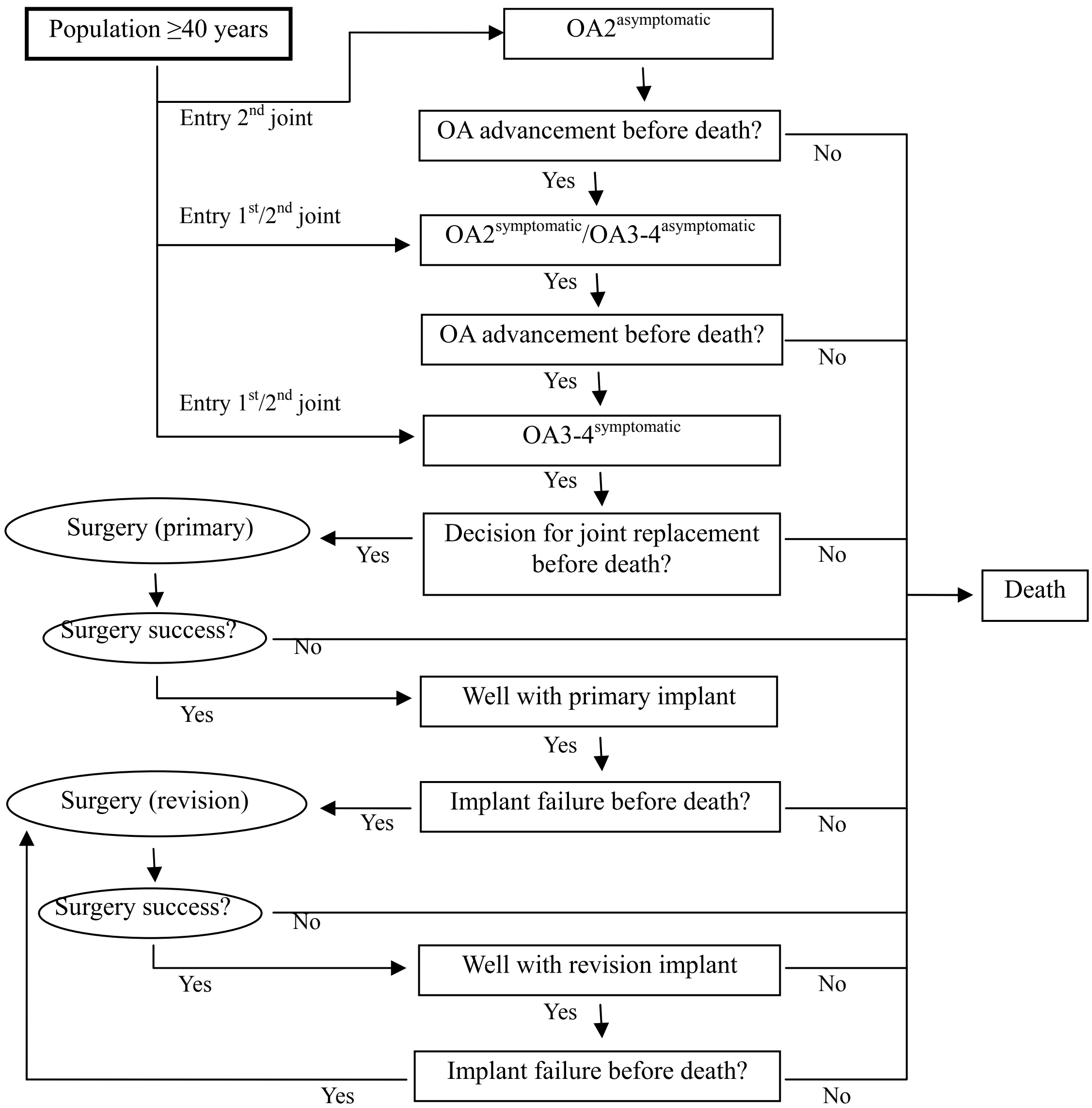
ACE Briefing paper hip & knee replacement - Appendix

Model concept

The individuals included in the model consisted of all people with at least one hip or knee osteoarthritis (OA) with grade 2 symptomatic/ grade 3 asymptomatic or worse severity. People could move from one grade of OA to higher grades, who would then make decisions for replacement surgeries followed by implants failure and revisions over time. Along the course of transitions, the person may die from surgical or other causes. All people who entered the model were followed-up until death. Figure A provides the schematic depiction of the model.

