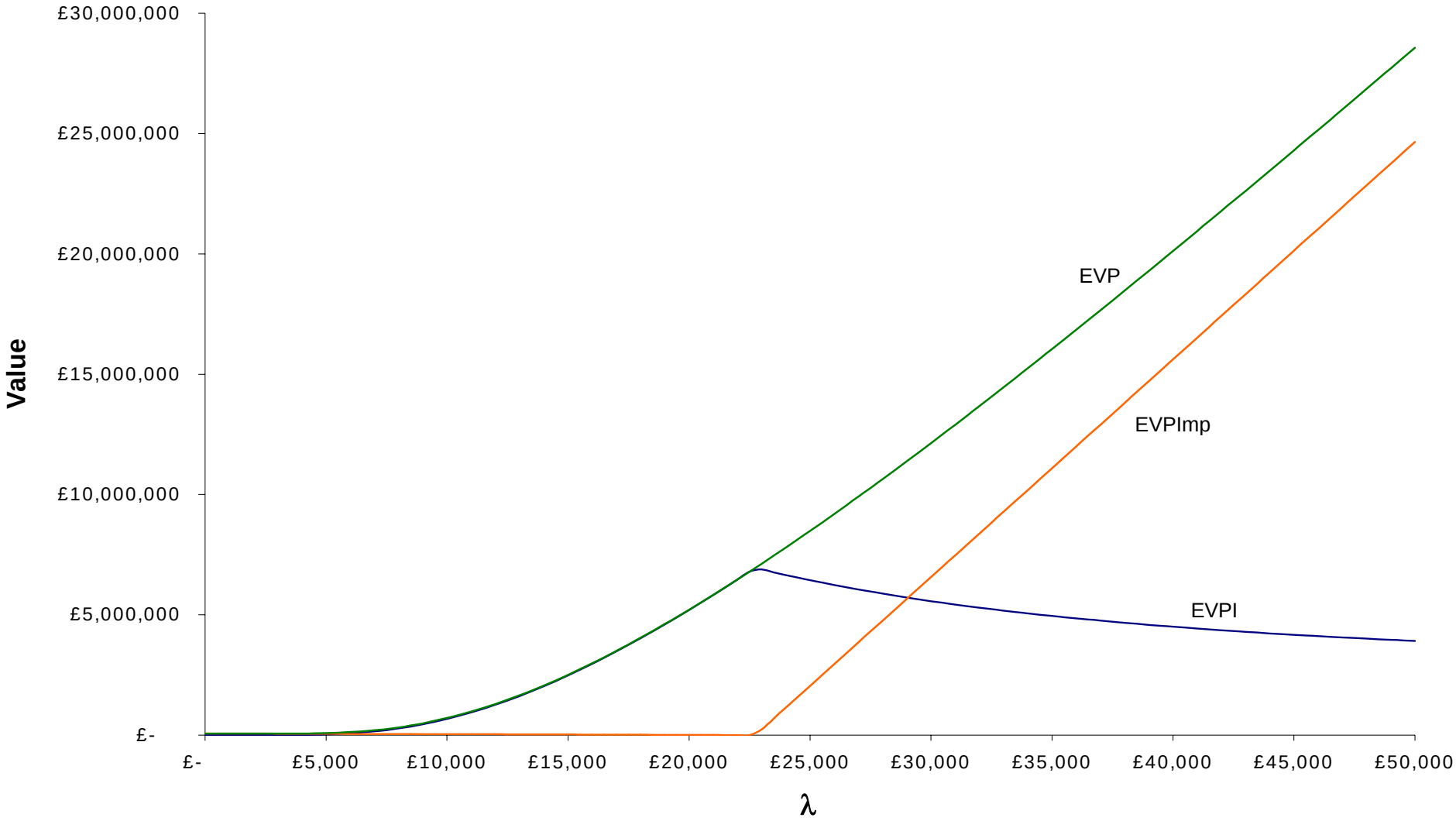

Figure 4: Expected value of information, implementation and 'perfection' for Zanamivir

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