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Supporting Information

Supplementary methods and results

**This appendix was part of the submitted manuscript and has been peer reviewed.
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Appendix to: Ross A, Kim J, McKay M, et al. The economics of a national anterior cruciate ligament injury prevention program for amateur football players: a Markov model analysis. *Med J Aust* 2024; doi: 10.5694/mja2.52385.

Supplementary methods

1. Program effectiveness rates

To calculate effectiveness rates for male and female players in the model, three studies (1-3) were used, using the reach, effectiveness, adoption, implementation, maintenance (RE-AIM) framework. (4)

A recent analysis of the Knee Control+ program (Sweden) was used for reach (66%). (2) The cross-sectional survey (440 Swedish coaches) covered 68% of amateur teams in a football district. (2)

To calculate the adoption rate, an Australian survey (328 players and 55 coaches) was used. (3) The survey investigated usage of the Fédération Internationale de Football (FIFA) 11+ program in amateur clubs and found that 75.8% of players and coaches who knew about it used the program. (3) This rate, together with the adoption rate reported for the Knee Control+ program (2), were added to the model by providing the mean proportion (75.8% + 51.1% / 2 = 63.5%).

Implementation figures from Sweden and Switzerland were used in the model. (1, 2) The implementation proportion from the Knee Control+ program was calculated by adding the proportions of coaches that used the program two times per week (39.2%), three times per week (12.7%) and four times per week or more (1%) (39.2% + 12.7% + 1% = 52.9%). The two session a week cut-off was used as high player adherence (two sessions per week and over) is associated with reduced ACL injury rates. (5) This rate and the implementation rate reported in Switzerland were added to the model as the mean proportion (52.9% + 22% / 2 = 37.5%).

As all coaches reported that they intended to continue using the Knee Control+ in the survey, we used 100% for the maintenance figure. (2)

2. Costs

Implementation costs

The logistical costs of implementing the program were estimated in consultation with the New Zealand Accident Compensation Corporation (6) as no Australian data are available. The total costs, which included cumulative inflation, for 1999–2021 were NZ$13,640,000. Football is one of the most popular sports in New Zealand (about 150,000 registered players) (7), and our model assumed 340,253 registered players. We therefore increased the program costs to reflect this difference (150,000/340,253 = 44.1% increase: $19,637,600). The costs have been projected for the full Markov model (*35 years = NZ$31,241,636) and adjusted according to the purchasing power parity for New Zealand and Australia dollars for 2021 (NZ$31,241,636*1.459/1.448). (8) The cost to implement the program is $31,478,969 for the entire model or $925,582 per year. The program costs include fixed (integrating injury prevention content into coaching education) and variable (injury prevention staff to deliver the education/program, resources) costs. However, it was beyond the scope of our analysis to provide a detailed breakdown of these costs.

Surgical, direct and indirect medical costs

Surgical costs for anterior cruciate ligament (ACL) reconstructions, total knee replacements and total knee replacement revisions were sourced from the Independent Hospital Pricing Authority Price Determination (9), which specifies the price paid to public and private hospitals (Table 1). The procedure costs were weighted according to public/private mix and, if a single procedure was included in multiple Australian Refined Diagnosis Related Groups (AR-DRGs) (e.g., ACL reconstruction), by the proportion each AR-DRG contributed to the total number of hospital admissions for the procedure. The AR-DRG codes included were I29Z, IO4A, IO4B, I32A, I32B and I32C. As we could not obtain knee arthroscopy costs from AR-DRGs, we excluded these costs from the model.

Rehabilitation costs for total knee replacements and total knee replacement revisions were obtained from an Australian Physiotherapy Association survey. (10) The direct and indirect costs (loss of income) for ACL reconstructions were derived from a retrospective descriptive epidemiological study based on New South Wales sports insurance records (2018-2020) for sub-elite football players. (11)

Table 1. Base surgical, direct and indirect cost assumptions (Australian dollars)

		Range for sensitivity analysis (95% confidence interval or +/- 20%)		
Parameters	**Value used**	**Low**	**High**	**Source**
Anterior cruciate ligament costs				
Surgery (including revision)	$8987	$7524	$9730	IHPA (9)
Direct costs including Rehabilitation	$1978	$1720	$2158	Ross et al (11)
Knee magnetic resonance imaging	$417.84 (122.34)*	Fixed cost	Fixed cost	MBS (12), DHAC (13)
In-direct costs (loss of income)	$12,137	$9688	$14,110	Ross et al (11)
Presenteeism (paid work)	$2418	-20%	+20%	Eggerding et al (14)
Unpaid work (e.g. household tasks)	$2244	-20%	+20%	Eggerding et al (14)
Anterior cruciate ligament costs total	**28,181.84**			
Total knee replacement costs				
Surgery	$23,992	$18,491	$31,466	IHPA (9)
Revision	$35,450	$29,773	$41,808	IHPA (9)
Rehabilitation	$765.37	-20%	+20%	APA (10)

APA=Australian Physiotherapy Association; DHAC=Department of Health and Aged care; IHPA=Independent Hospital Pricing Authority; MBS=Medicare Benefits Schedule; PBS=Pharmaceutical Benefits Scheme.

