Framework for Modelling the Cost-effectiveness of Systemic Interventions Aimed to Reduce Youth Delinquency

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Abstract

Background: Many interventions initiated within and financed from the health care sector are not necessarily primarily aimed at improving health. This poses important questions regarding the operationalisation of economic evaluations in such contexts.

Aims of the Study: We investigated whether assessing cost-effectiveness using state-of-the-art methods commonly applied in health care evaluations is feasible and meaningful when evaluating interventions aimed at reducing youth delinquency.

Methods: A probabilistic Markov model was constructed to create a framework for the assessment of the cost-effectiveness of systemic interventions in delinquent youth. For illustrative purposes, Functional Family Therapy (FFT), a systemic intervention aimed at improving family functioning and, primarily, reducing delinquent activity in youths, was compared to Treatment as Usual (TAU). “Criminal activity free years” (CAFYs) were introduced as central outcome measure. Criminal activity may e.g. be based on police contacts or committed crimes. In absence of extensive data and for illustrative purposes the current study based criminal activity on available literature on recidivism. Furthermore, a literature search was performed to deduce the model’s structure and parameters.

Results: Common cost-effectiveness methodology could be applied to interventions for youth delinquency. Model characteristics and parameters were derived from literature and ongoing trial data. The model resulted in an estimate of incremental costs/CAFY and included long-term effects. Illustrative model results point towards dominance of FFT compared to TAU.

Discussion: Using a probabilistic model and the CAFY outcome measure to assess cost-effectiveness of systemic interventions aimed to reduce delinquency is feasible. However, the model structure is limited to three states and the CAFY measure was defined rather crude. Moreover, as the model parameters are retrieved from literature the model results are illustrative in the absence of empirical data.

Implications for Health Care Provision and Use: The current model provides a framework to assess the cost-effectiveness of systemic interventions, while taking into account parameter uncertainty and long-term effectiveness.

Implications for Health Policies: The framework of the model could be used to assess the cost-effectiveness of systemic interventions alongside (clinical) trial data. Consequently, it is suitable to inform reimbursement decisions, since the value for money of systemic interventions can be demonstrated using a decision analytic model.

Implications for Further Research: Future research could be focussed on testing the current model based on extensive empirical data, improving the outcome measure and finding appropriate values for that outcome.

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Introduction

Child delinquency poses a high economic burden on society. Therefore, crime prevention and treatment of youth delinquents is of great importance to governments, in particular for Justice Departments. Systemic interventions, for instance Multisystemic Therapy (MST), Functional

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Family Therapy (FFT) or Parent Management Training Oregon (PTMO), are relatively costly interventions in youth health care aiming to reduce delinquent behaviour.\(^2\) Cost-effectiveness studies are still limited in the field of youth health care. However, these costly systemic family interventions compete with medical treatments and other interventions for health care budgets, increasing the need for knowledge regarding the operationalisation of economic evaluations in this context.

In The Netherlands, as part of an ongoing nationwide action plan of the Ministry of Justice, recently a selection was made of evidence-based treatments for delinquent youth,\(^3\) among which MST, FFT and PMTO were implemented given their apparent effectiveness in reducing criminal activity in youths. The aim of these systemic interventions is not primarily to produce health in the sense of physical health and absence of disease, as measured in the Quality Adjusted Life Years (QALY) outcome. These interventions attempt to improve family functioning and may even intervene with the peers and school environment of the youth (i.e.\(^4,5\) ). Still, these treatments are reimbursed by the Dutch social health insurance system and, as such, part of the health care sector. Therefore, like other health care interventions, each intervention needs to demonstrate value for money since it competes for limited funds with other interventions. Efficiency considerations are deemed important in guiding decisions on which treatments to reimburse or initiate. However, given the atypical aim of these systemic interventions, i.e. reducing youth delinquency, an important question is how these types of interventions could demonstrate their efficiency or value for money. The conventional health economic approach of measuring improvements in terms of QALYs may fall short in this context.

