

Supplemental materials for:

Tammes P, Purdy S, Salisbury C, MacKichan F, Lasserson D, Morris R. Continuity of primary care and emergency hospital admissions among older patients in England. *Ann Fam Med.* 2017;15(6):515-522.

APPENDIX

Supplementary Table 1: Cross tabulation of Bice and Boxerman (BB) Score and the Number of GP Consultations of 8,248 Patients in the Prospective Cohort Analysis

Continuity of Care (BB index)	Number of GP consultations (%)				Total
	2-9	10-16	17-26	27+	
COC = 0	95 (100.0)	0	0	0	95 (100.0)
Q1 COC>0 & <0.247	458 (24.2)	490 (25.9)	487 (25.7)	457 (24.2)	1892 (100.0)
Q2 COC>=0.247 & <0.383	397 (21.0)	444 (23.5)	471 (24.9)	579 (30.6)	1891 (100.0)
Q3 COC>=0.383 & <0.567	367 (19.3)	511 (26.9)	487 (25.6)	536 (28.2)	1901 (100.0)
Q4 COC>=0.567 & <1	257 (13.6)	500 (26.4)	547 (28.9)	590 (31.2)	1894 (100.0)
COC = 1	305 (53.0)	155 (27.0)	81 (14.1)	34 (5.9)	575 (100.0)
Total	1879 (22.8)	2100 (25.5)	2073 (25.1)	2196 (26.6)	8248 (100.0)

COC=continuity of care, BB= Bice and Boxerman index, Q=quartile

Supplementary Table 2: Association Between BB Index Score and Risk of Emergency Hospital Admission in the Prospective Cohort Analysis (N = 8,248)

	N	Hazard ratio	95% CI	P-value
<i>Continuity of Care (BB index)</i>				
COC is 0	95	2.272	1.371, 3.764	.001
Q1 COC>0 & <0.247	1892	1.123	0.882, 1.431	.35
Q2 COC>=0.247 & <0.383	1891	1.050	0.830, 1.329	.69
Q3 COC>=0.383 & <0.567	1901	1.053	0.837, 1.323	.66
Q4 COC>=0.567 & <1	1894	0.963	0.768, 1.206	.74
COC is 1 (ref.)	575			
<i>Gender</i>				
Male (ref.)	3560			
Female	4688	0.901	0.819, 0.992	.03
<i>Age</i>				
85+	1225	3.515	3.106, 3.978	<.001
75-84	2651	1.897	1.696, 2.123	<.001
65-74 (ref.)	4372			
<i>Deprivation (IMD)</i>				
Q1 – least deprived (ref.)	1455			
Q2	2055	1.057	0.888, 1.257	.53
Q3	1823	1.085	0.911, 1.292	.36
Q4	1435	1.298	1.078, 1.562	.01
Q5 – most deprived	1480	1.169	0.973, 1.403	.09
<i>Location</i>				
Cities & towns	4579	1.029	0.913, 1.161	.64
Rural	1104	0.824	0.681, 0.999	.05
Urban conurbation (ref.)	2565			
<i>Hospital admission in 2010-12</i>				
No (ref.)	6675			
Yes	1573	2.379	2.145, 2.639	<.001
<i>Number of consultations</i>				
Q1 2-9 (ref.)	1879			
Q2 10-16	2100	0.836	0.714, 0.980	.03
Q3 17-26	2073	0.857	0.734, 1.001	.05
Q4 >26	2196	0.689	0.588, 0.809	<.001
<i>Number of GPs in practice</i>				
Q1 <4 GPs (ref.)	882			
Q2 4-6 GPs	2213	0.944	0.776, 1.151	.57
Q3 7-8 GPs	2263	0.927	0.758, 1.133	.46
Q4 9+ GPs	2890	0.927	0.756, 1.136	.47
<i>Practice average COC (BB index)</i>				
Q1 COC<0.336	2085	0.968	0.809, 1.158	.70
Q2 COC>0.366 & <0.436	2017	0.853	0.718, 1.014	.07
Q3 COC >0.436 & <0.535	2068	0.878	0.744, 1.037	.12
Q4 COC>0.535 (ref.)	2078			
<i>Morbidities</i>				
Epilepsy	132	1.615	1.193, 2.189	.002
Chronic renal disease	133	2.220	1.736, 2.838	<.001
Cancer	864	1.124	0.976, 1.295	.10
Asthma	887	1.157	1.004, 1.334	.04
Stroke	671	1.103	0.955, 1.273	.18
Coronary heart disease	1114	1.392	1.239, 1.564	<.001
Diabetes	1001	1.242	1.092, 1.412	.001
COPD	398	1.583	1.335, 1.878	<.001
Schizophrenia	67	1.717	1.163, 2.535	.01
Depression	1629	1.196	1.067, 1.340	.002
Constant		0.001	0.001, 0.002	<.001
/Ln p		-0.302	-0.344, -0.259	<.001
Practice-level var(constant)		0.031	0.012, 0.086	

