Supplementary material

Table S1. Hazard ratios (95% confidence intervals) for predictors of hip fracture in the derivation (360 hip fractures) and validation cohorts (1001 hip fractures). Hazard ratios were estimated using univariate Cox regression models or in models containing age and gender in addition to the predictor variable.

Predictor	Crude				Adjusted for age and gender			
	Derivation cohort		Validation cohort		Derivation cohort		Validation cohort	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Ten years higher age	2·23	(2·07-2·40)	2·31	(2·20-2·42)	2·22	(2·06-2·39)	2·31	(2·20-2·42)
Female	1·33	(1·08-1·63)	1·22	(1·07-1·38)	1·15	(0·93-1·41)	1·05	(0·92-1·18)
Five units higher BMI (kg/m^2)	0·76	(0·67-0·85)	0·71	(0·67-0·76)	0·73	(0·65-0·83)	0·72	(0·67-0·76)
Ten cm taller	0·83	(0·74-0·93)	0·81	(0·77-0·86)	0·93	(0·80-1·09)	0·90	(0·83-0·96)
Current smoker	0·78	(0·58-1·07)	0·89	(0·75-1·05)	0·85	(0·62-1·15)	1·05	(0·89-1·24)
Current moderate/ heavy drinker[a]	0·90	(0·62-1·30)	0·73	(0·49-1·09)	1·06	(0·73-1·54)	0·93	(0·62-1·38)
Previous major osteoporotic fracture (MOF)	2·91	(2·15-3·94)	4·53	(3·85-5·34)	2·09	(1·54-2·84)	2·58	(2·18-3·05)
Previous fracture at non-MOF site	1·31	(0·99-1·73)	1·38	(1·19-1·58)	1·40	(1·06-1·84)	1·43	(1·24-1·64)
Dementia	8·01	(4·38-14·62)	4·78	(3·53-6·48)	2·19	(1·19-4·02)	1·58	(1·16-2·15)
History of falls	3·42	(2·51-4·66)	3·56	(3·06-4·15)	2·17	(1·58-2·97)	2·04	(1·75-2·39)
Asthma or chronic obstructive pulmonary disease	0·95	(0·66-1·36)	0·78	(0·64-0·96)	1·07	(0·75-1·55)	0·92	(0·75-1·12)
Cancer	4·13	(2·32-7·34)	2·38	(1·76-3·22)	1·86	(1·04-3·33)	1·08	(0·79-1·46)
Heart disease	2·17	(1·25-3·78)	2·88	(2·27-3·64)	0·70	(0·40-1·23)	1·09	(0·85-1·38)
Epilepsy or taking anticonvulsants	1·65	(1·32-2·07)	1·63	(1·43-1·85)	2·00	(1·59-2·51)	1·68	(1·48-1·91)
Liver or kidney disease	1·83	(0·86-3·86)	2·71	(2·08-3·53)	1·14	(0·54-2·40)	1·02	(0·78-1·33)
Diabetes	2·64	(1·86-3·74)	2·03	(1·69-2·44)	1·42	(1·00-2·02)	1·11	(0·92-1·33)
Antidepressants	1·60	(1·21-2·11)	1·25	(1·08-1·46)	1·37	(1·04-1·81)	1·07	(0·92-1·25)
Antipsychotics	1·59	(1·21-2·08)	1·75	(1·52-2·01)	1·31	(1·00-1·72)	1·42	(1·23-1·64)
Poor mobility/Parkinsons	1·11	(0·79-1·57)	1·54	(1·31-1·81)	1·16	(0·82-1·64)	1·37	(1·17-1·61)
Hearing impairment	1·16	(0·82-1·64)	1·19	(1·00-1·42)	1·07	(0·76-1·51)	1·06	(0·89-1·26)
Visual impairment	1·19	(0·72-1·96)	1·33	(1·08-1·64)	1·03	(0·62-1·69)	1·10	(0·90-1·36)
Sedatives and hypnotics	1·55	(1·09-2·19)	1·89	(1·57-2·27)	1·30	(0·92-1·85)	1·59	(1·32-1·91)
Proton pump inhibitors	1·98	(1·37-2·86)	2·16	(1·85-2·53)	1·28	(0·88-1·85)	1·31	(1·12-1·54)
Risperidone and/or hyperprolactinaemia	1·28	(0·78-2·08)	1·37	(1·10-1·71)	1·30	(0·80-2·12)	1·30	(1·04-1·62)
Type of intellectual disability[b]	..	..	..	..	..	..	..	..
Down syndrome	1·00	(0·71-1·40)	1·16	(0·94-1·44)	1·58	(1·12-2·23)	1·65	(1·33-2·05)
Other specified intellectual disability	0·52	(0·27-0·97)	0·77	(0·59-1·02)	0·62	(0·33-1·17)	0·96	(0·73-1·28)
Mild severity of intellectual disability[c]	1·27	(0·76-2·13)	0·79	(0·64-0·97)	1·17	(0·70-1·96)	0·84	(0·68-1·03)

a Moderate/heavy drinking is defined as 3+ alcohol units daily

b The remainder of the cohort had an unspecified intellectual disability.

c The remainder of the cohort had non-mild or unspecified severity of intellectual disability.

Table S2. Hazard ratios (HR) (95% confidence intervals (CI)) for predictors of major osteoporotic fracture (MOF) in the derivation (1045 MOF) and validation cohorts (2420 MOF). Hazard ratios were estimated using univariate Cox regression models or with models containing age and gender in addition to the predictor variable.

