The QRISK2 algorithm

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1 Introduction

This document describes the QRISK2 algorithm[1] which is a new algorithm that predicts the risk of cardiovascular disease for an individual patient. Annual updates to the QRISK2 algorithm will consist of changes to values in the tables given in the appendix.

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http://www.emis-online.com/products/QRisk/

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The QRISK2 algorithm takes 15 parameters from a patient record and calculates the that patient's 10 year risk of having a cardiovascular event. It is best described as a series of transformations on the input data, followed by a calculation, and this is what we do.

2 The input parameters

There are 15 parameters, namely

$$
\begin{aligned}
x_1 &= \text{age} \\
x_2 &= \text{body mass index} \\
x_3 &= \text{Townsend score} \\
x_4 &= \text{systolic blood pressure} \\
x_5 &= \text{cholesterol ratio} \\
x_6 &= \text{family history of coronary heart disease} \\
x_7 &= \text{smoking status} \\
x_8 &= \text{treated hypertension} \\
x_9 &= \text{type 2 diabetes} \\
x_{10} &= \text{atrial fibrillation} \\
x_{11} &= \text{rheumatoid arthritis} \\
x_{12} &= \text{chronic renal disease} \\
x_{13} &= \text{history of cardiovascular disease}
\end{aligned}
$$

$$
\begin{aligned}
x_{14} &= \text{ethnicity} \\
x_{15} &= \text{sex}
\end{aligned}
$$

Details can be found in the QRISK2 search definition document[2].

3 The first transform

Six of the parameters can be passed as a null, that is, the parameter is not present in the patient record and a default value is to be used by the algorithm. These parameters are x_2, x_3, x_4, x_5, x_7 and x_{14}. If they are null, x_2, x_4 and x_5 are set to age-sex averages (see the appendix below), whereas the others are set to zero.

4 The second transform

The algorithm is valid for the following range of values:

$$
\begin{aligned}
x_1 &: \text{35-74} \\
x_2 &: \text{15.0-50.0} \\
x_3 &: \text{-7.0-12.0} \\
x_4 &: \text{70.0-210.0} \\
x_5 &: \text{1.0-12.0} \\
x_6 &: \text{0 or 1} \\
x_7 &: \text{0 or 1} \\
x_8 &: \text{0 or 1} \\
x_9 &: \text{0 or 1} \\
x_{10} &: \text{0 or 1} \\
x_{11} &: \text{0 or 1} \\
x_{12} &: \text{0 or 1} \\
x_{13} &: \text{0} \\
x_{14} &: \text{0-17} \\
x_{15} &: \text{0 or 1}
\end{aligned}
$$

If a value is entered for the parameters $x_2 - x_5$, and that value is outside the range allowed, then it is rounded to the closest valid number. If any other parameter is not matched, then an error condition is raised. The constraint that x_{13} must be zero is there to make explicit that this algorithm does not apply to patients with a history of cardiovascular disease.

5 The third transform

The ethnicity parameter, x_{14}, is transformed by the following map:

old x_{14}	0	1	2	3	4	5	6	7	8	9
new x_{14}	1	1	1	1	9	9	9	9	2	3

and

old x_{14}	10	11	12	13	14	15	16	17
new x_{14}	4	5	6	7	9	8	9	1

.

6 The fourth transform

The age variable, x_1, is transformed by the following map:

$$x_1 \mapsto \log_e(x_1/10).$$

7 The fifth transform

For $i \in \{1..5\}$,

$$x_i \mapsto (x_i - \mu_{ij}),$$

where $j = x_{15}$, and μ_{ij} is as given in the appendix.

8 The calculation of the score

Setting $\epsilon = x_{14}$ and $j = x_{15}$, we form the following sum:

$$a = E_{\epsilon j} + \sum_{i=1}^{12} \kappa_{ij} x_i + x_1 \left(\sum_{i=2}^{4} \lambda_{ij} x_i + \sum_{i=6}^{10} \lambda_{ij} x_i \right),$$

where $E_{\epsilon j}$, κ_{ij} and λ_{ij} are given in the appendix.

