Improving the continuity of patient care through identification and implementation of novel patient handoff processes in Europe

Project Deliverable Report

Deliverable nr D7 – Report quantifying the expected benefits of the planned interventions

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Abstract (for dissemination)

Aim: The aim of this report is to assess the expected benefits of the proposed Handover interventions and to model the size of a potential trial to measure the effectiveness of this intervention.

Background: The HandOver project aims to develop a suite of interventions to improve the handover of patients between the hospital and the community. These interventions will be customisable and include several options with a focus on creating a virtual training environment called the Handover Training Toolbox.

Methods: A literature review identified readmission rates and adverse event rates among the plausible targets for such an intervention. A team of experts was invited to express their beliefs on the expected effects of the intervention in terms of an expected reduction in the attributable risk in both end points. Such beliefs were quantified using Bayesian prior distributions. An economic model was created to quantify the cost-effectiveness of the proposed intervention contingent on the prior beliefs. The size of a potential trial to measure the effectiveness of the intervention was also modelled. All models included sensitivity analyses.

Results: The pooled expert opinion suggested an improvement of 25% in the attributable risk of readmission rates and adverse event rates. The modelling exercise showed that such an effect would be cost-effective in a society that was willing to pay up to 20,000€ to avoid one death and obtain one Quality Adjusted Life Year (QALY).

A future trial to detect a reduced readmission rate would need to be very large to detect cost-effective and plausible effects over most assumptions.

Discussion: The implementation of the handover toolbox is likely to be cost-effective. The sample size for a trial to evaluate it is very large under most assumptions. Option value analysis and value of information analysis will be considered for deliverable 11 (due 30th Sept 2011).

Keywords List
Handover, patient safety, barriers, facilitators, primary care/hospital interface, prior beliefs, expected effectiveness, headroom analysis
Table of Contents

Table of Contents ................................................................................................................................. 3
Executive summary ........................................................................................................................................ 4
Chapter 1.  Introduction ............................................................................................................................. 7
  1.1  Service delivery interventions and their evaluation ................................................................. 7
  1.2  Focus of this report ...................................................................................................................... 9
  1.2.1  Work to develop the intervention ..................................................................................... 9
  1.2.2  Work to model the cost-effectiveness of the intervention ................................................ 9
Chapter 2.  Overview of the literature for the identification of end point ........................................... 10
  2.1  Introduction ............................................................................................................................ 10
  2.2  Taxonomy of handover interventions and outcome measures .............................................. 13
  2.3  Literature on the magnitude of problems associated with patient handover ...................... 15
  2.3.1  Source of data and study design ..................................................................................... 15
  2.4  Literature on the comparative effectiveness of handover interventions on hospital readmissions 18
  2.5  Literature on the attributable risk of problems associated with patient handover ............ 25

Summary ............................................................................................................................................. 29
Chapter 3.  Subject of the evaluation: the Handover Training Toolbox (HTT) ................................. 30
  3.1  The need for a description of the intervention in pre-implementation evaluations ............... 30
  3.2  Handover Training Toolbox .................................................................................................. 30
Chapter 4.  Description of the Bayesian elicitation exercise ................................................................. 31
  4.1  Philosophy of Bayesian statistical methods ............................................................................. 32
  4.2  Team of experts ....................................................................................................................... 33
  4.3  Elicitation of expert opinion: data collection form ................................................................. 33
  4.4  Elicitation of expert opinion: Details of the elicitation exercise ........................................... 34
    4.4.1  End point 1: Readmission rate .................................................................................. 34
    4.4.2  End point 2: Adverse event rate ............................................................................... 34
    4.4.3  End point 3: Incompleteness of information rate ..................................................... 34
  4.5  Quantification of opinions given by each expert by mean of distributions ............................ 35
  4.6  Methods used to pool the expert opinion .............................................................................. 36
  4.7  Sample size calculation ......................................................................................................... 36
Chapter 5.  Results of the elicitation exercise ...................................................................................... 38
  5.1  Experts involved in the development of the intervention, Nice 2010 .................................... 38
  5.2  Experts involved in the development of the intervention, Brussels 2010 .............................. 41
Chapter 6.  Pre-implementation economic evaluation: headroom analysis .................................... 47
  6.1  A framework for the evaluation of technologies at pre-development phase ......................... 47
  6.2  Methods for analysis ............................................................................................................... 47
  6.3  Headroom analysis for the Handover Training Toolbox ....................................................... 48
Chapter 7.  Discussion and recommendation ...................................................................................... 52
  7.1  Conclusions of this study - the economic evaluation ........................................................... 52
  7.2  Future work .......................................................................................................................... 54
    7.2.1  A framework for the evaluations of interventions at pre-implementation stage ............. 54
    7.2.2  Future trials and sample size calculation .................................................................. 54
    7.2.3  Attributable risk and sample sizes ............................................................................. 57
  7.3  Relevance of this work to future innovation and health policy ............................................. 59
  7.4  Limitations of this study ....................................................................................................... 59

References ............................................................................................................................................. 60
References of the literature review (Chapter 2) .................................................................................. 62
Acknowledgments ............................................................................................................................... 67
Appendix A - Elicitation form ............................................................................................................ 68
Executive summary

Introduction

The European HandOver research group aims to develop a suite of interventions to improve the handover of patients between the hospital and the community. The effectiveness of these interventions cannot be assessed using standard techniques (i.e. randomised studies) because the intervention has not yet been implemented. This situation is analogous to a new drug that is not yet ready for human testing. However, under the Bayesian paradigm, we are able to elicit the expected effectiveness of such interventions in a three step process:

1. **ENDPOINT IDENTIFICATION**: find the endpoints that are likely to be affected by the intervention and quantify the baseline rates by means of literature review;
2. **ELICITATION OF THE EXPECTED EFFECTIVENESS**: interview experts on the expected change that will be manifested in each of these endpoints as an effect of the intervention; and,
3. **MODEL COST-EFFECTIVENESS**: elicit beliefs and certain other assumptions. Includes sensitivity analysis and sample size calculations for a possible future trial.

End Point Identification

The literature review identified a large number of end points that might be affected by failures in handover. After discussion between the international members of the HandOver Research Collaborative, three of the endpoints identified in the literature were selected as propitious targets for an intervention and as potential endpoints for an evaluative study:

1. **Readmission rates**: Readmission to hospital is caused in part by failures in handover. Overall readmission after hospital discharge is considered a suitable measure for observing failures in handover. It was estimated that the overall readmission rate at 1 month after discharge was 13% [1]. In circa 15% of cases of readmission, this was due to failure in handover and it is these patient readmissions that may be prevented by a suitable intervention (i.e. an intervention that was 100% effective would be expected to reduce overall readmission rates by circa 2 percentage points; from 13% to 11%).
2. **Adverse events**: Failures in patient handover may also cause adverse events. The total adverse event rate after general hospital discharge was estimated at 19% [2]. One adverse event in three was considered potentially preventable. Thus, a suitable intervention could decrease the adverse event rate to no less than 13% (assuming 100% probability that “preventable” adverse events really could be prevented).
3. **Incompleteness of information**: One of the consequences of poor patient handover is missing or unclear information in medical records. We could find no data of this point in the literature and informally estimated that 20% of information is missing.
It is accepted that these are not independent end points. For example, incomplete information may be the precursor of one or more adverse events, and these, in turn, may be the antecedent of readmission.

**Elicitation of the expected effectiveness of an educational intervention developed under handover**

The rates at which end points attributable to handover occur are time dependant. We used the one month time point in our exercise since the literature (summarised below) confirms the intuitive idea that the proportions of clinically relevant end points that are preventable (i.e. that can be reduced by an intervention at handover) decrease rapidly over time. They are also context dependant, turning in particular on the mean age of the patient and the type of clinical scenario (e.g. all patients, medical patients, heart failure patients). We used as our base case general medical patients of mean age 60 years.

The effectiveness of an intervention that aims to reduce overall failures in handover can be measured for each of the endpoints mentioned above. Since the intervention is still at the design stage, the evaluation may be conducted on the basis of its potential value; a pre-implementation or early stage evaluation. Early stage evaluations inform decisions on the expected value of future interventions, not all of which can be funded in a world of limited resources [3]. Early stage evaluations can also be useful to improve the intervention itself. Finally, such evaluations can be used to inform the size of future evaluative studies by contributing to studies of the value of (perfect or sample) information [4, 5]

The elicitation of expert opinion was performed as a group exercise during the meeting on the 23rd of March 2010 in Nice, and then on the 15th of October 2010 in Brussels. First, the team directly responsible for developing the intervention to reduce errors in handover presented their proposed method. The subsequent elicitation consisted of two parts:

1. Informative session: during this part of the meeting, the Birmingham team rehearsed the philosophy of Bayesian statistics and described the process of elicitation. They then summarised existing literature covering base rates for relevant end points, estimates of preventability and the effectiveness of various interventions that have been evaluated; and,
2. Elicitation exercise: experts were asked to give their subjective belief on the expected effectiveness of the proposed intervention on relevant end points. Experts quantified their best guess and the plausible limits for the effectiveness of the intervention in reducing risk attributable to failures in handover.

The elicited effectiveness of the proposed intervention was then quantified by means of normal distributions to form a Bayesian prior probability distribution. A truncated normal distribution was used where the credible intervals were asymmetric with respect to the best value. Finally, the distribution of the average belief was obtained by linear pooling of the prior distributions. This pooled distribution was used to inform a pre-implementation cost-effectiveness analysis and the sample size for a future parallel randomised controlled trial. As a basis for comparison the calculations were also preformed for an *ad-hoc* sceptical prior belief.
Results of the elicitation exercise

Here we consider the two end points for which most literature is available: readmission rates and adverse event rates. From the elicitation exercise, experts indicated an expected reduction of circa 25% in the attributable risks of both of these end points as a result of the intervention.

A 25% reduction in attributable risk means that preventable readmissions decline from 2% to 1.5% and overall readmissions from 13% to 12.5%. A 25% reduction in adverse event rates corresponds to a reduction from 6% to 4.5% of preventable events, and an overall reduction of adverse events from 19% to 17.5%.

Despite these modest effect sizes, the modelling exercise in the main body of this report suggests that the above improvement in adverse event rates is likely to be highly cost-effective. In essence, this result is obtained because the cost of the intervention is relatively low and it is spread over a large number of recipients. Thus, it is sufficient that only a small proportion will benefit from the intervention that this may result to be cost-effective.

A very large clinical trial (over 100,000 participants) would be needed to detect the above improvement (half a percentage point) in readmission rates (at the usual false positive study result rate of 5% and false negative study result rate of 20%). A much smaller trial of about 20,000 participants would be needed to detect the larger improvement (1.5 percentage point) in adverse event rates. However, this would not necessarily be the least expensive option since adverse events data needs deeper (and more expensive) examination of each case while readmission data can be harvested by medical records at much lower costs.
Chapter 1. Introduction

1.1 Service delivery interventions and their evaluation

A causal chain which links structure, processes and outcomes was conceptualised by Donabedian Avedis [6]. This has been extended by the researchers in order to distinguish three very different types of processes [7]: clinical processes (at the micro level) closest to patients; targeted processes, which aim to improve specific clinical processes (at the meso level); and generic processes (at the macro level), that span out to affect a myriad of processes across the organization Figure 1-1. A process to improve the handover of patients can be classified as a generic process, since it is not targeted at a single specific clinical issue (say, anti-coagulant therapy) but at a constellation of processes relating to medicine reconciliation, information provision to GPs and patients, ensuring that abnormal test results have been identified, alerting social services to special needs and so on.

Interventions can be applied to any part of the causal chain. Clinical interventions aim to improve clinical outcomes by impacting critically on patient physiology and psychology and the evaluation is usually called Health Technology Assessment (HTA). Targeted and generic service interventions aim to improve targeted and generic processes respectively and are usually classified as service delivery (also management research or organizational research or health service research). Finally, upstream interventions at the policy level aim to change the environment in which the organization operates and structural interventions are usually classified as policy research. As for HTAs, the knowledge of the clinical and economic impact of service delivery interventions is crucial before a decision is made in favour of wide-spread implementation [3]. Service delivery interventions need careful pre-implementation evaluations, and iterative evaluation in use, in order to “maximise their prospects for success and minimise foreseeable risks” [6, 8]. Figure 1-2 shows the 3 stages of an intervention’s life:

1. Pre-development phase; the intervention is still an idea under development. This is the stage of pre-implementation evaluation. It may be tried out in simulations (alpha testing)
2. Early adoption in practice; Data is collected on the intervention before it is rolled out in practice (proof of principle or piloting)
3. Full Development of the intervention; the new technology has been implemented and data can be collected on its effectiveness (perhaps in a formal trial) as part of a cost-effectiveness analysis based on use across multiple settings.

As the development advances through these stages, information accrues and uncertainty around its expected benefit decreases. At early stage there are decision “gates” that determine whether the intervention should be abandoned, extended or adapted.
Figure 1-1 Modified Donabedian causal chain.

- Structure
  - Generic processes
  - Targeted processes
  - Clinical processes
  - Outcome
  - Intervening variables

- Process levels
  - Policy intervention
  - Generic process intervention
  - Targeted service intervention
  - Clinical intervention

Figure 1-2 Evaluation of interventions from development stage to implementation.

- Headroom analysis + value of investment analysis
  - Pre-development
- Iterate Value of investment analysis
  - Decision gate for early implementation
- Value of Information analysis
  - Further development
- Cost-effectiveness analysis
  - Full implementation
1.2 Focus of this report

This report focuses, of necessity, on stage 1 above, i.e. the pre-implementation evaluation. Different methods can be used to evaluate the intervention at this stage. These methods can basically be broken into two types.

1.2.1 Work to develop the intervention.

This includes understanding the problem through literature review and qualitative and quantitative observational studies of existing practice (in this case qualitative and quantitative studies of failures related to handover). The potential impact of the intervention can be modelled intellectually using methods such as Failure Models Effectiveness Analysis (FMEA) [9].

1.2.2 Work to model the cost-effectiveness of the intervention.

The Headroom analysis can be used to see whether the intervention could be effective if it performs as well as could be expected. If sufficient headroom is identified, then a more comprehensive model can be built to estimate the expected benefit of a pre-development intervention such as the handover intervention. Such analysis requires the identification of the endpoints of interest, an estimate of the overall and attributable risk for each relevant end point and an estimate of the potential effect of the intervention. This analysis is informed by information of different types:

1. Discussion among experts and literature reviews to identify relevant end points. It is important to consider negative as well as positive effects and the FMEA (see above) and other modes of risk assessment such as probabilistic risk assessment may inform this process.
2. Baseline rates of end points and attributable risks can be obtained from literature review.
3. Estimates of effectiveness at the design/early stage of an intervention rely on expert opinion. Such expert opinion can be captured in quantitative form by means of Bayesian prior probability densities. Elicitation of such prior probabilities should be informed from multiple sources, including:
   a) Rich description of the intervention
   b) The rationale for the intervention based on theory developed from observational studies
   c) Results of any FMEA or PRA
   d) Baseline rates and attributable risks for relevant end points
   e) Reviews of effectiveness of different types of intervention for the same problem and/or the same intervention for other types of problem.