BB= Bice and Boxerman, CI=confidence interval, COC=continuity of care, ref.=reference category

Note: Estimated hazard ratios are from mixed-effects Weibull regression analysis.

Supplementary Table 3: Association Between BB Index Score (tertiles) and Risk of Emergency Hospital Admission in the Prospective Cohort Analysis (N = 8,248)

	N	Hazard ratio	95% CI	P-value
<i>Continuity of Care (BB index, tertiles)</i>				
T1: COC ≥ 0 & < 0.3003	2796	1.121	0.980, 1.280	.09
T2: COC ≥ 0.3003 & < 0.5312	2703	1.076	0.953, 1.214	.24
T3: COC ≥ 0.5312 & ≤ 1 (ref.)	2749			
<i>Gender</i>				
Male (ref.)	3560			
Female	4688	0.901	0.818, 0.992	.04
<i>Age</i>				
85+	1225	3.486	3.081, 3.944	<.001
75-84	2651	1.888	1.688, 2.112	<.001
65-74 (ref.)	4372			
<i>Deprivation (IMD)</i>				
Q1 – least deprived (ref.)	1455			
Q2	2055	1.043	0.876, 1.243	.63
Q3	1823	1.071	0.898, 1.277	.44
Q4	1435	1.288	1.070, 1.552	.02
Q5 – most deprived	1480	1.161	0.966, 1.394	.11
<i>Location</i>				
Cities & towns	4579	1.016	0.901, 1.145	.80
Rural	1104	0.814	0.671, 0.986	.04
Urban conurbation (ref.)	2565			
<i>Hospital admission in 2010-12</i>				
No (ref.)	6675			
Yes	1573	2.378	2.144, 2.638	<.001
<i>Number of consultations</i>				
Q1 2-9 (ref.)	1879			
Q2 10-16	2100	0.810	0.694, 0.945	.01
Q3 17-26	2073	0.830	0.714, 0.963	.01
Q4 >26	2196	0.667	0.571, 0.778	<.001
<i>Number of GPs in practice</i>				
Q1 <4 GPs (ref.)	882			
Q2 4-6 GPs	2213	0.939	0.778, 1.135	.52
Q3 7-8 GPs	2263	0.934	0.767, 1.137	.50
Q4 9+ GPs	2890	0.942	0.769, 1.154	.56
<i>Practice average CoC (BB index, tertiles)</i>				
T1: COC ≥ 0.2210 & < 0.3746	2790	0.949	0.810, 1.113	.52
T2: COC ≥ 0.3746 & < 0.4934	2710	0.836	0.724, 0.966	.02
T3: COC ≥ 0.4934 & ≤ 1 (ref.)	2748			
<i>Morbidities</i>				
Epilepsy	132	1.607	1.186, 2.178	.002
Chronic renal disease	133	2.222	1.738, 2.840	<.001
Cancer	864	1.122	0.974, 1.292	.11
Asthma	887	1.158	1.004, 1.334	.04
Stroke	671	1.105	0.957, 1.276	.172
Coronary heart disease	1114	1.394	1.241, 1.567	<.001
Diabetes	1001	1.243	1.093, 1.414	.001
COPD	398	1.570	1.324, 1.861	<.001
Schizophrenia	67	1.727	1.170, 2.549	.01
Depression	1629	1.191	1.062, 1.334	.003
Constant		0.001	0.001, 0.002	<.001
/Ln_p		-0.303	-0.350, -0.260	<.001
Practice-level var(constant)		0.034	0.013, 0.087	

BB= Bice and Boxerman, CI=confidence interval, COC=continuity of care, ref.=reference category

Note: Estimated hazard ratios are from mixed-effects Weibull regression analysis.