* Out of pocket costs

Health care for knee osteoarthritis

The direct and indirect cost assumptions are outlined in Table 2. The proportion of people likely to consult a general practitioner after developing knee osteoarthritis (53.1%) was estimated using Australian Health Survey (2012) data (15) and applied to the total cost. The annual number of general practitioner consultations for a person with knee osteoarthritis (4.2 consultations) was derived from a study in the Netherlands that examined the consultation rate for people with common chronic diseases. (16) There are no Australian data investigating the number of annual general practitioner consultations for knee osteoarthritis. The Bettering the Evaluation and Care of Health (BEACH) survey estimated the percentage referral to radiology and orthopaedic surgeons for people with osteoarthritis. (17) A survey examining the Australian general practitioner management of hip and knee osteoarthritis was used to determine the proportion of general practitioners who refer patients to physiotherapy for knee osteoarthritis (54%). (18) The number of referrals to physiotherapy (3.0) (10) and orthopaedic surgical consultations (2.5) (19) was determined using the most up to date Australian data. It was assumed that a person would have only one knee x-ray only. Referrals for MRI were not included as this assessment is not covered by Medicare.

Table 2. Base knee osteoarthritis costs (Australian dollars)

		Range for sensitivity analysis (95% confidence interval or +/- 20%)		
Parameters	**Value used**	**Low**	**High**	**Source**
Direct health care costs				
- Annual cost of Medications	246.91	Fixed cost	Fixed cost	PBS (20), Chemist warehouse (21)
- General practitioner cost per visit	39.75 (30.76)*	Fixed cost	Fixed cost	MBS (12), DHAC (13)
- Number of general practitioner visits	4.2	Fixed cost	Fixed cost	Schellevis et al (16)
- Physio cost per visit,	56 (55.81)*	Fixed cost	Fixed cost	MBS (12), DHAC (13)
- Number of Physio visits	3	Fixed cost	Fixed cost	APA (10)
- Orthopaedic surgeon cost per visit	75.05 (102.13)*	Fixed cost	Fixed cost	MBS (12), DHAC (13)
- Knee x-ray cost	51.40	Fixed cost	Fixed cost	MBS (12)
- Intra-articular Corticosteroid injection	115.35	Fixed cost	Fixed cost	MBS (12)
Other direct nonmedical expenditures	191.66	Fixed cost	Fixed cost	Lapsley et al (22)
Indirect costs (loss of income)	7304.05	74.03	13918.58	Salmon et al (23)

APA=Australian Physiotherapy Association; DHAC=Department of Health and Aged care; MBS=Medicare Benefits Schedule; OA=osteoarthritis; PBS=Pharmaceutical Benefits Scheme; TKR=total knee replacement.

*Out of pocket costs

As a survey of Australian general practitioners found that they referred for an intraarticular cortisone in 10% of visits for knee osteoarthritis (18), we included this cost in our analysis. As general practitioners are the gatekeepers for nearly all outward referrals in primary care in Australia, the general practitioner consultation proportion was used for all other referrals. For example, the cost for physiotherapy was multiplied by the general practitioner referral rate and the physiotherapy referral rate (cost x number of ACL reconstructions x 0.531 x 0.54). Direct nonmedical costs relevant to osteoarthritis (alterations to house, use of private and community services, and special assistive equipment) were based on Australian health survey data. (22) Indirect costs for osteoarthritis were sourced from a systematic review that reported a weighted mean indirect cost from eight studies, (23) none of which included Australian data for indirect costs (not currently available).