In this report we begin with the definition of suitable end points, the elicitation of the overall and attributable risk from the literature and literature review of the effectiveness of various interventions targeted on the handover problem. This information is then used to frame the elicitation of the effectiveness of the proposed intervention from a team of experts. These prior probability estimates will then be used for a pre-evaluation analysis of the expected benefit of the intervention. Also, this information will be used to inform the calculation of the sample size for a randomised clinical trial for the evaluation of the proposed intervention.
Chapter 2. Overview of the literature for the identification of end point

2.1 Introduction

This section aims to provide an overview of literature pertinent to the estimation of the magnitude of problems associated with handovers during the transition of patients between hospital and community and the potential effectiveness of an intervention targeting the handover process. A separate literature review to identify the mechanisms and processes that are responsible for the results of implementation of handover interventions is included within another Work Package of the project.

Problems associated with handover between hospital and community have long been recognised and literature surrounding these issues is immense and diffuse. It is impractical to review and summarise this huge body of literature within this Work Package. Our point of departure is a systematic meta-review of systematic reviews of interventions aimed at reducing problems in adult patients discharged from hospital to home by Mistiaen and colleagues (2007). The meta-review was identified during our initial scoping of literature in the field. It covers key systematic reviews considered directly relevant to the Handover project and is reasonably up to date.

Mistiaen and colleagues identified no less than 41 relevant systematic reviews. They assessed the methodological quality of the reviews and included 15 reviews which were judged to be of higher quality. These included reviews covered a total of 265 primary studies. Key features and findings of these systematic reviews are summarised in Table 2.1. Some of the reviews were Cochrane reviews which have subsequently been updated since the publication of the meta-review. Information from the updated Cochrane reviews (rather than from the reviews included in the overview) was presented in the Table in such cases.

Among the wealth of information included in the meta-review, the taxonomy of interventions that have been evaluated and of the end points that have been used in the literature is of particular value to guide this literature overview and will be expanded in the next section.
Table 2.1 Systematic reviews included in the meta-review by Mistiaen et al (2007) or updated/published subsequently

<table>
<thead>
<tr>
<th>Systematic reviews</th>
<th>Literature searched</th>
<th>Type of intervention</th>
<th>Setting/patient group</th>
<th>Discharge preparation</th>
<th>Discharge support/aftercare</th>
<th>Key findings/conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameron 2002</td>
<td>Inception to 2002</td>
<td>Specialised multidisciplinary inpatient rehabilitation</td>
<td>Older patients with proximal femoral fracture</td>
<td>v</td>
<td></td>
<td>Outcomes (e.g. death or institutional care) tended to favour the intervention groups but the results were heterogeneous and not statistically significant.</td>
</tr>
<tr>
<td>Cole 2001</td>
<td>1975 to 2000</td>
<td>Geriatric post-discharge services</td>
<td>Older patients</td>
<td>v</td>
<td></td>
<td>There was little evidence that the interventions had an impact on the mental state of older patients.</td>
</tr>
<tr>
<td>Day 2004</td>
<td>1980 to 2003</td>
<td>Specialist geriatric services</td>
<td>Older patients</td>
<td>v</td>
<td>v</td>
<td>The review generally supported the efficacy of the intervention in community settings but the benefits were not consistent across all outcomes and were not always significant; the efficacy of the interventions was more diverse in inpatient settings, with results being significantly in favour of the interventions only for some outcomes.</td>
</tr>
<tr>
<td>Gwardry 2004</td>
<td>Inception to 2000</td>
<td>Multidisciplinary heart failure management programs</td>
<td>Patients with heart failure</td>
<td>v</td>
<td></td>
<td>The interventions significantly decreased hospital readmissions but did not affect mortality rates.</td>
</tr>
<tr>
<td>Handoll 2004</td>
<td>Inception to 2004</td>
<td>Different mobilisation strategies and programmes</td>
<td>Patients undergone fracture surgery</td>
<td>v</td>
<td>v</td>
<td>There was insufficient evidence from randomised trials to determine the effectiveness of interventions.</td>
</tr>
<tr>
<td>Hyde 2000</td>
<td>Inception to 1997</td>
<td>Supported discharge</td>
<td>Older patients with undifferentiated clinical problems</td>
<td>v</td>
<td></td>
<td>The interventions increased the proportion of patients staying at home 6-12 months after initial admission and reduced subsequent admissions to long-stay care, but the effect on subsequent hospital readmission was uncertain. There were no rigorous data on functional status and patient/carer satisfaction.</td>
</tr>
<tr>
<td>Kwan 2002</td>
<td>1975 to 2003</td>
<td>Care pathways</td>
<td>Patients with acute stroke</td>
<td>v</td>
<td></td>
<td>The interventions might be associated with positive and negative effects. Most results were derived from non-randomised studies and there was insufficient supporting evidence to justify the routine implementation of the interventions.</td>
</tr>
<tr>
<td>Outpatient Service Trialists (OST) 2003</td>
<td>Inception to 2001</td>
<td>Therapy-based rehabilitation services</td>
<td>Patients with stroke</td>
<td>v</td>
<td></td>
<td>The interventions reduced the odds of a poor outcome and had a beneficial effect on a patient’s ability to perform activities of daily living. However the interventions were heterogeneous.</td>
</tr>
<tr>
<td>Reference</td>
<td>Inception to</td>
<td>Description</td>
<td>Patient Group</td>
<td>Type</td>
<td>Findings</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
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<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------------</td>
<td>------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Parker G 2000</td>
<td>1988 to 1999</td>
<td>Different locations of acute, post- and sub-acute and rehabilitation care</td>
<td>Older patients</td>
<td>v</td>
<td>Despite considerable development of different forms of the interventions, evidence about effectiveness and costs was weak.</td>
<td></td>
</tr>
<tr>
<td>Parker S 2002</td>
<td>Inception to</td>
<td>Discharge arrangement</td>
<td>Older patients</td>
<td>v</td>
<td>Evidence did not suggest the interventions had effects on mortality or length of hospital stay, but supported beneficial effects on readmission rates. Interventions provided across the hospital-community interface, both in hospital and in the patient’s home showed the largest effects. Evidence from randomised controlled trials was not available to support the general adoption of discharge planning protocols, geriatric assessment processes or discharge support schemes.</td>
<td></td>
</tr>
<tr>
<td>Phillips 2004</td>
<td>Inception to</td>
<td>Comprehensive discharge planning and post-discharge support</td>
<td>Patients with chronic heart failure</td>
<td>v</td>
<td>The interventions significantly reduced readmission rates and might improve health outcomes such as survival and quality of life without increasing costs.</td>
<td></td>
</tr>
<tr>
<td>Richards 2003</td>
<td>Inception to</td>
<td>Interventions to improve access to health and social care following discharge</td>
<td>Older patients</td>
<td>v</td>
<td>Interventions were heterogeneous. There was some evidence that services combining needs assessment, discharge planning and a method for facilitating the implementation of these plans were more effective than services that do not include the latter action.</td>
<td></td>
</tr>
<tr>
<td>Shepperd 2008*</td>
<td>Inception to</td>
<td>Hospital at home</td>
<td>Adult patients</td>
<td>v</td>
<td>There was no evidence from the analysis to suggest that admission avoidance hospital at home leads to outcomes that differ from inpatient hospital care.</td>
<td></td>
</tr>
<tr>
<td>Shepperd 2010*</td>
<td>Randomised controlled trials, Inception to March 2009</td>
<td>Discharge planning</td>
<td>v</td>
<td>The evidence suggested that the interventions probably brought about small reductions in hospital length of stay and readmission rates for older people admitted to hospital with a medical condition. The impact of discharge planning on mortality, health outcomes and cost remains uncertain.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teasell 2003</td>
<td>1995 to 2002</td>
<td>Early supported discharge programmes</td>
<td>Patients with stroke</td>
<td>v</td>
<td>Patients with milder stroke who received home-based therapies had similar functional outcomes to patients who received traditional inpatient rehabilitation. Limited evidence suggested patients with moderate-to-severe deficits were unsuitable candidates for early supported discharge programmes.</td>
<td></td>
</tr>
</tbody>
</table>

*Cochrane reviews updated after the publication of the overview by Mistiaen et al (2007). Information shown in the table was extracted directly from the updated reviews.*
2.2 Taxonomy of handover interventions and outcome measures

Handover is a complex process involving many health care professionals, patients and their carers. Problems can occur in numerous steps of handover and between different parties involved. Assessing the magnitude of the problems associated with handover is therefore a challenging task, as are devising interventions to tackle the problems and measuring the impact of the interventions. Mistiaen and colleagues (2007) classified interventions into two main categories:

- Discharge preparation – these are interventions that take place mainly during hospital admissions
- Discharge support/aftercare – these are interventions that take place mainly after discharge from hospital

In addition, the framework proposed by Parker and colleagues (2002) in a HTA report included in the meta-review was considered useful:

- Comprehensive discharge planning protocols – these are standardised procedures surrounding discharge carried out by an individual health professional such as a nurse discharge coordinator
- Comprehensive geriatric assessment – these are multidisciplinary, multidimensional assessment of older people either in hospital or in the community. Many of the interventions cover discharge planning but the main aim usually is to improve functional status and independent living in hospital and/or post-discharge rather than to focus on discharge itself
- Discharge support arrangements – these are monitoring or interventions provided by hospital or community staff after discharge, and range from a post-discharge telephone call to provision of services by a multidisciplinary team in the patient’s home after discharge
- Educational interventions – there are targeted at patients to improve their ability to manage their conditions after discharge

It is worth noting that the categorisation of interventions could be arbitrary and some interventions covered components from more than one category.

Many end points have been used either as a direct measure of a component of potential problems in the handover process, or as an indicator of the quality of handover or broader hospital care. Mistiaen and colleagues (2007) classified the end points reported in the literature into three main categories:

1. Discharge status of patients
   - Length of hospital stay
   - Discharge destination
   - Dependency at discharge
2. Functioning of patients after discharge
   - Physical status
   - Emotional status
   - Social status
   - Health status – including mortality and morbidity
3. Health care services use and costs
   - Readmissions
   - Use of health care services post discharge
   - Costs

A few outcome measures not mentioned above have also been used in previous studies:

- Adverse events
- Patient / carer knowledge

Among all these outcome measures, hospital readmission is one of the most widely used indicators of problems associated with handover. It has the advantage of being an objective outcome measure and is routinely recorded. The following sections of this literature overview therefore mainly focus on hospital readmission as an indicator of problems associated with handover and as an outcome measure for estimating the effectiveness of the interventions.

It is worth pointing out that many factors may contribute to hospital readmissions. Only a proportion of them are attributable to problems associated with handover and potentially preventable. A crucial issue relating to the use of hospital readmission as an indicator of the quality of handover or as an outcome measure of interventions aiming to improve the handover process is therefore to determine the cause and preventability of readmissions. This will be expanded in another section following the sections on the magnitude of problems and effectiveness of interventions.
2.3 Literature on the magnitude of problems associated with patient handover

2.3.1 Source of data and study design

Information with regard to the magnitude of the problems associated with patient handover can be obtained from the following sources:

- Epidemiological – observational studies
- Control group in intervention studies
- Pre-intervention rates in both intervention & control groups in before & after controlled studies

One review by Benbassat and Taragin (2000) examined literature published between 1991 and 1998 on hospital readmissions. They found 18 studies providing information on all patient discharges from general acute care hospitals and observed that the proportions of readmissions reported in the studies varied substantially and depended on the patient population (i.e. age and disease condition) and time scale. After 1 month, the reported rates ranged from 5 to 14% for unselected inpatients, 12 to 16% for geriatric patients and as high as 35% for selected ‘high risk’ patients. After 1 year, the reported rates of patient readmission ranged from 32 to 49% for unselected inpatients, 34 to 67% for geriatric patients and up to 70% for high-risk geriatric patients.

The citation search of the review by Benbassat and Taragin identified a few recent studies. The findings are generally in line with the review by Benbassat and Taragin but again showed a wide variation of reported readmission rates, ranging from around 5% for unplanned readmission in an Australian hospital (McLean et al. 2008) to 19.6% (at 1 month) – 34.0% (at 3 months) for patients in the Medicare Fee-for-Service program in the US.

Studies of interventions aimed at reducing problems associated with discharge process are another possible source of information. Findings from control groups of these comparative studies were essentially observational studies of readmission rates without intervention, whereas differences observed in these studies between intervention groups and control groups provided some indication of the proportion of readmissions that were amenable to interventions. Among the reviews mentioned in the previous section, the Cochrane review on discharge planning from hospital to home (Shepperd et al. 2010) was considered most relevant to the Handover project and most up to date. The results from primary studies included in this review and an additional key trial (Coleman et al. 2006) aimed at the handover process were extracted and presented in Table 2.2.

Data shown in Table 2.2 demonstrate that readmission rates varied substantially depending on patient population and time scale, which is consistent with findings based on epidemiological/observational studies described earlier.

