Cost-effectiveness of self-management of blood pressure in hypertensive patients over 70 years with sub-optimal control and established cardiovascular disease or additional CV risk diseases (TASMIN-SR)

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Distribution of primary CVD events (named stroke, MI or UA)

Patient level data from TASMIN-SR indicated that the 'high risk history' of patients entering the model was best reflected through presence or absence of four main underlying conditions (diabetes, stroke, Coronary Heart Disease - CHD and Chronic Kidney Disease - CKD). This gives 16 possibilities (2×2×2×2) of underlying conditions. Since all patients had at least one of the four main conditions the group "none of these" was omitted, leaving fifteen different groups.

The risks associated to each of three possible cardiovascular events (stroke, Myocardial Infarction - MI or Unstable Angina - UA) for high risk condition patients within a year were calculated by age ranges, gender and for the total population:

1. Risks associated to the four main high risk conditions were identified in various sources. [1-5] Data were not always available per age ranges or gender, in which case these risks were applied directly to the four relevant risk groups.
2. When the probability of an event (Stroke, MI or UA) was not available stratified by age group, the following assumption was made: the average relationship between available probabilities of an event by age ranges was used to calculate

missing values. Table 1 shows the available data for the annual risk of stroke for a 65 years old person.

eTable 1 Risk of stroke for given existing condition

Age group	Diabetes (stratified data available)	CKD (stratified data available)	Stroke (missing values in blue)
65	0.0196	0.0072	0.0348*
75	0.0262	0.0147	to be estimated
85	0.0298	0.0189	to be estimated

* Probability of a 65 years old patient with a history of stroke of having a stroke within a year

To estimate the probability of a repeat stroke for a 75 year old patient with a history of (previous) stroke, the relative risk (compared to age 65) was estimated as the average of the relative risks for the other two existing conditions, that is

$$\frac{1}{2}\left(\frac{0.0262}{0.0196}+\frac{0.0147}{0.0072}\right)=1.6925.$$

Multiplying 0.0348 by 1.6925 gives an estimated risk of 0.0589 for a 75 year old patient.

Similar calculations for an 85 patient give an estimated risk of 0.0713.

3. Annual transition probabilities of having an unstable angina or a myocardial infarction per age ranges in a population with diabetes were estimated based on the NICE Type 2 Diabetes guidelines.[3] The following assumptions were adopted: i) baseline risk of CVD for a 65-year old non-diabetic is 0.02; ii) this risk increases 0.0003 per a one year increase in age in males and 0.0002 in females; iii) the risk of CVD in diabetics compared to non-diabetics is 2.5 fold; and iv) the proportion of MI and UA population in relation to the total CVD population remains the same during the lifetime.
4. Risks induced by patient's underlying conditions are additive.
5. For risk groups reflecting the presence in a given patient of two or more high risk conditions, assumptions to calculate the risk of an event (stroke, MI or UA) were made: the probability of an event (stroke) will be the sum of the individual probabilities of the event for the existing conditions. Using data from Table 1 above as an example, the risk of stroke for a 65-year old patient with a history of (previous) diabetes (DM) and Chronic Kidney Disease (CKD) was estimated as,

$$Risk\ Stroke\ 65\ yrs = [1 - (1 - DM) * (1 - CKD)]$$

Risk Stroke 65 yrs = [1-(1-0.0196)*(1-0.0072)]

Risk Stroke 65yrs = [1-(0.9804)*(0.9928)]

Risk Stroke 65yrs = [1-0.9733]

Risk Stroke 65yrs = 0.0267

6. The probability of an event (stroke, MI or UA) stratified by gender and age group was only available for the high risk condition Chronic Kidney Disease (CKD). [2] For other high risk conditions for which data stratified by gender was not available, assumptions were adopted: i) within the population the proportion of men and women are the same; ii) the risk ratio men to women was assumed to be the same as per individuals without underlying conditions; iii) risk ratios male to female for a one year risk of stroke, MI and UA were estimated from table 1, TASMINH2, [6] from where the one year risk ratio (RR) male/female of stroke was estimated to be 1.8 and the one year RR male/female of MI and UA was estimated to be 2.0. Risks by gender were estimated from the following relationship:

   The risk in a population with underlying conditions of developing a Stroke (TP)

   TP = (RR*F/2) + (F/2)

   Where RR is the one year male/female risk ratio of having a stroke; F is the risk for a female of developing a stroke per age range. Solving the equation for F, we have:

F = (2*TP) / (RR + 1)

For example, the risk for a 65 years female with previous history of diabetes of developing stroke within a year was estimated as:

F = (2*0.0196) / (1.8+1)

F = 0.0140

7. Since the cycle length of the TASMIN-SR model is six months, annual transition probabilities needed to be converted into six-month transition probabilities following standard practice[7]:

   Annual transition probabilities were transformed into instant six-month rates:

   R = - [ln (1-P)] / t

   Where R is the instant 6-month rate, P is the annual probability of the event and t is the time period of interest. Rates were then transformed back into probabilities:

