Cost-effectiveness analysis of telemedicine to evaluate diabetic retinopathy in a prison population

Aoki N, Dunn K, Fukui T, Beck J R, Schull W J, Li H K

Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The study compared two screening strategies, teleophthalmology and non-teleophthalmology, for detecting diabetic retinopathy in prison inmates with Type 2 diabetes.

The teleophthalmology strategy used a hypothetical teleophthalmology system designed by an ophthalmologist at the University of Texas Medical Branch at Galveston (UTMB). Under this strategy, the patient's vision is evaluated using the Snellen chart and pinhole and patients are imaged using a Topcon store-and-forward telemedicine system. Screening and follow-up evaluations were performed using teleophthalmology, as described. The patients received periodic telemedicine evaluation based on the severity of retinopathy. A patient received pan-retinal laser photocoagulation if proliferative retinopathy was detected, or focal laser photocoagulation if clinically significant macular oedema was detected. The reader is referred to the paper for a precise description of the system.

In the non-teleophthalmology group, screening was performed directly by eye care providers in the authors' setting (UTMB). Many patients would receive periodic evaluation, but others might not receive diagnostic and therapeutic effort until they experienced decreased vision from complications due to proliferative retinopathy or clinically significant macular oedema.

Type of intervention
Screening.

Economic study type
Cost-utility analysis.

Study population
As this was a modelling study, the authors chose a 40-year-old African-American male with Type 2 diabetes as the reference type. A hypothetical cohort of 750 inmates was used for the base-case analysis. The characteristics of the population were described in another study (Baillargeon et al. 2000, see ‘Other Publications of Related Interest’ below for bibliographic details). No further exclusion or inclusion criteria were reported.

Setting
The setting was various prison units in East Texas area and the Texas Department of Corrections Eastern Regional Medical Facility. The economic study was carried out in the USA.

Dates to which data relate
The effectiveness data were derived from studies published between 1985 and 2003. The dates of some cost data were not reported, while other cost data were derived from sources published between 1992 and 2000. All costs were reported for the price year 2003.
Source of effectiveness data
The effectiveness data were derived from a review and synthesis of completed studies, and also authors’ assumptions.

Modelling
A Markov model was constructed to compare the two strategies in terms of their costs and clinical effectiveness. The time horizon of the model equalled the patients’ lifetime, and the duration of each cycle was 1 month. The different health states of the model were no retinopathy (NR), nonproliferative retinopathy (NPDR), clinically significant macular oedema (CSME), proliferative retinopathy (PDR), legal blindness (defined as visual acuity of <20/1,000 in the better eye) and death. A patient with PDR or CSME could progress to legal blindness with or without photocoagulation. In each health state the patient could progress to death. The duration of each health state was assumed: NR 12 months, PDR 3 months, CSME 3 months and NPDR 6 months. Transition probabilities were converted from rates using the DEALE (declining exponential approximation of life expectancy) method.

The model was based on several assumptions. First, the total number of patients with diabetes in a targeted prison was 750 (estimated according to prevalence of diabetes and average number of prison inmates. Second, in the target population, 25% of examined patients were assumed to have been screened with teleophthalmology. Finally, the proportion of patients subsequently being screened with teleophthalmology was assumed to be 75%.

Outcomes assessed in the review
The following input parameters were used in the model:

the prevalence of NR, NPDR and PDR;

the annual transition probabilities of progression from NR to NPDR, from NPDR to PDR, from NPDR to CSME, from PDR to legal blindness with and without photocoagulation, and from CSME to legal blindness with and without photocoagulation;

the annual probabilities of death when having NR, NPDR, PDR or CSME;

the sensitivity and specificity of screening tests in the non-teleophthalmology (face-to-face examination) and teleophthalmology (digital image evaluation) strategies in detecting NPDR, PDR and CSME; and

the percentage of patients examined using non-teleophthalmology and teleophthalmology.

Study designs and other criteria for inclusion in the review
The authors included large long-term cohort studies and published clinical guidelines in their review. They do not seem to have used strict study design criteria for inclusion in the review.

Sources searched to identify primary studies
Not reported.

Criteria used to ensure the validity of primary studies
Not reported.

Methods used to judge relevance and validity, and for extracting data
The authors do not seem to have used any methods to judge the relevance and validity of the data.