Figure A: State transitions of individuals with OA



NB: Two joints (1st and 2nd joints) for each person will follow the passage of this diagram independently

Time to revision of hip and knee implants

Time to failure of implants was assumed to be caused either by short-term or long-term causes. We assumed separate Weibull distributions for each cause and derived two cumulative density curves. The time to revision was modelled as the weighted and normalised sum of these two curves by fitting the estimated values to the observed values from literature (see Table A for list of literature) by means of weighted least square. The Solver function of Microsoft Excel was used for the calculation.

$$TTFcomb_{age} = TTFshort_{age} \times WTshort_{age} + TTFlong_{age} \times (1 - WTshort_{age})$$

where

$\frac{TTFshort}{\frac{long}{comb}}_{age}$ is the probability density of time to failure of hip or knee implants at short-term, long-term, or both combined, for primary/revision for hip/knee in each age-group; and $WTshort_{age}$ is the weight[1] of short-term cause of failure of hip or knee implants for primary/revision surgeries in each age-group.

Table A: Data used to model the time to failure of joint implants

	Hip implant	Knee implant
Short-term		
Primary	Australian joint replacement registry 2008[1]	Australian joint replacement registry 2008[1]
Revision	ditto	ditto
Long-term		
Primary	Schulte et al.,[2] Madey et al.,[3] Callaghan et al.,[4] Callaghan et al.[5]	Rand et al.[6]
Revision	Schreurs et al.[7]	Rand & Ilstrup.[8]

The Weibull parameters estimated by the Solver function are provided in Table B. Alpha represents the scale parameter and Beta the shape parameter.

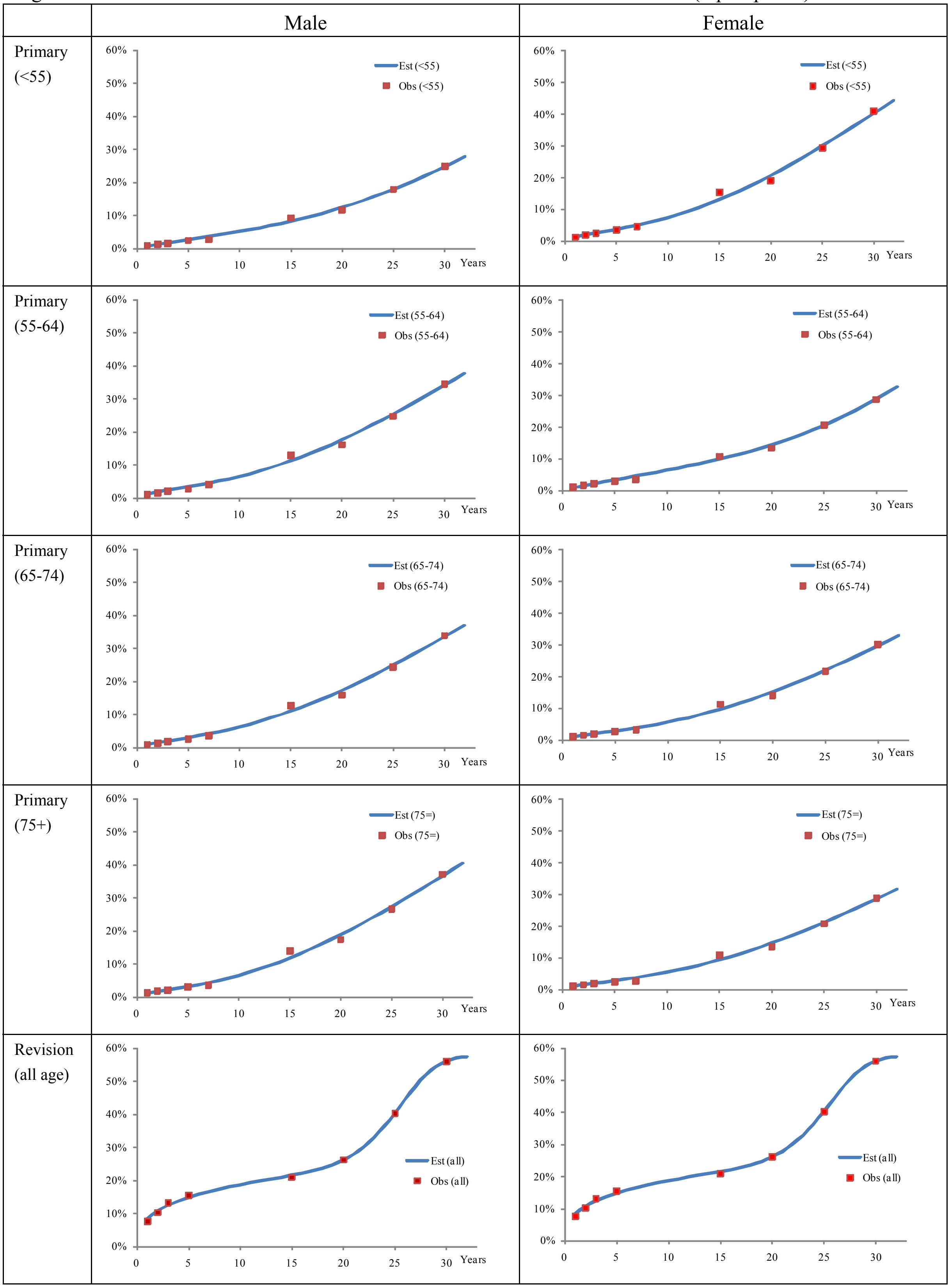
[1] We defined the "weight" as the probability of a failure being attributed to short-term cause over long-term. Therefore the weight of long-term cause is calculated as 1 – (estimated weight of short-term cause).