Indeed, considering the literature on reducing youth delinquency, it becomes clear that important differences exist between economic evaluations performed in the health care sector and evaluations of crime prevention and treatment programs. It seems that both fields commonly perform sophisticated effect studies, including randomized controlled trials, meta-analyses and systematic reviews.\(^6-10\) Considering economic evaluations of crime prevention and treatment programs the classical cost-benefit analysis is conventionally used.\(^11,12\) An extensive cost-benefit evaluation of crime prevention and intervention programs has been performed by Aos et al.\(^2\) in the United States. That evaluation was based on a literature review, computation of average effects per treatment program, assignment of a monetary value to the effects and subsequently calculation of a net present value in a cost-benefit model structure. Furthermore, French et al.\(^13,14\) for example, conducted cost-benefit analyses on addiction treatment for substance abusers. These cost benefit analyses were deterministic models.\(^2,13,14\) In addition, Aos et al. assessed costs and benefits from a taxpayer perspective.\(^2\) In health economic literature, cost-effectiveness analyses are preferably conducted from a societal perspective. Another difference between the two fields is, that in health economics sophisticated methodological guidelines for economic evaluations have been developed, while in the field of criminal justice such guidelines do not (yet) appear to exist. Furthermore, in health economic literature, cost-effectiveness or cost-utility analyses dominate.\(^12\) In the field of crime prevention and treatment, these analyses are limited. Nevertheless, McCollistar et al.\(^15-17\) and French et al.\(^18\) conducted various cost-effectiveness analyses related to substance abuse treatment, where the effectiveness is for example measured as days of re-incarceration\(^15-17\) or as a delinquency score.\(^18\) These studies show clearly the use of state of the art methods developed in the field of health care, applied in the field of crime prevention and treatment. On the other hand, these cost-effectiveness analyses were relatively conventional as parameter uncertainty was not captured in the model and long-term estimates were not taken into account. A common way to assess the cost-effectiveness in health care is the so-called decision analytic model.\(^19,20\) This approach provides a mathematical structure, synthesizing the evidence on costs and effects in a treated population under a variety of treatment options and makes the uncertainty around estimates visible. An additional advantage of this decision analytic modelling approach is that long-term effects can be modelled, even beyond the duration of the trial. Decision-analytic modelling and in particular inclusion of long-term effects may be especially relevant for interventions aiming to reduce criminal behaviour. Several authors suggested that criminal behaviour during adulthood tends to be preceded by behavioural disorders during childhood. Berger and Boendermaker\(^21\) stated that serious offenders often have a history of problematic behaviour in their early years of life. Kim-Cohen et al.\(^22\) mentioned that most mental disorders in adults “...should be reframed as extensions of juvenile disorders”. This suggests that systemic interventions for juvenile disorders may reduce future criminal activity later on in life. Estimates of long-term effects are therefore essential to the analysis of these interventions.

The current study aims to build a probabilistic decision analytic model like common models in health care for assessing interventions primarily aimed at crime prevention and treatment in youth care. In developing the model the following requirements had to be met:

(i) The model should be applicable to assess costs and effects of systemic interventions primarily aimed at reducing delinquent behaviour;  
(ii) The initial model should be fairly simple however easy to adjust to sophisticated details (i.e. severity of delinquency);  
(iii) The model should be probabilistic, taking uncertainty into account;  
(iv) The model should be suitable for long-term analysis;  

As an illustration an initial assessment of the cost-effectiveness of Functional Family Therapy (FFT) compared to treatment as usual (TAU) is presented. As the aim of the study is the application of the probabilistic decision analytic modelling for to interventions aimed at reducing delinquency, the interventions compared could be substituted by other systemic interventions mentioned.

The article is structured as follows. The methods section provides information on the health economic model type and
general characteristics of the model. The results section elaborates on the applicability of the decision analytic model and outcome measure to the field of systemic interventions specifying necessary adaptations to the health economic approach based on an initial assessment of cost-effectiveness of FFT. The conclusion relates our findings to the general objective of applying health economic methods to systemic interventions not primarily aimed at improving health.