Number of primary studies included
Fourteen primary studies provided effectiveness evidence.

**Methods of combining primary studies**
Most of the primary studies were not combined.

**Investigation of differences between primary studies**
The authors did not investigate any differences between the primary studies.

**Results of the review**
The prevalence of NR was 0.741.

The prevalence of NPDR was 0.254.

The prevalence of PDR was 0.005.

The annual transition probability was:
from NR to NPDR, 0.065;
from NPDR to PDR, 0.116;
from NPDR to CSME, 0.115;
from PDR to legal blindness with photocoagulation, 0.017,
from PDR with legal blindness without photocoagulation, 0.088;
from CSME to legal blindness with photocoagulation, 0.015; and
from CSME to legal blindness without photocoagulation, 0.050.

In the non-teleophthalmology group, the sensitivity of CSME was 0.82 and the specificity was 0.79.

In the teleophthalmology group, the sensitivity of CSME was 0.88 and the specificity was 0.94.

Other characteristics of the screening tests were described in detail in the paper.

**Methods used to derive estimates of effectiveness**
The authors made assumptions, based on the available medical literature, to derive some estimates of effectiveness.

**Estimates of effectiveness and key assumptions**
Based on medical literature, the authors assumed that the relative benefit of treatment versus no treatment was permanent. The frequency of evaluation for each stage of retinopathy was based on clinical recommendations provided by the American Academy of Ophthalmology. NPDR was assumed to last 6 months.

**Measure of benefits used in the economic analysis**
The authors used quality-adjusted life-years (QALYs) as a measure of benefit in the economic analysis. The utility values assigned to legal blindness were derived from a published study that used a standard gamble approach. The authors also assessed the percentage of patients reaching blindness in each group. The health benefits were discounted at an annual rate of 3%.
Direct costs
Adopting a health care system perspective, the following costs were included in the analysis:

- the initial cost of teleophthalmology (including the costs of devices, training and overheads);
- the annual cost of teleophthalmology (including human resources, equipment maintenance and overheads);
- fundus photograph evaluation costs;
- transportation costs (for transferring images to the teleophthalmology centre from satellite prisons);
- face-to-face examination costs; and
- the transportation fee (including actual cost of transportation, fee for guardians and one-night stay costs).

Also included in the analysis were the costs for pan-retinal photocoagulation and focal photocoagulation, and the annual cost of care for legally blind patients over and under the age of 65 years. The unit costs were not reported as the authors used summary costs. As the time horizon of the model was the patients’ lifetime, the costs were appropriately discounted at a rate of 3%. Most of the costs were based on actual data and were reported for the price year 2003.

Statistical analysis of costs
The costs were treated deterministically.

Indirect Costs
The indirect costs were not included in the analysis.

Currency
US dollars ($).

Sensitivity analysis
The authors conducted a probabilistic sensitivity analysis. Using first-order Monte Carlo simulations, they tried to explore variation among individual patients using a hypothetical cohort of 10,000 diabetic inmates based on the age, gender and ethnicity distribution of the Texas prison system. Using second-order Monte Carlo simulations, the authors explored variability in the data and applied case-mix in the decision analysis. Each variable was derived from its probability distribution and the simulation was run 10,000 times. In these simulations, the authors used a log normal distribution for the cost of blindness and a normal distribution for the cost of photocoagulation and the examination cost. The authors also carried out a one-way sensitivity analysis on all input parameters of the model, and a two-way sensitivity analysis to estimate clinically influential combinations of parameters.

Estimated benefits used in the economic analysis
The teleophthalmology strategy resulted in an average of 18.73 QALYs and the non-teleophthalmology strategy in an average of 18.58 QALYs.

In the teleophthalmology strategy, 12.4% of patients reached blindness versus 20.5% in the non-teleophthalmology strategy. The absolute risk reduction for blindness was 8.1%. The number-needed-to-screen was 12.4, which means 12.4 prisoners need to be evaluated by teleophthalmology to prevent one case of blindness using reference data.

Cost results
The cost results were reported per patient. The total cost per patient was $16,514 in the teleophthalmology group and...
$17,590 in the non-teleophthalmology group.