Predictor	Unadjusted				Adjusted for age and gender			
	Derivation cohort		Validation cohort		Derivation cohort		Validation cohort	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Ten years older age	1.61	(1.42-1.82)	1.86	(1.81-1.92)	1.48	(1.31-1.67)	1.84	(1.79-1.90)
Female at age 40 years	1.74	(1.66-1.81)	1.56	(1.44-1.69)	1.72	(1.65-1.79)	1.41	(1.30-1.53)
Five units higher body mass index (kg/m2)	0.91	(0.86-0.97)	0.85	(0.82-0.88)	0.88	(0.82-0.94)	0.84	(0.81-0.87)
10cm taller	0.85	(0.79-0.91)	0.83	(0.80-0.86)	1.01	(0.91-1.11)	0.99	(0.94-1.04)
Current smoker	0.91	(0.77-1.08)	0.94	(0.84-1.04)	0.98	(0.83-1.17)	1.09	(0.98-1.22)
Current moderate/ heavy drinker[a]	1.17	(0.97-1.43)	1.12	(0.91-1.38)	1.33	(1.09-1.61)	1.46	(1.19-1.81)
Non-white ethnicity	0.44	(0.24-0.79)	0.39	(0.32-0.48)	0.60	(0.33-1.09)	0.54	(0.44-0.66)
Previous major osteoporotic fracture (MOF)	3.51	(2.97-4.15)	4.47	(4.01-4.97)	2.87	(2.42-3.40)	2.92	(2.62-3.26)
Previous fracture at non-MOF site	1.43	(1.22-1.68)	1.50	(1.37-1.64)	1.52	(1.30-1.78)	1.59	(1.45-1.73)
Dementia	4.79	(3.07-7.46)	3.66	(2.93-4.57)	1.84	(1.17-2.87)	1.46	(1.17-1.84)
History of falls	3.02	(2.50-3.66)	3.26	(2.94-3.61)	2.16	(1.78-2.62)	2.12	(1.91-2.35)
Malabsorption	1.40	(0.78-2.54)	1.34	(1.01-1.79)	1.45	(0.80-2.63)	1.31	(0.98-1.75)
Endocrine problems	2.22	(1.37-3.58)	1.61	(1.19-2.18)	1.57	(0.97-2.54)	1.20	(0.89-1.64)
Asthma or chronic obstructive pulmonary disease	1.19	(0.98-1.44)	1.08	(0.96-1.21)	1.28	(1.05-1.55)	1.22	(1.09-1.36)
Cancer	3.03	(2.05-4.47)	2.05	(1.66-2.53)	1.68	(1.13-2.48)	1.09	(0.89-1.35)
Heart disease	1.76	(1.23-2.52)	2.54	(2.16-2.98)	0.78	(0.54-1.13)	1.23	(1.04-1.45)
Epilepsy or taking anticonvulsants	1.62	(1.42-1.85)	1.77	(1.63-1.92)	1.82	(1.59-2.08)	1.78	(1.64-1.93)
Rheumatoid arthritis or systemic lupus erythematosus	2.74	(1.47-5.11)	2.98	(2.07-4.30)	1.66	(0.89-3.09)	1.94	(1.35-2.80)
Liver disease	1.46	(0.81-2.64)	3.39	(1.92-5.98)	1.36	(0.75-2.46)	2.68	(1.52-4.72)
Chronic kidney disease	3.06	(1.73-5.42)	2.08	(1.71-2.54)	1.42	(0.80-2.51)	0.91	(0.74-1.11)
Diabetes	2.01	(1.60-2.53)	1.71	(1.51-1.95)	1.27	(1.01-1.60)	1.06	(0.93-1.20)
Steroid tablets	1.41	(0.70-2.83)	2.58	(1.90-3.50)	0.99	(0.49-1.98)	1.92	(1.41-2.60)
Oestrogen only hormone replacement therapy	2.03	(0.97-4.27)	1.07	(0.53-2.14)	1.46	(0.69-3.08)	0.88	(0.44-1.76)
Antidepressants	1.58	(1.34-1.86)	1.46	(1.33-1.61)	1.36	(1.15-1.60)	1.25	(1.13-1.37)
Antipsychotics	1.38	(1.17-1.63)	1.46	(1.33-1.60)	1.19	(1.01-1.41)	1.22	(1.11-1.34)
Poor mobility/Parkinsons	1.02	(0.83-1.25)	1.37	(1.23-1.52)	1.04	(0.85-1.28)	1.25	(1.12-1.39)
Hearing impairment	1.06	(0.86-1.30)	1.17	(1.04-1.31)	1.01	(0.82-1.24)	1.09	(0.97-1.22)
Self-injurious behaviour	0.69	(0.39-1.23)	1.48	(1.15-1.91)	0.84	(0.47-1.48)	1.77	(1.37-2.28)
Visual impairment	1.46	(1.12-1.91)	1.36	(1.19-1.55)	1.34	(1.02-1.75)	1.17	(1.03-1.34)
Hypogonadism (including taking progesterone)	1.02	(0.75-1.39)	0.86	(0.70-1.04)	1.49	(1.09-2.05)	1.21	(0.99-1.48)
Sedatives and hypnotics	1.26	(1.01-1.57)	1.69	(1.49-1.91)	1.09	(0.87-1.36)	1.44	(1.27-1.63)
Proton pump inhibitors	1.92	(1.54-2.38)	2.05	(1.85-2.27)	1.41	(1.14-1.76)	1.39	(1.25-1.55)
Risperidone and/or hyperprolactinaemia	1.23	(0.92-1.64)	1.20	(1.03-1.39)	1.21	(0.91-1.62)	1.12	(0.96-1.30)
Type of intellectual disability[b]								
Down syndrome	0.69	(0.55-0.87)	0.85	(0.73-1.00)	0.86	(0.68-1.09)	1.02	(0.87-1.20)
Other specified intellectual disability	0.68	(0.49-0.94)	0.88	(0.74-1.04)	0.76	(0.55-1.06)	1.03	(0.87-1.22)
Mild severity of intellectual disability[c]	1.10	(0.80-1.53)	0.93	(0.82-1.05)	1.06	(0.77-1.46)	0.96	(0.85-1.09)

a Moderate/heavy drinking is defined as 3+ alcohol units daily; b The remainder of the cohort had an unspecified intellectual disability.
c The remainder of the cohort had non-mild or unspecified severity of intellectual disability.

Table S3. IDfracture prediction models for hip and major osteoporotic fracture (MOF)

	Major osteoporotic fracture	Hip fracture
Coefficents	..	..
(Age at index (years) - 40)/10 in females	0.5604	0.8330
(Age at index (years) - 40)/10 in males	0.4438	0.7334
Female	0.2192	-0.0561
(Body mass index(kg/m2) - 25)/5	-0.1505	-0.3473
(Height (cm) - 165)/10	-0.0265	-0.0399
Current smoker	-0.0845	-0.1783
Current moderate/ heavy drinker[a]	0.2473	0.0872
Non-white ethnicity	-0.4247	..
Previous major osteoporotic fracture (MOF)	0.9947	0.6359
Previous fracture at non-MOF site	0.4712	0.3725
Dementia	0.2724	0.2640
History of falls	0.5000	0.5514
Malabsorption	0.3340	..
Endocrine problems	0.3431	..
Asthma or chronic obstructive pulmonary disease	0.1572	0.0584
Cancer	0.3982	0.5716
Heart disease	-0.3720	-0.4186
Epilepsy or taking anticonvulsants	0.5503	0.6383
Rheumatoid arthritis or systemic lupus erythematosus	0.4116	..
Liver disease	0.1401	..
Chronic kidney disease	0.2088	..
Liver or kidney disease		0.0208
Diabetes	0.2382	0.4749
Steroid tablets	-0.1751	..
Oestrogen only hormone replacement therapy	0.2464	..
Antidepressants	0.2349	0.2637
Antipsychotics	0.1003	0.2419
Poor mobility/Parkinsons	-0.2750	-0.1886
Hearing impairment	-0.0844	-0.0338
Self-injurious behaviour	-0.4389	..
Visual impairment	0.1736	-0.1111
Hypogonadism (including taking progesterone)	0.3480	..
Sedatives and hypnotics	-0.1530	0.0256
Proton pump inhibitors	0.2140	0.1254
Risperidone and/or hyperprolactinaemia	0.0557	0.0114
Down syndrome	0.0296	0.6577
Other specified intellectual disability[b]	-0.2616	-0.3791
Mild severity of intellectual disability[c]	0.0063	0.2469
Optimism correction	0.9657	0.9539
10-year baseline survival	0.9773	0.9934