Where the readmission rates are measured at baseline (i.e. before the intervention/study period) in a comparative study, the baseline rates for both intervention and control groups are an additional source of information. The
information is particularly useful for monitoring if changes other than the intended intervention have occurred during the study period that might have impacted upon the observed outcomes irrespective of the intervention or control status of the groups. However we have not identified any studies in which baseline readmission rates were measured prior to the intervention period.
### Table 2.2 Rates of hospital readmissions, sorted by length of follow-up

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Condition</th>
<th>Mean age</th>
<th>Follow-up (months)</th>
<th>Control</th>
<th>Intervention</th>
<th>Absolute risk reduction</th>
<th>Relative risk reduction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moher 1992</td>
<td>Canada</td>
<td>Medical and surgical</td>
<td>65</td>
<td>0.5</td>
<td>18 131</td>
<td>13.7%</td>
<td>22 136 16.2%</td>
<td>-2.4%* -18%</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>USA</td>
<td>Elderly - surgical</td>
<td>76</td>
<td>0.5</td>
<td>7 66</td>
<td>10.6%</td>
<td>5 68 7.4%</td>
<td>3.3% 31%</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>76</td>
<td>0.5</td>
<td>11 70</td>
<td>15.7%</td>
<td>3 72 4.2%</td>
<td>11.5% 73%</td>
</tr>
<tr>
<td>Jack 2009</td>
<td>USA</td>
<td>Medical</td>
<td>50</td>
<td>1</td>
<td>59 368</td>
<td>16.0%</td>
<td>47 370 12.7%</td>
<td>3.3% 21%</td>
</tr>
<tr>
<td>Balaban 2008</td>
<td>USA</td>
<td>Medical and surgical</td>
<td>56</td>
<td>1</td>
<td>4 49</td>
<td>8.2%</td>
<td>4 47 8.5%</td>
<td>-0.3%* -4%</td>
</tr>
<tr>
<td>Coleman 2006</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>76</td>
<td>1</td>
<td>44 371</td>
<td>11.9%</td>
<td>31 379 8.2%</td>
<td>3.7% 31%</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>USA</td>
<td>Elderly - surgical</td>
<td>76</td>
<td>1.5</td>
<td>16 66</td>
<td>24.2%</td>
<td>12 68 17.6%</td>
<td>6.6% 27%</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>76</td>
<td>1.5</td>
<td>18 70</td>
<td>25.7%</td>
<td>7 72 9.7%</td>
<td>16.0% 62%</td>
</tr>
<tr>
<td>Shaw 2000</td>
<td>UK</td>
<td>Psychiatry</td>
<td>≥70</td>
<td>3</td>
<td>12 46</td>
<td>26.1%</td>
<td>5 51 9.8%</td>
<td>16.3% 62%</td>
</tr>
<tr>
<td>Pardessus 2002</td>
<td>France</td>
<td>Elderly - fall</td>
<td>≥65</td>
<td>3</td>
<td>3 30</td>
<td>10.0%</td>
<td>5 30 16.7%</td>
<td>-6.7%* -67%</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>USA</td>
<td>Elderly - surgical</td>
<td>76</td>
<td>3</td>
<td>21 66</td>
<td>31.8%</td>
<td>19 68 27.9%</td>
<td>3.9% 12%</td>
</tr>
<tr>
<td>Coleman 2006</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>76</td>
<td>3</td>
<td>83 371</td>
<td>22.4%</td>
<td>63 379 16.6%</td>
<td>5.7% 25%</td>
</tr>
<tr>
<td>Kennedy 1987</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>80</td>
<td>3</td>
<td>14 40</td>
<td>35.0%</td>
<td>11 39 28.2%</td>
<td>6.8% 19%</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>76</td>
<td>3</td>
<td>29 70</td>
<td>41.4%</td>
<td>18 72 25.0%</td>
<td>16.4% 40%</td>
</tr>
<tr>
<td>Nazareth 2001</td>
<td>UK</td>
<td>Elderly - medical</td>
<td>84</td>
<td>3</td>
<td>69 176</td>
<td>39.2%</td>
<td>64 164 39.0%</td>
<td>0.2% 1%</td>
</tr>
<tr>
<td>Harrison 2002</td>
<td>Canada</td>
<td>Elderly - CHF</td>
<td>76</td>
<td>3</td>
<td>24 77</td>
<td>31.2%</td>
<td>18 80 22.5%</td>
<td>8.7% 28%</td>
</tr>
<tr>
<td>Laramee 2003</td>
<td>USA</td>
<td>Elderly - CHF</td>
<td>71</td>
<td>3</td>
<td>46 125</td>
<td>36.8%</td>
<td>49 131 37.4%</td>
<td>-0.6% -2%</td>
</tr>
<tr>
<td>Rich 1993</td>
<td>USA</td>
<td>Elderly - CHF</td>
<td>≥70</td>
<td>3</td>
<td>16 35</td>
<td>45.7%</td>
<td>21 63 33.3%</td>
<td>12.4% 27%</td>
</tr>
<tr>
<td>Rich 1995</td>
<td>USA</td>
<td>Elderly - CHF</td>
<td>79**</td>
<td>3</td>
<td>59 140</td>
<td>42.1%</td>
<td>41 142 28.9%</td>
<td>13.3% 32%</td>
</tr>
<tr>
<td>Coleman 2006</td>
<td>USA</td>
<td>Elderly - medical</td>
<td>76</td>
<td>6</td>
<td>114 371</td>
<td>30.7%</td>
<td>97 379 25.6%</td>
<td>5.1% 17%</td>
</tr>
<tr>
<td>Naylor 2004</td>
<td>USA</td>
<td>Elderly - CHF</td>
<td>76</td>
<td>12</td>
<td>67 121</td>
<td>55.4%</td>
<td>53 118 44.9%</td>
<td>10.5% 19%</td>
</tr>
</tbody>
</table>

*Relative risk reduction was defined as (absolute risk reduction divided by control group rate) x 100%

*A minus figure indicates the rate of readmission increased in the intervention group compared to the control group; **Median
2.4 Literature on the comparative effectiveness of handover interventions on hospital readmissions

Systematic reviews that evaluated the effectiveness of interventions aiming at reducing problems associated with patients discharged from hospital to home were included in the meta-review by Mistiaen and colleagues (2007). Many of the reviews were targeted at patients with specific disease conditions, and some have focused on interventions carried out mainly at patients’ homes. This section focuses on findings from two of reviews that are considered most relevant to the handover project: the Cochrane review (Shepperd et al. 2010) on discharge planning from hospital to home, and the health technology assessment (HTA) report on discharge arrangements for older people by Parker and colleagues (2002). Results from these reviews are presented in a series of tables. Table 2.2 in the previous section and Table 2.3 below summarises findings from the Cochrane review. Table 2.4 - Table 2.8 summarises findings from the HTA report.

Table 2.2 and Table 2.3 demonstrate that substantial variations exist between studies included in the Cochrane review (Shepperd et al. 2010) with regard to both the absolute risk reductions (difference in the proportion of readmissions between intervention and control groups) and relative risk reductions (i.e. the proportion of readmissions that could be avoided by the intervention out of all readmissions observed in the control group). The reported relative risk reductions range from -67% (i.e. the intervention increased readmissions by 67%) to 73% (i.e. the intervention reduced readmission by 73%).
Table 2.3 Randomised controlled trials included in the Cochrane review on the effectiveness of discharge planning (Shepperd et al. 2010): unscheduled readmission within 3 months of discharge

<table>
<thead>
<tr>
<th>Study</th>
<th>Control group no. of events (n/N)</th>
<th>Control group risk</th>
<th>Intervention effect (Relative risk, 95% CI: (RR &lt;1 favours intervention)</th>
<th>Absolute risk reduction (ARR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balaban 2008</td>
<td>4/49</td>
<td>8.2%</td>
<td>1.04 (0.28 to 3.93)</td>
<td>-0.3%*</td>
</tr>
<tr>
<td>Harrison 2002</td>
<td>31/77</td>
<td>40.3%</td>
<td>0.71 (0.46 to 1.11)</td>
<td>11.5%</td>
</tr>
<tr>
<td>Jack 2009</td>
<td>59/368</td>
<td>16.0%</td>
<td>0.79 (0.56 to 1.13)</td>
<td>3.3%</td>
</tr>
<tr>
<td>Kennedy 1987</td>
<td>14/40</td>
<td>35.0%</td>
<td>0.81 (0.42 to 1.55)</td>
<td>6.8%</td>
</tr>
<tr>
<td>Laramee 2003</td>
<td>46/125</td>
<td>36.8%</td>
<td>1.02 (0.74 to 1.40)</td>
<td>-0.6%</td>
</tr>
<tr>
<td>Moher 1992</td>
<td>18/131</td>
<td>13.7%</td>
<td>1.18 (0.66 to 2.09)</td>
<td>-2.4%*</td>
</tr>
<tr>
<td>Naylor 1994</td>
<td>11/70</td>
<td>15.7%</td>
<td>0.97 (0.45 to 2.10)</td>
<td>0.4%</td>
</tr>
<tr>
<td>Nazareth 2001</td>
<td>69/176</td>
<td>39.2%</td>
<td>1.00 (0.76 to 1.30)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Rich 1993</td>
<td>16/35</td>
<td>45.7%</td>
<td>0.73 (0.44 to 1.20)</td>
<td>12.4%</td>
</tr>
<tr>
<td>Rich 1995</td>
<td>59/140</td>
<td>42.1%</td>
<td>0.69 (0.50 to 0.95)</td>
<td>13.3%</td>
</tr>
<tr>
<td>Shaw 2000</td>
<td>12/46</td>
<td>26.1%</td>
<td>0.38 (0.14 to 0.99)</td>
<td>16.3%</td>
</tr>
<tr>
<td>Pooled estimate (11 studies)</td>
<td><strong>0.85 (0.74 to 0.97)</strong></td>
<td><strong>I²=0%</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pardessus 2002a</td>
<td>3/30</td>
<td>10.0%</td>
<td>1.67 (0.44 to 6.36)</td>
<td>-6.7%*</td>
</tr>
<tr>
<td>Pooled estimate (12 studies)</td>
<td><strong>0.85 (0.75 to 0.97)</strong></td>
<td><strong>I²=0%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A minus figure indicates the rate of readmission increased in the intervention group compared to the control group

**I²=0% indicates there is no heterogeneity between the results of individual studies.

a This study enrolled older people admitted to hospital following a fall. The patient population was regarded as a different population from the patients in the other 11 studies, all of which enrolled patients with a medical condition.

Table 2.3 showed that the results for most individual studies were not statistically significant but the pooled estimate suggested that, on average, discharge planning interventions significantly reduced the risk of unscheduled hospital readmission within three months of discharge by 15%. No significant heterogeneity was found between the studies (i.e. the results, when expressed as relative risk between intervention and control groups, were consistent across studies and the variation observed in the results between studies is no more than that would be expected by chance). Assuming a baseline risk of 30.5% (i.e. the median control group risk across studies included in the review), the pooled estimate indicates that the interventions would reduce the risk of readmissions within 3 months of discharge to 25.9% (95%CI 22.9 % to 29.6%), equivalent to an absolute risk reduction of 4.6% (95% CI 0.9% to 7.6%).

Table 2.4 to Table 2.8 summarise the rates of readmissions and estimated effect sizes of discharge arrangements for older people in the HTA report (Parker et al. 2002), by types of interventions. Interventions were classified into four categories as described previously: discharge planning, comprehensive geriatric assessment programmes, discharge support arrangements, and education interventions (mainly targeted at patients). These categories are not mutually exclusive and some interventions can be included in more than one category.
Table 2.4 Rates of readmission and estimated effect sizes of discharge arrangements for older people in the HTA report (Parker et al. 2002): Discharge planning

<table>
<thead>
<tr>
<th>RCTs investigating the effectiveness of discharge arrangement</th>
<th>Length of follow-up (m)</th>
<th>Control group no. of events</th>
<th>Control group event rates (n per 100 per month)</th>
<th>Intervention group no. of events</th>
<th>Intervention group event rates (n per 100 per month)</th>
<th>Reduction in event rates (per 100 patients per month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kennedy 1987</td>
<td>2</td>
<td>35/41</td>
<td>42.68</td>
<td>29/39</td>
<td>37.18</td>
<td>5.50</td>
</tr>
<tr>
<td>Naylor 1994 – Medical DRG</td>
<td>3</td>
<td>11/70</td>
<td>5.24</td>
<td>11/72</td>
<td>5.09</td>
<td>0.15</td>
</tr>
<tr>
<td>Naylor 1994 – Surgical DRG</td>
<td>3</td>
<td>7/68</td>
<td>3.43</td>
<td>5/66</td>
<td>2.53</td>
<td>0.90</td>
</tr>
<tr>
<td>Evans 1993</td>
<td>1</td>
<td>35/417</td>
<td>8.39</td>
<td>24/418</td>
<td>5.74</td>
<td>2.65</td>
</tr>
<tr>
<td>Evans 1993</td>
<td>9</td>
<td>N/A</td>
<td>14.63</td>
<td>N/A</td>
<td>13.16</td>
<td>1.47</td>
</tr>
<tr>
<td>McInnes 1999</td>
<td>6</td>
<td>40/159</td>
<td>4.17</td>
<td>62/205</td>
<td>5.00</td>
<td>-0.83*</td>
</tr>
</tbody>
</table>

Pooled estimate (Ratio of readmission rates) (6 studies) 0.80 (0.57 to 1.10) I²=7 p=0.166

*A minus figure indicates the rate of readmission increased in the intervention group compared to control group; N/A indicates the figure was not reported.*
Table 2.5 Rates of readmission and estimated effect sizes of discharge arrangements for older people in the HTA report (Parker et al. 2002): Comprehensive geriatric assessment programmes

<table>
<thead>
<tr>
<th>RCTs investigating the effectiveness of discharge arrangement</th>
<th>Length of follow-up (m)</th>
<th>Control group no. of events</th>
<th>Control group event rates (n per 100 per month)</th>
<th>Intervention group no. of events</th>
<th>Intervention group event rates (n per 100 per month)</th>
<th>Reduction in event rates (per 100 patients per month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltz 1988</td>
<td>6</td>
<td>26/87</td>
<td>4.98</td>
<td>36/86</td>
<td>6.98</td>
<td>-2.00*</td>
</tr>
<tr>
<td>Hogan 1987</td>
<td>12</td>
<td>6/56</td>
<td>10</td>
<td>9/57</td>
<td>16</td>
<td>-6.00*</td>
</tr>
<tr>
<td>Siu 1996</td>
<td>2</td>
<td>37/176</td>
<td>10.5</td>
<td>43/178</td>
<td>12.1</td>
<td>-1.60*</td>
</tr>
<tr>
<td>Hansen 1995</td>
<td>6</td>
<td>62/97</td>
<td>10.7</td>
<td>42/96</td>
<td>7.3</td>
<td>3.40</td>
</tr>
<tr>
<td>Landefeld 1995</td>
<td>3</td>
<td>109/300</td>
<td>12.1</td>
<td>104/303</td>
<td>11.4</td>
<td>0.70</td>
</tr>
<tr>
<td>White 1994</td>
<td>1</td>
<td>6/18</td>
<td>33.3</td>
<td>4/19</td>
<td>21</td>
<td>12.30</td>
</tr>
<tr>
<td>Thomas 1993</td>
<td>6</td>
<td>35/58</td>
<td>10.1</td>
<td>21/62</td>
<td>5.65</td>
<td>4.45</td>
</tr>
<tr>
<td>Rubenstein 1984</td>
<td>12</td>
<td>30/60</td>
<td>4.16</td>
<td>22/63</td>
<td>2.91</td>
<td>1.25</td>
</tr>
<tr>
<td>Slaets 1997</td>
<td>6</td>
<td>29/97</td>
<td>5.0</td>
<td>24/140</td>
<td>2.9</td>
<td>2.10</td>
</tr>
<tr>
<td>Winograd 1993</td>
<td>12</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>-2.00*</td>
</tr>
</tbody>
</table>

Pooled estimate (Ratio of readmission rates) (10 studies) **0.90 (0.73 to 1.11)** \( I^2 = ? \) \( p = 0.310 \)

*A minus figure indicates the rate of readmission increased in the intervention group compared to control group; N/A indicates the figure was not reported.*
Table 2.6 Rates of readmission and estimated effect sizes of discharge arrangements for older people in the HTA report (Parker et al. 2002): Discharge support arrangements