Supplementary Table 4: Cross Tabulation of a Patient's Bice and Boxerman (BB) Score and the Number of GP Consultations of 2,892 Patients in the Nested Case-Control Analysis

Continuity of Care (BB index)	Number of GP consultations (%)				Total
	2-7	8-12	13-19	20+	
COC is 0	74 (100.0)	0	0	0	74 (100.0)
Q1 COC>0 & <0.257	135 (21.3)	187 (29.5)	159 (25.1)	153 (24.1)	634 (100.0)
Q2 COC>=0.257 & <0.395	145 (23.9)	126 (20.7)	150 (24.7)	187 (30.8)	608 (100.0)
Q3 COC>=0.395 & <0.576	109 (16.5)	177 (26.7)	173 (26.1)	203 (30.7)	662 (100.0)
Q4 COC>=0.576 & <1	73 (11.6)	164 (26.0)	162 (25.7)	231 (36.7)	630 (100.0)
COC is 1	151 (53.2)	61 (21.5)	51 (18.0)	21 (7.4)	284 (100.0)
Total	687 (23.8)	715 (24.7)	695 (24.0)	795 (27.5)	2892 (100.0)

COC=continuity of care, BB= Bice and Boxerman, Q=quartile

Supplementary Table 5: Association Between BB Index Score and Odds of Emergency Hospital Admission in the Nested Case-Control Analysis (N = 2,892)

	N	Odds ratio	95% CI	P-value
<i>Continuity of Care (BB index)</i>				
COC is 0	74	2.148	1.009, 4.572	.05
Q1 COC>0 & <0.257	634	1.832	1.157, 2.901	.01
Q2 COC>=0.257 & <0.395	608	1.569	1.002, 2.427	.05
Q3 COC>=0.395 & <0.576	662	1.370	0.881, 2.130	.16
Q4 COC>=0.576 & <1	630	1.170	0.758, 1.807	.48
COC is 1 (ref.)	284			
<i>Gender</i>				
Male (ref.)	1256			
Female	1636	0.824	0.675, 1.005	.06
<i>Hospital admission in 2010-12</i>				
No (ref.)	2264			
Yes	628	2.330	1.858, 2.922	<.001
<i>Number of consultations</i>				
Q1 2-7 (ref.)	687			
Q2 8-12	715	1.116	0.810, 1.538	.50
Q3 13-19	695	1.647	1.209, 2.243	.002
Q4 >19	795	2.753	1.995, 3.799	<.001
<i>Morbidities</i>				
Epilepsy	50	0.612	0.283, 1.325	.21
Chronic renal disease	61	2.706	1.494, 4.901	.001
Cancer	347	1.107	0.831, 1.475	.49
Asthma	358	0.895	0.669, 1.197	.46
Stroke	247	0.945	0.679, 1.315	.74
Coronary heart disease	428	1.256	0.975, 1.617	.08
Diabetes	393	1.347	1.022, 1.775	.04
COPD	158	1.774	1.194, 2.636	.01
Schizophrenia	27	1.861	0.782, 4.428	.16
Depression	623	0.979	0.773, 1.239	.86

BB= Bice and Boxerman, CI=confidence interval, COC=continuity of care, ref.=reference category

Note: Estimated odds ratios from a conditional (fixed-effects) logistic regression analysis.