The 10-year risk of fracture for an individual is calculated as $1 - [S_{0t}{}^{\exp(LP)}]$ where S_{0t} is the 10-year baseline survival and LP is the linear predictor. LP is calculated by multiplying the value of each variable by its coefficient, and then summing over all variables. The value of binary variables is 1 if they have the condition, otherwise 0. Continuous variables must be scaled as described in the table. After summing the optimism corrected LP is calculated by multiplying by the optimism correction term.

a Moderate/heavy drinking is defined as 3+ alcohol units daily
b The remainder of the cohort had an unspecified intellectual disability.
c The remainder of the cohort had non-mild or unspecified severity of intellectual disability.

Table S4. Predicted 10-year risks for hip fracture or major osteoporotic fracture (MOF) under various scenarios

Gender	Age (years)	Other	Risk of hip fracture (%)		Risk of MOF (%)	
			IDfracture	Qfracture 2016	IDfracture	Qfracture 2016
Male	40		0.6	0.1	2.1	0.6
Male	50		1.2	0.2	3.3	0.9
Male	60		2.3	0.6	5.0	1.5
Male	70		4.6	1.7	7.5	2.9
Male	50	Epilepsy	2.1	0.4	5.5	1.7
Male	50	Down's syndrome	2.2	--	3.3	--
Female	40		0.6	0.1	2.7	0.9
Female	50		1.2	0.3	4.5	2.0
Female	60		2.7	1.0	7.7	4.3
Female	70		5.9	3.4	12.8	8.6
Female	50	Epilepsy	2.2	0.4	7.6	3.0
Female	50	Down's syndrome	2.3	--	4.7	--

10-year risk scores were calculated for males height 174 cm, BMI 26.4 kg/m^2; females height 161 cm, BMI 27.0 kg/m^2. All other variables were assumed to take the reference value. For IDFracture we used the formulae and coefficients in Table S3. For Qfracture we used the 2016 risk calculator on https://qfracture.org/ (last accessed 9 Nov 2025).

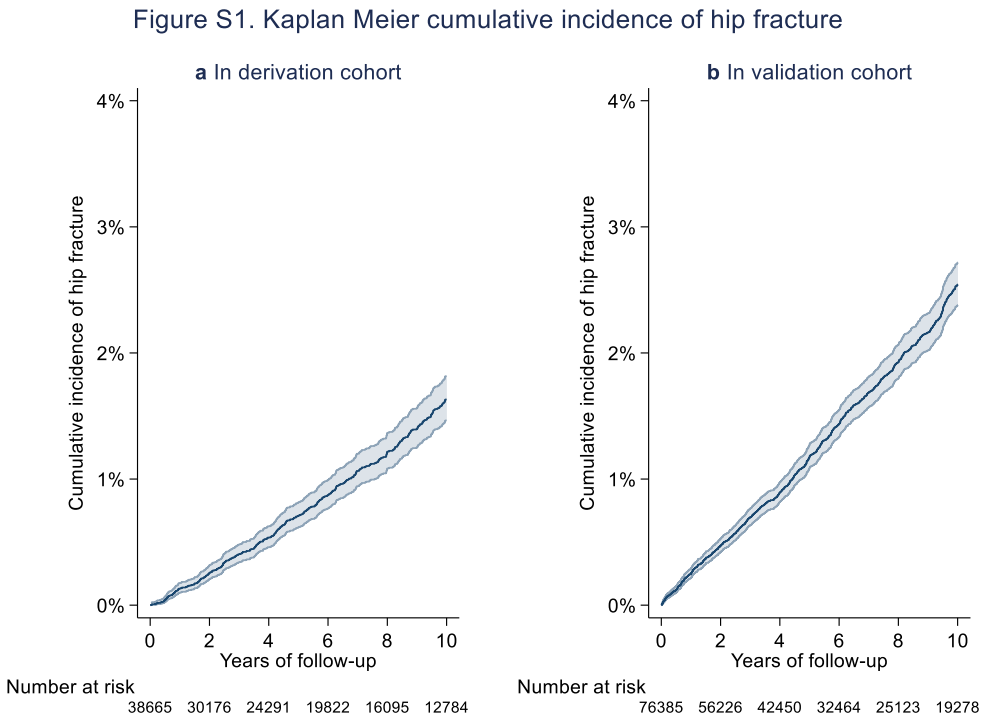

Figure S1 Kaplan Meier curves for cumulative incidence of hip fracture in the GOLD derivation cohort and in the Aurum validation cohort