Table B Weibull parameters for time to failure of hip or knee implants

Type	Term	Age	Male			Female		
			Alpha	Beta	Weight	Alpha	Beta	Weight
Hip								
Primary	Short	<55	0.87	45.51	0.18	0.56	152.96	0.23
		55-64	0.57	240.21	0.27	0.99	101.56	0.64
		65-74	0.66	172.30	0.26	0.57	397.46	0.31
		75+	0.43	274.13	0.15	0.58	412.47	0.30
	Long	<55	2.84	51.90	0.82	2.43	38.32	0.77
		55-64	2.38	41.67	0.73	4.25	36.90	0.36
		65-74	2.34	42.67	0.74	2.39	43.38	0.69
		75+	2.24	42.11	0.85	2.34	44.92	0.70
Revision	Short	All	0.39	200.36	0.70	0.39	200.36	0.70
	Long	All	8.92	26.05	0.30	8.92	26.05	0.30
Knee								
Primary	Short	<55	0.55	131.27	0.50	0.66	149.67	0.68
		55-64	0.32	241.20	0.10	0.69	409.25	0.13
		65-74	0.71	846.51	0.39	0.70	947.36	0.37
		75+	1.58	658.23	0.28	1.69	559.00	0.28
	Long	<55	2.98	29.88	0.50	3.64	27.20	0.32
		55-64	1.62	40.83	0.90	1.60	45.15	0.87
		65-74	1.66	28.66	0.61	1.61	34.31	0.63
		75+	1.62	31.54	0.72	1.62	32.46	0.72
Revision	Short	All	1.44	1.91	0.17	1.44	1.91	0.17
	Long	All	2.48	21.13	0.83	2.48	21.13	0.83