Supplementary Table 6: Association Between BB Index Score (tertiles) and Odds of Emergency Hospital Admission in the Nested Case-Control Analysis (N = 2,892)

	N	Odds ratio	95% CI	P-value
<i>Continuity of Care (BB index, tertiles)</i>				
T1: COC ≥ 0 & < 0.3182	964	1.589	1.212, 2.084	.001
T2: CoC ≥ 0.3182 & < 0.5632	964	1.304	1.013, 1.678	.04
T3: COC ≥ 0.5632 & ≤ 1 (ref.)	964			
<i>Gender</i>				
Male (ref.)	1256			
Female	1636	0.823	0.675, 1.004	.05
<i>Hospital admission in 2010-12</i>				
No (ref.)	2264			
Yes	628	2.333	1.862, 2.924	<.001
<i>Number of consultations</i>				
Q1 2-7 (ref.)	687			
Q2 8-12	715	1.118	0.822, 1.523	.48
Q3 13-19	695	1.637	1.216, 2.204	.001
Q4 > 19	795	2.758	2.025, 3.758	<.001
<i>Morbidities</i>				
Epilepsy	50	0.631	0.291, 1.366	.24
Chronic renal disease	61	2.740	1.517; 4.948	.001
Cancer	347	1.108	0.832, 1.476	.48
Asthma	358	0.907	0.679, 1.213	.51
Stroke	247	0.937	0.674, 1.302	.80
Coronary heart disease	428	1.256	0.975, 1.617	.08
Diabetes	393	1.343	1.012, 1.771	.04
COPD	158	1.799	1.211, 2.672	.004
Schizophrenia	27	1.916	0.803, 4.571	.14
Depression	623	0.977	0.773, 1.239	.86

BB= Bice and Boxerman, CI=confidence interval, COC=continuity of care, ref.=reference category

Note: Estimated odds ratios from a conditional (fixed-effects) logistic regression analysis.

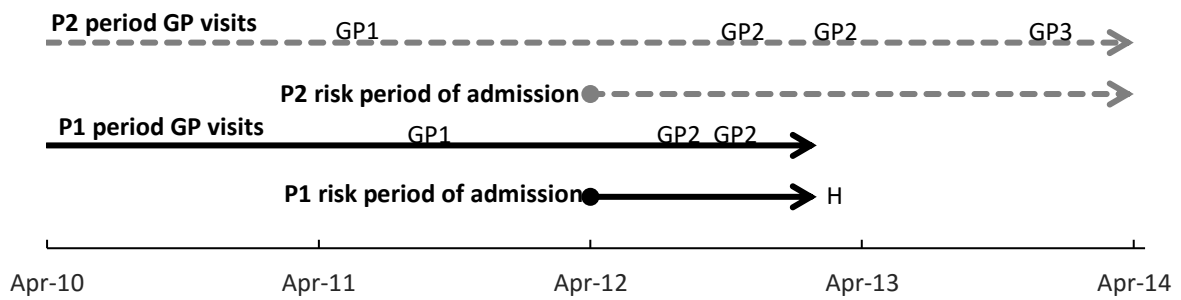
Supplementary Table 7: Association Between Appointed General Practitioner Index Score and Odds of Emergency Hospital Admission in the Nested Case Control Analysis (N = 2,892)

	N	Odds ratio	95% CI	P-value
<i>Continuity of Care (BB index)</i>				
<i>Index GP</i>				
Q1 (0.01 - <0.18)	635	2.318	1.481; 3.627	<.001
Q2 (0.18 - <0.4)	669	1.614	1.033; 2.522	.04
Q3 (0.4 - <0.71)	645	1.496	0.963; 2.325	.07
Q4 (>0.71 - <1)	659	1.031	0.666; 1.596	.89
GP index score=1 (ref.)	284			
<i>Gender</i>				
Male (ref.)	1256			
Female	1636	0.805	0.659, 0.984	.03
<i>Hospital admission in 2010-12</i>				
No (ref.)	2264			
Yes	628	2.268	1.801, 2.846	<.001
<i>Number of consultations</i>				
Q1 2-7 (ref.)	687			
Q2 8-12	715	1.035	0.757, 1.416	.83
Q3 13-19	695	1.489	1.100, 2.014	.01
Q4 >19	795	2.524	1.840, 3.643	<.001
<i>Morbidities</i>				
Epilepsy	50	0.626	0.288, 1.359	.24
Chronic renal disease	61	2.660	1.463; 4.832	.001
Cancer	347	1.102	0.826, 1.470	.51
Asthma	358	0.889	0.663, 1.194	.44
Stroke	247	0.932	0.670, 1.300	.68
Coronary heart disease	428	1.260	0.976; 1.627	.08
Diabetes	393	1.362	1.032, 1.799	.03
COPD	158	1.773	1.193, 2.636	.01
Schizophrenia	27	1.943	0.803, 4.700	.14
Depression	623	0.959	0.755, 1.218	.73