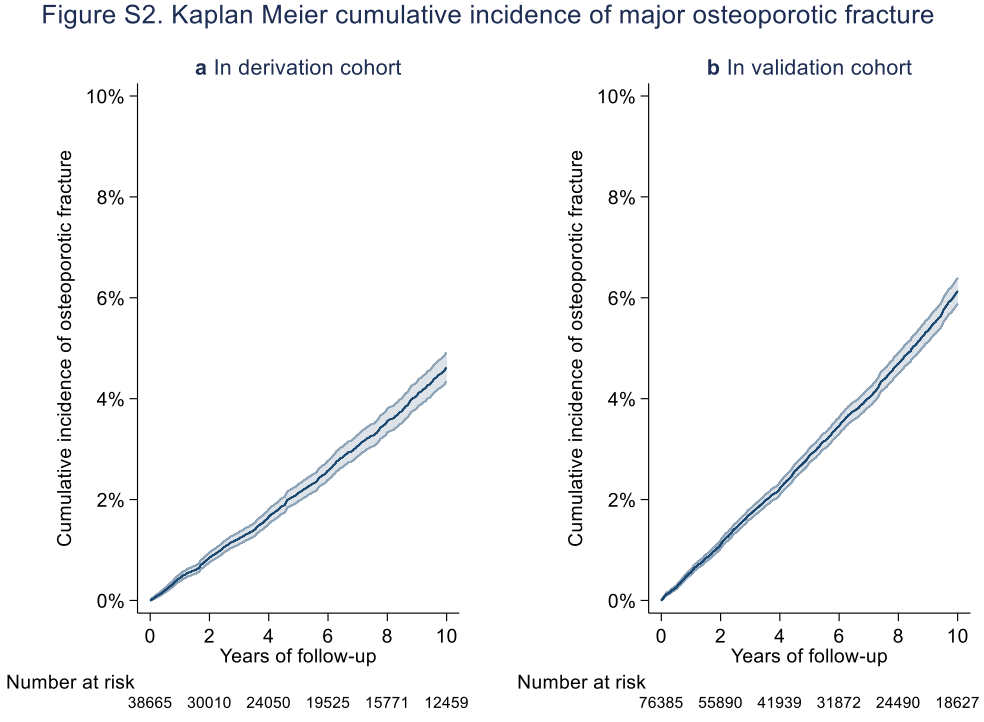

Figure S2 Kaplan Meier curves for cumulative incidence of major osteoporotic fracture (MOF) in the GOLD derivation cohort and in the Aurum validation cohort

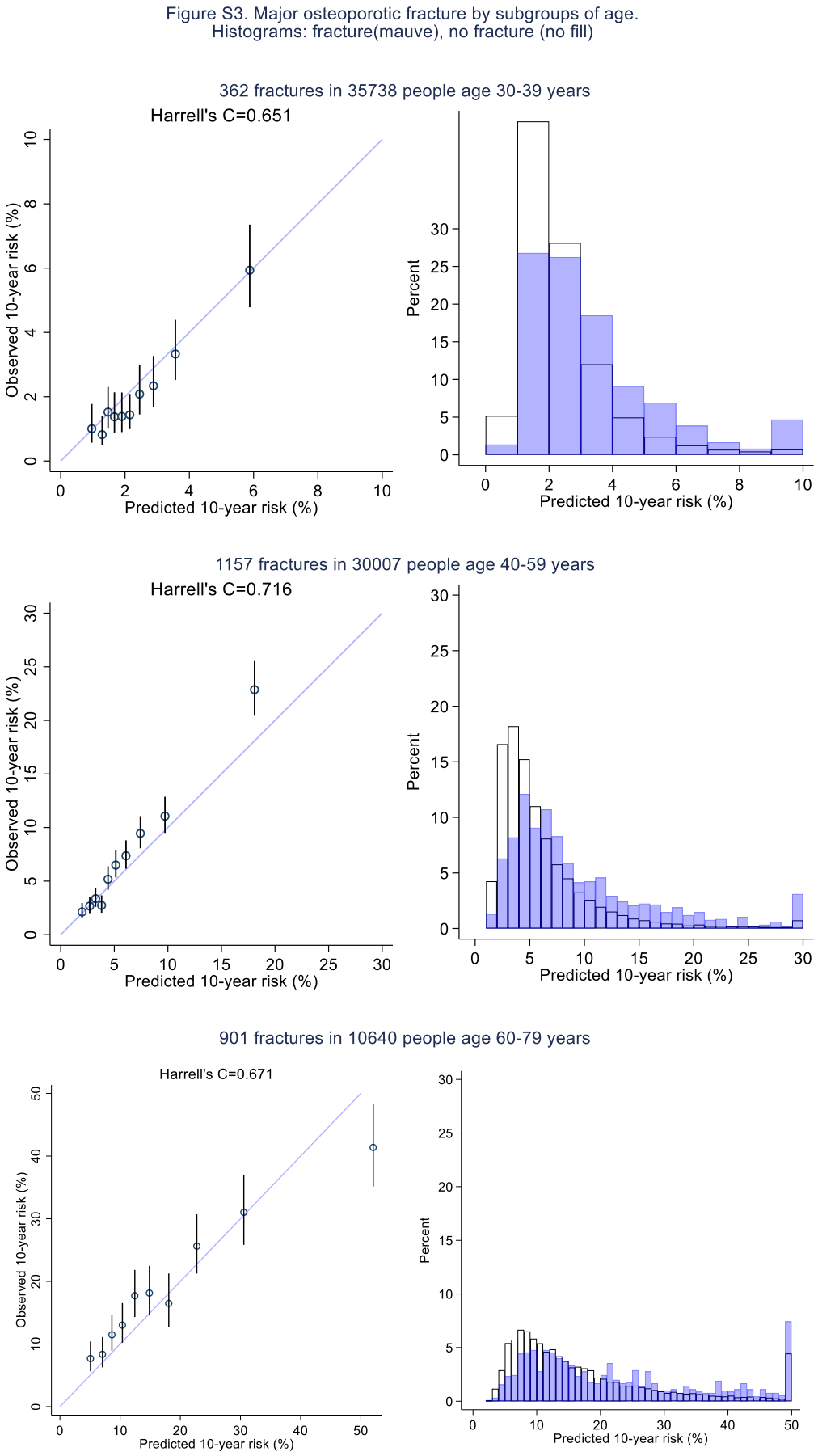

Figure S3 Calibration plots for the performance of the major osteoporotic fracture (MOF) prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of age at index.

Figure S4. Major osteoporotic fracture by subgroups of sex.
Histograms: fracture(mauve), no fracture (no fill)