Methods

Model Structure

We constructed a probabilistic Markov cohort model. Disease progression in common Markov models is described using transitions between ‘states’, where a subject can move between states or remain in the current state. The transition rates between states are typically estimated based on short run data. Long-term predictions are made based on repetition of transition cycles and assumptions based on for example literature.

In order to keep the initial model as transparent as possible, a Markov model was constructed consisting of three states, i.e. A – criminal behaviour, B - non criminal behaviour and C – dead. The model structure is shown in Figure 1. All subjects in our study started in state A, moved to either state B or C or remained in state A and could then move between criminal and non-criminal states. Death acted as the absorbing state. Note that subjects could also remain in their present state (depicted by the u-turns).

Outcome Measures and Model Parameters

In order to apply health economic methods meaningfully in the field of crime prevention and treatment, we introduce a new and neutral outcome measure of cost-effectiveness modified for this particular type of intervention: criminal activity free years (CAFYs). The CAFY was defined as a measure of time spent in a dichotomous criminal or non-criminal state. When extensive data is available, criminal activity can e.g. be defined as having had police contacts or committed crimes in the past half year. For the purpose of demonstrating the model functioning and in the absence of extensive clinical data, the criminal state in this study was based on adolescent recidivism derived from clinical trial findings reported by Sexton and Alexander. Transition probabilities differed according to the treatments offered. Treatment costs also differed per treatment type whereas all other costs (Table 1) in the different states were assumed to be independent of the treatment arm but dependent on the state. The cycle length used in the model was six months. This corresponds to the period common for follow up intervals in clinical trials in the field of crime prevention.

In the developed model two treatment alternatives were compared. To provide an example of a cost-effectiveness analysis of systemic interventions, a group receiving FFT therapy and a comparison group receiving TAU were evaluated. TAU refers to a comparable treatment, which delinquent youth would have received if they had not received FFT. As institutions offer diverse types of alternative therapies to FFT, TAU may differ between the different institutions. In one institution TAU may be MST, while another institution may offer Cognitive Behavioural Therapy (CBT) as an alternative to FFT. In our illustration subjects could not switch between FFT and TAU.

For an extensive comparison between two systemic interventions, the model should include several types of cost categories. Table 1 depicts the common cost categories in health economic evaluations; direct and indirect costs inside and outside the health care system adapted to the field of crime. The included types of costs are derived from a...
combination of the costs commonly included in health economic evaluations and literature on cost of crime. These costs not only pertain to costs incurred by the delinquent juvenile, e.g. costs due to criminal activities or treatment, but also to costs falling on family, caregivers and the society as a whole. For reasons of comparability with other interventions in health care, the model included all relevant societal costs in accordance with the Dutch manual for costing in economic evaluations.

Discount rates for future costs and effects were set consistent with guidelines for economic evaluations in the Netherlands. (Note that differential discounting is required in the Netherlands to account for the growth in the value of health over time. See for example Brouwer et al. for the rationale behind this. Therefore, by using these rates it was implicitly assumed here, that the value of a criminal activity free year (CAFY) will also increase over time, comparable to the rate of a QALY.)

Data Analytic Procedures: Cost-effectiveness and Scenario Analyses

In effect studies, uncertainty is generally represented as a confidence interval, i.e. the magnitude of uncertainty is expressed in standard deviations of the measurement error. This assumes that all relevant uncertainty is measurable in a single outcome measure, and that the distribution of the measurement error is reasonably normal. As both assumptions do not apply in typical health economic evaluations, normal t-tests and other parametric statistics are not particularly useful in health economic modelling. Instead, probabilistic analysis was conducted to take the uncertainty of the model parameters into account. In this analysis uncertainty was simulated by running the Markov model several times using a large cohort of subjects, each time with slightly different parameter values. These values were obtained by randomly sampling from each of the parameter distributions, i.e. gamma distributions for costs, and Dirichlet distributions for transition parameters. One thousand Monte Carlo simulations were performed. In each simulation a random draw from the parameter distributions was taken, which creates a unique set of cost and effect parameters. The expected costs and effects were then calculated and could be plotted on a cost-effectiveness plane. Four additional scenarios were run to demonstrate model behavior under different assumptions. As the transition probabilities constitute important model parameters, a scenario was created in which probabilities for both interventions were equal. Subsequently, the intervention costs are important parameters, since systemic interventions are concerned to be relatively costly. From a societal perspective, family costs are assumed to be important, therefore it was investigated how exclusion of these costs would influence the results in the third scenario.