BB= Bice and Boxerman, CI=confidence interval, ref.=reference category

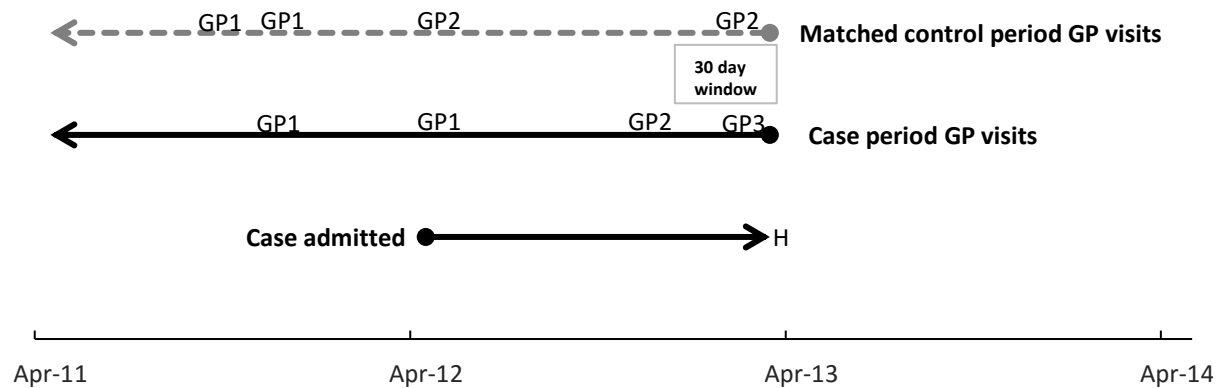
Note: Estimated odds ratios from a conditional (fixed-effects) logistic regression analysis.

Supplementary Figure 1: Time line Prospective Cohort Approach.



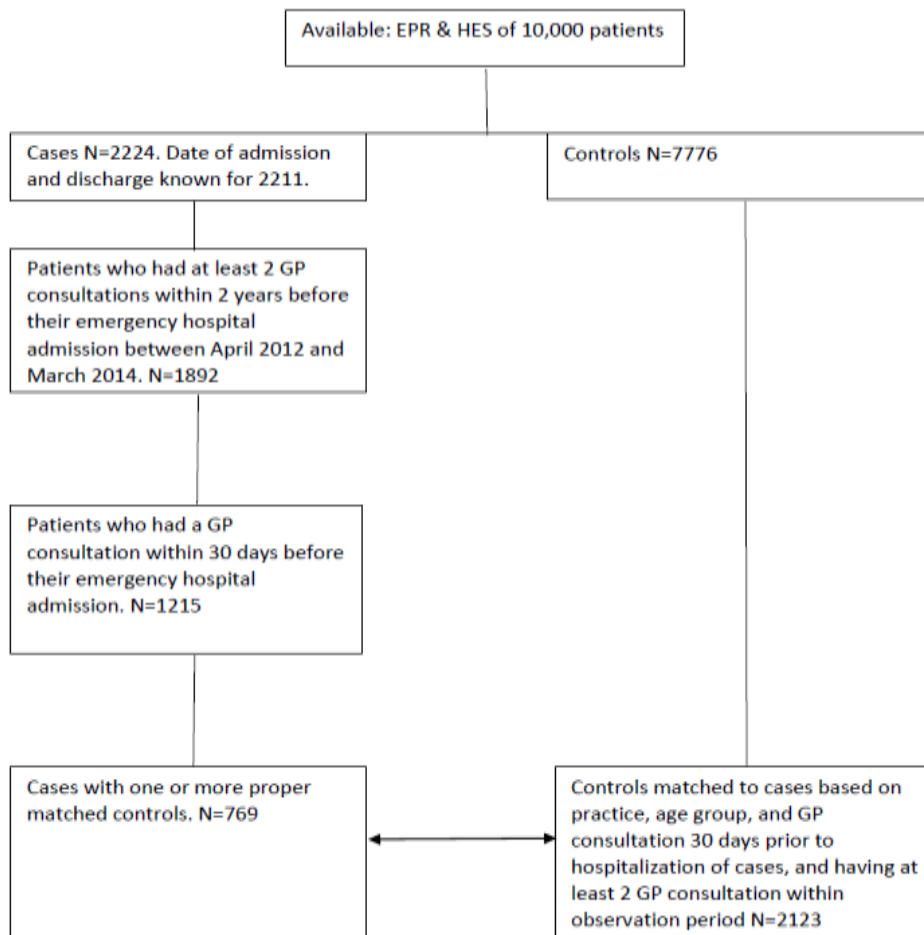
GP= consultation with a GP, H= emergency hospital admission, P= patient