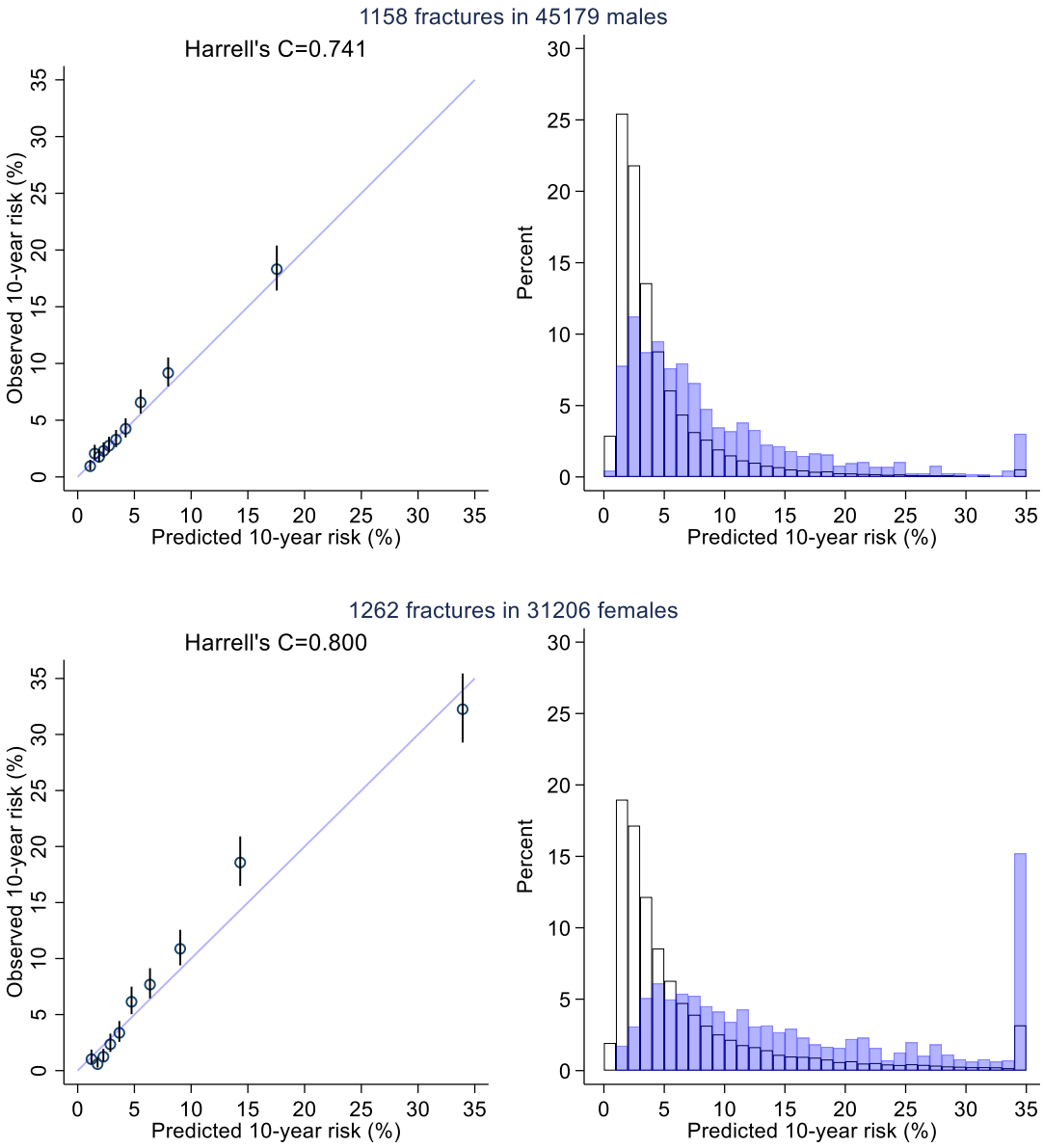

Figure S4 Calibration plots for the performance of the major osteoporotic fracture (MOF) prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of sex.

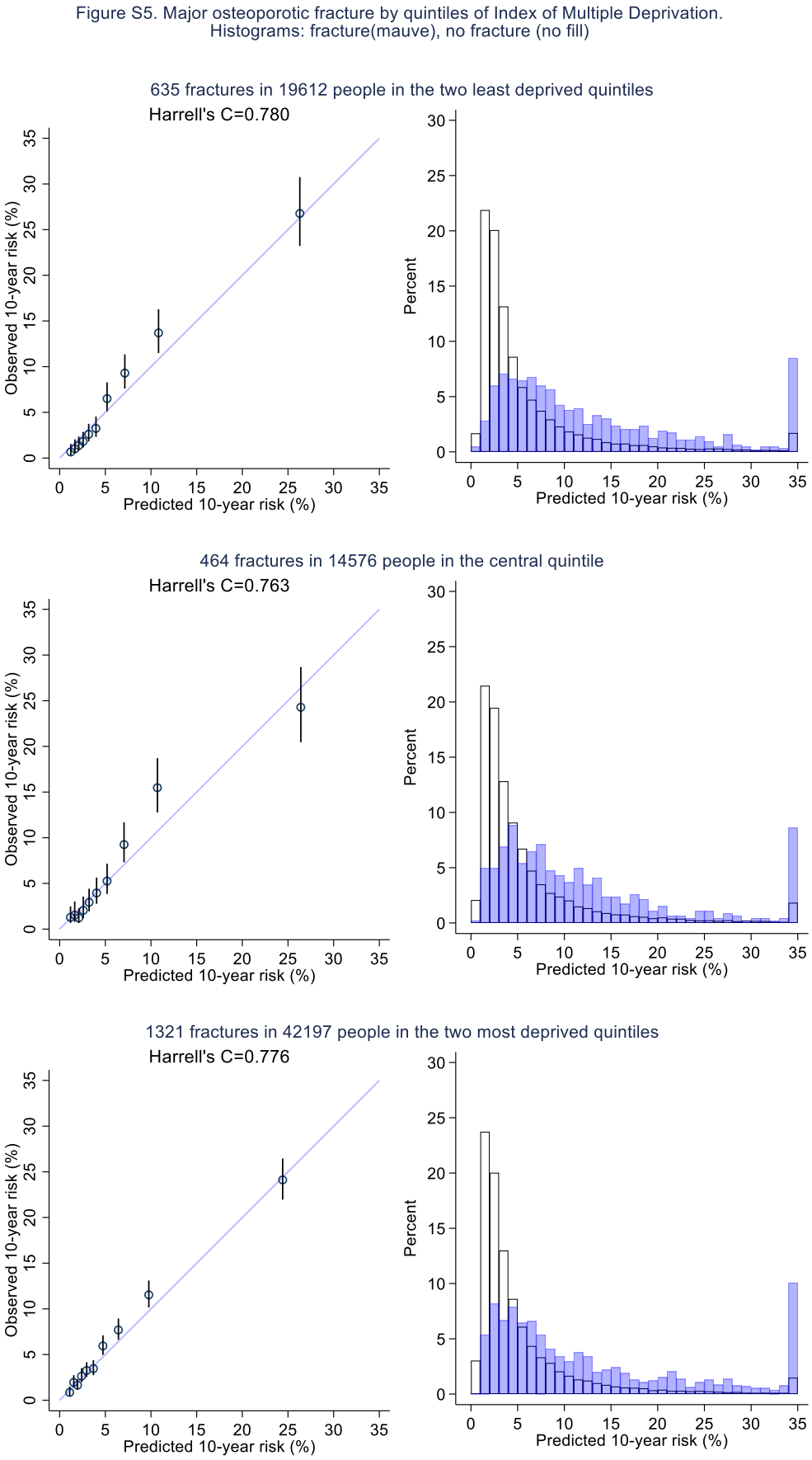

Figure S5 Calibration plots for the performance of the major osteoporotic fracture (MOF) prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of Index of Multiple Deprivation.