Results

The resulting health economic model for systemic interventions showed that modelling an intervention with a primary aim of decreasing delinquency was feasible. Based on the illustrative comparison of FFT versus TAU, costs and

* Included until age 30

Table 1. Included Types of Costs

<table>
<thead>
<tr>
<th>Cost categories</th>
<th>Direct</th>
<th>Indirect</th>
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<tbody>
<tr>
<td>Health care</td>
<td>Medical and mental health care child</td>
<td>Productivity losses parent</td>
</tr>
<tr>
<td></td>
<td>(psychologist, psychiatrist, GP, specialist, ER, hospital (day) care,</td>
<td>(absence from work, inefficiency at work)</td>
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<tr>
<td></td>
<td>medication, youth welfare agency (bureau jeugdzorg)<em>, foster home</em>,</td>
<td>Informal care/ support child</td>
</tr>
<tr>
<td></td>
<td>residential institution, centre for addiction treatment, social worker)</td>
<td>(community centre/ church/ moskee/ association, care/support by family or</td>
</tr>
<tr>
<td></td>
<td>Medical and mental health care parent</td>
<td>acquaintances)</td>
</tr>
<tr>
<td></td>
<td>(psychologist, psychiatrist, GP, specialist, foster care*, center for</td>
<td>Criminal justice system child</td>
</tr>
<tr>
<td></td>
<td>addiction treatment, social worker)</td>
<td>(Council of child protection, Bureau Halt*, Police, Lawyer, Court,</td>
</tr>
<tr>
<td>Outside health care</td>
<td>Travel expenses (incl.parking)</td>
<td>Incarceration costs)</td>
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<tr>
<td></td>
<td>Time spent by child on exercises as part of therapy*</td>
<td>Informal care/ support parent</td>
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<tr>
<td></td>
<td>Time spent by parent on exercises as part of therapy*</td>
<td>(community centre/ church/ moskee/ association)</td>
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* Included until age 30
effects could be expressed in costs per CAFY. This section elaborates on the specific characteristics of the resulting decision analytic model. Obviously, the combination using different sources for the inputs of a model is certainly not without problems, but we stress that the emphasis here was on building an illustrative model and demonstrating the model functioning.

**Model structure**

Estimates of long-term effects were essential to the analysis and were taken into account in the current model. This required some (informed) assumption regarding the endurance of effects of treatment also taking into account the influence that reaching a certain age or experiencing certain life events may have on criminal behaviour.\(^{28}\) For the current model, information on these parameters was taken from the literature. Moffitt\(^{29}\) roughly suggested that after adolescence or at approximately age 30 subjects who are criminal during their entire life, life-course-persistent offenders, will remain criminal and subjects who only show criminal behaviour during their adolescence, so-called adolescence-limited offenders, will have returned to non-criminal behaviour. This implies a stable state of criminal activity among individuals of age 30 and older. To illustrate the option of incorporating earlier theory and evidence on

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**Figure 2. Percentage of Youth in Model States over Time for FFT**

**Figure 3. Percentage of Youth in Model States over Time for TAU**
the development of offending and antisocial behaviour we integrated parts of the long-term stabilising effects described by Moffitt into the current model framework. This effect is implemented in the model by extending the effectiveness of the treatment till the age of 30 years. Consequently youth remain in their current state after that age. Thus after reaching the age of 30, youth reach a stable state in their criminal behaviour, which means the transition probabilities in the model are from then on defined by mortality rates only. The time horizon of the model is 50 years.

To illustrate how long-term effects may influence model results, Figure 2 and Figure 3 present the percentage of youth in each model state over the time horizon of the model, for FFT and TAU respectively. Figure 2 and Figure 3 demonstrate that a stable state is already reached after about 1 year, which implies that the actual impact of the incorporation of a stabilising effect, based on the theory of Moffitt is minor in this model. However, as the model results are only as good as the available input used to fill the model, the current results only illustrate how long-term effects could be included in the present model, as it is mainly based on assumptions made and empirical data are lacking.

