

Supplemental materials for:

Stam H, Maarsingh OR, Heymans MW, van Weert HC, van der Wouden JC, van der Horst HE.
Predicting an unfavorable course of dizziness in older patients. *Ann Fam Med.* 2018;16(5):428-435.

Supplemental Appendix 1

Univariate association of potential candidate predictors with an unfavorable course of dizziness after 6 months					
Figures are number (percentage) unless stated otherwise					
	Unfavorable course of dizziness (n=150)	Favorable course of dizziness (n=53)	OR	95% CI	P value
Demographic characteristics					
Age in years, mean \pm SD	78.3 \pm 7.05	75.5 \pm 5.9	1.062	1.008-1.119	0.025
Female gender	99 (66.0)	29 (54.7)	1.629	0.831-3.194	0.155
Ethnicity					ref
Dutch	115 (76.7)	47 (88.7)			ref
Western immigrant	24 (16.0)	3 (5.7)	2.780	0.786-9.832	0.113
Non-Western immigrant	11 (7.3)	3 (5.7)	1.725	0.352-8.448	0.500
Educational level					ref
Low	13 (8.7)	3 (5.7)			ref
Middle	100 (66.7)	34 (64.2)	0.786	0.185-3.345	0.744
High	37 (24.7)	16 (30.2)	0.615	0.135-2.796	0.528
Living situation, independent	144 (96.0)	52 (98.1)	0.556	0.062-4.947	0.598
Living alone	90 (60.0)	21 (39.6)	0.416	0.239-0.890	0.021
Health status variables					
Cardiovascular disease	108 (72.0)	35 (66.0)	1.340	0.673-2.667	0.404
Neurological disease	32 (21.3)	14 (26.4)	1.463	0.713-3.002	0.300
Psychiatric illness* ^a	25 (16.7)	5 (9.4)	2.718	0.749-9.865	0.128
Hypertension	69 (46.0)	25 (47.2)	0.932	0.485-1.790	0.832
Ischemic heart disease	39 (26.0)	15 (28.3)	0.855	0.407-1.798	0.680
Myocardial infarction	14 (9.3)	7 (13.2)	0.612	0.224-1.673	0.338
Arrhythmia	49 (32.7)	12 (22.6)	1.979	0.885-4.425	0.096
Heart valve disease	15 (10.0)	1 (1.9)	4.906	0.630-38.23	0.129
Cerebrovascular disease	51 (34.0)	6 (11.3)	2.317	0.823-6.524	0.111
Migraine	20 (13.3)	7 (13.2)	0.923	0.631-2.357	0.867
Parkinson disease	2 (1.3)	1 (1.9)	0.699	0.062-7.881	0.772
Epilepsy	5 (3.3)	0 (0.0)	NA	NA	1.000
Multiple sclerosis	0 (0.0)	0 (0.0)	NA	NA	NA
Depressive disorder ^b	3 (2.0)	0 (0.0)	NA	NA	1.000
Anxiety disorder ^c	20 (13.3)	4 (7.5)	2.147	0.568-8.110	0.259
Panic disorder	7 (4.7)	1 (1.9)	1.925	0.208-17.79	0.563
Diabetes mellitus	25 (16.7)	8 (15.1)	1.172	0.470-2.923	0.733
Thyroid disease	16 (10.7)	5 (9.4)	1.267	0.405-3.963	0.684
Cataract	62 (53.0)	18 (34.0)	2.517	1.230-5.151	0.012
Weekly alcohol use, mean \pm SD	5.19 \pm 7.9	7.57 \pm 8.6	0.967	0.930-1.006	0.100
Benign paroxysmal positional dizziness	11 (7.3)	6 (11.3)	0.605	0.210-1.740	0.351
Meniere's disease	8 (5.3)	3 (5.7)	0.906	0.226-3.639	0.889
Number of chronic diseases, mean \pm SD	1.9 \pm 1.41	1.6 \pm 1.38	1.155	0.904-1.476	0.248
Impaired functional mobility ^d	22 (14.7)	3 (5.7)	2.937	0.707-12.20	0.138
Use of hearing aid	43 (28.7)	12 (22.6)	1.987	0.651-6.062	0.368
Use of glasses	140 (93.3)	46 (86.8)	1.418	0.662-3.036	0.227
Use of walking aid	51 (34.0)	10 (18.9)	2.184	0.970-4.916	0.059
Number of prescribed drugs, mean \pm SD	5.8 \pm 3.41	4.9 \pm 4.0	1.090	0.904-1.315	0.170
Polypharmacy (\geq 5 prescribed drugs)	94 (62.7)	25 (47.2)	1.797	0.947-3.409	0.073
Number of prescribed FRIDs, mean \pm SD	2.1 \pm 1.85	1.8 \pm 1.8	1.090	0.904-1.315	0.366

SD: standard deviation; FRID: Fall risk increasing drug; DHI-s: Screening version of Dizziness Handicap Inventory; ref: reference category; NA not applicable.