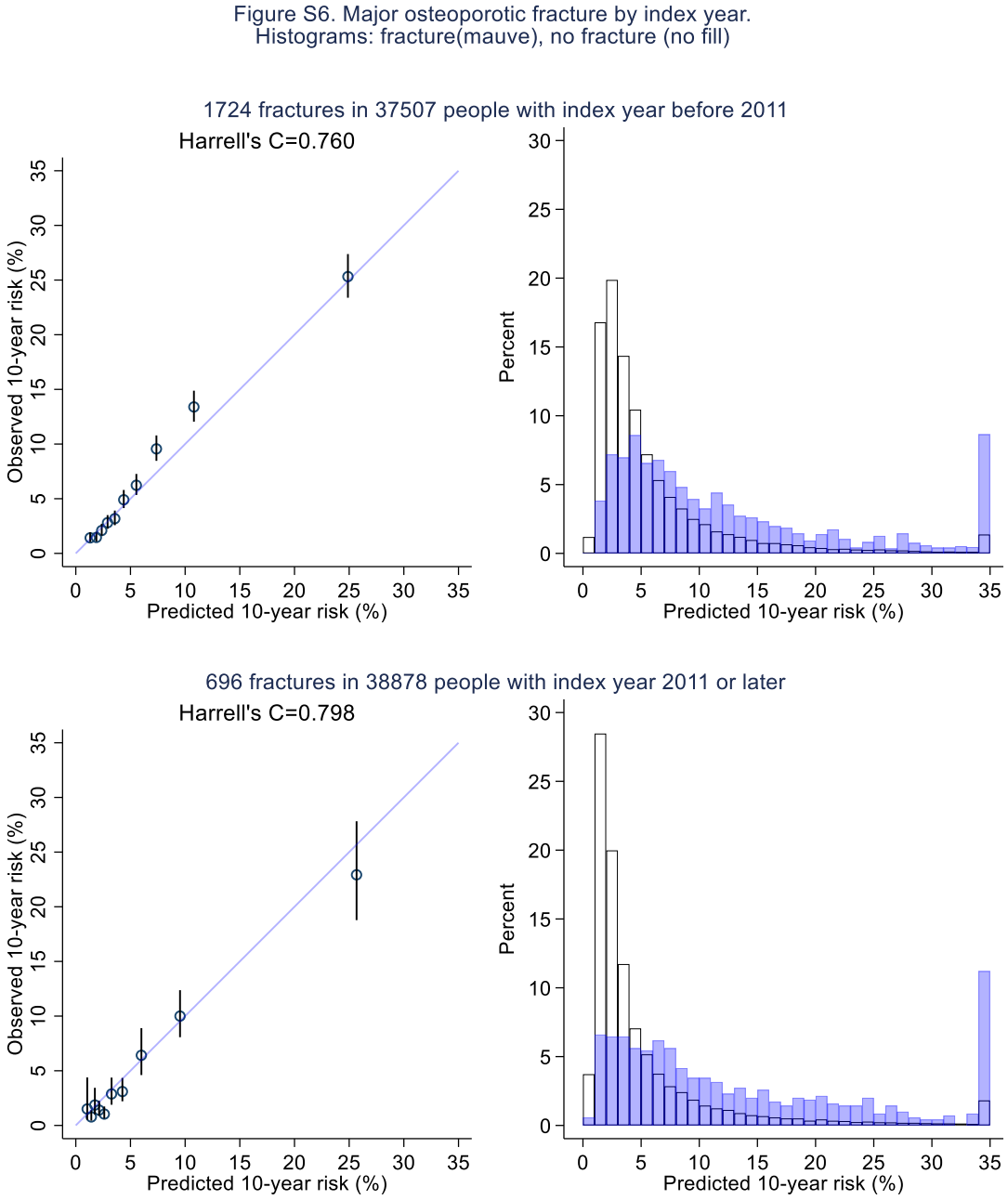

Figure S6 Calibration plots for the performance of the major osteoporotic fracture (MOF) prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of year of index date.