Outcome Measure: CAFY

In health economic evaluations, cost-effectiveness is most commonly estimated in cost per quality-adjusted life year (QALY). However, as the predominant effect of behavioural interventions for criminal youths is the reduction of criminal activity [30] and thus is not directly or exclusively linked to physical health and absence of disease, the effect measure QALY seems inadequate to capture the full benefit of interventions in adolescent mental health. Therefore, a different outcome measure that sufficiently captures the goals of crime prevention and treatment was required. Considering the societal perspective of the policymaker, a broad outcome measure, directly linked to the goal of a reduction in criminal activity, was chosen. As a first step in this context, we chose the outcome measure of criminal activity free years (CAFYs), which can be used to determine the (incremental) costs per CAFY, i.e. the costs per criminal activity free year. Using CAFYs as the effect measure enables decisions based on a non-monetary value that is comparable between interventions and that properly reflects the goals of the Ministry of Justice while fitting into the health economic modelling approach. Existing examples of an effectiveness measure that resembles the use of the CAFY measure, is the use of days re-incarcerated.17

As the model has two states defined as either being criminal or not being criminal, the transition from state A, criminal, to state B, not criminal, represents the rate of not being criminal after treatment. The transition of state B to state A on the other hand represents the rate becoming criminal after having been not criminal. It is assumed all youth enter the model as not being criminal. The outcome of (incremental) costs per CAFY, was (as a first and rather simplified step) obtained by assigning different costs to individuals according to their current state, criminal state A or non criminal state B. Determining the net present value of the additional costs incurred in state A and state B over the full lifespan of subjects and dividing these by the amount of additional years the individual spends in the non criminal state B during his entire life (compared to TAU) yielded an estimate of incremental costs per CAFY. This process of calculating lifetime costs and dividing these by life-time criminal-activity-free years was repeated 1000 times by means of simulation in order to reflect variability in input parameters.

Model Parameters: Transition Probabilities

Transition probabilities were dependent on the definition of the states reflecting the choice of outcome measure. In the current model, criminal behaviour was chosen as most relevant outcome measure so that the states were defined as ‘criminal’ and ‘non criminal’ and transition probabilities between the states could be retrieved from literature.

Several studies showed the effectiveness of FFT compared to TAU. Yet, there is no consistent outcome regarding the effectiveness of FFT in comparison to TAU. The results based on adolescent recidivism derived from clinical trial findings reported by Sexton and Alexander were most applicable and comparable to the formulation of our model parameters and definition of the comparison group. So demonstrating the model, we used the effectiveness rates of that study. As the rate of recidivism based on the clinical trial reported in the study of Sexton and Alexander is 33 percent, we assumed this rate could be equal to the transition from state B to state A in the model and is therefore supposed to be equal to 33 percent. As the sum of all transition probabilities related to one state in the model sums up to 100 percent, the transition rate of state B to state B (individuals remaining in the non criminal state) is set at 67% (100% minus 33%). As for illustrative purposes we assumed here that the probability of individuals staying non-criminal (B to B) to be equal to the probability of becoming non-criminal (A to B), the transition from state A to state B, was fixed at 67 percent as well. Again subtracting this transition rate from 100% resulted in a probability of 33% for individuals remaining in the criminal state (A to A). Sexton and Alexander furthermore suggested that “FFT reduces recidivism and/or the onset of offending between 25 and 60 percent more effectively than other programs”. As TAU refers to a comparable treatment, we took the average of this range as a reasonable and illustrative estimate of the effectiveness of TAU. The model therefore was constructed under the illustrative assumption that FFT reduces criminal activity 42.5 percent more effectively than TAU.

Transition probabilities were assumed to be fixed over the years, as no further long term effectiveness is known yet.