<table>
<thead>
<tr>
<th>RCTs investigating the effectiveness of discharge arrangement</th>
<th>Length of follow-up (m)</th>
<th>Control group no. of events</th>
<th>Control group event rates (n per 100 per month)</th>
<th>Intervention group no. of events</th>
<th>Intervention group event rates (n per 100 per month)</th>
<th>Reduction in event rates (per 100 patients per month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beckie 1989</td>
<td>1.5</td>
<td>9/37</td>
<td>16.22</td>
<td>2/37</td>
<td>3.60</td>
<td>12.62</td>
</tr>
<tr>
<td>Beckie 1989</td>
<td>6</td>
<td>6/61</td>
<td>1.64</td>
<td>7/59</td>
<td>1.98</td>
<td>-0.34</td>
</tr>
<tr>
<td>Townsend 1988</td>
<td>3</td>
<td>102/439</td>
<td>7.75</td>
<td>102/464</td>
<td>7.33</td>
<td>0.42</td>
</tr>
<tr>
<td>Townsend 1988</td>
<td>18</td>
<td>173/439</td>
<td>2.19</td>
<td>176/464</td>
<td>2.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Smith 1988</td>
<td>Variable</td>
<td>N/A</td>
<td>11.3</td>
<td>N/A</td>
<td>11.6</td>
<td>-0.30*</td>
</tr>
<tr>
<td>Weinberger 1996</td>
<td>6</td>
<td>310/701</td>
<td>7.37</td>
<td>343/695</td>
<td>8.23</td>
<td>-0.86*</td>
</tr>
<tr>
<td>Siu 1996</td>
<td>2</td>
<td>37/176</td>
<td>10.5</td>
<td>43/178</td>
<td>12.10</td>
<td>-1.60*</td>
</tr>
<tr>
<td>Donald 1995</td>
<td>6</td>
<td>6/30</td>
<td>3.33</td>
<td>9/30</td>
<td>5.00</td>
<td>-1.67*</td>
</tr>
<tr>
<td>Hansen 1995</td>
<td>6</td>
<td>62/97</td>
<td>10.7</td>
<td>42/96</td>
<td>7.30</td>
<td>3.40</td>
</tr>
<tr>
<td>Melin 1995</td>
<td>6</td>
<td>32/99</td>
<td>5.38</td>
<td>51/150</td>
<td>5.67</td>
<td>-0.29*</td>
</tr>
<tr>
<td>Martin 1994</td>
<td>1.5</td>
<td>9/25</td>
<td>24.00</td>
<td>4/29</td>
<td>9.20</td>
<td>14.80</td>
</tr>
<tr>
<td>Martin 1994</td>
<td>3</td>
<td>N/A</td>
<td>6.67</td>
<td>N/A</td>
<td>5.75</td>
<td>0.92</td>
</tr>
<tr>
<td>Fitzgerald 1994</td>
<td>12</td>
<td>N/A</td>
<td>10.20</td>
<td>N/A</td>
<td>9.90</td>
<td>0.30</td>
</tr>
<tr>
<td>Hansen 1992</td>
<td>12</td>
<td>111/205</td>
<td>4.50</td>
<td>107/199</td>
<td>4.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Dunn 1994</td>
<td>6</td>
<td>51/102</td>
<td>8.33</td>
<td>49/102</td>
<td>8.01</td>
<td>0.32</td>
</tr>
<tr>
<td>Williams 1994</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Rodgers 1997</td>
<td>3</td>
<td>5/46</td>
<td>3.62</td>
<td>5/45</td>
<td>3.70</td>
<td>-0.08*</td>
</tr>
<tr>
<td>Rawl 1998</td>
<td>4</td>
<td>7/51</td>
<td>3.40</td>
<td>11/49</td>
<td>5.60</td>
<td>-2.20*</td>
</tr>
<tr>
<td>Stewart 1998</td>
<td>6</td>
<td>197/381</td>
<td>8.62</td>
<td>154/381</td>
<td>6.74</td>
<td>1.88</td>
</tr>
</tbody>
</table>

**Pooled estimate (Ratio of readmission rates)**

| (18 studies) | **0.91 (0.81 to 1.04)** | \( I^2 = \text{N/A} \) | \( p=0.183 \) |

* A minus figure indicates the rate of readmission increased in the intervention group compared to control group; N/A indicates the figure was not reported.
Table 2.7 Rates of readmission and estimated effect sizes of discharge arrangements for older people in the HTA report (Parker et al. 2002): Education interventions (mainly educating the patients)

<table>
<thead>
<tr>
<th>RCTs investigating the effectiveness of discharge arrangement</th>
<th>Length of follow-up (m)</th>
<th>Control group no. of events</th>
<th>Control group event rates (n per 100 per month)</th>
<th>Intervention group no. of events</th>
<th>Intervention group event rates (n per 100 per month)</th>
<th>Reduction in event rates (per 100 patients per month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beckie 1989</td>
<td>1.5</td>
<td>9/37</td>
<td>16.22</td>
<td>2/37</td>
<td>3.60</td>
<td>12.62</td>
</tr>
<tr>
<td>Beckie 1989</td>
<td>6</td>
<td>6/61</td>
<td>1.64</td>
<td>7/59</td>
<td>1.98</td>
<td>-0.34*</td>
</tr>
<tr>
<td>Rich 1995</td>
<td>3</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Rich 1993</td>
<td>3</td>
<td>N/A</td>
<td>15.19</td>
<td>N/A</td>
<td>11.1</td>
<td>4.09</td>
</tr>
<tr>
<td>Stewart 1998</td>
<td>3</td>
<td>197/381</td>
<td>17.24</td>
<td>154/381</td>
<td>13.47</td>
<td>3.77</td>
</tr>
<tr>
<td>Stewart 1998</td>
<td>6</td>
<td>197/381</td>
<td>8.62</td>
<td>154/381</td>
<td>6.74</td>
<td>1.88</td>
</tr>
<tr>
<td>Cline 1998</td>
<td>12</td>
<td>43/110</td>
<td>3.26</td>
<td>22/96</td>
<td>1.91</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>Pooled estimate (Ratio of readmission rates)</strong> (5 studies)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.67 (0.57 to 0.78)</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

*A minus figure indicates the rate of readmission increased in the intervention group compared to control group; N/A indicates the figure was not reported.

Results shown in Table 2.4 to Table 2.7 were all in favour of interventions compared to control groups, but only the pooled estimate for education interventions reached statistical significance, showing a 33% reduction in the rate of readmission. Assuming a baseline rate of 15.2 patient readmissions per 100 patient per month (according to Rich 1993), the pooled estimate suggests that the intervention would reduce the rate of patient readmissions to 10.2 (95% CI 8.7 to 11.9), equivalent to an absolute reduction of 5 patient readmissions per 100 patients per month (95%CI 3.3 to 6.5).

Although the results could suggest that interventions with patient education components are effective, the authors highlighted that the majority of trials included in this category were patients with cardiac conditions (mainly heart failure) and thus whether the results are generalisable to other types of patients is uncertain. In addition, heterogeneity was not reported in this review and thus it is difficult to assess whether the results were consistent across studies, and in particular, how the different timeframes (i.e. length of follow-up) impact on the effect estimates.
Table 2.8 Further estimates of effect sizes by the features of the interventions from the HTA report (Parker et al. 2002)

<table>
<thead>
<tr>
<th>Type of intervention</th>
<th>Number of studies</th>
<th>Ratio of rates of readmission (RRR), 95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home only</td>
<td>10</td>
<td>0.80 (0.61 to 1.03)</td>
<td>0.085</td>
</tr>
<tr>
<td>Inpatient only</td>
<td>7</td>
<td>0.93 (0.80 to 1.09)</td>
<td>0.377</td>
</tr>
<tr>
<td>Phone only</td>
<td>3</td>
<td>0.92 (0.45 to 1.89)</td>
<td>0.819</td>
</tr>
<tr>
<td>Multiple</td>
<td>15</td>
<td>0.83 (0.69 to 1.00)</td>
<td>0.045</td>
</tr>
<tr>
<td>Intervention delivery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By single professional</td>
<td>16</td>
<td>0.83 (0.70 to 0.97)</td>
<td>0.023</td>
</tr>
<tr>
<td>By a team</td>
<td>19</td>
<td>0.86 (0.74 to 1.03)</td>
<td>0.105</td>
</tr>
<tr>
<td>Overall</td>
<td>35</td>
<td>0.85 (0.67 to 0.95)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Table 2.8 demonstrates that combining results from all four categories of interventions produced a pooled estimate indicating a statistically significant 15% reduction in the rate of hospital readmission. The estimate is virtually identical to the estimate produced in the Cochrane review of discharge planning (Shepperd et al. 2010). Heterogeneity between studies was not assessed/reported.

Across the reviews included in the meta-review, Mistiaen and colleagues (2007) observed that some statistically significant effect in favour of the interventions was occasionally found, but most review reached no firm conclusions with regard to the effectiveness of the interventions. They concluded that some interventions, particularly those with educational components and those that combine pre-discharge and post-discharge interventions, may have positive impact but on the whole the evidence was limited.

The data presented above aims to provide a general feel of what is in the literature with regard to hospital readmissions in relation to the handover process rather than to provide a definite estimate of the effect sizes. Some critiques of methodology relating to the studies evaluating the effectiveness of handover interventions are offered below. Readers may wish to consider these points when interpreting the figures presented in the tables above.

- The majority of the studies were conducted in USA. Most studies focused on older people, many possessed one or more risk factors for unplanned readmission, such as congestive heart failure and polypharmacy. On the other hand, frail or cognitively impaired older people admitted from/discharged to nursing home were often excluded.
- The exact nature of readmission (unplanned vs. planned) and case-mix (medical vs. surgical patients) were sometime not clearly described.
- All the studies randomised patients individually, i.e. they were not clustered trials. There are two potential implications:
  1. ‘Contamination’ (exposure of control group patients to some elements of the intervention) was possible, although this would tend to result in under-estimation of the effectiveness of the intervention;
  2. Intra-cluster correlation was not taken into account (patients treated by the same health care professional/team/hospital tend to have similar
characteristics and outcomes and thus the variation within the ‘cluster’ is likely to be smaller than what would be expected from a sample of ‘independent’ individuals, also called Berksonian bias). This would not influence the estimated effect sizes but is likely to result in under-estimation of the uncertainty (confidence intervals for the estimated effect sizes are narrower than they should be).

2.5 Literature on the attributable risk of problems associated with patient handover

While hospital readmission rates are commonly used end points measure in the handover literature, the determination of the proportion of hospital readmissions (and other adverse outcomes) that is actually preventable/avoidable is crucial in order to provide more accurate estimates of the magnitude of the problems and the potential effectiveness of the interventions. This is the focus of this section.

The aforementioned review by Benbassat and Taragin (2000) identified seven studies that have assessed the preventability of patient readmissions. Between 9 to 50% of all unplanned readmissions were judged to be preventable in these studies based on retrospective chart reviews. The reasons associated with potentially preventable patient readmission include poor resolution of the main problem, unstable therapy at discharge and inadequate post-discharge care.

We searched Medline and identified several studies that were published after 2000 and that have assessed the preventability of hospital readmissions. These studies are summarised in Table 2.9 and are briefly described below.
Table 2.9 Studies that evaluated the preventability or avoidability of hospital readmissions

<table>
<thead>
<tr>
<th>Study &amp; country</th>
<th>Study design</th>
<th>Patient population and setting</th>
<th>Rate of readmissions</th>
<th>Proportion of readmissions judged to be (potentially) preventable/avoidable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halfon 2002, Switzerland</td>
<td>Retrospective automated screening of hospital records followed by case note review</td>
<td>Random sample of 3474 hospital admissions of an 800 bed university hospital during 1997</td>
<td>32.1% (1115/3474) at 12 months 13% at 1 months</td>
<td>5.3% of readmissions at 12 months 15% of readmissions at 1 months</td>
<td>Stated 'the instantaneous risk of avoidable readmissions decreases sharply over 1 month and became quasi-negligible after 4 months'.</td>
</tr>
<tr>
<td>Halfon 2006, Switzerland</td>
<td>Retrospective automated screening of hospital records followed by case note review</td>
<td>131,809 hospitalizations of patients discharged alive from 49 hospitals</td>
<td>Not reported</td>
<td>- (5.2% of hospitalisations)</td>
<td>The proportion (5.2%) shown was potentially avoidable readmissions detected by computer algorithm. Review of a sample of the medical records suggested that 18.2% of these were clearly avoidable.</td>
</tr>
<tr>
<td>Ballia 2008, Israel</td>
<td>Interview of patients with non-elective readmissions and review of medical records</td>
<td>1988 urgent admissions (1913 discharge) over a 3-month period in a large academic medical centre</td>
<td>14.2% (271/1913) at 30 days</td>
<td>33% (90/271) of readmissions</td>
<td>Proportion of readmissions in which quality of care problems were identified – all were deemed preventable.</td>
</tr>
<tr>
<td>Goldfield 2008, USA</td>
<td>Retrospective automated screening of hospital records using refined Diagnosis Related Groups</td>
<td>4,311,653 admissions from 234 Florida hospitals during 2004-5</td>
<td>13.0% (494,808/3,816,845) at 15 days</td>
<td>5.1% (7 days) 7.9% (15 days) 11.0% (1 month) of hospitalizations</td>
<td>Admissions were categorised into candidate admissions (denominator) and potentially preventable readmission chains (numerator) that took into account repeated readmissions associated with one initial admission. Figures shown are potentially preventable readmissions.</td>
</tr>
</tbody>
</table>
Halfon and colleague (2002) conducted a study of from a random sample of 3474 inpatients discharged alive from a university hospital in Switzerland. Medical records of 1115 patients (32.1%) readmitted within one year were initially screened by computerised algorithm to classify the readmissions as foreseen readmissions, unforeseen readmissions for a new affection, or unforeseen readmissions for a previously known affection. Cases in the latter category were then subject to a manual review of records to determine whether the readmissions were potentially avoidable. The researchers found that 5.3% of all readmissions (59/1115) were potentially avoidable, i.e. 1.7% (59/3474) of all hospitalisations were followed by a potentially avoidable readmission. The instantaneous risk of these avoidable readmissions decreased sharply over one month and became almost negligible after four months. The findings have two implications: (1) a relatively short time period (i.e. around one month) may be the optimal timeframe for assessing potential impact of interventions aiming at reducing hospital readmissions; (2) the low proportion of patient readmission judged to be avoidable suggests that hospital readmission rates may be an imprecise estimate of the quality of patient handovers and an insensitive outcome measure for interventions targeted at improving the process of clinical handover.

The same group of researchers subsequently in 2000 conducted a validation study of 131,809 hospitalisations in which patients discharged alive in 49 Swiss acute care hospitals (Halfon et al. 2006). Potentially avoidable readmissions were detected using the computer algorithm developed in the previous study using 30 days as the cut-off point. The computer algorithm identified 6843 potentially avoidable readmissions (5.2% of all hospitalisations; the total number of readmissions was not reported and thus it is not clear what proportion of readmissions was potentially avoidable). A stratified random sample of 570 readmitted cases were submitted for medical record review. The manual record review confirmed that 18.2% (104/570) of the potentially avoidable readmissions detected by the algorithm were clearly avoidable.

Balla and colleagues (2008) assessed 271 unplanned readmissions following 1913 discharges from two hospital departments of medicine in Israel. Readmitted patients were interviewed and their medical records were reviewed by two senior clinicians. Quality of care problems were identified in a third (90/271) of readmissions, or 4.5% (90/1988) of hospitalisations. All the identified quality of care problems were considered preventable. These problems included incomplete workup, too short hospital stay, inappropriate medication, diagnostic error and failure to act upon a significant laboratory result.