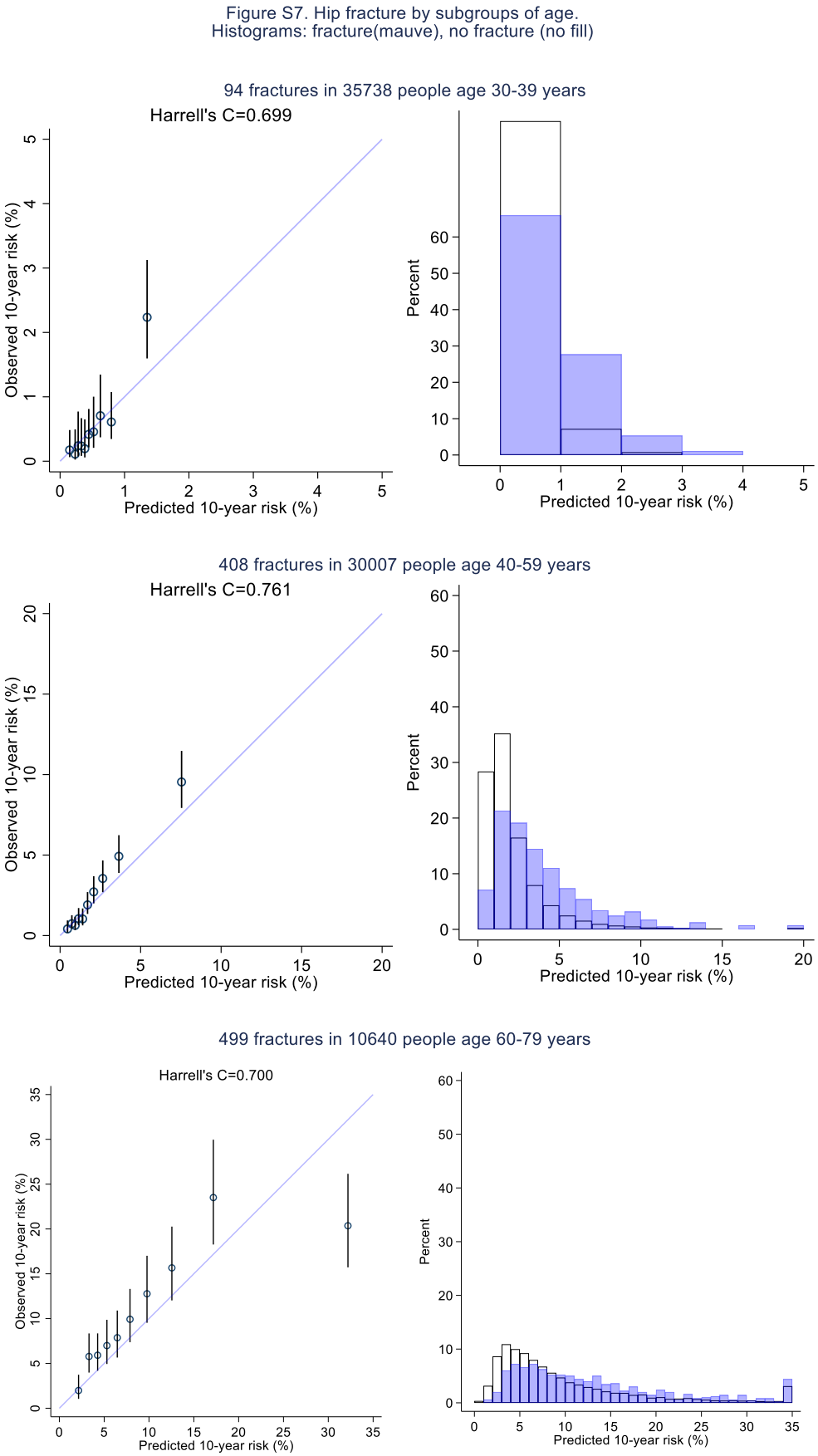

Figure S7 Calibration plots for the performance of the hip fracture prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of age at index.

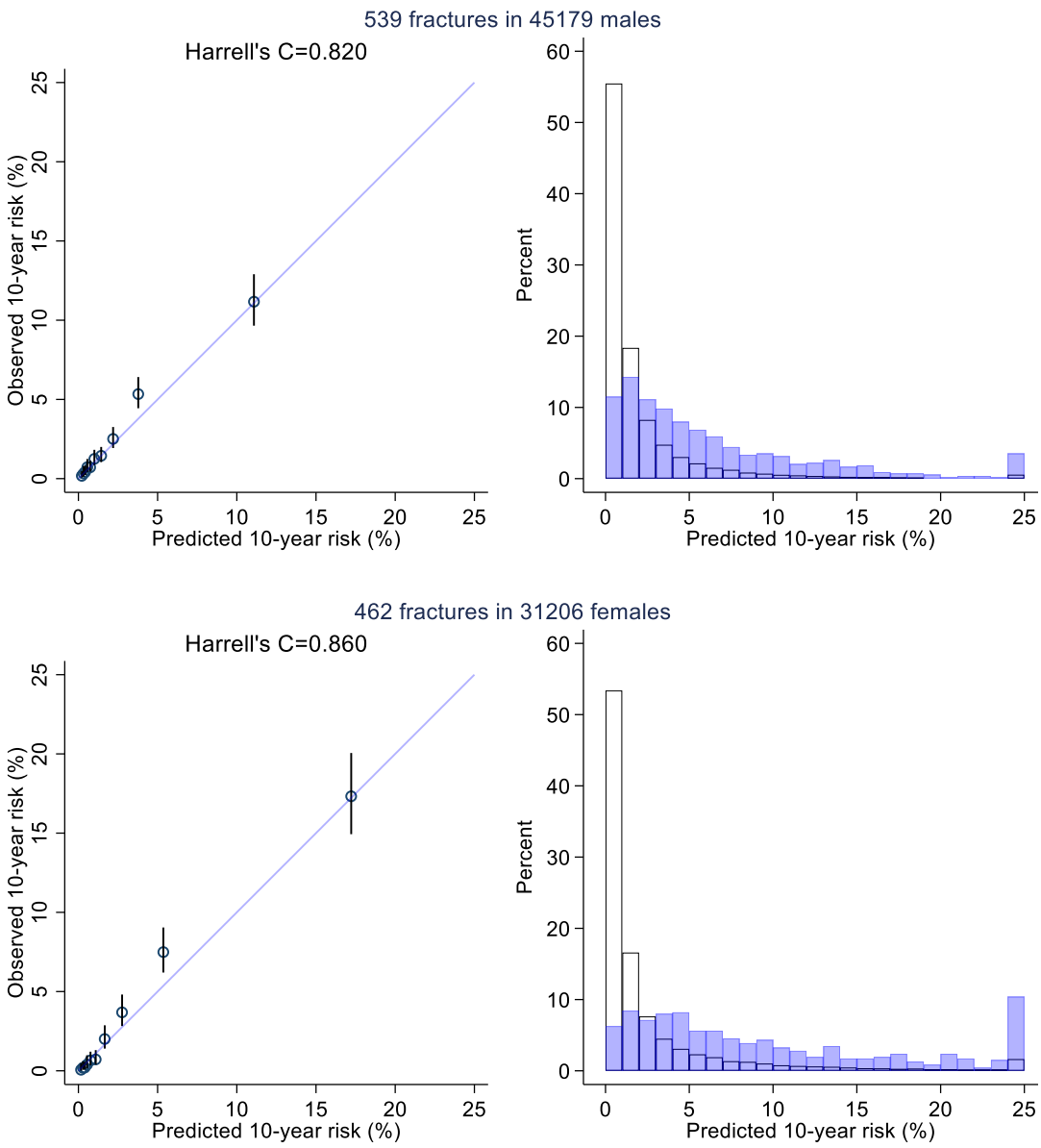

Figure S8 Calibration plots for the performance of the hip fracture prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of sex.