The score is then given as

$$100 \left(1 - {s_j}^{\exp^a} \right),$$

where s_j is given in the appendix.

References

[1] Hippisley-Cox J, Coupland C, Vinogradova Y, Robson J, Minhas R, Sheikh A, and Brindle, P, *Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2.* BMJ 2008:bmj.39609.449676.25.

[2] Hippisley-Cox, J, *QRISK2 search definition (version 2.7)*, http://www.-qresearch.org/Public_Documents/QRISK2_Search_Definition_(version_2.7).-pdf, 2008.

A The tables

i	$j = 0$ (female)	$j = 1$ (male)
1	1.602503777	1.580074787
2	26.11306	26.57570839
3	-0.552380145	-0.428255409
4	132.7940979	135.58255
5	3.820816755	4.496264935

Table 1: μ_{ij}

ϵ	ethnic grouping	$j = 0$ (female)	$j = 1$ (male)
0	Not recorded	0	0
1	White	0	0
2	Indian	0.35824692	0.37126994
3	Pakistani	0.59029885	0.68049689
4	Bangladeshi	0.29907399	0.51493365
5	Other Asian	0.13956593	0.31605348
6	Black Caribbean	0.07972442	-0.47769203
7	Black African	-0.5370966	-0.45775464
8	Chinese	-0.36824281	-0.66621017
9	Other ethnic group	0.04342772	-0.09920695

Table 2: Ethnicity, $E_{\epsilon j}$

i	$j = 0$ (female)	$j = 1$ (male)
1	5.3404546	4.874016
2	0.01612434	0.01708499
3	0.06257538	0.03306506
4	0.00903992	0.00849546
5	0.15980458	0.17420282
6	0.68598342	0.76144644
7	0.59038691	0.50127585
8	0.43057065	0.52086143
9	0.93295828	0.78775883
10	1.1193915	0.87528042
11	0.40301589	0.32254429
12	0.53302873	0.55764718

Table 3: κ_{ij}

i	$j = 0$ (female)	$j = 1$ (male)
2	-0.05057926	-0.03270808
3	-0.13478689	-0.05691302
4	-0.01806834	-0.01902445
6	-0.7949737	-0.83599424
7	-0.74584065	-0.73827742
8	-0.51071393	-0.92196849
9	-1.0639771	-1.0789045
10	-1.6063741	-1.1894002

Table 4: λ_{ij}

	$j = 0$ (female)	$j = 1$ (male)
	0.974264	0.9538617

Table 5: s_j

age	female	male
35	26.113025665283203	26.776933670043945
36	26.240478515625	26.96689224243164
37	26.360139846801758	27.134483337402344
38	26.472320556640625	27.281757354736328
39	26.577316284179688	27.410551071166992
40	26.675397872924805	27.522502899169922
41	26.766826629638672	27.61907958984375
42	26.851844787597656	27.701601028442383
43	26.93067741394043	27.771259307861328
44	27.0035400390625	27.829124450683594
45	27.070634841918945	27.876169204711914
46	27.13215446472168	27.913272857666016
47	27.188278198242188	27.94123077392578
48	27.239177703857422	27.960773468017578
49	27.285015106201172	27.972558975219727
50	27.325944900512695	27.977191925048828
51	27.36211585998535	27.975221633911133
52	27.39366340637207	27.9671573638916
53	27.42072296142578	27.953454971313477
54	27.44342041015625	27.93454360961914
55	27.46187400817871	27.910812377929688
56	27.47620391845703	27.882617950439453
57	27.486515045166016	27.850292205810547
58	27.492916107177734	27.814138412475586
59	27.495506286621094	27.774438858032227
60	27.494382858276367	27.7314510345459
61	27.489635467529297	27.6854190826416
62	27.48135757446289	27.636560440063477
63	27.46963119506836	27.585084915161133
64	27.454540252685547	27.53118133544922
65	27.436159133911133	27.47502899169922
66	27.414567947387695	27.416790008544922
67	27.38983726501465	27.35662078857422
68	27.362037658691406	27.294660568237305
69	27.331235885620117	27.23104476928711
70	27.29749870300293	27.165895462036133
71	27.260887145996094	27.099328994750977
72	27.22146224975586	27.031450271606445
73	27.17928123474121	26.962364196777344
74	27.134403228759766	26.892160415649414