Model Parameters: Costs

To fill in the cost parameters in the model the costs in the criminal state were retrieved from an ongoing trial of FFT. The volumes of costs in the non criminal state were derived from scaling volumes in the criminal state with a ratio of cost volumes of anti-social versus “normal” youths presented in a UK study on the financial costs of anti-social youths. Unit prices were taken from the Dutch manual for costing in...
economic evaluations. In absence of Dutch unit costs, mean treatment costs of the interventions compared were derived from American costs presented in the study of Aos et al.\textsuperscript{2} These costs are not related to the states but depend on the intervention a youth received.

**Cost-effectiveness**

As the comparison of FFT with TAU in the current model is illustrative, the model results solely fulfil this objective. These illustrative cost-effectiveness results from the model point towards lower costs of FFT when compared to TAU. Taking the mean from the stochastic results, the number of CAFYs for FFT exceeds the number of CAFYs for TAU by 6.88 and the costs of FFT appear lower than TAU with incremental cost savings of 8,577EUR (Table 2), positioning the intervention in the South East quadrant of the cost-effectiveness plane (Figure 3). Incremental cost-effectiveness from the illustrative model data expressed in costs per CAFY amounts to cost savings of 1,246 EUR/CAFY. These exemplifying results suggest that FFT produces better effects at lower cost when compared to TAU.

**Scenario Analyses**

Scenario analysis can reveal how the results change if certain parameters are changed. The scenario analysis indicates that the model is particularly sensitive to changes in transition rates whereas the results appear rather robust to changes in other input parameters (Table 2). When transition rates of TAU and FFT are assumed equal (Table 2, Scenario 1), cost savings and CAFY gains entirely vanish. Simulation then results, on average, in an incremental effect of zero and negligible differences in costs between the interventions. The results of the model thus appear to strongly depend on accurate estimates of transition probabilities. Variation in intervention costs does not yield significant differences in costs or effects (Table 2, Scenario 2), whereas exclusion of family costs not only results in a decrease in cost savings but also decreases the variance of the incremental costs (Table 2, Scenario 3).

**Discussion and Conclusions**

This study created a framework for the evaluation of interventions aimed at reducing criminal activity in delinquent youth. A probabilistic Markov model approach was constructed allowing the assessment of the incremental cost-effectiveness of two systemic interventions. For
illustrative purposes, the interventions considered were FFT and TAU. As the comparison of FFT with TAU in the current model is solely an example to demonstrate model functioning, the model results are illustrative in absence of empirical data. As a first step to come to suitable outcome measures in this field, we introduced the outcome measure of Criminal Activity Free Years (CAFY) in a probabilistic decision analytic model. The presented methodology may provide a basis for further development of the model and outcome measures and, ultimately, decision-making by both Ministries of Justice and, in particular, Health. Policymakers may compare cost and effects between different types of interventions aiming to reduce delinquency among youth.

An advantage of using decision analytic models is that this approach enables calculation of hypothetical scenarios. Hence, questions of policymakers, for example on differences in cost-effectiveness within subgroups of youth or on the optimal age for intervention may be answered. Moreover, the decision uncertainty is represented in the model results by taking into account the uncertainty surrounding the input parameters of the model. The current study showed that it was feasible to apply health economic methodology to assess interventions aimed at reducing delinquency rates. The approach was developed to be consistent with health economic guidelines. To our knowledge, this was the first economic evaluation using decision-analytic modelling in the evaluation of systemic interventions for crime prevention and treatment.

However, a number of important questions remain. First of all, the outcome measure presented here is clearly sector-specific. While this enables choosing between interventions with similar aims, it does not directly allow comparisons with other interventions. This problem is not unique for this context. For instance, interventions in elderly care or social care may not be primarily aimed at producing health as well. Outcome measures such as the OPUS and ICECAP have been proposed as better capturing the benefits of such care. This does raise the question, however, of how to trade-off between interventions when their aim is not similar and when different outcome measures were used to assess cost-effectiveness. This seems to be an important area for future research.