Goldfield and colleagues (2008) analysed data for hospital admissions from all 249 inpatient hospitals in Florida from 2004 and 2005. They utilised a refined Diagnosis Related Groups (DRGs) to establish whether a readmission was clinically related to an initial admission and thus would be regarded as a potentially preventable readmission. Eligible index admissions (the denominator) and readmissions were clearly defined, and potentially preventable readmission chains (where applicable, repeated readmissions associated with the same index admission were counted as one chain) were used as the numerator. Three cut-off points following the index admission were used (7, 15 or 30 days). The estimated proportions of potentially preventable readmissions ranged from 5.05% (7-day cut-off) to 11.03% (30-day cut-off). No review of individual case notes was conducted and thus it is not clear what proportion of these readmissions was detected by automated analysis could in fact be prevented.
In addition to hospital readmissions, the preventability and avoidability of adverse events following discharge was assessed by Forster and colleagues (2003). They conducted a study of 400 consecutive patients discharged home from general medical wards in a tertiary care academic hospital and described the incidence and preventability or ameliorability of adverse events affecting patients post discharge. They found that 19% (76/400, 95%CI 15% to 23%) of the patients experienced adverse events after discharge. Of these about one-third were preventable (23/76, or 6% of all patients) and another one-third were ameliorable (24/76, or 6% of all patients).

Although the literature on assessing the preventability of hospital readmissions and other adverse outcomes is growing, the quantification of the attributable risk associated with patient handover (the proportion of adverse outcomes that is attributable to suboptimal handover) remains challenging:

- Estimated proportion of preventable readmission varied substantially between published studies, ranging from 5% to 50%. The variation may be caused by differences in the definition of eligible admissions/readmissions, different case mix in the patient populations studied, different timeframes used and different methods for identifying and verifying preventable readmissions.
- Some of the preventable readmissions are not related to the handover process, and so only a proportion of the estimated preventable readmissions would be amenable to handover interventions.
- Many interventions aiming to improve patient outcomes post discharge incorporate interventions targeting at various aspects of in-hospital and/or community care in addition to the handover process. The estimated effect sizes (e.g. a relative reduction of 15% to 33% of readmissions) from some of the systematic reviews may therefore be larger than what might be observed for an intervention that targets solely the handover process.
- Assessment of preventability/avoidability of readmission by case note is time-consuming and labour-intensive. Automated methods such as those reported by Halfon et al. (2006) and Goldfield et al. (2008) have been developed. These methods however rely heavily on the quality and completeness of routine data which is known to be rather poor, and the potentially preventable readmissions detected by computers inevitably includes many readmissions that in fact could not have been prevented. Caution is needed when interpreting the figures obtained from these automated methods.
Summary

- Hospital readmission rates are frequently used as an indicator of quality of hospital care and discharge process.
- These events are quite common but only a proportion is caused by problems with care and only a proportion of those with problems specifically at handover. Hospital readmission may therefore be an insensitive measure of problems associated with handover and effects of interventions targeting this process.
- Readmission rates are heavily influenced by age and reason for admission and are dependent on time since first admission.
- Most preventable readmissions occur within one month after discharge.
- Current literature suggests that promising interventions:
  - Combine pre- and post discharge actions;
  - Combine discharge planning and discharge support;
  - Include educational components (mainly patient education).
Chapter 3. Subject of the evaluation: the Handover Training Toolbox (HTT)

3.1 The need for a description of the intervention in pre-implementation evaluations

The development of the intervention is a very long and expensive process. At the end of which, in case of ineffectiveness or inefficiencies, a huge amount of resources could have been wasted. Thus, methods for economic evaluations are being developed to assess the expected benefit of interventions in their development stage; that is when the intervention is still an idea. However, this idea still needs to be a detailed description of what the proposed intervention will be. In an HTA, the description of the intervention is available from multiple sources. In case of pre-implementation evaluations, often the authors of the intervention are the only clear source of information.

Behind the development of the idea of the intervention there has been a long period of literature research on the types and causes of handover failures, and discussions between the groups participating to this project. During the April 2010 meeting in Nice the idea was formalised in a first description of the Toolbox as a virtual environment which could support training needs for either trainees or trainers by mean of tools, which are easy to access and can be customised in different settings (flexible environment). Finally, the Toolbox was named Handover Training Toolbox (HTT) during the meeting in Brussels [10] and the alpha version presented and made accessible to the members of the HandOver research groups for testing. In this section follows a description of the Toolbox by the authors.

3.2 Handover Training Toolbox

The toolbox allows more flexibility than typical training materials. Conventional training material tends to provide a ‘one-size fits all’ strategy, whereas the toolbox acknowledges that training needs differ [11]. The eclectic training needs were derived from 36 interviews with training specialists in Poland, Spain and The Netherlands [12], and supported by the literature on patient handover. It makes sense to search for a solution that allows training specialists to customize their training in order to deal effectively with differences regarding:

- The role of medical professionals in handover situations: for example, nurses, specialists and general practitioners differ in their responsibility, status, contacts etc. Therefore they might have slightly different learning needs;
- Stage of concern: ranging from raising awareness for handover issues (e.g., students) to responsibility for hands-on practice in the work setting (e.g. managers and senior staff); and,
- Cultural differences: that is, countries in the EU differ in how the medical system is facilitating or inhibiting medical professionals’ efforts to deal with handover issues. For example, the IT information system linking hospital and community providers is more highly developed in Sweden than in other EU countries and thus facilitates communication between primary care and hospital teams.

The first prototype of the toolbox will be primarily designed for training specialists in the EU who are responsible for designing and delivering training to improve handover practices.
These specialists are considered the key audience for our intervention. However, because the materials in the toolbox will also contain valuable content for medical professionals and students who are looking for information about this subject we will design the toolbox in such a way that they also can navigate efficiently and effectively through the toolbox. Thus the focus is eventually on different target groups, but the first priority remains a toolbox for training specialists.

The toolbox will offer different categories of information, such as: 1) *Backgrounds* on handover issues. For example: articles explaining what handover is, why it can be problematic, figures demonstrating the magnitude of the handover problems, and research stressing the importance of training in handover practice. 2) *Information about designing Handover training*, such as appropriate training activities and their pros and cons, training delivery issues (e.g. mixed groups of nurses and doctors), how to evaluate the effectiveness of your training, follow up and transfer of training.

The toolbox does not only supply information, it also serves as a place where training specialists can meet and share their experiences. For this purpose the toolbox offers several opportunities for training specialists a) to add their own information sources to the existing collection of information already available in the toolbox, b) to discuss the existing information in the toolbox, c) to raise questions, d) to discuss particular topics with fellow training specialists, etcetera. It even offers training specialists possibilities to create their own training space that can serve as a meeting point for the participants. We envision that the toolbox is not just a box with static information, it will evolve into an online community that attracts various visitors interested in training about handover issues; a type of dedicated Wikipedia or Facebook.

The toolbox will be constructed on a platform that allows creating the abovementioned functionalities for storing information and online community activities. The selection criteria for the platform are: proven stability, comprehensiveness (so not everything needs to be build from scratch), user friendliness, easy to maintain (in case the toolbox will be continued after the project then this does not require substantial technical skills for the hosting partner). During the HANDOVER project the toolbox will be hosted by the Open University.

Last but not least it is important to keep in mind that the Toolbox is a means for training specialists and NOT the intervention as such. Training is an effective and appropriate way to support the implementation of interventions. For example, when a department decides to implement the SBAR approach, then training can be used to make sure all involved staff members learn how to use SBAR in an effective way. The intervention for handover is therefore a compound process consisting of deploying (matching) the “toolbox”, and the toolbox itself. Respondent to the elicitation that follows were asked to imagine a well developed toolbox that has been well matched to a receptive audience. This is consistent with the headroom method that seeks to find out whether a new method would be worthwhile if its development is successful at a technical level [13].
Chapter 4. Description of the Bayesian elicitation exercise

4.1 Philosophy of Bayesian statistical methods

Reverend Thomas Bayes, during his life in the middle XVIII century, uncovered a direct consequence of the laws of probability, which is now at the centre of a statistical paradigm. The Bayes theorem reverses conditional probabilities by means of marginal probabilities. In inference, Bayes theorem focuses on the probability of the model given the data by using the probability of the data given the model (likelihood) and a priori probability of the model. The prior probability is the probability of the model prior to the experiment, and the experiment aims to updating the prior belief using the information generated by the data, in order to obtain a posterior probability of the model. As a step by step exercise, such posterior probability can be used as a priori probability to the next experiment.

A team of experts in the field can elicit the a priori probability of the model. For example, one may want to know the distance between Birmingham and Brussels. The elicitation of this quantity involves the “best guess”, the lowest plausible value and the highest plausible value from each expert. Such values could then be quantified via prior distributions, which could be pooled together to inform the distribution of the average opinion. Plausible prior opinion will identify the best value located between the lowest and highest plausible value. The latter form the boundaries of the expert’s credibility interval. The limits of the credible interval are often defined on the basis that any more extreme value has probability of 0.025 of less. The credible interval is then analogous to, albeit not the same as, the 95% confidence interval as in frequentist statistics.

In the case of handover, prior opinions can be elicited for the effectiveness of the intervention for each identified endpoint. Thus, given an incompleteness of information rate currently estimated at 20%, respondents will be asked to provide their best estimate of the incompleteness of information rate (along with the boundaries of the credibility interval), that will be achieved as a result of the planned intervention.

Similarly, given an overall readmission rate of 13%, and a preventable readmission rate of about 2% within first month after discharge, the best estimate and credibility boundaries will be elicited by each expert for the improvement in readmission after the proposed intervention has been implemented.

Finally, considering a current adverse event rate of 19%, of which one third is preventable, the adverse event rate and credible interval after the implementation of the proposed intervention will be elicited from each expert.

It has been argued that the elicitation of such values from experts who are not involved in the development of such an intervention is crucial for the evaluation of the expected effectiveness of the intervention prior to a formal experiment[14]. Khalil argued, albeit with no empirical justification, that the ideal candidate for elicitation is an expert in the general domain (who therefore understands the existing information and the logic of the subject) but who does not have a (psychological) personal stake in the outcome. In any event, we are lucky to have a sample of both types of experts, those who are involved in the development of the intervention and those who are not. This will allow us to compare the two types of prior beliefs that we rely on.
4.2 Team of experts

Data on the effectiveness of the new intervention was collected by interviewing a team of European experts. A first team of experts was selected within the HandOver project among those participating to the Handover meeting in Nice on the 20th of April 2010. Sixteen delegates were interviewed over a set of personal and clinical questions. They can be divided by areas of research in three groups: six were medical doctors; 7 were researchers in the social sciences (i.e. nursing, sociology, education); 3 were researchers in organizational and technological subjects. During the subsequent HandOver meeting in Brussels in October 2010, a team of experts who was not directly involved in the handover project was invited to participate to a set of discussions on the problems related to handover failures, the proposed intervention and on the possible future developments.

The team of experts also represents the ideal source of Bayesian beliefs. A recent publication refers to this phenomenon as the Bayesian fallacy [14], and defines the kind of opinion elicited in Nice as potential conviction, also referred to as wishful thinking. When the exercise was repeated for the second time, the new team of experts, not involved in the development of the intervention, constituted the sample. They could be defined as professionals with domain expertise (i.e. in policy making, public health and health technology evaluations), and high intellect, but no ‘interest’[14].

4.3 Elicitation of expert opinion: data collection form (see appendix)

The intervention/toolbox discussed in section 3.2 was first described. The elicitation exercise was performed twice:

- HandOver Meeting (Nice, France, March, 2010). The expert opinions were elicited on two end points: incompleteness of information rates and readmission rates after one month from discharge.
- HandOver meeting (Brussels, October, 2010). Expert opinions were elicited on readmission rates and adverse event rates. Experts not directly involved with HandOver project were invited to participate.

The elicitation questionnaire was divided into three parts:

1. A “warm-up question” on the shortest cycling distance between Paris and Brussels, knowing that the shortest distance by car was 311 Km.
2. Collection of expert beliefs on the effectiveness of the intervention in the form of Bayesian prior probabilities (see section 4.4). The expert was first asked whether intervention would have a positive effect. Those who responded affirmatively were then asked to quantify the range of the expected reduction (-100% to -75%, -75% to -50%, -50% to -25%, -25% to 0% reduction). Finally respondent was asked to quantify precisely the expected effect of the intervention on attributable risk.
3. Collection of personal information (see Table 5-1 and Table 5-2).

The Elicitation exercise was preceded by an introduction to the Bayesian paradigm and the need to quantify prior opinions for prospective value of information/investment analysis. The questions were explained and the respondents were given a chance to discuss the exercise. The experts were then invited to complete the questionnaires. The authors were available to
answer questions of method during the elicitation exercise. A copy of the elicitation form is available in “Appendix A - Elicitation form” of this report.

4.4 Elicitation of expert opinion: Details of the elicitation exercise

The clinical beliefs on the impact of the complex intervention developed throughout this project were collected over 3 outcomes, of which 2 are considered most relevant: readmission rates and adverse event rates.

4.4.1 End point 1: Readmission rate

For readmission rates, it is assumed that 13% of patients are readmitted within 1 month of discharge, and that in 15% of cases this is the result of failure in handover (i.e. circa 2% of patients are readmitted within 1 month of discharge for failure in handover, see Chapter 2, Table 2.9, Halfon 2002). The first question asks whether the readmission rate due to failure in handover will be lower as a result of the intervention (i.e. lower than the 2% baseline rate, possible answers “yes”, “no”, “don’t know”). In case of positive answer, the respondent is asked to select the range within which the reduced rate will lie: decrease of 0-25%, 25-50%, 50-75% or 75-100%. The second and the third questions are more specific, and ask respondent to identify on the absolute scale (i.e. that measures absolute differences in readmission rate resulting from the intervention). The most likely value for the decrease in readmission rate after the new intervention was then elicited, followed by the lowest and highest plausible values. These are the limits of the credible interval and are often defined on the basis that any more extreme value has probability of 0.025 of less.

4.4.2 End point 2: Adverse event rate

Similarly, for adverse event rates, it is assumed that 19% of patients experience adverse events within 1 month from discharge, and that in 1 of 3 cases this is due to a failure in handover (i.e. 6% of patients present adverse event as a result of failures in handover). The first question, as the case of readmission rates, asked whether the adverse event rate due to failure in handover will be lower as a result of the intervention (i.e. lower than 6%, possible answers “yes”, “no”, “don’t know”). The range in which such a result will lie is also elicited: a decrease of 0-25%, 25-50%, 50-75% or 75-100%. The second and the third question are more specific, and asked respondents to identify on the absolute scale (i.e. that measures the rate after the new intervention) the most likely value for the decrease of adverse events after the new intervention, along with the corresponding lowest and highest plausible values.

4.4.3 End point 3: Incompleteness of information rate

For incompleteness of information, it is assumed that at least one clinically relevant item of information is omitted from the discharge information provided to the community in 20% of cases. A “missing rate” of 20% is considered the base line value. The first question asked whether the new intervention will lower the incompleteness of information rate (i.e. whether the incompleteness of information rate after implementation of the new intervention will be lower than 20%); the answer “don’t know” is allowed for. In case of positive answer, the range in which such rate will lie is also elicited: a decrease of 0-25%, 25-50%, 50-75% or 75-100%, corresponding to a range of incompleteness of information respectively of 15-20%, 10-15%, 5-10% or 0-5% respectively. The second and the third question are more specific,
and asked respondents to identify, on the absolute scale, the most likely value for the decrease of incompleteness of information after the new intervention. Again the lowest and highest plausible values were elicited.