   6-month probability = 1 – Exp (- R * 1), where R is 6-month rate

   Table 2 shows all the estimated 6-month probabilities of cardiovascular events by high risk conditions for the total population, by gender and age ranges.

eTable 2 Six-month probabilities of cardiovascular events by risk conditions, age and gender

Risk condition*	Stroke			MI			UA		
	65	75	85	65	75	85	65	75	85
Total									
Risk 1	0.0098	0.0132	0.0150	0.0045	0.0050	0.0056	0.0021	0.0024	0.0026
Risk 2	0.0036	0.0074	0.0095	0.0026	0.0057	0.0086	0.0012	0.0027	0.0040
Risk 3	0.0176	0.0299	0.0363	0.0070	0.0117	0.0117	0.0070	0.0117	0.0117
Risk 4	0.0176	0.0298	0.0363	0.0339	0.0572	0.0572	0.0268	0.0451	0.0451
Risk 5	0.0134	0.0205	0.0244	0.0070	0.0107	0.0141	0.0033	0.0050	0.0066
Risk 6	0.0211	0.0370	0.0455	0.0095	0.0173	0.0202	0.0082	0.0143	0.0157
Risk 7	0.0211	0.0370	0.0455	0.0363	0.0626	0.0653	0.0279	0.0476	0.0489
Risk 8	0.0272	0.0427	0.0508	0.0114	0.0166	0.0172	0.0090	0.0140	0.0142
Risk 9	0.0272	0.0426	0.0508	0.0382	0.0620	0.0625	0.0288	0.0473	0.0476
Risk 10	0.0348	0.0588	0.0713	0.0406	0.0682	0.0682	0.0335	0.0562	0.0562
Risk 11	0.0307	0.0497	0.0598	0.0139	0.0222	0.0256	0.0102	0.0166	0.0182
Risk 12	0.0307	0.0497	0.0598	0.0406	0.0673	0.0705	0.0299	0.0499	0.0514
Risk 13	0.0443	0.0712	0.0853	0.0449	0.0729	0.0734	0.0355	0.0584	0.0587
Risk 14	0.0383	0.0658	0.0802	0.0431	0.0735	0.0762	0.0347	0.0587	0.0600
Risk 15	0.0478	0.0781	0.0940	0.0473	0.0782	0.0814	0.0367	0.0610	0.0625
Male									
Risk 1	0.0113	0.0152	0.0173	0.0051	0.0058	0.0064	0.0024	0.0027	0.0030
Risk 2	0.0042	0.0076	0.0091	0.0039	0.0079	0.0111	0.0019	0.0037	0.0052
Risk 3	0.0195	0.0333	0.0405	0.0078	0.0130	0.0130	0.0078	0.0130	0.0130
Risk 4	0.0202	0.0344	0.0419	0.0391	0.0661	0.0661	0.0308	0.0520	0.0520
Risk 5	0.0155	0.0226	0.0262	0.0090	0.0137	0.0175	0.0042	0.0064	0.0082
Risk 6	0.0237	0.0406	0.0492	0.0117	0.0208	0.0239	0.0096	0.0167	0.0181
Risk 7	0.0244	0.0417	0.0506	0.0428	0.0735	0.0765	0.0326	0.0556	0.0570
Risk 8	0.0306	0.0479	0.0570	0.0128	0.0187	0.0193	0.0101	0.0156	0.0159
Risk 9	0.0313	0.0490	0.0584	0.0440	0.0715	0.0721	0.0331	0.0546	0.0549
Risk 10	0.0393	0.0665	0.0806	0.0465	0.0782	0.0782	0.0383	0.0643	0.0643
Risk 11	0.0347	0.0551	0.0656	0.0167	0.0265	0.0302	0.0119	0.0193	0.0211

Risk 12	0.0354	0.0563	0.0670	0.0477	0.0788	0.0824	0.0349	0.0581	0.0598
Risk 13	0.0502	0.0807	0.0965	0.0514	0.0835	0.0841	0.0406	0.0668	0.0671
Risk 14	0.0434	0.0736	0.0890	0.0503	0.0855	0.0885	0.0401	0.0678	0.0692
Risk 15	0.0542	0.0876	0.1047	0.0551	0.0908	0.0943	0.0424	0.0703	0.0720
Female									
Risk 1	0.0075	0.0101	0.0115	0.0034	0.0039	0.0043	0.0016	0.0018	0.0020
Risk 2	0.0033	0.0073	0.0097	0.0018	0.0046	0.0077	0.0009	0.0022	0.0036
Risk 3	0.0130	0.0220	0.0268	0.0052	0.0086	0.0086	0.0052	0.0086	0.0086
Risk 4	0.0134	0.0228	0.0277	0.0258	0.0435	0.0435	0.0205	0.0343	0.0343
Risk 5	0.0108	0.0173	0.0210	0.0052	0.0084	0.0119	0.0024	0.0040	0.0056
Risk 6	0.0162	0.0292	0.0362	0.0070	0.0132	0.0162	0.0060	0.0108	0.0122
Risk 7	0.0167	0.0299	0.0371	0.0276	0.0479	0.0509	0.0213	0.0364	0.0378
Risk 8	0.0204	0.0319	0.0380	0.0085	0.0125	0.0129	0.0067	0.0104	0.0106
Risk 9	0.0209	0.0327	0.0388	0.0292	0.0472	0.0476	0.0220	0.0361	0.0363
Risk 10	0.0262	0.0444	0.0537	0.0309	0.0518	0.0518	0.0255	0.0427	0.0427
Risk 11	0.0236	0.0390	0.0473	0.0104	0.0170	0.0204	0.0076	0.0126	0.0142
Risk 12	0.0241	0.0397	0.0481	0.0309	0.0516	0.0549	0.0228	0.0382	0.0398
Risk 13	0.0336	0.0540	0.0646	0.0342	0.0555	0.0558	0.0270	0.0444	0.0446
Risk 14	0.0294	0.0513	0.0629	0.0327	0.0562	0.0591	0.0264	0.0447	0.0461
Risk 15	0.0367	0.0609	0.0736	0.0359	0.0598	0.0631	0.0279	0.0465	0.0480