Supplementary Figure 2: Time Line Nested Case-Control Approach.

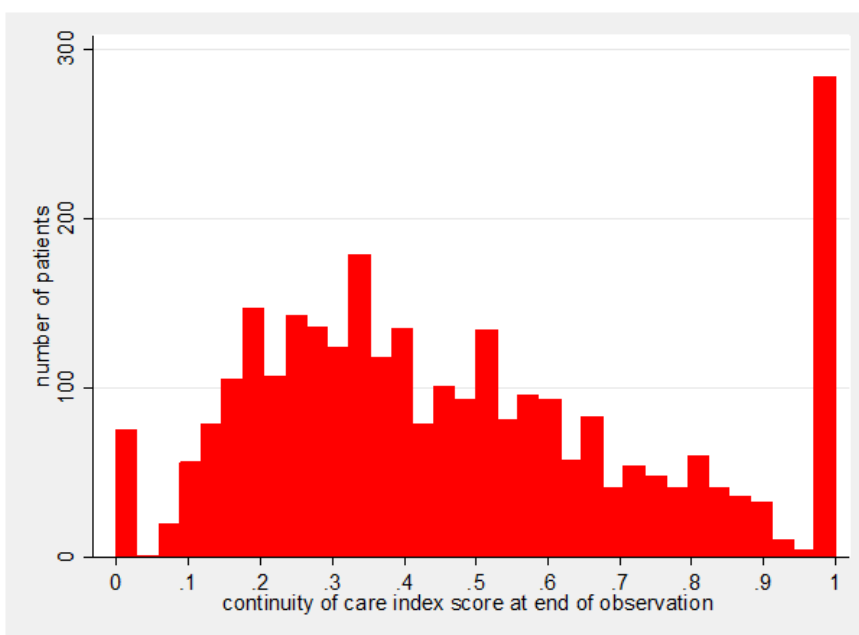


GP= consultation with a GP, H= emergency hospital admission

Supplementary Figure 3: Flow Chart of the Nested Case-Control Approach.



Supplementary Figure 4: Distribution of Bice and Boxerman Index Scores among the 2,892 Patients in the Nested Case-Control Analysis.



Supplementary Textbox 1: Bice and Boxerman (BB) and the Appointed GP Index.

The BB measure is an individual-based measure that takes account of the proportion of consultations with the same doctor, adjusted for the number of consultations, with values between 0 and 1, where 0 indicates complete absence of continuity and 1 indicates complete provision. This measure was split into 6 categories; patient scoring 0, 1 and quartiles between 0.01 and 0.99. Besides the individual BB index score, we also calculated the general effect of continuity of care at the practice level by combining the individual BB index scores of all the patients within the same practice, allowing to distinguish between the individual and the practice level continuity of care.

The second measure used was (a variation on) the index provider identification. Usually this index defines the first provider seen as the primary provider. In our study we calculated this index concentrating on the last GP seen before hospitalisation. We refer to this measure as the appointed GP index and this was only relevant for the nested case-control approach to our analysis. This allowed us to calculate the proportion of times the last GP was seen in consultations during the previous two years. As all patients had consulted the appointed GP at least once, possible values for the proportions range from 0.01 to 1. A low proportion indicates that a patient saw another GP more often than the last GP. This measure was subdivided into 5 categories: patient scoring 1, and quartiles between 0.01 and 0.99.