Osteoarthritis medication costs

An annual medication cost was calculated for over the counter and prescribed medications for knee osteoarthritis. The medication type was determined by the recommended osteoarthritis medications from the guidelines outlined by the Royal Australian College of General Practitioners (24) and a survey examining Australian general practitioner management of hip and knee osteoarthritis. (18) The costing followed methods derived by Lewis et al (25) with the medication dose and individual cost obtained from the Pharmaceutical Benefits Scheme (PBS) website (20) using the dispensed price maximum quantity as the cost. The Chemist Warehouse (https://www.chemistwarehouse.com.au) search function was used to calculate the cost and dose of over-the-counter medication. Table 3 outlines the cost of each medication.

Table 3. Osteoarthritis over the counter and prescribed medication costs (Australian dollars)

Medications (over the counter)	**Capsules/day**	**Total in pack**	**DPMQ**
Oral analgesics			
Paracetamol (Osteomol)	3	96	19.16
Oral non-steroidal anti-inflammatory drugs			
Diclofenac sodium 25mg	2	50	14.46
Ibuprofen 400mg	3	90	17.06
Topical Non-steroidal anti-inflammatory drugs			
Duloxetine gel	-	-	16.71
Diclofanac sodium 3% gel, 25g	-	-	59.20
Alternative supplements			
Glucosamine Sulfate & Chondroitin for Joint Health 320 Tablets	2	320	29.99
Fish oil	1	150	28.49
Total cost **= $185.07**			
Medications (prescription)			
Opioids			
Tramadol 50mg	0.5	10	14.97
Paracetamol 500mg plus codeine30mg	0.5	10	14.60
Oral Non-steroidal anti-inflammatory drugs			
Meloxicam 7.5 mg	1	30	15.15
Celecoxib 100mg	1	60	17.15
Total cost = **$61.87**			

3. Transition probability estimates

ACL yearly rupture rate and concomitant injuries

ACL rupture and re-rupture rates are presented as absolute risk probabilities. For ACL injuries the base absolute risk calculations were taken from Lewis et al (25) (reported in the technical Appendix of the article), based on data published in 2011 in Janssen et al (26) (Table 4). The absolute risk numbers were updated by applying the annual ACL incidence increases reported by Zbrojkiewicz et al. (27) (3.8% for players aged 25 years or younger; 1.7% for players aged 26 years or older). Zbrojkiewicz et al (27) reported incidence increases over a 15 year period (2000-2015) with data projected to 2024/5, but Janssen et al(26) reported data to 2009. To stay in line with cost data reported to 2021 we included ACL incidence increases over a 13-year period (2008-2021). For example, the 0.00497631 in the 15-25 age group was increased by 49.4% (13 years x 3.8% annual increase) to 0.007434607. Re-rupture rates were obtained from Kaeding et al (28) and are presented in Table 5. Concomitant meniscal injury following ACL rupture was estimated to be present in 48% of cases, the mean value of reported meniscal injury at the time of injury (25%-70%). (29-31)

Table 4. ACL rupture probability by age group

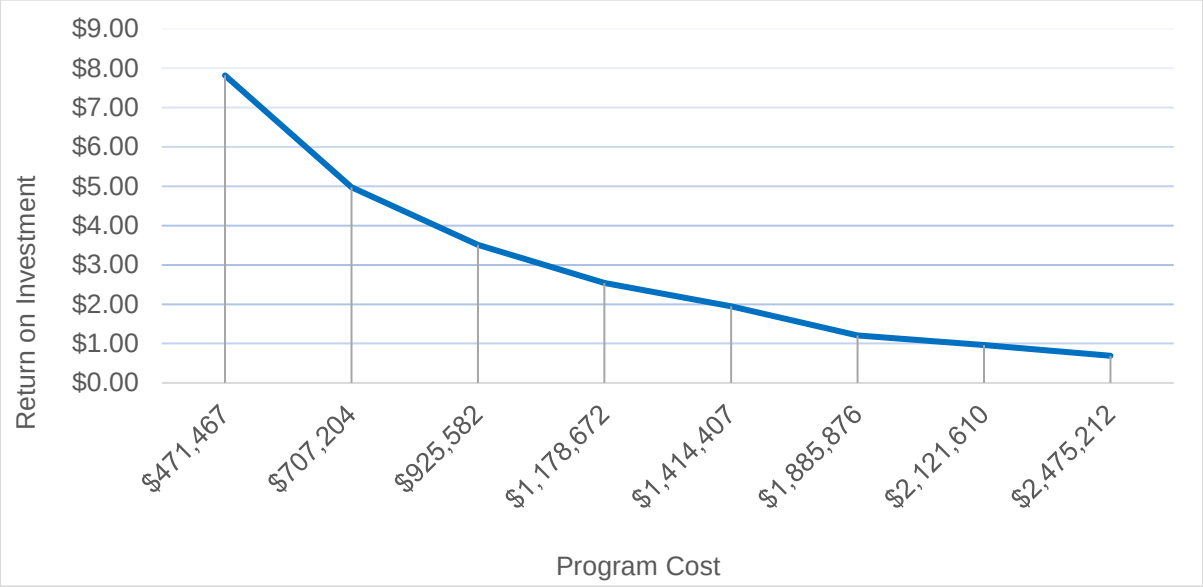
Age group	Yearly probability of ACL rupture
10-14	0.000583448
15-25	0.007434607
26-29	0.006076074
30-39	0.005266379
40-49	0.003217711
50-59	0.001335018
60+	0.000476594