4.5 Quantification of opinions given by each expert by mean of distributions

Once the opinions have been collected they need to be quantified in terms of probabilities and probability density functions. The probability density functions are usually defined over random variables and quantify the probability associated with every possible value of the random variable (i.e. if \( X \) is the random variable and \( x \) is one of its possible occurrences, than \( p(X=x) \) is the probability density function and indicates the probability associated with the occurrence \( x \)). Under the Bayesian paradigm, when a statistical model is defined, its parameters are considered as realizations of random variables, that is a probability density function describes the uncertainty across its plausible values. The questions (see section 4.4) were used to obtain the best guess on the value of \( (\theta_{IT}) \) (i.e. the adverse event rate, readmission rate or incompleteness of information rate) for the \( i^{th} \) expert, and the lower and upper bound within which this best guess might vary \([L_{IT}; U_{IT}]\). T stands for treatment because the current rates for the identified end points (control rates) are given by empirical evidence (i.e. \( \theta_{IC} = \theta_{C} = 0.06 \) for adverse event rate; \( \theta_{IC} = \theta_{C} = 0.02 \) for readmission rate; \( \theta_{IC} = \theta_{C} = 0.20 \) for incompleteness of information rate, as specified in 4.4). The best guess can be interpreted as the mode of the prior distribution of the parameter of interest.

Where the mode was situated near the centre of the two extreme values, the normal distribution was used to calculate probabilities. When the mode was eccentric, a truncated normal distribution was fit to the mode in order to derive probability distribution: more specifically, when the expert opinion was fairly symmetric, one of the sides of the distribution in respect to the mode was less than twice than the other side (i.e. \( 0.5 < \frac{U_{IT}-\theta_{IT}}{\theta_{IT}-L_{IT}} < 2 \)). Where the opinion was clearly not symmetric (\( 0.5 > \frac{U_{IT}-\theta_{IT}}{\theta_{IT}-L_{IT}} > 2 \) or \( 0.5 < \theta_{IT}-L_{IT} < 2 \)), the truncated normal distribution could be used. All distributions were implemented using the software WinBUGS [15] via the package WBDev (WinBUGS Development) [16]. The truncated normal distribution is specified by 4 parameters, the mean of the normal distribution before the truncation (that corresponds also to its mode), the precision as inverse of the variance, and the lower/upper limit of the truncation (see Figure 4-1). Truncation allowed the mode to be where specified by the expert.

Figure 4-1 The normal distribution with mode 0, variance 1, and left truncated at 0, as simulated using winBUGS.
4.6 Methods used to pool the expert opinion

Before pooling prior beliefs together, a crude test for plausibility was performed and implausible priors were excluded. Although support was given during the elicitation exercise, it was on request and some forms contained implausible combinations of values. For example, opinions where the best value was reported to lie outside the credible interval, or failure in indicating either the best guess or the credible interval, were considered implausible.

There is no agreed or axiomatically correct method to pool expert’s opinion. We were guided by Johnson’s [17] methodological review of the methods used for pooling and controlling for potential biases during the elicitation exercise. The opinions of the experts were pooled to obtain the distribution of the average opinion using linear pooling. Linear pooling requires the pooled opinion to be a linear combination of the single elicited opinions: \( \theta_{\text{pooled}} = \sum_{i=1}^{n} w_i \theta_i \), where \( w_i \)'s are the weights assigned to each experts according to the influence that each expert’s opinion should have on the pooled opinion. Equal weights have been assumed (i.e. \( w_i = \frac{1}{n} \), assuming that all expert opinions have the same importance) as base case. However, we also used different weighting to allow for more difference in experience between experts. In this case the choice of weight is quite arbitrary. We have used the expert’s score for their expertise \( s_i \) and (i.e. \( w_i = \frac{s_i}{\sum_i s_j} \); see Table 5-1 and Table 5-2).

If all the opinions could be expressed as normal distributions with a mean \( \mu_i \) and variance \( \sigma_i^2 \), and equal weights were used, then \( \theta_{\text{pooled}} \sim N\left( \frac{\sum_{i=1}^{n} \mu_i}{n}, \frac{\sum_{i=1}^{n} \sigma_i^2}{n^2} \right) \). The distribution of the pooled opinion is not straightforward when the opinions themselves are not assumed distributed as normal, or, as in our case, when truncation has been applied (the distributional asymmetries need to be considered into the pooled opinion). Therefore, the distribution of the pooled opinion was calculated by mean of simulations implementing \( \theta_{\text{pooled}} = \sum_{i=1}^{n} w_i \theta_i \) for each end point, in WinBUGS after all opinion were translated in terms of distributions. Ideally, this process corresponds to \( i. \) extract each opinion from the underlying distribution as elicited from experts; \( ii. \) pool the opinions using linear poling as explained above; \( iii. \) repeat these two points for a sufficiently high number of times; \( iv. \) Use the results from the previous point to build the pooled opinion distribution.

4.7 Sample size calculation

The quantification of the effectiveness of a new intervention to improve the handover of patients from the community to the hospital will need to be measured in a clinical experiment. We base calculations on an individual randomized controlled trial to compare the effectiveness of the new intervention with the current standards accepted rates. We considered the sample size for a parallel randomized controlled trial, at the usual level of significance \( \alpha = 0.05 \), and power \( \beta =80\% \).

The elicitation of prior opinions results in a distribution for \( \theta_T \), the parameter of interest. The variability in \( \theta_T \) can be reflected in the sample size calculation by implementing the formula in a simulation software (i.e. winBUGS), thus obtaining a mean and credible interval for the sample size [18]. This process is explained below.
For the base case we consider the pooled prior distribution and use its centre to construct the alternative hypothesis. The difference between the null and the alternative hypothesis gives the “plausible effect size” ($\Delta$) on which the calculation of the sample size is based. Thus, $\Delta$ is the difference between the rate at the control level, which we assumed to be fixed, and the rate as a result of the intervention, which was elicited from the experts and translated in form of probability density function. Using the software winBUGS, the rate as a result of the intervention could iteratively be sampled from its prior distribution and then plugged into the calculation of the sample size. Finally, the values of the sample size as calculated at each iteration could be used to obtain the distribution of the sample size and, consequently, 95% credible limits could be obtained.

We considered that the elicitation of prior beliefs could produce optimistic prior opinions on the effectiveness of the proposed intervention. Before the elicitation, an ad-hoc sceptical prior, represented by a 10% reduction in attributable risk, was constructed and used for the sample size calculation. This formed the basis for comparison with sample sizes informed by expert beliefs.
Chapter 5. Results of the elicitation exercise

5.1 Experts involved in the development of the intervention, Nice 2010.

Fifty percent of the “experts” interviewed rated themselves either expert (37.5%) or highly expert (12.5%), 12.5% rated themselves moderately expert and the remaining 37.5% rated themselves either lay (31.5%) or highly lay (6.25%). The collection of expert’s opinions was not anonymous, although this report does not include any reference to expert identities.

Only 12.5% of the experts indicated a reduction in incompleteness of information rate of more than 50%, 68% of the experts indicated that a reduction between 25% and 50% was more likely to occur (although it will be shown below that such reduction is much closer to 25% than 50%), and only 19% of the experts indicated a reduction below 25%. For readmission rate experts seemed less optimistic: 62.5% of the experts indicated that the reduction in readmission rate will likely lie between 0% and 25%, and 25% of the experts expressed their belief on the likely reduction between 25% and 50%. Two experts (12.5%) did not answer this question, but gave the best guess and plausible boundaries of the Bayesian elicitation (see below).

Figure 5-2 is a horizontal forrest plot that represents the expert’s opinions (1 to 16), the pooled opinion using equal weights (pooled 1) and expertise adjusted weights (pooled 2), and a sceptical prior that we selected. Opinions are represented as best values (red dots, modes of the normal or truncated normal distribution) and lower (triangle) and upper (square) intervals as indicated by the experts themselves during the elicitation exercise. Opinions above zero on the relative scale (vertical axis on the right) are in favour of the standard intervention (i.e. there is some chance that the new intervention will perform worse than the standard intervention). Opinions below the zero on the relative scale are in favour of the new intervention. All opinions indicated that the new intervention is expected to decrease the end points of the intervention, although some have indicated that there is some chance that the new intervention will not bring any improvement.

After a crude test for plausibility, it was necessary to exclude experts 7, 8 and 15 from the pooled opinion. The first two did not indicate the interval around the best value of either outcome while the other respondent reported the best value outside of the interval.

Linear pooling did not give different results when expertise adjusted weights were used. Overall, the pooled opinions with equal weights (pooled 1 on Figure 5-1 and Figure 5-2) and with adjusted weights (pooled 2 on Figure 5-1 and Figure 5-2) indicated approximately a 25% reduction in readmission rates due to failures in the handover process. As stated above (see section 4.4), 13% of patients are readmitted within one month and circa 2% are readmitted because of failure in handover. The best guess was a 25% reduction in the 2% readmission rate attributable to handover, resulting in a 0.5% reduction in overall readmission rate. Thus, the overall readmission rate is expected to fall from 13% to 12.5%. An almost 30% reduction in incompleteness of information was predicted. In order to balance any over-optimism on the part of the experts, a sceptical prior has been identified for both outcomes (sceptical on Figure 5-1 and Figure 5-2), and it indicated a 10% reduction in readmission due to failures in handover (95% CrI(1.8 to 2.0)) and incompleteness of information (95% CrI(18 to 20)).
## Table 5-1 Level of expertise indicated by the experts, Nice 2010

<table>
<thead>
<tr>
<th>Degree of expertise</th>
<th>Description</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Highly expert</td>
<td>I have a significant prior knowledge about the Handover intervention and/or its evaluation // I was involved in the handover implementation</td>
<td>6 (37.50)</td>
</tr>
<tr>
<td>2 Expert</td>
<td>I have over 10 years experience of health service research or evaluating complex interventions in the UK or beyond</td>
<td>2 (12.50)</td>
</tr>
<tr>
<td>3 Moderately expert</td>
<td>I have over 5 years experience of health service research or evaluating complex interventions in the UK or beyond</td>
<td>2 (12.50)</td>
</tr>
<tr>
<td>4 Lay</td>
<td>I have up to 5 years experience of health service research or evaluating complex intervention in the UK or beyond</td>
<td>5 (31.25)</td>
</tr>
<tr>
<td>5 Highly Lay</td>
<td>I have no prior experience of health services research or evaluating complex interventions in the UK or beyond</td>
<td>1 (6.25)</td>
</tr>
</tbody>
</table>
Figure 5-1 Forrest plots of the experts opinions elicited during the elicitation exercise on the incompleteness of information (Nice, 2010).

![Forrest plots of the experts opinions elicited during the elicitation exercise on the incompleteness of information](image1)

Figure 5-2 Forrest plots of the experts opinions elicited during the elicitation exercise on readmission rate (Nice, 2010).

![Forrest plots of the experts opinions elicited during the elicitation exercise on readmission rate](image2)
5.2 Experts involved in the development of the intervention, Brussels 2010.

The elicitation exercise was repeated during the HandOver Expert meeting in Brussels, where experts with domain expertise, and high intellect, but no ‘interest’ (Khalil, 2010) where interviewed after the toolbox (alpha version) was officially presented to them.

A literature search and discussion within our group indicated that the adverse event rates are likely to be better end points than incompleteness of information rates. Finally, the endpoints on which expert’s opinions were elicited are readmission rates and adverse event rates.

Among the experts interviewed during the meeting in Brussels, 11 (61%) classified themselves highly expert (i.e. with more than 10 years experience in health service research); 3 (18%) experts did not report their identity on the elicitation form. Their opinions were included in the calculation of the distribution of the pooled opinion.

The greatest number of experts expressed a belief that the reduction in both end points would be in the range between 0% to 25% (10 (55%) experts for adverse event rate and 12 (66%) experts for readmission rate). Six (33%) placed the reduction in adverse event rate between 25% and 50% and 5 (28%) the reduction in readmission rate between 25% and 50%. Four (22%) experts did not answer this question and also did not give personal details.

Figure 5-3 shows the Bayesian subjective probabilities relating to readmission rates. The highest reduction on readmission rate related to failures in handover processes was 50% of the attributable risk (on the relative scale). The smallest reduction was 10% of the attributable readmission rate, thus, representing the most sceptical prior. The distribution of the pooled opinion on readmission rate was not very sensitive to the weights given to each expert. The average of the distribution of the pooled opinion using equal weights was 0.5% reduction in attributable readmission rate (about 25% reduction in attributable readmission rate) with credible limits 0.38% to 0.72%. This corresponds to a reduction in overall rate of readmissions from 13% to 12.5%.

Figure 5-4 shows the results of the elicitation exercise for the adverse event rate. The highest “best guess” for a reduction in adverse event rates was 65%. The smallest reduction was 0%, but this respondent placed more probability in favour of the intervention via an asymmetric credible interval. The pooled opinion was again not sensitive to the weights given to experts on the basis of their experience. The average of the prior distribution of the pooled opinion using equal weights for all experts was a 25% reduction in attributable risk from 6% to 4.5%, see Figure 5-6.

Intuitively, patient readmissions and adverse events are likely to be largely correlated end points, since adverse events may result in hospital readmissions. An estimate a priori of such correlations can be obtained by the elicited opinions. Figure 5-7 shows the elicited best values for the two rates in a scatter plot. Such opinions were positively correlated; for example, an expert who indicated a strong reduction after the intervention in readmission rates was also likely to indicate a strong reduction in adverse event rates (correlation 0.58).
Finally, this second group of experts enabled a comparison to be made between the two types of experts (domain experts in Brussels and handover collaboration in Nice). A comparison between the two types of opinion can be done only on readmission rates because the effect of the intervention on this end point was elicited from both groups. This comparison shows no significant differences between the distributions of average opinions (the best guess and credible intervals were similar across those groups).

Moreover, considering that the linear pooling method produces smaller credible intervals as more experts participate to the exercise, and considering that the second group of experts were almost twice the size of the first group, we could say that the average uncertainty indicated by the first group was larger, probably as a result of the lower amount of information available on the toolbox during the first exercise. Thus, a limitation of this comparison is the time between the two elicitations (about 7 months), during which the intervention was finally developed.
Table 5-2 Level of expertise indicated by the experts, Brussels 2010*.

