**Health economics modelling**

The model was developed using a two-stage approach which involved:

1. Developing a **problem-oriented model**. This entails mapping the full range of supposed factors, causal relationships, events and health states relevant in a given area of policy or given population. This stage could also be viewed as conceptual mapping, and the main output is often a flow diagram of the problem area.
2. Developing the **decision-oriented model**. This is a simplification of, and based selectively on, the problem-oriented model, depending on the availability of specific data, research and stakeholder views on the importance or negligibility of different factors, and also the overall purpose of the model (e.g. to assess the cost-effectiveness of specific strategies or policies). The decision-oriented model is usually a simulation model, capable of producing estimates of the outcomes of interest when different interventions or policies are implemented.

We reviewed a number of different sources:

1. The data and findings from the NIHR-funded COCOA study.1
2. Previous economic modelling of similar problems or prison populations by the Revolving Door Agency and the Home Office.2,3
3. Economic evaluations of other health interventions in UK prison populations (for people with mental health problems, substance misuse or communicable diseases; based on a systematic review by Rachael Hunter, UCL).
4. The realist review to inform the theory and development of the Engager intervention.4
5. A recently published model-based economic evaluation of diversion and aftercare interventions in for prisoners identified as substance abusing.5
6. Other sources cited or referred to in these sources that looked relevant.

**Methods – developing and implementing the decision-oriented model**

The model has been developed to evaluate the potential value of the Engager intervention by comparing the costs and outcomes associated with a strategy which includes the Engager intervention with a strategy that does not include the Engager intervention, referred to as Current Practice.

The pilot decision model aims to capture the health-related short-term impacts of the Engager intervention on offenders who are soon to be released. The model will be expanded to account for longer-term health and non-health related impacts of the Engager intervention. Contact with GP, mental health, drug and other health services, and the costs of these contacts, are considered in the pilot model.

A population of offenders who are 4 months from release and have common mental health problems are simulated in the model. Each individual may have a substance misuse problem and/or a physical health problem in addition to the common mental illness. As the model focusses on access to services and how that changes depending on the level of service contact and care that is received, it is likely that many individuals will continue to have mental health problems, especially for the duration of the pilot model.

Data on the characteristics of the simulated population will be informed by the Engager trial.

Individuals are 4 months from release at the start of the pilot model, and are followed for 6 months after release to coincide with the time period of the Engager trial. Thus, the current model has a time horizon of 10 months. This will be extended so that longer-term impacts of the Engager intervention can be captured.

**Model structure/relationships**

The model is structured as a discrete event model, so that individuals can experience different events at different times, with some events occurring simultaneously. Events can be time-limited episodes (e.g. a hospital admission) or mark the transition to a different health state, e.g. from having a substance misuse problem to not having a substance misuse problem. This model structure is not necessarily important for the pilot model which only includes those short-term health events, but for the fully developed model which will consider longer-term health and non-health events, this structure will be important. For both treatment strategies, Engager and Current Practice, the model simulates an individual’s pathway through different events, recording the events experienced and calculating the total costs and outcomes associated with that pathway. Whether an individual experiences an event is determined by probability. A large number of individuals are simulated in the model to obtain variation in pathways and events.

For the 4 months that individuals are assumed to be in prison, those not receiving the Engager intervention are assumed, for simplicity, to have no changes to their mental and physical health or substance misuse status. Therefore, if an individual has a substance abuse and/or physical health problem in addition to their mental health problem 4 months prior to release, they are assumed to still have the problem on release. Similarly, those individuals who do not have a substance abuse or physical health problem in addition to their mental health problem 4 months prior to release are assumed to remain without such health issues for the remainder of time in prison.

Once an individual has been released, their mental and physical health and any substance misuse problems can change.

**Engager intervention**

The only difference between the Current Practice and Engager strategies is the introduction of the Engager intervention while individuals are still in prison. The model assumes that not all individuals start the Engager intervention at the same time before release. Instead, the Engager intervention is assumed to commence between 1 and 4 months prior to an individual’s release. Individuals may discontinue treatment at any time (before or after release), but for those continuing with treatment, the Engager intervention ends 3 months after release.

For those receiving the Engager intervention:

* In prison there is a probability of an improvement to mental health once treatment with the Engager intervention starts. However this advantage of the Engager intervention on mental health only occurs in prison
* On release there is an increase in the probability of planned contact with health services (with probabilities differing depending on the type of health service), and therefore a subsequent decrease in the probability of unplanned contact with services after release.

Thus in the model, the effectiveness of the Engager intervention is determined by a higher chance of improvement in mental health problems prior to release, and an increase in planned contact with health services on release, which translates to a decrease in unplanned contacts with health services.

This part of the model will be informed by data from the Engager trial.