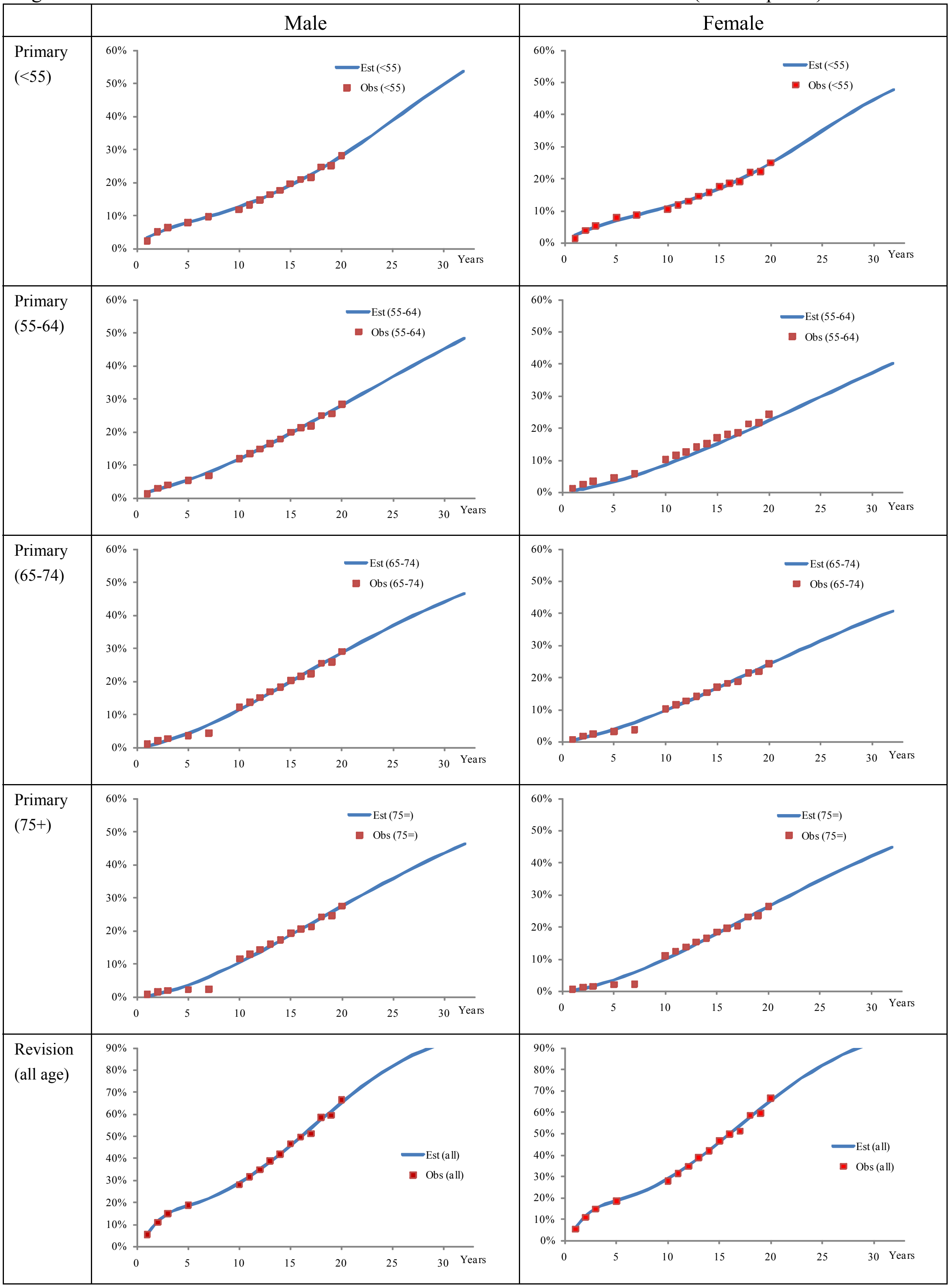
Based on these parameters and the above equation, we derived the probability density curve and cumulative distribution curve to simulate the time to failure of joint implants. Figures C and D provide the cumulative distribution curves, where the red dots represent the observed cumulative implant failure rates from the literature (Table A) and the blue line the estimated values.

Figure B: Cumulative distribution curve of time to revision with observed values (hip implants)



Est: estimated curve; Obs: observed values

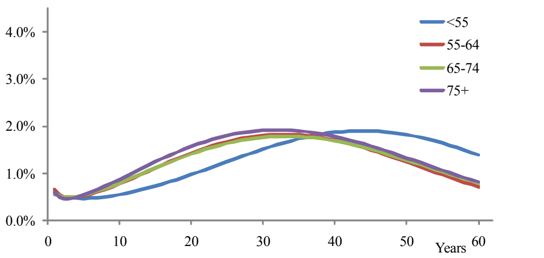
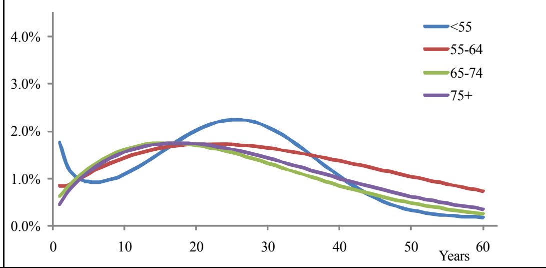
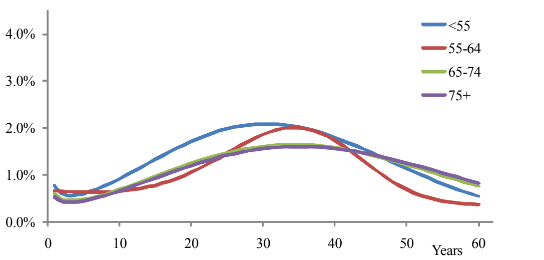
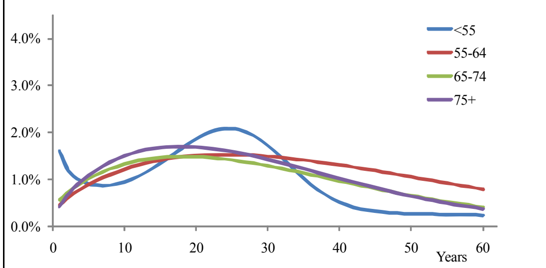
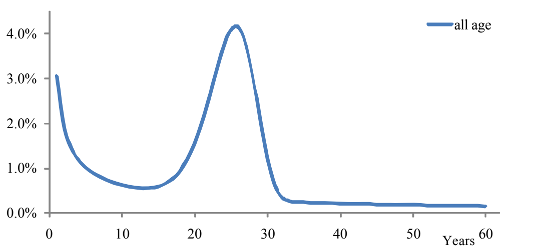
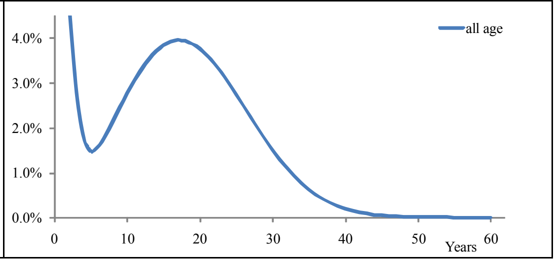
Figure C: Cumulative distribution curve of time to revision with observed values (knee implants)