<table>
<thead>
<tr>
<th>Degree of expertise</th>
<th>Description</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Highly expert</td>
<td>I have a significant prior knowledge about the Handover intervention and/or its evaluation // I was involved in the handover implementation</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>2 Expert</td>
<td>I have over 10 years experience of health service research or evaluating complex interventions in the UK or beyond</td>
<td>11 (61.10)</td>
</tr>
<tr>
<td>3 Moderately expert</td>
<td>I have over 5 years experience of health service research or evaluating complex interventions in the UK or beyond</td>
<td>1 (6.05)</td>
</tr>
<tr>
<td>4 Lay</td>
<td>I have up to 5 years experience of health service research or evaluating complex intervention in the UK or beyond</td>
<td>5 (27.80)</td>
</tr>
<tr>
<td>5 Highly Lay</td>
<td>I have no prior experience of health services research or evaluating complex interventions in the UK or beyond</td>
<td>1 (6.05)</td>
</tr>
</tbody>
</table>

* Three anonymous forms were not considered in this table.
Figure 5-3 Results of the elicitation exercise of the attributable readmission rate on a group of experts (Brussels 2010).

Figure 5-4 Results of the elicitation exercise of the attributable adverse event rate on a group of experts (Brussels 2010).
Figure 5-5 Results of the elicitation exercise of the overall readmission rate on a group of experts (Brussels 2010)

![OVERALL RE-ADMISSION RATE](image1)

Figure 5-6 Results of the elicitation exercise of the overall adverse event rate on a group of experts (Brussels 2010)

![OVERALL ADVERSE EVENTS RATE](image2)
Figure 5-7 Scatter plot of the elicited opinions during the HandOver meeting in Brussels, 2010.
Chapter 6. Pre-implementation economic evaluation: headroom analysis.

6.1 A framework for the evaluation of technologies at pre-development phase

The shortage of resources and the increasing costs of health care make health economic evaluation crucial for an optimal allocation of resources [3]. This is standard practice for evaluation of health technologies (i.e. interventions that affect clinical processes, HTA), but is arguably even more important when policy or service interventions are evaluated. In this section we discuss the need to adapt the standard model for health economic used in HTA.

Cost–effectiveness analysis is widely used for the economic evaluation of new technologies. Recently, attention has been drawn to the evaluation of technologies in pre-development phase, also referred to as evaluation at the supply side[13, 19]. Service delivery and policy interventions seldom arrive fully formed from the laboratory. They are generally developed and advanced in “the real world laboratory” of the service itself. This means that the intervention can be evaluated before it is fully developed as a type of integral pilot or a tracker study [20]. The choice to implement the intervention can be conditioned to the fact that interim evaluations and intermediate decision gates will be put in place. Evaluations at the supply side refer to the evaluation of such interventions before their development and subsequent roll out. The key point to consider is that the subsequent availability of decision gates can be taken into account at this initial phase because the decision gate creates the “option value”. Furthermore, the degree of uncertainty (variance in the prior probability) has a large influence on the option value- the mathematics of this issue have recently been explicated by our group [21].

The ideas behind pre-development evaluations are: i. the intervention under evaluation is still an idea; ii. the effectiveness of the intervention is a pure guess. In this case it is not possible to know if the intervention is cost-effective, rather one can aim to know how effective an intervention should be in order to be cost-effective. This reverse approach to economic evaluation is called Headroom analysis [13, 19] which identifies the size of improvement and then cost-effectiveness analysis based on Bayesian prior distribution. In the section that follows we will explain cost-effectiveness analysis at the pre-implementation stage in the context of handover. However, we will not take the option value into account at this stage. This will be included in the final deliverable from the Birmingham team.

6.2 Methods for analysis

A common measure of benefit is the QALY (Quality Adjusted Life Year). This is interpreted as life years weighted by the quality of life (QoL). Quality of life is a measure of utility that an individual experiences in a particular status of health; for example, QoL is 1 for an individual in full health or 0 in case of death.

If an adverse event causes minimal impairment for a period of 5 weeks (0.1 years), so that the QoL in that period is 0.8, then these 5 weeks will be equivalent to 0.08 QALY. Alternatively, we can quantify the disutility in terms of 1-QALY. In the case above, the disutility generated from the minimal impairment is 0.02 QALY.
The cost-effectiveness threshold is defined as the amount of money that the health system is willing to pay for one more QALY after the intervention is implemented. In England the threshold is about 30,000€ (20,000£). However, this may be too generous for a service delivery intervention and we will assume 20,000€ in the subsequent analyses.

The Headroom can be defined as the reduced disutility after the intervention is implemented multiplied by the cost effectiveness threshold, and indicates how much the intervention can cost given the best information available of its effectiveness. The resulting benefits in terms of QALY gained after reducing the disutility due to particular health status can be modelled from such estimate. Headroom (HR) can then be calculated as:

\[ HR = \Delta QALY \times 20,000EUR \]

The gained QALY can be calculated as the reduction in disutility multiplied by the period this reduction refers to

\[ \Delta QALY = (1 - QoL) \times \text{time(years)} \]

This calculation is quite straightforward when all patients are affected in the same way by the intervention. For example, let’s suppose a situation of minimal impairment for 5 weeks for 10 people. This situation results in 0.8 QALY (10 patients x 0.8 QoL x 0.1 years).

Typically, the intervention will help only a proportion of people. For example, the intervention might avoid impairment to 20% of patients, i.e. 2 people avoid minimal impairment. This results in (8 patients x 0.8 QoL x 0.1 years) + (2 patients x 1 QoL x 0.1 years) = 0.84 QALY. The increase in utility is 0.04 QALY, which corresponds to the same amount of decrease in disutility:

\[ \Delta QALY = \frac{(1 \times QoL) - 0.8 \times QoL}{10 \text{ patients}} \times 2 \text{ patients} = 0.04 \]

where the individual disutility is weighted by the proportion of patients who do not experience impairment. In this case the headroom would be 1200€, that is the intervention must cost no more than 120€ per person to prove cost-effective.

### 6.3 Headroom analysis for the Handover Training Toolbox

The headroom analysis can be applied to the Handover Training Toolbox (HTT) in order to assess how much the development of the intervention can cost and still be cost-effective given available information. This information concerns the effectiveness of the intervention elicited from the experts in Brussels and some information on the utility generated by adverse events. Such information can also be obtained either from the literature or from elicitation.

HTA typically allows just two outcomes, years of life and the quality of life during this period. Service delivery interventions, on the other hand, offer a very large range of outcomes. Brennan et al classify the adverse events in categories of disability [22].

Below, we describe such categories and also give the expected level of utility derived by each outcome in terms of time spent in a certain condition and the utility loss during the period:
1. Death, this is considered the most extreme case of disability. Assuming an average life expectancy of 10 years for a 65 year old patient, and the disutility is of 1 QoL for each year of life lost;

2. Permanent with disability of more than 50%. As for death, it is assumed a life expectancy of 10 years and a QoL of 0.4, which corresponds to a disutility of 0.6 QoL per each year of life in this status;

3. Permanent with disability of less than 50%. Similarly, it is assumed a life expectancy of 10 years and a QoL of 0.7, which corresponds to a disutility of 0.3 QoL per each year of life in this status;

4. Moderate impairment, recovery after 6 months. It is assumed an average duration of 1 year in this status at a QoL 0.8, which corresponds to a disutility of 0.2 QoL;

5. Moderate impairment, recovery between 1 and 6 months. It is assumed an average duration of 3 months in this status at a QoL 0.8, which corresponds to a disutility of 0.2 QoL;

6. Minimal impairment, recovery within 1 month at a disutility level of 0.05

Brennan et al also give incidence of such adverse events for a large review or records in a [22]. These incidences are reported in Table 6-1. It must be noted that in 6.5% of cases they were not able to classify the disability level. It seemed sensible to assume these people have a minimal impairment (i.e. the lowest level utility loss was associated with this category).

The following analysis is based on the assumption that the target population presents the adverse events described in Brennan study with the same incidences. Although this publication gives an interesting categorization of adverse events, which allow for utility losses to be easily estimated, the target population of the handover intervention may differ. Sensitivity to these assumptions can be tested by varying the structure of the population.

In case of a plausible 25% reduction in attributable adverse event rate as specified in section 5.2 (i.e. from 19% to 17.5% in the overall rate), the intervention could cost up to a maximum of 495€ per person, which corresponds to a total 23,750,000€ for every 50,000 admissions to a large European hospital. This means that even a smaller effectiveness for the intervention would make it cost effective. For example, a budget to develop of 7,000,000€, implement and maintain such intervention, would be justified against even a reduction of 0.004 in the overall adverse event rate (i.e. 7% reduction of the attributable adverse event rate).

One of the requirements of a headroom analysis is the elicitation of the effectiveness of the intervention in terms of reduction in attributable risk of adverse events. Thus, a distribution of such reduction had been elicited, but only the central values were used in the headroom evaluation. We then implemented the headroom analysis by using WinBUGS to allow the uncertainty in the elicited responses to be reflected in the calculated headroom. Thus, considering 50,000 admissions to hospital, the intervention could cost 23,750,000€ (95% CrI 21,000,000€ to 31,000,000€) given the elicited effectiveness. The credible interval gives a measure of the variation of such costs given the prior opinion. The interpretation is that the estimated headroom will be within such interval at 95% probability, given the information into the prior distribution is true. Obviously this is a guess, but we can say that this is the best guess we have at this stage. As the development will continue and more information will be obtained, such variability will decrease and possibly the true benefit of the intervention will become clearer.
Table 6-1. Deterministic Headroom analysis for adverse event rate

<table>
<thead>
<tr>
<th>HEADROOM ANALYSIS FOR ADVERSE EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data from Brennan 2004 2000 BMJ</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Overall adverse event rate</td>
</tr>
<tr>
<td>Attributable to failures in handover</td>
</tr>
<tr>
<td>Total preventable</td>
</tr>
</tbody>
</table>

<p>| Proportion of | time(years) | Disutility | ΔQALY (per 10,000 people) |</p>
<table>
<thead>
<tr>
<th>attributable adverse</th>
<th></th>
<th>QoL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>not clear</td>
<td>0.066</td>
<td>1/12</td>
<td>0.05</td>
</tr>
<tr>
<td>Death</td>
<td>0.136</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Permanent&gt;50%</td>
<td>0.026</td>
<td>10</td>
<td>0.6</td>
</tr>
<tr>
<td>Permanent&lt;50%</td>
<td>0.039</td>
<td>10</td>
<td>0.3</td>
</tr>
<tr>
<td>moderate impairment, recovery&gt;6mth</td>
<td>0.028</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>moderate impairment, recovery 1 to 6mth</td>
<td>0.137</td>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>minimal impairment, recovery 1 mth</td>
<td>0.568</td>
<td>1/12</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Total disutility:** 990.8

**Disutility per person:** 0.099

\[
HR=0.099\times20,000€=1,980€ \quad (\text{maximum cost person of the intervention at 100\% relative reduction})
\]

\[
HR=198€ \quad (\text{maximum cost person of the intervention at 10\% relative reduction, sceptical})
\]

\[
HR=495€ \quad (\text{maximum cost person of the intervention at 25\% relative reduction, plausible and elicited})
\]

\[
HR=990€ \quad (\text{maximum cost person of the intervention at 50\% relative reduction})
\]
Chapter 7. Discussion and recommendation

7.1 Conclusions of this study - the economic evaluation

The quantification of the expected benefit of an intervention at the pre-implementation stage is a complex process. Major difficulties arise from the lack of direct comparative data such as that from head to head trials.

Instead, effectiveness has to be estimated using indirect data. Information used for this purpose include a complete description of the intervention, an understanding of the theory behind the intervention, identification of end points that may be effected by the intervention. It is absolutely necessary to describe the base line rates for selected end points and to understand attributable risk. By attributable risk we mean the proportion of end points that result from failure of the process at which the intervention is targeted. Estimating the effectiveness of interventions can also be assisted by “borrowing strength” from the effect of similar interventions aimed at different processes of different intervention aimed at the same process. All these feed into the estimation of the expected effectiveness of the intervention. The expected effectiveness can be obtained using Bayesian techniques for the elicitation of prior beliefs and their quantification via prior distributions of probability. The Bayesian paradigm allows parameters such us readmission rate or adverse event rate to be considered as random variables (i.e. uncertainty around their estimate can be expressed by means of probability). The Bayesian estimation can be used in an economic evaluation called headroom analysis that aims to determine whether is plausible that an intervention will be cost-effective. If the intervention passes this “plausibility test”, then a more complete supply side health economic model can be constructed.

Pre-implementation evaluation, like value of information analysis, is completely dependent on subjective probabilities. Prior belief represents the only source of information on the effect of intervention that have not been implemented. Arguably, such prior belief estimation should be obtained from people who are experts in the domain, but are not intimately involved in the intervention, as discussed in Chapter 3. We finally believe that such experts should be “equipped” by both ground information and indirect information as cited above.

Although experts were all optimistic on the effect that the intervention can have on the attributable risks, such beliefs represented small reductions in the overall effects of the proposed end points. This resulted in bigger sample sizes for hypothetical trials (before and after study or individual randomised clinical trial). For interventions on service delivery, such as the proposed toolbox, cluster trials will be needed since it will not be possible to hypothecate the tool at individual patients.

Even bigger sample sizes than those indicated above, are likely to be needed and the problem would be magnified if it was felt that results are likely to be very context specific, such that, for example, they needed to be replicated in different countries.

The magnitude of the expected effect of the proposed intervention is small but the model shows that such an effect would nevertheless be cost-effective. In fact, the pooled prior belief yields a result wall within the cost-effectiveness threshold.
Our evaluation was not restricted to any particular population. However, the method we have used could be applied to evaluate the headroom of the intervention for special groups of patients such as geriatric patients or heart failure patients, which are characterised by higher base line rates and are supposed to be more sensitive to this type of intervention.
7.2 Future work

7.2.1 A framework for the evaluations of interventions at pre-implementation stage

The intervention was designed to work across Europe, which is a heterogeneous federation of countries that are characterised by diverse cultures, economies and health systems. The clinical and economic impact of the proposed intervention will be likely to be different across those countries. Our team is in charge of evaluating the intervention from an economic perspective. Our future work will focus on the measurement of the expected resource use that the proposed intervention will have across different European countries. This will involve the definition of a number of different sub-interventions deriving from the implementation of the proposed intervention (i.e. training sessions supported by the toolbox) and their costing under different country-specific settings. Such sub-interventions will represent benchmarks for the evaluation of the value of investment/information for the comparison with the possible alternatives which may become available (i.e. option value at pre-implementation stage). This analysis will be included in deliverable 11 (due by 30th of Sept. 2011). We will also be collaborating closely with other handover members to consider the design of an evaluation study.

7.2.2 Future trials and sample size calculation

Here, we propose a sample size calculation based on the elicited prior probabilities for reductions in adverse event and readmission rates. The sample sizes (n) refer to the number of individuals in each group of a randomised parallel clinical trial.

Table 7-1 lists sample sizes based on the opinion of each expert interviewed in Brussels (2010). We have then followed a Bayesian approach to the calculation of sample sizes in which the effect size is treated as a random variable [18]. The calculation of the sample size was implemented in WinBUGS and all the uncertainty in the prior opinion is reflected in the credible interval for the sample size. Prior distributions were used to build the alternative hypothesis of a reduction in the end point of interest resulting from the intervention.