Secondly, we proposed the measure of CAFY as a first step to demonstrate how interventions aimed to reduce delinquency could be evaluated within a probabilistic decision model. If such interventions were to be evaluated more systematically using methodology like the one presented here, clearly, the outcome measure deserves more attention. The outcome measure of the CAFY is a very simple and crude one. One could compare it to ‘natural units’ used in cost-effectiveness analysis like gained life years and event free life years. An important problem with these measures and the CAFY is that they do not reflect the seriousness of the events (e.g. living in a poor or good health state or, in this case, engaging in many and severe criminal activities or a few minor felonies). However, the definition of criminal activity free could be based on different measures, like the number of police contacts or youth self-report of committed crimes. Since not all committed crime, irrespective of the seriousness of the crime, is reported to the police, the difference in definition could give different effectiveness and cost-effectiveness results. Preference weighted measures (like the QALY) would be preferred in this context. Such measures could add a weight to different types of criminal activities and be more comprehensive in terms of the benefits they include (which could even entail a mix of health and crime-related outcomes).

Reducing delinquent behaviour is an important outcome of systemic interventions, but multiple other outcomes may be relevant as well, among which for example the ability to live at home after treatment, school attendance or family functioning. As these multiple outcomes are not considered in the current model, it could be valuable to extend the model or broaden the outcome measure.

Before further use, the model would require improvement, since our analysis had a number of limitations. First, the model was limited to three states. Although a model is always a simplification of reality, and the current model even was an illustration, it should be investigated whether three states are sufficient to provide reasonable estimations of reality. Secondly, the states used now were dichotomous (criminal or non-criminal behaviour). The severity of criminal offenses is likely to be important as well, also as a predictor of future criminal activity. The frequency or the types of crime could be an important differentiating factor to discriminate more detailed states. Using more differentiated states would therefore add validity to the model. However, a necessary condition for the formulation of a more complex model is the availability of more and detailed trial data. Third, an individual’s history of offenses could be used to predict future behaviour and, thus, it may be useful to relax the ‘memoryless’ feature of the Markov model. This feature encompasses that once a subject has moved from one state to another, the Markov model will have ‘no memory’ regarding which state the subject has come from or the timing of that transition. Using the history of earlier offences in the model could also improve the resulting estimates. The incorporation of long-term effects in the model was based on the coarse assumption individuals reach a stable state of criminal behaviour after an age of 30. However, the impact of using this theory in the current model was minor. In future research one could consider incorporating other relevant theories like the one used here to improve long-term effect modelling. Various other theories and studies about the development of offending and antisocial behaviour exist, that could be used to incorporate long-term effects into the model. For example, Sampson and Laub suggest that offending depends on the strength of bonding to society, like bonding to family, peers, school and social institutions. In addition, an early age of onset predicts a relatively long criminal career and several risk factors for the early onset of offending are acknowledged. Besides using studies like those mentioned, a stabilising effect could be modelled more smoothly over time or could be based on empirical, long-term follow-up data to add more detail to modelling long-term effects. Furthermore, Value of Information (VoI) analyses should explore the additional value of further research to
characterize the uncertainty of the model inputs, including long-term effects. Fourth, the cost parameters in the model are depicted from a combination of costs used in health economic evaluations and literature on cost of crime. However, victim costs and intangible costs, which include direct economic losses of the victims and indirect losses suffered by these victims, respectively, are not taken into account. Addition of these costs could be of value. Finally, model parameters were solely based on the limited evidence base of available literature and where retrieved out of different literature sources. Ideally, these parameters would be retrieved from more comprehensive empirical data. For example, the transition probabilities could be linked to the presence or absence of police contacts, contacts with judicial institutions or committed crimes. Availability of additional data can refine the input data of the model and increase the validity of the model structure and the accuracy of the results.

Concluding, we used the methods commonly employed in health economic evaluations to create a framework for determining the value for money of interventions targeted at reducing youth delinquency. The results are encouraging, but important further steps still need to be taken. A first next step may be the collection of empirical data to test the presented methodology. We further suggest the construction of a multidimensional outcome measure that enables researchers to capture the multiple dimensions of the treatment goals, in a preference-weighted manner. A final matter that deserves attention is the value we assign to outcomes such as reduced delinquency. Calculating cost-effectiveness is especially useful when the results can be judged against some ‘threshold’ value. What this should be in this context remain.

References