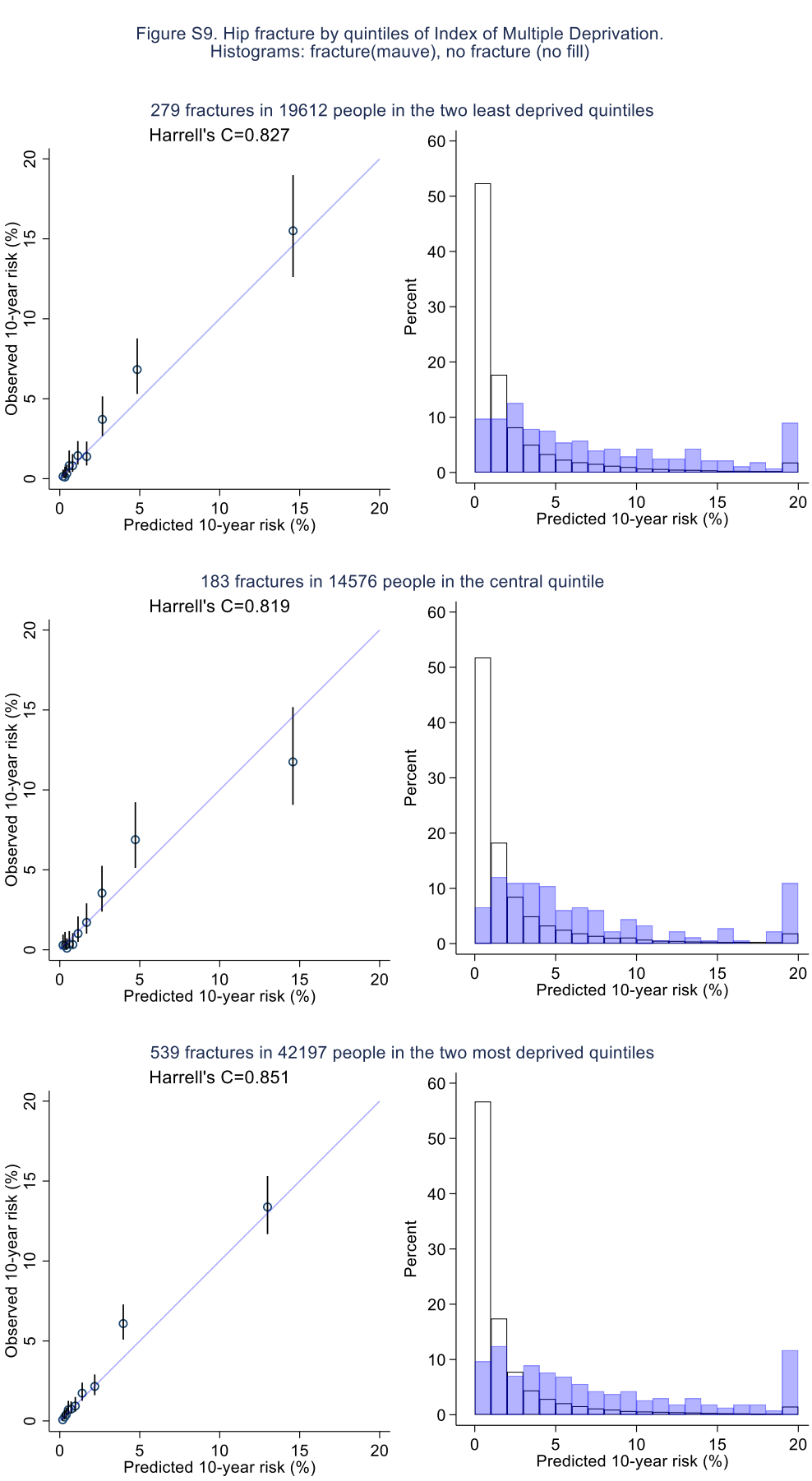

Figure S9 Calibration plots for the performance of the hip fracture prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of Index of Multiple Deprivation.

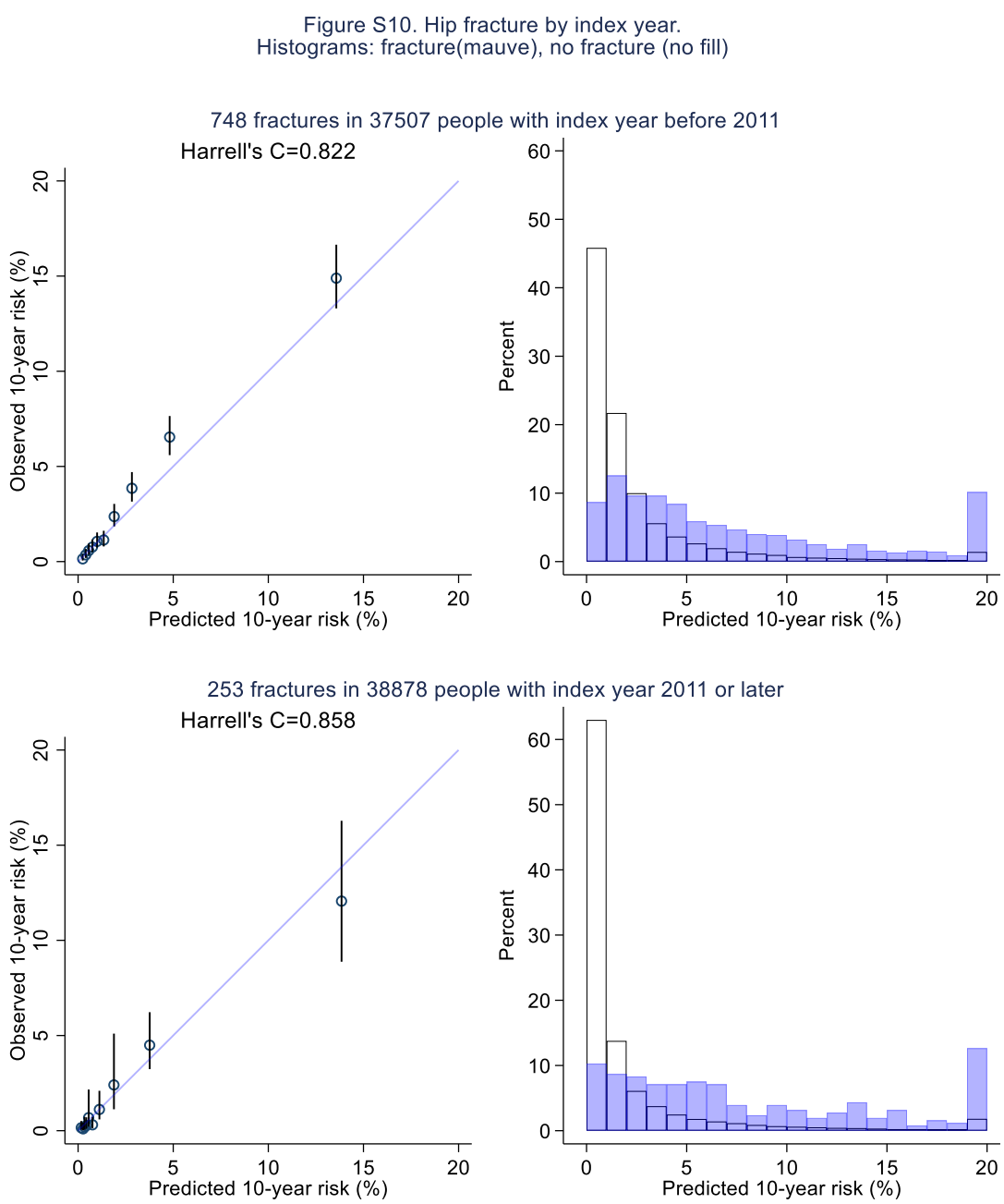

Figure S10 Calibration plots for the performance of the hip fracture prediction model in the Aurum validation data. Groups are deciles of predicted risk. Validation was done by subgroup of year of index date.