Consider, for example, readmission rates. The null hypothesis is that the overall readmission rate would not change after the intervention (i.e. remains at 13%). Using the pooled opinion to build the alternative hypothesis (i.e. the readmission rate after the intervention decrease to 12.5%), a sample size of 56,090 patients in each group would be needed. Because we also elicited the variability around the readmission rate as a result of the implementation of the intervention, we can then include this variability into this estimate as already explained in section 4.7. The 95% credible interval yields sample size of 32,890 to 117,500. Similarly, considering a sceptical prior this suggests that 435,000 individuals (95%CrI 108,900 to 35,043,000) per group should be sampled. These sample sizes are quite large and are characterised by wide uncertainty which raise doubts on the feasibility of a trials to evaluate such intervention. However, the situation regarding adverse event rate is more propitious requiring 9,366 individuals (95%CrI 6,451 to 14,680) per group. However, as soon as a sceptical prior effect is considered for adverse events, the suggested sample size increases to 62,540 individuals per group (95% CrI 15,950 to 3,815,000). In conclusion, a clinical trial based on adverse event rate would require much small sample sizes but more intensive examination of each case to determine whether or not an adverse event had occurred.
Evaluating readmission requires larger samples but each case is easier and cheaper to evaluate since readmission can be observed from routinely collected data.
Table 7-1 Expert’s beliefs informed estimation of the sample sizes, for each group of a parallel randomised controlled trial, at the usual significance level ($\alpha=0.05$) and power ($\beta=0.80$), for the two outcomes of interest. (i.e. an estimate of total number of patients in the trial can be calculated by doubling the group specific sample size). In case of multicentre study, then the trial sample size needs to be multiplied by the number of centres available.

<table>
<thead>
<tr>
<th>Expert’s beliefs</th>
<th>Readmission rate</th>
<th>Adverse event rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>median sample size (95% CrI)</td>
<td>median sample size (95% CrI)</td>
</tr>
<tr>
<td>1</td>
<td>16,710 (5,173 to 392,800)</td>
<td>15,650 (3,729 to 1,499,000)</td>
</tr>
<tr>
<td>2</td>
<td>157,900 (14,830 to 75,480,000)</td>
<td>6,973 (1,990 to 252,300)</td>
</tr>
<tr>
<td>3</td>
<td>259,800 (24,750 to 118,400,000)</td>
<td>82,170 (9,736 to 51,130,000)</td>
</tr>
<tr>
<td>4</td>
<td>17,560 (4,960 to 1,530,000)</td>
<td>3,795 (1,489 to 19,360)</td>
</tr>
<tr>
<td>5</td>
<td>88,030 (10,080 to 44,440,000)</td>
<td>9,811 (1,886 to 2,119,000)</td>
</tr>
<tr>
<td>6</td>
<td>95,260 (8,803 to 34,020,000)</td>
<td>33,130 (3,104 to 18,730,000)</td>
</tr>
<tr>
<td>7</td>
<td>37,200 (13,430 to 355,400)</td>
<td>1,513 (974 to 2,671)</td>
</tr>
<tr>
<td>8</td>
<td>18,610 (4,565 to 5,319,000)</td>
<td>2,396 (953 to 13,690)</td>
</tr>
<tr>
<td>9</td>
<td>103,900 (14,660 to 1,313,000)</td>
<td>36,340 (4,532 to 11,450,000)</td>
</tr>
<tr>
<td>10</td>
<td>18,950 (4,381 to 9,784,000)</td>
<td>2,923 (1,267 to 77,970)</td>
</tr>
<tr>
<td>11</td>
<td>45,240 (7,815 to 13,240,000)</td>
<td>6,760 (1,947 to 271,900)</td>
</tr>
<tr>
<td>12</td>
<td>135,000 (14,330 to 71,430,000)</td>
<td>37,510 (3,472 to 13,800,000)</td>
</tr>
<tr>
<td>13</td>
<td>177,000 (17,800 to 83,600,000)</td>
<td>53,240 (4,949 to 32,060,000)</td>
</tr>
<tr>
<td>14</td>
<td>64,980 (9,290 to 25,160,000)</td>
<td>10,020 (2,306 to 1,211,000)</td>
</tr>
<tr>
<td>15</td>
<td>170,500 (14,660 to 1,313,000)</td>
<td>1,644 (848 to 4,236)</td>
</tr>
<tr>
<td>16</td>
<td>238,200 (23,910 to 133,700,000)</td>
<td>54,980 (7,739 to 27,510,000)</td>
</tr>
<tr>
<td>17</td>
<td>58,680 (7,479 to 19,970,000)</td>
<td>22,480 (3,812 to 5,543,000)</td>
</tr>
<tr>
<td>18</td>
<td>144,700 (14,610 to 66,640,000)</td>
<td>22,820 (3,784 to 7,215,000)</td>
</tr>
<tr>
<td>19</td>
<td>67,700 (10,680 to 21,850,000)</td>
<td>9,933 (2,703 to 466,900)</td>
</tr>
<tr>
<td>20</td>
<td>34,150 (5,436 to 14,130,000)</td>
<td>9,787 (2,096 to 1,700,000)</td>
</tr>
<tr>
<td>21</td>
<td>26,730 (6,948 to 1,950,000)</td>
<td>16,000 (2,888 to 3,411,000)</td>
</tr>
<tr>
<td>22</td>
<td>7,270 (4,203 to 11,290)</td>
<td>9,829 (2,014 to 1,248,000)</td>
</tr>
<tr>
<td>23</td>
<td>35,030 (6,940 to 6,233,000)</td>
<td>5,586 (1,899 to 58,130)</td>
</tr>
<tr>
<td>24</td>
<td>220,300 (20,280 to 108,200,000)</td>
<td>22,850 (3,845 to 7,007,000)</td>
</tr>
<tr>
<td>pooled 1</td>
<td>56,090 (32,890 to 117,500)</td>
<td>9,366 (6,451 to 14,680)</td>
</tr>
<tr>
<td>pooled 2</td>
<td>55,100 (30,840 to 125,200)</td>
<td>9,969 (6,619 to 16,590)</td>
</tr>
<tr>
<td>sceptical</td>
<td>435,100 (108,900 to 35,430,000)</td>
<td>62,540 (15,950 to 3,815,000)</td>
</tr>
</tbody>
</table>
7.2.3 Attributable risk and sample sizes

The systematic review (section Chapter 2) showed that almost all individual trials of interventions to improve handover yielded a null result. However, certain meta-analyses of systematic reviews of similar interventions yielded a result that was significant at the p=0.05 level. In the case of the Cochrane review of discharge planning, analysis of 12 trials yielded a typical relative risk of 0.85 –a 15% reduction in risk of readmission (Table 2.3). These studies included 2,612 participants and the absolute risk reduction was 4.6 percentage points (a median reduction of 3 month readmission rates from 30.5 to 25.9%). If the same proportion 15% reduction was extrapolated to the 13% within our study, then the intervention readmission rate would be 11%. This is a larger reduction then the estimated plausible improvement elicited from experts in Brussels – the pooled median improvement here was 0.5 percentage point (from 13% to 12.5%). In fact, the 2 percentage point observed in the Cochrane review would account for the full cases readmitted according to Halfon. However, Halfon may have under-estimated the proportions of readmissions that are preventable since he used case note review and this method may overlook come problems, such as those missing from poor communication between clinicians and patients. In the sensitivity analysis we assume:

1. that 13% of cases are readmitted within one month as per Halfon;
2. the relative risk reduction is 25% as suggested by pooling expert priors, with credible limits as before
3. the attributable risk is not 15% of readmissions within one month (as suggested by Halfon), but 33% as suggested by Balla (2008).

In Figure 7-1 we recalculate the sample sizes required for a proposed randomised controlled trial. This figure also shows that the required sample size is very sensitive to different assumptions about attributable risk.
Figure 7-1 Sample size calculated for readmission rate, assuming the same overall readmission rate of 13%, the same expected reduction of 25%, but different quota of attributable risk.
7.3 Relevance of this work to future innovation and health policy

This work has relevance for the future innovation and evaluation of the proposed intervention. In this report, all the uncertainty around the effectiveness of the toolbox was taken into account and used to define its expected efficiency in terms of future return on investment. We are defining the benchmarks within which this intervention would need to operate in order to affective and efficient. Moreover, the use of virtual tools (i.e. software and internet based applications) is spreading in service delivery and policy interventions. Our methodologies for the evaluations at the supply side can be applied to any type of intervention that aims to improve health policy related outcomes.

This report has defined for the first time a clear framework for the evaluation of new technologies during the earlier phases of their life (from conception to implementation). An article is being written to develop this argument and will shortly be submitted for publication. A similar pathway was presented by Cosh et al [13], who have defined the decision gates which a new technology may undergo during its development. We aim to focus on the practical and theoretical value of different techniques during the pre-implementation stage of the life of a new technology, and define when and how such methodologies should be used.

7.4 Limitations of this study

One very important limitation of this study is the uncertainty around the effectiveness and effects of the intervention. Unfortunately, not many European studies exist to define the overall risk of the defined endpoints and the risk attributable to failures in handover. The majority of significant work has been done in USA and Australia and other non European countries. However, the sensitivity analysis has been used as the most sensible tool to account for such possible differences.

The methods used in this report to assess the expected cost-effectiveness of the interventions aim to account for the great uncertainty around the intervention itself. This uncertainty is an obvious limitation to decision making, and for this reason we advocate the need for multiple analyses during the early life of such interventions which represent decision gates at which new information is included. Uncertainty should decrease as a result of such new information deriving from experimental data, and resources can be directed toward the development of those methods that appear to be the most cost-effective.

Therefore, our analysis needs to be considered as an indication based on the best available information at this stage of the development of the proposed intervention. For these reasons, the economic headroom was not calculated at the optimistic side of the prior expected effectiveness of the proposed intervention, but at its centre, and credible intervals were given to account for full uncertainty in such estimates.
References


References of the literature review (Chapter 2)


Mistiaen P, Francke AL, Poot E. Interventions aimed at reducing problems in adult patients discharged from hospital to home: a systematic review. BMC Health Services Research 2007;7:47.


Outpatient Service Trialists. Therapy-based rehabilitation services for stroke patients at home. Cochrane Database of Systematic Reviews 2003: CD002925.


Acknowledgments

We acknowledge Peter Chilton, research fellow at the University of Birmingham, for the support given to the elicitation exercise performed in Nice in April 2010.

We also acknowledge the contribution of all the experts who participated to the meeting in Brussels and that played the elicitation exercise with us.

Finally, we thank the members of the Handover project for having undertaken the elicitation exercise in diverse moments of the last year of project, and for their contribution to the improvement of the elicitation form.
Appendix A - Elicitation form

Bayesian elicitation for the effectiveness of a complex intervention to improve clinical handover in Europe.

Let us suppose you are planning to cycle from Brussels to Paris and want to know the cycling distance on the quickest route, given that by car the quickest route measures 311Km.

a. What is your best guess about the quickest cycling distance between Brussels and Paris?

Please mark an X showing your best guess on the scale below.

```
Absolute

  |   |   |   |   |   |   |   |   |   |   |   |   |   |
  0  80 150 230 311 450 600 Km

Current (control) level
```

b. Please, it is very important that you indicate your lowest and highest plausible estimates\(^1\) on both sides of your best guess above (using the same scale).

OUR GROUP MEMBERS ARE LOOKING FORWARD TO HELPING.

\(^1\) By lowest and highest plausible changes we mean an effect size roughly at the extreme 2.5% and 97.5% limits (i.e. bands on your 95% credible intervals)
Let us say that 13% of acute medical patients are re-admitted to hospital one month after discharge, and that in one case out of seven this is due to failure in handover (i.e. in a hospital where there is a readmission every day, one readmission per week is due to a handover problem). This would mean that circa 2% of patients are re-admitted because of a handover problem.

1. Do you think that this intervention will work so that 2% readmission rate is reduced?

   Yes ☐  No ☐  Don’t know ☐

   ii. If you answered ‘yes’, then do you think that this decrease will be:

   Please tick the box that is closest to your best guess

   A decrease of up to 25% (i.e. 2% to 1.5% re-admitted) ☐
   A 25% - 50% decrease (i.e. 1.5% to 1% re-admitted) ☐
   A 50% - 75% decrease (i.e. 1% to 0.5% re-admitted) ☐
   A 75% - 100% decrease (i.e. 0.5% to 0% re-admitted) ☐

2. What is your best guess about the decrease or increase in readmission as a result of the proposed intervention?

   Please mark an X showing your best guess on the scale below.

   Absolute

<table>
<thead>
<tr>
<th>0%</th>
<th>1%</th>
<th>2%</th>
<th>3%</th>
<th>4%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   Current (control level)

3. Please indicate your lowest and highest plausible estimates\(^2\) on both sides of your best guess above (using the above scale).

\(^2\) By lowest and highest plausible changes we mean an effect size roughly at the extreme 2.5% and 97.5% limits (i.e. bands on your 95% credible intervals)
Let us say that 19% of acute medical patients experience adverse events and that in one case out of three this is due to failure in handover. This would mean that circa 6% of patients experience adverse events because of a handover problem.

4. Do you think that the intervention will reduce the 6% rate of avoidable adverse events?

Yes [ ] No [ ] Don’t know [ ]

ii. If you answered ‘yes’, then do you think that this decrease will be:

Please tick the box that is closest to your best guess

A decrease of up to 25% (i.e. 6% to 4.5% re-admitted) [ ]

A 25% - 50% decrease (i.e. 4.5% to 3% re-admitted) [ ]

A 50% - 75% decrease (i.e. 3% to 1.5% re-admitted) [ ]

A 75% - 100% decrease (i.e. 1.5% to 0% re-admitted) [ ]

5. What is your best guess about the decrease or increase in adverse events as a result of the proposed intervention?

Please mark an X showing your best guess on the scale below.

Absolute

0% 3% 6% 9% 12%

Current (control) level

6. Please indicate your lowest and highest plausible estimates\(^3\) on both sides of your best guess above (using the scale above).

---

\(^3\) By lowest and highest plausible changes we mean an effect size roughly at the extreme 2.5% and 97.5% limits (i.e. bands on your 95% credible intervals)
Having read the information above and taking into account your previous knowledge and experience, how expert do you think your opinion on the Handover intervention will be, on a scale of 1–5 (please mark the statement that most applies):

- **1 – Highly Expert** (e.g. I have significant prior knowledge about the Handover intervention and/or its evaluation // I was involved in the Handover implementation)
- **2 - Expert** (e.g. I have over 10 years experience of health services research or evaluating complex interventions)
- **3 - Moderately Expert** (e.g. I have over 5 years experience of health services research or evaluating complex interventions)
- **4 - Lay** (e.g. I have up to 5 years experience of health services research or evaluating complex interventions)
- **5 – Highly Lay** (e.g. I have no prior experience of health services research or evaluating complex interventions)

We would be grateful if you could also provide the following information:

<table>
<thead>
<tr>
<th>Your Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td></td>
</tr>
<tr>
<td>Email</td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
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<tr>
<td>Discipline</td>
<td></td>
</tr>
<tr>
<td>Title / position</td>
<td></td>
</tr>
</tbody>
</table>

THANK YOU VERY MUCH FOR YOUR TIME!

If you could please return your completed questionnaire to Nicola at the end of this session.

--- Contact us ---

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