**Synthesis of costs and benefits**

Although the teleophthalmology strategy generated higher QALYs and a lower cost in comparison with the non-teleophthalmology strategy (i.e. teleophthalmology was a dominant strategy), the authors calculated average cost-effectiveness ratios for each strategy. The teleophthalmology strategy yielded an average cost of $882 per QALY, while the non-teleophthalmology strategy yielded an average cost of $947 per QALY.

The Monte Carlo simulations demonstrated that teleophthalmology was a cost-effective option for 90% of diabetic inmates.

The one-way sensitivity analysis demonstrated that the results were most sensitive to the number of patients examined with teleophthalmology. In particular, the teleophthalmology strategy yielded a cost of less than $50,000/QALY when more than 151 patients were examined and a cost of less than $20,000/QALY if more than 260 patients were examined. If the number of patients examined exceeded 500, teleophthalmology was the dominant strategy.

**Authors' conclusions**

Teleophthalmology is less costly and more effective than face-to-face examination for evaluating diabetic retinopathy in prison inmates with Type 2 diabetes.

**CRD COMMENTARY - Selection of comparators**

The selection of the comparators was sufficiently justified. You should decide if these represent widely used health technologies in your own setting.

**Validity of estimate of measure of effectiveness**

The authors did not state that a systematic review of the literature had been carried out. The authors used data from the available studies selectively. Although this is common practice with models, uncertainty about the literature search and possible omission of relevant studies remains since no details of any search strategy were reported in the paper. The authors did not note any differences between the efficacy estimates from the primary studies. There was little commentary on the quality of the retrieved studies, making it difficult to comment on the quality of the efficacy estimates. However, the authors carried out several sensitivity analyses, which improved both the internal validity and the generalisability of the study by demonstrating the robustness of the results to changes in the base-case estimates.

**Validity of estimate of measure of benefit**

The authors used health utility (QALYs) as a measure of benefit in the economic analysis. The utility values were derived from the literature, but no specific details of the method used to derive them were reported in the current study. This makes it difficult to comment on the quality of the estimates used.

**Validity of estimate of costs**

The cost analysis was performed from the perspective of a health care system. It seems that all the relevant categories of costs have been included in the analysis. Summary costs of different cost categories were reported, while individual unit costs were not. This does not enable the analysis to be easily reworked for other settings. An extensive sensitivity analysis on the costs was conducted to assess the robustness of the estimates used. The ranges used, which were authors' estimates, appear to have been appropriate. The authors used actual charges to proxy transportation costs, but it is unlikely that this has affected the study results. Discounting was appropriately carried out but, although the costs were derived from sources referring to different price years, the authors did not report appropriate inflation adjustments. The price year was reported, which will aid any future reflation exercises.
Other issues
The authors did not compare their findings with other published results. However, this might have been due to a lack of published literature in this specific area. The authors stressed that their results can only apply to the telemedicine programme in Texas, although their model could be used and modified to meet the needs of similar programmes in other geographical areas. The authors' results do not appear to have been presented selectively. Although the reference case subject was a 40-year-old African-American man with Type 2 diabetes, the sensitivity analysis showed that the authors' conclusions were generalised across all races and age groups.

The authors reported a number of limitations to their study. First, detailed data relating to the profile of diabetic inmates were not available in the literature and, therefore, were not accounted for in the analysis. Second, the data used in the study might have been rather out-of-date as more recent medical literature was not incorporated in the study. Finally, the authors reported that a societal perspective could not be adopted in the economic analysis since the annual cost of prison inmates exceeded the amount of $50,000 that is an acceptable threshold for medical interventions.

Implications of the study
The authors did not make explicit recommendations for changes in policy or practice. However, the discussion indicated some areas where more information is needed.

Source of funding
Supported in part by unrestricted grants from Research to Prevent Blindness, New York (University of Texas Medical Branch, Department of Ophthalmology and Visual Sciences).

Bibliographic details

PubMedID
15111527

Other publications of related interest

Indexing Status
Subject indexing assigned by NLM

MeSH
Blindness /epidemiology; Costs and Cost Analysis; Diabetic Retinopathy /diagnosis /epidemiology /therapy; Disease Progression; Humans; Prevalence; Prisoners; Prisons; Telemedicine /economics /methods; Texas /epidemiology

AccessionNumber
22004000677

Date bibliographic record published
28/02/2006

Date abstract record published
28/02/2006