**Outcomes**

Outcomes from the model currently include:

* proportion of individuals having planned and unplanned contact with health services (within prison and on release)
* number of planned and unplanned contacts per week/month with health services (within prison and on release)
* number of non-fatal self-harm events (within prison and on release)
* length of time with common mental health problem
* length of time with substance misuse problem (if individual has such a problem)
* costs of planned and unplanned contact with health services (within prison and on release)
* quality of life, estimated as utility
* number of deaths.

When the model is extended in time horizon, other social and economic outcomes can be incorporated, where data to inform the relevant causal relationships is reliable.

Each contact an individual may have with services is assigned a cost from the perspective of the NHS and personal social services (PSS). Hospitalisation costs resulting from a non-fatal self-harm event are accounted for, as are medication costs.

Utilities (estimates of quality of life) are assigned to individuals and change depending on the health problems the individual may be experiencing. In the pilot model, it is assumed that a utility for a particular health state does not depend on whether the individual is being treated for that health issue. However, in reality, utilities may be expected to be lower for those individuals not being treated for their health problems. This will be further explored in the full model.

The model was run with a sample of 5000 simulated individuals. The results for each strategy (Current Practice and Engager) are averaged and compared to estimate the incremental costs and effects of the Engager strategy compared to the Current Practice strategy. Many of the parameter values currently used in the model are not evidence-based, but the full model will be informed by the Engager trial. Therefore, the results presented below from the pilot model are for illustration purposes only to show the minimum outcomes from the model. With further development, the model will also provide outcomes relevant to employment, accommodation, reoffending and conviction, and relationships, as well as longer-term health outcomes.

To illustrate the pilot model, the parameter values in the Appendix below were used. The data sources for the pilot model are shown, as well as the likely data sources for the fully developed model.

**Reconsideration of feasibility and value of EVPI analysis**

In preparation for and to inform the design of definitive RCTs of health interventions, probabilistic decision modelling can be extended to explore which sets of parameters contribute the most to the decision uncertainty (Estimated Value of Perfect Information). Combining the outputs of such analyses with data or assumptions about the research costs of reducing the uncertainty of different parameter estimates, such methods can be extended further to inform optimal research design (Estimated Value of Sampling Information). However, both these approaches are predicated on (a) the intervention primarily or only having an impact on health, and (b) there being an accepted societal willingness to pay for a single outcome which captures all health outcomes. This explains why these methods have mainly been applied in the field of health technology assessment6 where the cost-effectiveness of specific treatments for specific conditions can be plausibly captured by health-related quality-adjusted life-years.

For many public health interventions, and almost certainly for the Engager intervention, the use of EVPI and EVSI methods are much more difficult to justify. This is because both the intended and the unintended effects of the intervention are expected to go beyond health7,8 and also the budgetary impact of different patterns of service use is on multiple government sectors (in addition to the NHS, on the criminal justice system, but also social care, housing/local government)9,8 In such a context, to base an analysis only on changes in health-related quality of life, and only on the opportunity costs of additional spending in the NHS (which is what NICE’s cost-effectiveness threshold should represent) would represent a very partial evaluation of the true potential value of further research.9,10

On the other hand, current methods of economic evaluation do not lend themselves to the appropriate consideration of health and non-health related outcomes and cross-sector costs when the perspective of the analysis goes beyond health. Weatherley et al8 report that current methods are not sufficient to account for outcomes across different sectors and so investment into the development of different outcomes is needed. Similarly the practicalities of assuming that different sectors might compensate or transfer funds to other sectors also needs consideration8 For instance,9 state that such compensation or transfers may not be feasible in practice, e.g. if those making decisions about health technologies then become part responsible for public expenditure and allocation. However, even if issues surrounding the capture of all relevant health and non-health outcomes and the distribution of costs from different budgets were resolved, identifying a societal willingness to pay threshold on which funding decisions would be made is needed before such analyses can inform future research, as recent examples in the literature highlight.10,11

EVSI methods also assume some discretion over the size of a randomised trial, assuming a very large pool of patients who might participate. The constraints on the roll out and evaluation of the Engager intervention, are at a more practical level such that whatever the scientific optimum trial size (and duration of recruitment etc.) factors inherent to the prison system, mental health care, and how they are organised will dominate many aspects of study design.

For these reasons, and because of the enormous challenges that the cost-effectiveness modelling will already face in trying to capture both health and a range of non-health outcomes, and account for prevalent co-morbidities in this target group, we have decided not to pursue the EVPI element of the analysis. Instead, we have designed a model, which by being a discrete event simulation is scalable, both in terms of time horizon and morbidities/service use. This first stage of modelling has implemented a model with service use for mental health and drug misuse, as well as GP attendance. Where data exist about how certain co-morbidities multiply attendance rates, or where routine planned service use and monitoring for a problem leads to fewer acute episodes/relapses/re-offending, and therefore fewer unplanned attendances (or re-convictions). It has also been designed to make best use of the planned trial outcomes that will be measured.

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