* Psychiatric illness: presence of depressive disorder and/or anxiety disorder and/or panic disorder.

Depressive disorder, anxiety disorder and panic disorder were assessed with Patient Health Questionnaire-9,^{1,2} Generalized Anxiety Disorder-7,³ and Patient Health Questionnaire Panic Module⁴. Impaired functional mobility: Timed Up-and-Go score \geq 20 seconds.⁵

Missing values in ^a1%, ^b0.5%, ^c0.5%, ^d2%, ^e9.4% and ^f3.4% of participants.

Univariate association of potential candidate predictors with an unfavorable course of dizziness after 6 months (continued)

	Unfavorable course of dizziness (n=150)	Favorable course of dizziness (n=53)	OR	95% CI	P value
Dizziness characteristics					
DHI score, mean \pm SD ^e	48.8 \pm 13.5	38.8 \pm 10.1	1.018	1.040-1.125	<0.001
DHI-s score, mean \pm SD ^f	18.7 \pm 6.8	13.6 \pm 5.1	1.140	1.071-1.212	<0.001
Onset of dizziness					
1-4 weeks	1 (0.7)	1 (1.9)	0.409	0.026-6.333	0.521
1-6 months	14 (9.3)	13 (24.5)	0.443	0.158-1.240	0.121
6-48 months	26 (17.3)	15 (28.3)	0.623	0.236-1.647	0.341
2-10 years	46 (30.7)	15 (28.3)	1.080	0.421-2.770	0.873
>10 years	30 (20.0)	9 (17.0)			ref
Frequency of dizziness symptoms					
Continuous	14 (9.3)	2 (3.8)			ref
Daily	80 (53.3)	28 (52.8)	0.409	0.087-1.927	0.258
Weekly	36 (24.0)	14 (26.4)	0.380	0.076-1.905	0.240
Monthly	14 (9.3)	6 (11.3)	0.323	0.055-1.895	0.211
Annually	6 (4.0)	3 (5.7)	0.286	0.038-2.173	0.226
Duration of dizziness symptoms					
<10 sec	40 (26.7)	9 (17.0)			ref
10-60 sec	21 (14.0)	9 (17.0)	0.520	0.166-1.624	0.671
Several minutes	31 (20.7)	13 (24.5)	0.511	0.182-1.435	0.498
Several minutes to 1 h	12 (8.0)	8 (15.1)	0.317	0.096-1.044	0.436
>1 h	13 (8.7)	4 (7.5)	0.644	0.161-2.567	0.149
>1 day	7 (4.7)	3 (5.7)	0.499	0.105-2.374	0.795
Combination of above possibilities	27 (18.0)	7 (13.2)	0.799	0.247-2.459	0.583
Description of dizziness					
Instability or unsteadiness	119 (79.3)	44 (83.0)	0.803	0.349-1.894	0.607
Loss of balance	126 (84.0)	39 (73.6)	1.787	0.808-3.949	0.151
Light-headedness	105 (70.0)	40 (75.5)	0.716	0.336-1.529	0.388
Rotational sensation	97 (64.7)	40 (75.5)	0.863	0.446-1.667	0.660
Tendency to fall	102 (68.0)	33 (62.3)	1.232	0.623-2.436	0.548
Giddy	82 (54.7)	33 (62.3)	0.691	0.353-1.352	0.280
Environment spinning	61 (40.7)	23 (43.4)	0.599	0.285-1.257	0.175
Becoming unwell	43 (28.7)	17 (32.1)	0.860	0.423-1.747	0.676
Near faint	42 (28.0)	17 (32.1)	0.818	0.404-1.658	0.578
Everything turning black	30 (20.0)	9 (17.0)	1.292	0.548-3.047	0.558
Provoking factors					
Bending forward	98 (65.3)	33 (62.3)	1.110	0.567-2.176	0.760
Turning head	104 (69.3)	35 (66.0)	1.145	0.576-2.278	0.699
Looking up	102 (68.0)	27 (50.9)	2.098	1.053-4.179	0.035
Exercise	65 (43.3)	15 (28.3)	2.025	0.985-4.160	0.055
Standing still	37 (24.7)	11 (20.8)	1.194	0.555-2.565	0.650
Strong emotions	32 (21.3)	13 (24.5)	0.860	0.401-1.841	0.697
Getting up from a lying or sitting position	114 (76.0)	39 (73.6)	1.065	0.505-2.244	0.869
Associated symptoms					
Falling/almost falling	65 (43.3)	17 (32.1)	1.415	0.639-3.134	0.392
Trouble with walking	77 (51.3)	23 (43.4)	1.129	0.488-2.614	0.776
Nausea	32 (21.3)	13 (24.5)	0.688	0.299-1.581	0.378
Sweaty, pale, or clammy	27 (18.0)	13 (24.5)	0.563	0.244-1.301	0.179
Fear	33 (22.0)	10 (18.9)	1.129	0.469-2.719	0.786
Dyspnea	21 (14.0)	4 (7.5)	2.008	0.547-7.368	0.293
Tinnitus	22 (14.7)	10 (18.9)	0.664	0.266-1.657	0.380
Palpitations	16 (10.7)	7 (13.2)	0.627	0.227-1.729	0.367
Chest pain	8 (5.3)	3 (5.7)	0.729	0.170-3.130	0.671
Diplopia	0 (0.0)	0 (0.0)	NA	NA	NA
Hearing problems	7 (4.7)	4 (7.5)	0.504	0.136-1.862	0.304
Trouble with speaking or swallowing	10 (6.7)	2 (3.8)	1.621	0.337-7.796	0.546