Table 6: Age-sex predicted mean BMI

age	female	male
35	3.566315174102783	4.493016242980957
36	3.575978994369507	4.521395683288574
37	3.585739850997925	4.54364538192749
38	3.595575332641601	4.560487270355225
39	3.605462551116943	4.572552680969238
40	3.615377902984619	4.580392360687256
41	3.625297307968139	4.5844902992248535
42	3.635195970535278	4.585272312164307
43	3.645048379898071	4.5831122398376465
44	3.654828786849975	4.578342437744141
45	3.664510250091552	4.571254730224609
46	3.674066066741943	4.56210994720459
47	3.683468341827392	4.551138401031494
48	3.692688703536987	4.538546085357666
49	3.701698780059814	4.5245161056518555
50	3.710469245910644	4.509211540222168
51	3.718970060348510	4.49277925491333
52	3.727171421051025	4.4753499031066895
53	3.735042333602905	4.457040786743164
54	3.742551803588867	4.437956809997559
55	3.749667882919311	4.418193340301514
56	3.756358861923217	4.397834777832031
57	3.76259183883667	4.376957893371582
58	3.768333911895752	4.3556318283081055
59	3.773551940917968	4.333918571472168
60	3.778211593627929	4.3118743896484375
61	3.782279014587402	4.289549350738525
62	3.785719156265259	4.266989707946777
63	3.788497447967529	4.244235992431641
64	3.790577888488769	4.2213263511657715
65	3.791924715042114	4.198293685913086
66	3.792502164840698	4.175169467926025
67	3.792273044586181	4.151979923248291
68	3.791200399398803	4.128751277923584
69	3.789247274398803	4.105504989624023
70	3.786375522613525	4.08226203918457
71	3.782547235488891	4.059040069580078
72	3.777723789215088	4.0358567237854
73	3.771866798400879	4.012725830078125
74	3.764936685562134	3.989661693572998

Table 7: Age-sex predicted mean Cholesterol/HDL ratio

age	female	male
35	117.71205139160156	127.75093841552734
36	118.19584655761719	128.1344451904297
37	118.75687408447266	128.52503967285156
38	119.3781967163086	128.9220733642578
39	120.04591369628906	129.32492065429688
40	120.74859619140625	129.73292541503906
41	121.47685241699219	130.14540100097656
42	122.22295379638672	130.56166076660156
43	122.98052978515625	130.98097229003906
44	123.7443618774414	131.40260314941406
45	124.51016235351562	131.82579040527344
46	125.27442932128906	132.24977111816406
47	126.03429412841797	132.67373657226562
48	126.78742980957031	133.0968780517578
49	127.531982421875	133.51837158203125
50	128.2664337158203	133.9373779296875
51	128.98960876464844	134.35302734375
52	129.70059204101562	134.7644500732422
53	130.39866638183594	135.17074584960938
54	131.0832977294922	135.57101440429688
55	131.75413513183594	135.96432495117188
56	132.4109344482422	136.34974670410156
57	133.05355834960938	136.72633361816406
58	133.6819305419922	137.0930938720703
59	134.2960968017578	137.44906616210938
60	134.89613342285156	137.79324340820312
61	135.482177734375	138.1246337890625
62	136.0543670654297	138.4421844482422
63	136.61294555664062	138.74490356445312
64	137.15809631347656	139.03170776367188
65	137.6901092529297	139.3015594482422
66	138.20921325683594	139.55337524414062
67	138.71571350097656	139.7860565185547
68	139.20985412597656	139.99851989746094
69	139.69195556640625	140.18966674804688
70	140.1623077392578	140.3583526611328
71	140.62118530273438	140.5034637451172
72	141.06887817382812	140.62384033203125
73	141.50570678710938	140.71832275390625
74	141.93194580078125	140.7857666015625

Table 8: Age-sex predicted mean systolic blood pressure