Screening Plus Corneal cross-linking for Keratoconus is Cost-Effective for New Zealand: A Proof-of-Concept Markov Analysis

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Introduction

The prevalence of keratoconus in New Zealand has been shown to be higher compared to the global prevalence of 1.38 per 1000, with Māori and Pacific Islander being over-represented. Among high school students, the prevalence have been shown to be 5 per 1000. Studies have also suggested that the form of keratoconus in New Zealand may have a more rapid progression of disease. Corneal cross-linking have demonstrated efficacy in slowing or arresting the progression of keratoconus.

In this study, we aimed to evaluate the cost-effectiveness of a keratoconus screening programme for the New Zealand population, with corneal cross-linking as treatment for those screening positive.

Methods

A hybrid decision tree Markov model was developed to compare the long-term clinical and economic outcomes of a keratoconus screening program in New Zealand. We simulated the clinical path if two hypothetical cohorts of individuals from age 15 until assumed death at age 90.

Cohorts were assigned to either:

- Usual care with corrective lenses and optometry follow-up
- Screening at age 15 with those screening positive treated with corneal cross-linking (+ repeat cross-linking if showing progression after 2 years)

Model structure:

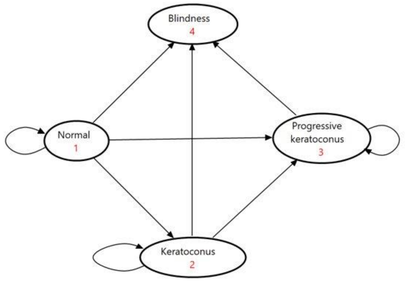


Figure 1: Markov model structure – ovals represents health state, arrows represents state transition.

- Screened with Pentacam (Ocululs Inc, WA)
- Prevalence at age 15 = 0.009
- Transition probabilities: model calibration
- Efficacy of cross-linking: 0.95 (0.90 – 1.00)
- Non-responders after 1st cross-linking: 0.10 (0.04 – 0.22)
- Non-responders after 2nd cross-linking: 0.09 (0.00 – 0.17)
- Quality adjusted life-years (QALYs): obtained from inverting disability weights from World Health Organisation's global burden of disease estimates.
- Willingness-to-pay (WTP) = NZ$76,534 per QALY

Results

For our base case, screening with Pentacam (Oculus Inc, WA) and treatment with corneal cross-linking for keratoconus results in an ICER of -NZ$22,384.78 (95% CI: -22,575.73, -22,196.81) per QALY gained, compared to usual care. This is cost-saving at NZ$161.72 (95% CI: 161.28, 162.16) per individual screened.

	Screening + corneal cross-linking
ICER (NZ$/QALY)	-$22, 384.78
Effect (QALYs, per person screened)	0.0072
Excess lifetime cost (NZ$ per 1000,000 screened)	-$16.17 million
Incremental cost (NZ$) per person	$161.72
QALYs gained per 100,000 screened	722
Progresisve keratoconus prevented per 100,000 screened	500
Blindness prevented per 100,000 screened	100

Figure 2: Base case analysis – Screening at age 15 years, population prevalence of keratoconus at 0.009 and using 3% discount rate. ICER: Incremental cost-effectiveness ratio.

The cost-effectiveness plane shows that most of the simulation (99%) resulted in an ICER below the WTP threshold.

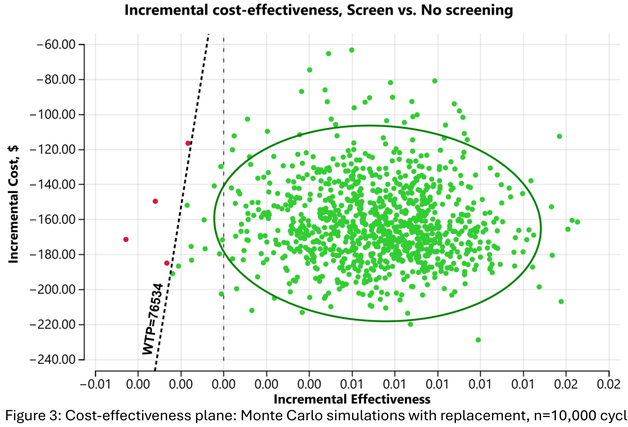


Figure 3: Cost-effectiveness plane: Monte Carlo simulations with replacement, n=10,000 cycles.

Sensitivity analysis show that factors that had most influence on ICER were prevalence of keratoconus at time of screening, specificity of the screening test, discount rate, the annual costs of having keratoconus or severe/progressive keratoconus and adherence.

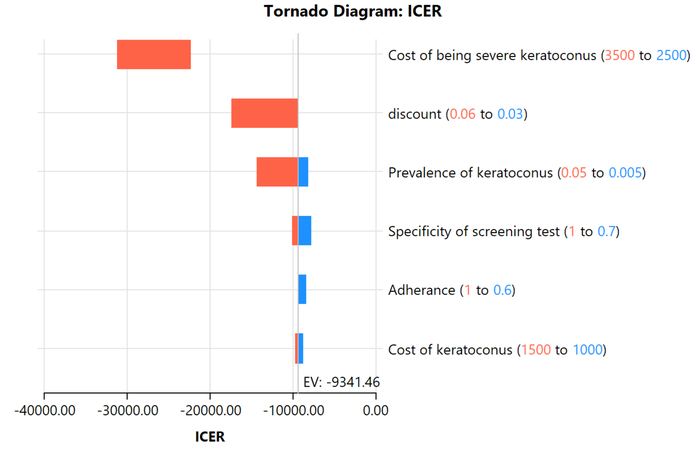


Figure 4: Tornado plot: probability sensitivity analysis.

Conclusion

This study provides the first analysis of screening for keratoconus followed by corneal cross-linking in the New Zealand setting. Parameters and data are region specific, and results should not be extrapolated to other countries or populations.

Limitations include incomplete aga-specific incidence/prevalence data, lack of long-term evidence for progression of keratoconus after cross-linking (we assumed a reduced lifetime risk of progression) and not including bilateral asymmetric disease in modelling.

Results from our Markov model suggest that screening children at age 15 for keratoconus and treatment with corneal cross-linking is cost saving, with a saving of NZ$22,385 per QALY gained. There is evidence for introducing a keratoconus screening program in New Zealand to ensure that we identify and treat those at risk early in their course of disease before significant visual loss has occurred.