Supplemental Appendix 2

This appendix presents the results of an additional prediction model introducing dizziness-related impairment as a continuous outcome. The outcome was defined as dizziness-related impairment at 6 months follow-up. Dizziness-related impairment was assessed with the Dizziness Handicap Inventory (DHI).

Model development and performance

Twenty-two candidate predictors were univariate associated with the outcome (see table B of this appendix). Predictors of the final prediction model were age, sex, DHI screening version (DHI-s) score, standing still as provoking factor, looking up as provoking factor, history of cerebrovascular disease, ≥ 1 fall in the past year, dizziness frequency, and ethnicity (see table A of this appendix). For linear regression models R-squared is the goodness-of-fit measure. The prediction model demonstrated an R^2 of 39,3% in the development sample and external validation resulted in an R^2 of 36.4%, which is accurate.

Table A. Prediction model for dizziness-related impairment at 6 months follow-up (backwards selection with p out >0.157)

Predictor	B	95% CI	P value
Intercept	-22.580		
DHI-s score, per point	1.245	0.910-1.580	<0.001
Age, per year	0.400	0.068-0.733	0.018
Gender, male vs female	4.966	0.324-9.608	0.036
Looking up (provoking factor)*	6.011	1.308-10.714	0.012
Standing still (provoking factor)*	4.012	-1.301-9.324	0.139
History of cerebrovascular disease*	4.375	-1.348-10.099	0.134
≥ 1 fall in the past year*	3.643	-0.846-8.132	0.112
Frequency of dizziness symptoms (vs continuous)			
Daily	-1.085	-9.574-7.403	0.802
Weekly	-0.303	-9.333-8.727	0.948
Monthly	-8.735	-19.385-1.916	0.108
Annually	-2.700	-15.637-10.238	0.683
Ethnicity (vs Dutch)			
Western immigrant	2.398	-4.543-9.340	0.498
Non-Western Immigrant	9.503	0.322-18.685	0.043

B: regression coefficient; CI: confidence interval; DHI: Dizziness Handicap Inventory; DHI-s: screening version of DHI.

* Yes = 1, no = 0.

Table B. Univariate association of potential candidate predictors with dizziness-related impairment (continuous outcome) after 6 months. Figures are number (percentage) unless stated otherwise.