Notation:

1. DM = diabetes mellitus; CKD = chronic kidney disease; ST = stroke and CHD = coronary heart disease
2. Risk 1=DM; Risk 2=CKD; Risk 3=ST; Risk 4=CHD; Risk 5= DM-CKD; Risk 6= CKD-ST; Risk 7= CKD-CHD; Risk 8= DM-ST; Risk 9= DM + CHD; Risk 10= CHD-ST; Risk 11= DM-CKD-ST; Risk 12= DM-CKD-CHD; Risk 13= DM-ST-CHD; Risk 14= CKD-ST-CHD, and Risk 15= DM-ST-CHD-CKD

* Relative risks for which information was not available were imputed

† Relative risks for two or more conditions (Risk groups 5 to 15) are equivalent to the sum of the individual risk conditions

Sources: PROGRESS (2001); NICE guidelines on diabetes; NICE guidelines on lipid modification; Kerr et al, (2012)

Quality of life utilities

Utilities in the model for stroke, MI and unstable angina (UtilityAngina, UtilityStroke and UtilityMI) are the resultant of multiplying:

Utility multipliers for CVD (from Cooper et al, table 14, Lipid Modification guidelines) * Absolute utility by age (Non-CVD population) * time in acute state (assumption is half cycle or 0.5) * Mult_dist (PSA)

eTable 3 Costs of equipment and training

Costs 2013	Equipment	Main training cost[a]	Total intervention costs
VAT	0.200		
Equipment (cost per monitor)	55.0		
capital outlay (K)	66.0	90.0	156.0
Interest/Discount rate (r)	0.035	0.035	0.035
Useful life of equipment (n years)	5	5	5
Equivalent annual cost (£)	14.6	19.9	34.6[b]

[a] Training costs assumed each patient required 2 training face-to-face sessions by a practice nurse

[b] Annuitized costs for equipment and training

eTable 4 Un-adjusted results of cost-effectiveness Analysis

	Costs (£)	QALYs	Incremental cost (£)	Incremental QALYs	ICER (£ per QALY)
Total population					
Usual care	8,169	6.0370			
Self-management	7,381	6.2415	-787	0.2045	Dominant
Female					
Usual care	7,321	6.2507			
Self-management	6,601	6.4408	-719	0.1901	Dominant
Male					
Usual care	8,635	5.9081			
Self-management	7,816	6.1203	-819	0.2122	Dominant

eTable 5 Un-adjusted results of sensitivity analysis: results of cost-effectiveness analysis by time horizon

	Costs	QALYs	Incremental cost	Incremental QALYs	ICER
20-year					
Usual care	7,691	5.8873			
Self-management	6,942	6.0923	-749	0.2050	Dominant
10-year					
Usual care	5,227	4.7793			
Self-management	4,693	4.9217	-534	0.1424	Dominant
5-year					
Usual care	2,868	3.1198			
Self-management	2,566	3.1732	-302	0.0533	Dominant
3-year					
Usual care	1,680	2.0865			
Self-management	1,541	2.1041	-140	0.0177	Dominant
2-year					
Usual care	1,111	1.4653			
Self-management	1,059	1.4718	-52	0.0064	Dominant
1-year					
Usual care	603	0.7729			
Self-management	625	0.7736	22	0.0006	34,791

Note: un-adjusted results of CE for 1-year time horizon did not change as compared to the adjusted results because the age-related risk reductions remained the same at 6M

eTable 6 Un-adjusted results of sensitivity analysis: results of cost-effectiveness analysis by reducing the effect of BP lowering

	Costs (£)	QALYs	Incremental cost (£)	Incremental QALYs	ICER (£ per QALY)
10-year					
Usual care	8,169	6.0370			
Self-management	7,546	6.2202	-622	0.1832	Dominant
5-year					
Usual care	8,169	6.0370			
Self-management	7,890	6.1596	-278	0.1227	Dominant
2-year					
Usual care	8,169	6.0370			
Self-management	8,364	6.0497	195	0.0127	15,313

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