Est: estimated curve; Obs: observed values

Similarly, Figure D provides the probability density curve modelled from the estimated parameters.

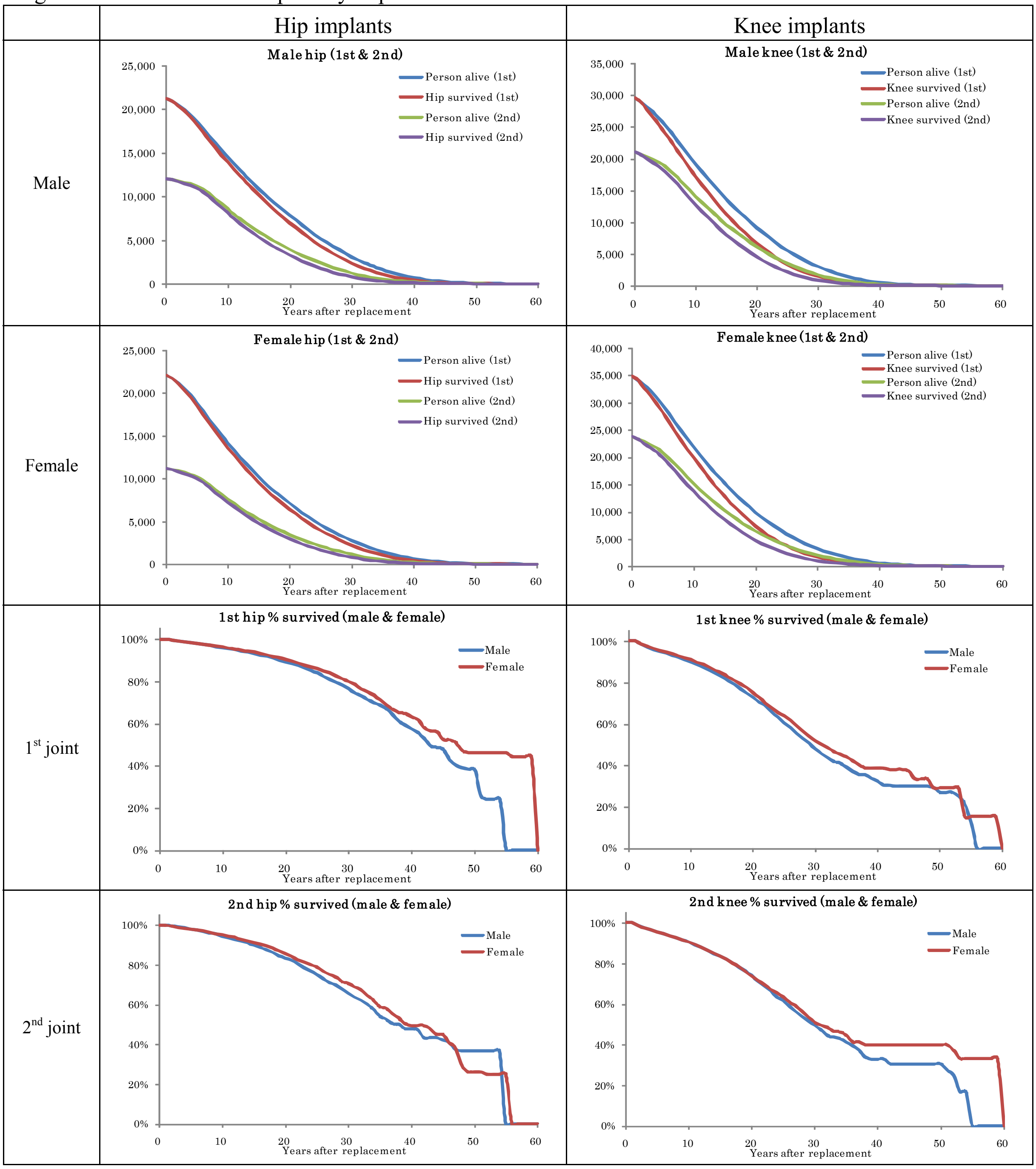
Figure D: Probability density curve of time to revision