	Total study population (n=203)	B	95% CI	P value
Demographic characteristics				
Age in years, mean \pm SD	77.53 \pm 7.04	0.347	-0.043–0.737	0.081
Female gender	127 (62.6)	6.772	1.377–12.168	0.014
Ethnicity				
Dutch	162 (79.8)			ref
Western immigrant	27 (13.3)	3.227	-4.609–11.064	0.420
Non-Western immigrant	14 (6.9)	10.513	-0.286–21.311	0.056
Educational level				
Low	16 (7.9)			ref
Middle	134 (66.0)	-7.858	-18.190–2.473	0.136
High	53 (26.1)	-10.983	-21.933– -0.033	0.049
Living situation, independent	196 (96.6)	-2.531	-17.616–2.554	0.742
Living alone	111 (54.7)	8.525	3.335–13.716	0.001
Health status variables				
Cardiovascular disease	142 (70.0)	1.591	-4.167–7.349	0.588
Neurological disease	65 (32.0)	3.976	-1.659–9.612	0.167
Psychiatric illness* ^a	29 (14.3)	14.589	7.018–22.159	<0.001
Hypertension	94 (46.3)	0.429	-4.925–5.783	0.157
Ischemic heart disease	54 (26.6)	0.903	-5.097–6.903	0.768
Myocardial infarction	21 (10.3)	-3.067	37.450–43.058	<0.001
Arrhythmia	59 (29.1)	3.182	-2.685–9.050	0.288
Heart valve disease	16 (7.9)	5.731	-4.036–15.498	0.250
Cerebrovascular disease	37 (18.2)	6.194	-0.668–13.055	0.077
Migraine	27 (13.3)	-0.685	-8.493–7.123	0.863
Parkinson disease	3 (1.5)	12.244	-9.252–33.740	0.264
Epilepsy	5 (2.5)	3.920	-13.300– 21.139	0.655
Multiple sclerosis	0 (0.0)	NA	NA	NA
Depressive disorder ^b	3 (1.5)	29.296	8.104–50.488	0.007
Anxiety disorder ^c	24 (11.8)	12.584	4.252–20.916	0.003
Panic disorder	8 (3.9)	10.389	-4.028–24.807	0.158
Diabetes mellitus	32 (15.8)	1.188	-6.180–8.555	0.316
Thyroid disease	21 (10.3)	1.140	-7.564–9.843	0.797
Cataract	102 (50.2)	5.452	0.196–10.709	0.042
Weekly alcohol use, mean \pm SD	5.51 \pm 7.71	-0.540	-0.876– -0.205	0.002
Benign paroxysmal positional dizziness	17 (8.4)	-6.557	-15.983–2.870	0.173
Meniere's disease	11 (5.4)	1.323	-10.473– 13.118	0.826
Number of chronic diseases, mean \pm SD	1.82 \pm 1.40	1.249	-0.644–3.143	0.169
Impaired functional mobility ^d	25 (12.3)	4.658	-3.625–12.941	0.270
Fall(s) in the past year	101 (49.8)	5.238	0.011–10.466	0.050
Use of hearing aid	148 (72.9)	0.103	-5.919–6.125	0.973
Use of glasses	186 (91.6)	-3.295	-12.847–6.257	0.499
Use of walking aid	61 (30.0)	-6.199	-12.057– -0.341	0.038
Number of prescribed drugs, mean \pm SD	5.54 \pm 3.56	0.446	-0.294–1.186	0.238
Polypharmacy (\geq 5 prescribed drugs)	119 (58.6)	2.186	-3.162–7.534	0.423
Number of prescribed FRIDs, mean \pm SD	1.99 \pm 1.85	0.516	-0.921–1.953	0.482

B: regression coefficient; SD: standard deviation; FRID: Fall risk increasing drug; DHI-s: Screening version of Dizziness Handicap Inventory; ref: reference category; NA not applicable.

* Psychiatric illness: presence of depressive disorder and/or anxiety disorder and/or panic disorder.

