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Are educational interventions to prevent catheter-related bloodstream infections in intensive care unit cost-effective?

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SUMMARY

Background: There is increasing interest in evidence-based educational interventions in central venous catheter care. It is unclear how effective these are at reducing the risk of bloodstream infections from the use of intravascular catheters (catheter-BSIs) and the associated costs and health benefits.

Aim: To estimate the additional costs and health benefits from introducing such interventions and the costs associated with catheter-BSIs.

Methods: A comprehensive epidemiological and economic review was performed to develop the parameters for an economic model to assess the cost-effectiveness of introducing an educational intervention compared with clinical practice without the intervention. The model follows the clinical pathway of cohorts of patients from their admission to an intensive care unit (ICU), where some may acquire catheter-BSI, and estimates the associated costs, mortality and life expectancy.

Findings: The additional cost per catheter-BSI episode was £3940. The results of this model demonstrate that introducing an additional educational intervention to prevent catheter-BSI improved patient life expectancy and reduced overall costs.

Conclusion: Introducing evidence-based education is likely to reduce the incidence of catheter-BSI and the model results suggest that the cost of introducing the interventions will be outweighed by savings related to reduced ICU bed occupancy costs.

Introduction

Bloodstream infections resulting from the use of intravascular catheters (catheter-BSIs) are the most frequent infection in intensive care unit (ICU).[1] Catheter-BSIs increase patients' length of stay in hospital and their risk of health complications and death. They also impose an associated burden on health

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services resources.[1] However, there is growing evidence that these infections are preventable through the use of evidence-based educational interventions, potentially leading to best practice being employed by ICU staff. The Keystone ICU project, a multi-component educational intervention conducted in 103 ICUs predominantly in Michigan, USA, more than halved catheter-BSI incidence.[2] The intervention was a central venous catheter care (CVC) bundle that encompassed education together with five elements: optimal hand hygiene, chlorhexidine skin antisepsis, maximal barrier precautions for catheter insertion, choice of optimal insertion site, and prompt catheter removal. This approach has since been replicated with similar initiatives in the UK (Matching Michigan) and Australia (CLAB ICU project).[3,4]

The evidence for the effectiveness of single and multi-module interventions to prevent catheter-BSI has recently been reviewed, but uncertainty remains around the likely costs and health benefits associated with bundle interventions.[5] An economic model is a simplified mathematical representation of the clinical pathway and is a useful tool to synthesize evidence on health consequences and costs from many different sources in order to inform health decision-makers about clinical practices and healthcare resource allocations.[6,7] This article describes the model developed for the UK Health Technology Assessment Programme to synthesize the health and cost consequences of introducing a multi-component educational intervention (CVC care bundle) to catheter-BSI prevention.

Methods

Economic model

As no previous relevant economic model existed, we developed a model to estimate the costs, health benefits and cost-effectiveness of implementing a CVC care bundle for preventing catheter-BSI in adult patients in ICUs in England and Wales compared with current clinical practice. The CVC care bundle in this analysis replicated the original US Keystone ICU project approach, with data parameters from the Matching Michigan programme in the UK, and the CLAB ICU project.[2–4] Current clinical practice was defined as clinical care that did not implement all elements in the CVC care bundle.

The decision-analytic model follows hypothetical cohorts of patients, who receive the CVC care bundle or receive current clinical practice, from ICU admission for the remainder of their lifetime, and estimates the costs during hospital stay and the subsequent life expectancy and quality of life.[7] The economic evaluation was from the perspective of the UK National Health Service (NHS). The health benefits were discounted to give a time preference to costs and health outcomes that happen in the near rather than distant future, at 3.5% per year, as recommended by the National Institute for Health and Clinical Excellence.[8] The base price year for the costs was 2011. Where necessary, costs were inflated to that year using the Inflation Indices from the Unit Costs of Health and Social Care.[9]

The numbers of ICU patients infected with catheter-BSI depend upon the incidence rate, the proportion of patients with a CVC and the effectiveness of the intervention (CVC care bundle or current clinical practice) for preventing infections. Patients may die during their hospital stay and the risk of mortality is greater for those with catheter-BSI. Furthermore, patients' length of stay (LOS) in hospital is greater for those with catheter-bloodstream infection (BSI). This model estimates the number of people who contract catheter-BSI, those who die in hospital and the total LOS for the two cohorts. The long-term survival of patients after discharge from the ICU is estimated using a simple Markov model with states for alive and dead.[7] Quality of life is included in the model by estimating quality-adjusted life years (QALYs) by adjusting lifetime survival using patient health-state utility values, which vary between 0 for death and 1 for perfect health.[7] The model is used to calculate costs for each cohort, including those for hospital stay, the treatment and diagnosis of the catheter-BSI infections and the costs of implementing the CVC care bundle.

Several simplifying assumptions were made in the model structure due to lack of data. For the purposes of the model, we assumed that catheter-associated BSI (CABSI) and catheter-related BSI (CRBSI) were synonymous and were collectively referred to as catheter-BSI.[10] It was assumed that the catheters were inserted or removed mainly within the ICUs and that no multiple catheterizations existed. The consequences of catheter-BSI were also assumed not be dependent on age, disease severity or causative micro-organisms. It was assumed that mortality rates during the hospital stay following intensive care discharge, and after hospital discharge, did not differ between patients who had catheter-BSI in the ICU and those who did not.

One-way deterministic sensitivity analyses were performed by varying one parameter at a time, from its base case value, leaving all other variables unchanged. The ranges used were from the confidence intervals from the primary data. The sensitivity analyses investigated the effect of uncertainty around the model assumptions, structure and parameter values on the cost-effectiveness results, in order to highlight the most influential parameters and to test the robustness of the cost-effectiveness results.

Multi-parameter uncertainty in the model was addressed using probabilistic sensitivity analysis (PSA).[11] In the PSA, probability distributions were assigned to point estimates of all parameters used in the base case analysis. The model was run for 1000 iterations, with a different set of parameter values for each iteration, by sampling parameter values at random from their probability distributions. The parameters included in the PSA, the distribution used for sampling each parameter, and the upper and lower limits assumed for each variable are reported in Table I.

Data sources

Data used in the economic model were identified through a systematic review of the clinical effectiveness of the educational intervention, literature searches, and through discussion with clinical experts (Table II).[5] For the purposes of our analyses, we have used the baseline incidence of catheter-BSI in the model to reflect clinical practice without implementation of the CVC care bundle for the most recent UK period available, i.e. before the introduction of the Matching Michigan intervention.[3]

The effectiveness of a CVC care bundle was based upon a systematic review.[5] There were no UK data available, at the time of the analysis, and we considered the 'CLAB ICU' study in Australia to be the most appropriate for use in the economic model, as it was a good methodological study with multiple centres, specifically intended to replicate the original US