Table 5. ACL re-rupture probability by age group

Age group	Yearly probability of ACL re-rupture
10-19	0.082
20-29	0.04
30-39	0.018
40-49	0.017

Supplementary results

Figure 1. Program costs per year and return on investment



* Were the annual program implementation cost to rise to $2 000 000, the implementation costs would exceed the amount saved by averting ACL injuries; that is, the program would no longer be a dominant strategy.

4. Sensitivity analyses

Table 6 presents the probability sensitivity analysis results for return on investment, quality-adjusted life years, total costs, program costs, and ACL injuries averted by the program. The ROI, QALYs gained, and total costs median Probabilistic Sensitivity Analysis (PSA) outputs are approximately 40% higher than our reported results. This suggests that we may have underestimated the effects of the program. The program cost median PSA output is similar to the baseline results. Figure 2 presents the ROI acceptability curve.

Table 6. Probability sensitivity analysis results (costs in Australian dollars)

Outcome	Median (interquartile range)
Return on investment	$6.27 ($3.61 to $8.98)
Quality-adjusted life years gained	590 (265 to 1016)
Total costs*	$93 634 258 ($54 453 912 to $133 693 771)
The program costs*	$14 931 928 ($13 922 683 to $15 981 146)
Anterior cruciate ligament injuries averted (male players)	3232 (1684 to 4883)
Anterior cruciate ligament injuries averted (female players)	1088 (549 to 1624)

* Costs are 5% discounted.

Figure 2. Return on Investment acceptability curve (in Australian dollars)*

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CHEERS 2022 checklist

	Item	Guidance for Reporting	Reported insection
TITLE			
Title	1	Identify the study as an economic evaluation and specify theinterventions being compared.	✓
ABSTRACT			
Abstract	2	Provide a structured summary that highlights context, key methods,results and alternative analyses.	✓
INTRODUCTION			
Background and objectives	3	Give the context for the study, the study question and its practical relevance for decision making in policy or practice.	✓
METHODS			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	N/A
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	✓
Setting and location	6	Provide relevant contextual information that may influence findings.	✓
Comparators	7	Describe the interventions or strategies being compared and why chosen.	✓
Perspective	8	State the perspective(s) adopted by the study and why chosen.	
Time horizon	9	State the time horizon for the study and why appropriate.	✓ 35 YEARS RELEVANT FOR ACL INJURIES
Discount rate	10	Report the discount rate(s) and reason chosen.	✓
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s)and harm(s).	✓
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s)were measured.	✓
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	✓
Measurement and valuation of resources and costs	14	Describe how costs were valued.	✓
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus thecurrency and year of conversion.	✓
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	✓ Technical model information available in supplementary document
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, anyextrapolation methods, and approaches for validating any model used.	✓ Technical model information available in supplementary document
Characterizing heterogeneity	18	Describe any methods used for estimating how the results of the studyvary for sub-groups.	✓ Age, sex stratification
Characterizing distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	✓ Age, sex stratification
Characterizing uncertainty	20	Describe methods to characterize any sources of uncertainty in the analysis.	✓ Sensitivity analyses completed
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (e.g., clinicians or payers) inthe design of the study.	✗
RESULTS			
Study parameters	22	Report all analytic inputs (e.g., values, ranges, references) includinguncertainty or distributional assumptions.	✓
Summary of main results	23	Report the mean values for the main categories of costs and outcomes ofinterest and summarise them in the most appropriate overall measure.	✓
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon,if applicable.	✓

Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community,or stakeholder involvement made to the approach or findings of the study	×
DISCUSSION			
Study findings, limitations, generalizability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured,and how these could impact patients, policy, or practice.	✓
OTHER RELEVANT INFORMATION			
Source of funding	27	Describe how the study was funded and any role of the funder inthe identification, design, conduct, and reporting of the analysis	✓
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	✓

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