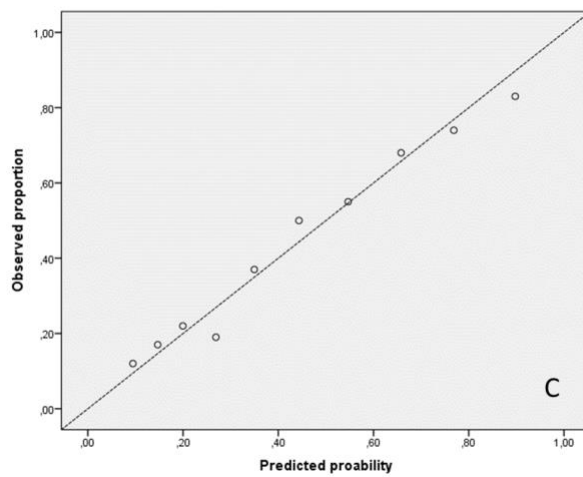
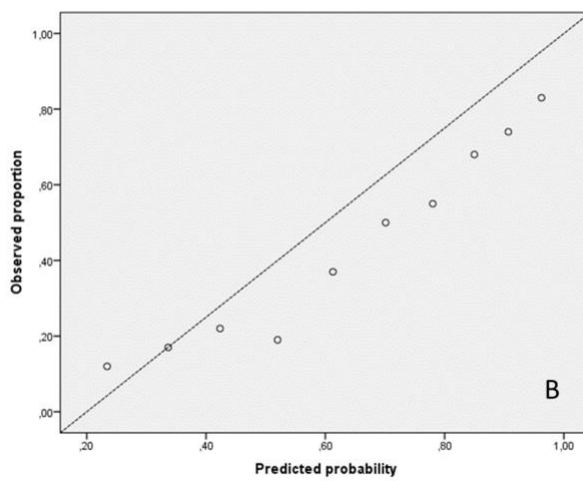
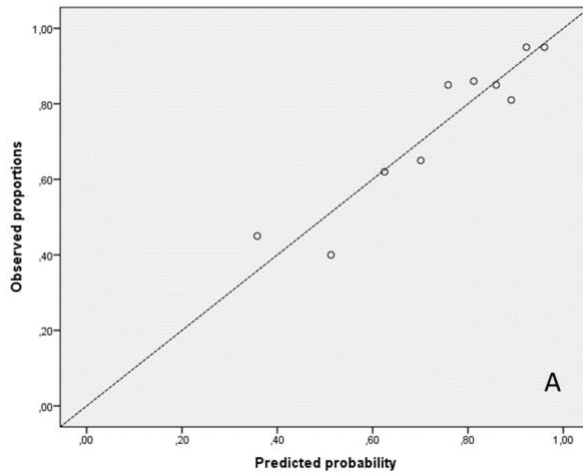
Depressive disorder, anxiety disorder and panic disorder were assessed with Patient Health Questionnaire-9,^{1,2} Generalized Anxiety Disorder-7,³ and Patient Health Questionnaire Panic Module⁴. Impaired functional mobility: Timed Up-and-Go score \geq 20 seconds.⁵

Missing values in ^a1%, ^b0.5%, ^c0.5%, ^d2%, ^e9.4% and ^f3.4% of participants.

Table B. Univariate association of potential candidate predictors with dizziness-related impairment (continuous outcome) after 6 months. (continued)

	Total study population (n=203)	B	95% CI	P value
Dizziness characteristics				
DHI score, mean \pm SD ^e	46.13 \pm 13.45	0.765	0.582–0.948	< 0.001
DHI-s score, mean \pm SD ^f	17.39 \pm 6.88	1.432	1.097–1.768	< 0.001
Onset of dizziness				
1-4 weeks	3 (1.5)			ref
1-6 months	34 (16.7)	7.571	-17.565–32.707	0.554
6-48 months	49 (24.1)	10.571	14.207–35.348	0.402
2-10 years	74 (36.5)	12.920	11.618–37.457	0.301
>10 years	43 (21.2)	15.878	8.901–40.657	0.208
Frequency of dizziness symptoms				
Continuous	16 (7.9)			ref
Daily	108 (53.2)	-10.910	-20.799– -1.020	0.031
Weekly	50 (24.6)	-8.548	-19.152–2.056	0.114
Monthly	20 (9.9)	-13.833	-26.351– -0.316	0.030
Annually	9 (4.4)	-14.070	-29.375–1.235	0.072
Duration of dizziness symptoms				
<10 sec	49 (24.1)			ref
10-60 sec	29 (14.3)	-3.427	-12.256–5.402	0.447
Several minutes	44 (21.7)	-3.730	-11.783–4.324	0.364
Several minutes to 1 h	20 (9.9)	-1.144	-11.231–8.942	0.824
>1 h	17 (8.4)	-0.837	11.680–10.005	0.880
>1 day	10 (4.9)	-0.978	13.960–12.005	0.883
Combination of above possibilities	34 (16.7)	3.473	-5.002–11.947	0.422
Description of dizziness				
Instability or unsteadiness	162 (79.8)	-0.731	-7.343–5.881	0.828
Loss of balance	165 (81.3)	7.088	0.271–13.906	0.042
Light-headedness	145 (71.4)	-2.843	-8.711–3.024	0.342
Rotational sensation	137 (67.5)	0.206	-5.442–5.853	0.943
Tendency to fall	135 (66.5)	1.984	-3.645–7.612	0.490
Giddy	115 (56.7)	0.167	-5.292–5.626	0.922
Environment spinning	84 (41.4)	-3.066	-8.522–2.390	0.271
Becoming unwell	60 (29.6)	-0.018	-5.990–5.954	0.995
Near faint	59 (29.1)	-3.084	-9.140–2.972	0.318
Everything turning black	39 (19.2)	4.217	-2.544–10.977	0.221
Provoking factors				
Bending forward	131 (64.5)	5.378	-0.079–10.834	0.053
Turning head	139 (68.5)	4.828	-0.945–10.600	0.101
Looking up	129 (63.5)	9.655	4.321–14.988	< 0.001
Exercise	80 (39.4)	9.184	3.916–14.452	0.001
Standing still	48 (23.6)	6.464	0.300–12.627	0.040
Strong emotions	44 (21.7)	8.093	1.776–14.410	0.012
Getting up from a lying or sitting position	153 (75.4)	2.407	-3.722–8.537	0.441
Associated symptoms				
Falling/almost falling	119 (58.6)	0.781	-5.383–6.945	0.804
Trouble with walking	100 (49.3)	4.318	-2.185–10.821	0.193
Nausea	45 (22.2)	-2.781	-9.526–3.964	0.419
Sweaty, pale, or clammy	39 (19.2)	-0.384	-7.230–6.461	0.912
Fear	43 (21.2)	6.053	-0.627–12.732	0.076
Dyspnea	25 (12.3)	6.175	-2.831–15.181	0.178
Tinnitus	32 (15.8)	2.235	-5.160–9.629	0.554
Palpitations	23 (11.3)	-0.233	-8.726–8.260	0.957
Chest pain	11 (5.4)	-2.642	-14.503–9.219	0.662
Diplopia	0 (0.0)	NA	NA	NA
Hearing problems	11 (5.4)	-7.110	-18.659–4.439	0.228
Trouble with speaking or swallowing	12 (5.9)	4.812	-6.411–16.035	0.401