	Hip implants	Knee implants
Male		
Female		
Revision (male & female)		

Survival curve of implants (primary joint replacement)

The simulated survival curves of primary implants for hips and knees are provided in Figure E.

Figure E: Survival curve for primary implants



Person alive(1st): number of people who are alive X years after primary replacement of 1st joint

Person alive (2nd): number of people who are alive Y years after primary replacement of 2nd joint

Intervention effect

Table C provides the regression coefficients used to estimate the intervention effect of hip replacement.

Table C: Regression coefficients for EQ-5D index estimation (hip replacement)

Variable	Pre-surgery			Post-surgery		
	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
Constant	-0.456	0.040	0.000	-1.658	0.077	0.000
Age	-0.001	0.001	0.372	0.001	0.002	0.692
Male	-0.188	0.031	0.000	-0.226	0.058	0.000
Revision	-0.042	0.038	0.267	0.503	0.058	0.000

Source: Briggs et al.[9]

For knee replacement, we referred to the literature reporting pre and post scores of EQ-5D, HAQ, and SF-36 (converted to a single index by means of TTU method)[10] and estimated the effect size of individual study as:

$$Effect_n^{(M/F)} = ([(1 - PYLD_{(mean\ age\ n)}^{(M/F)}) - Score_n^{post}] + (1 - PYLD_{(mea\ldots$$

where

$Effect_n^{\frac{M}{F}}$ is the effect size of knee replacement for male or female derived from the n^th^ literature;

$PYLD^{\frac{M}{F}}_{mean\frac{age}{+1}n}$ is the prevalent years lived with disability of the Australian males or females obtained from ABOD 2003 at the mean age or one year older of the study sample in the n^th^ literature (this was included to account for the age variations of samples between literature); and

$Score_n^{\frac{pre}{post}}$ is the single index reported or converted from EQ-5D, HAQ, and SF-36 of pre/post knee replacement in the n^th^ literature,

and performed a non-parametric bootstrap with 5,000 iterations to obtain the mean values and 95% CI of the effect size. The list of literature used for this modelling is provided in Table D.

Table D: Literature and indexes included for bootstrap (knee replacement)

Literature	Sample size	Index	Transformed index	
			Pre-surgery	Post-surgery
Brazier et al.[11]	109	EQ-5D	0.45[a]	0.54[a]
	109	HAQ	0.37[a]	0.43[a]
	109	SF-36	0.39	0.50
van Essen GJ et al.[12]	73	SF-36	0.47	0.56
Bennett KJ et al.[13]	41	SF-36	0.42	0.46
Dawson J et al.[14]	117	SF-36	0.40	0.59
Heck DA et al.[15]	291	SF-36	0.45	0.65
Kiebzak GM et al.[16]	78	SF-36	0.46	0.55
Shields RK et al.[17]	24	SF-36	0.53	0.73
Jones CA et al.[18]	276	SF-36	0.39	0.58
Jones CA et al.[19]	222	SF-36	0.39	0.60
	35	SF-36	0.37	0.54
Bachmeier CJ et al.[20]	108	SF-36	0.43	0.63
Bayley KB et al.[21]	117	SF-36	0.50	0.65
Hozack WJ et al.[22]	149	SF-36	0.50	0.65
Kiebzak GM et al.[23]	235	SF-36	0.45	0.60

[a] These indexes are original values

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