Supplemental Appendix 3



Calibration plots. Diagonal lines indicate perfect calibration. Circles represent observed and predicted rates of an unfavorable course of dizziness in deciles. A. Original model in development cohort (of multiple imputation dataset 1 as example). B. Adjusted model on external validation (of multiple imputation dataset 1 as example). C. Updated model with recalibrated intercept (-1.08) (of multiple imputation dataset 1 as example).

Supplemental Appendix 4

Sensitivity, specificity and predictive values at different risk score thresholds in development sample								
Threshold of risk score (percentage of total sample)	TP (n)	TN (n)	FP (n)	FN (n)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
≥ 79 (100)	150	0	53	0	100.0	NA	73.9	NA
≥ 99 (90)	141	11	42	9	94.0	20.8	77.0	55.0
≥ 107 (80)	132	23	30	18	88.0	43.4	81.5	56.1
≥ 112 (70)	120	31	22	30	80.0	58.5	84.5	50.8
≥ 118 (60)	104	38	15	46	69.3	71.7	87.4	45.2
≥ 123 (50)	89	41	12	61	59.3	77.4	88.1	40.2
≥ 129 (40)	70	44	9	80	46.7	83.0	88.6	35.5
≥ 133 (30)	54	47	6	96	36.0	88.7	90.0	32.9
≥ 138 (20)	39	51	2	111	26.0	96.2	95.1	31.5
≥ 147 (10)	18	52	1	132	12.0	98.1	94.7	28.3
> 173 (0)	0	53	0	150	NA	100.0	NA	26.1

TP: True Positives; TN: True Negatives; FP: False Positives; FN: False Negatives; PPV: Positive Predictive Value; NPV: Negative Predictive Value; NA: Not Applicable

Supplemental Appendix 5

Dizziness Handicap Inventory – screening version (DHI-s)

Instructions: The purpose of this scale is to identify difficulties that you may be experiencing because of your dizziness. Please check “yes”, or “no” or “sometimes” to each question. Answer each question only as it pertains to your dizziness problem.

	Yes	Sometimes	No
Because of your problem, do you restrict your travel for business or recreation?			
Does your problem significantly restrict your participation in social activities, such as going out to dinner, going to the movies, dancing, or going to parties?			
Because of your problem, are you afraid to leave your home without having someone accompany you?			
Because of your problem have you been embarrassed in front of others?			
Does walking down a sidewalk increase your problem?			
Because of your problem, is it difficult for you to concentrate			
Because of your problem, is it difficult for you to walk around your house in the dark?			
Because of your problem, are you depressed?			
Does your problem interfere with your job or household responsibilities?			
Does bending over increase your problem?			

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