5 Results

Results of the one-year analysis are presented separately for analysis of the 80%, 20% and 100% in-hospital mortality data sets, and stratified by peer group (although data from all hospitals was combined for each of the three analyses). Peer groups were identified using the National Hospital Cost Data Collection (NHCDC) Round 10 (2005–2006) Peer Group Report (DoHA 2007). Cost-weighted separations were calculated by applying the AIHW 2005–06 DRG cost weights to each separation and summing these cost weights to calculate the number of cost-weighted separations. A selection of descriptive statistics for the total sample is presented in Table 3.

Effect of Women's and Children's hospitals

Women's and Children's hospitals have very different mortality profiles from other centres, and it makes little sense to compare these specialised centres with anything other than similarly specialised centres. However, there are many more general hospitals that include obstetrics, gynaecology and paediatrics in their casemix. The effect of including WCHs in the principal analyses was assessed by comparing the HSMRs based on diagnoses for the leading 80% of in-hospital deaths with and without WCHs included in the logistic regression model. Because HSMRs were virtually identical with both approaches, the data from WCHs were included in all analyses. The WCHs were also analysed as a specific peer group (A2), though the results of the single-year analysis are not presented in this report.

Table 3: Selected descriptive statistics for the total sample of 2005–06 hospital separations

	N	Per cent
Gender		
Male	3,438,248	47.02
Female	3,873,645	52.98
Persons[(a)]	7,311,983	
Mode of separation		
Discharged at own risk	35,707	0.49
Died in hospital	71,122	0.97
Type of episode of care		
Acute care	7,016,160	95.95
Rehabilitation care	151,527	2.07
Palliative care	25,741	0.35
Other	109,685	1.50
Not stated	8,870	0.12
Health-care sector		
Public hospital	4,450,509	60.87
Private hospital	2,298,437	31.43
Public psychiatric hospital	15,567	0.21
Private free standing day hospital	547,470	7.49
Diagnosis groups		
High risk (80% of total in-hospital deaths)	1,109,758	
Low risk (20% of total in-hospital deaths)	4,924,758	
All diagnoses (100%of total in-hospital death)	6,034,516	

(a) Total does not sum due to a small number of cases with unknown gender

5.1 Inclusions and exclusions

Of the 7,311,983 records in the original 2005–06 data set, 1,277,467 were excluded, as follows: 900,832 due to admission category being neither elective or emergency; 295,823 admitted for a reason other than acute care; 36,553 due to being a palliative care patient (note that the recalibration process described in Section 3.3.8 was confined to the numbers of palliative care patients selected for analysis); 32,856 due to patients being discharged against medical advice; 11,164 due to being a neonate (infants age between 0 and 28 days); 189 due to length of stay being greater than 365 days; 40 due to gender not being recorded as either male or female; and 10 due to having a recorded age that was not in the range 0 to 120 years.

5.1.1 High-risk group (80% of in-hospital mortality)

Of the 6,034,516 records retained after the above exclusions, 4,931,241 records were omitted because the principal diagnosis was not one of the 68 diagnoses in the 'high-risk' group, associated with 80% of deaths in hospital (Appendix 1).
The remaining 1,103,275 records were included in the analysis (see Table 4).
Of the 923 hospitals in the original 2005–06 data set, 817 had admitted patients meeting these inclusion criteria in 2005–06.

Table 4: Selective descriptive statistics for the high-risk case group (80% of in-hospital mortality in 2005–06)

	N	Per cent
Gender		
Male	588,106	53.31
Female	515,169	46.69
Mode of separation		
Discharged at own risk	0	0.00
Died in hospital	36,046	3.27
Health-care sector		
Public hospital	744,481	67.48
Private hospital	309,064	28.01
Public psychiatric hospital	9	0.00
Private free standing day hospital	49,721	4.51

5.1.2 Lower risk group (20% of in-hospital mortality)

We also analysed in-hospital mortality for the in-scope records not included in the 'high-risk' group. Table 5 describes this group.

Table 5: Selective descriptive statistics for the lower risk case group (20% of in-hospital mortality in 2005–06)

	N	Per cent
Gender		
Male	2,324,908	46.97
Female	2,624,987	53.03
Mode of separation		
Discharged at own risk	0	0.00
Died in hospital	9,128	0.18
Health-care sector		
Public hospital	2,841,781	57.41
Private hospital	1,669,056	33.72
Public psychiatric hospital	13,113	0.26
Private free standing day hospital	425,952	8.61

5.1.3 Total in-hospital mortality

All in-scope records were included in this part of the analysis. Table 6 presents descriptive statistics.

Table 6: Selective descriptive statistics for the case group including 100% of in-hospital mortality in 2005–06

	N	Per cent
Gender		
Male	2,913,014	48.12
Female	3,140,156	51.88
Mode of separation		
Discharged at own risk	0	0.00
Died in hospital	45,174	0.75
Health-care sector		
Public hospital	3,586,262	59.25
Private hospital	1,978,120	32.68
Public psychiatric hospital	13,122	0.22
Private free standing day hospital	475,673	7.86

5.2 Model building and the effect of covariates on odds of in-hospital mortality

The odds ratios for the effect of each of the included covariates on in-hospital mortality for 80%, 20% and 100% mortality groups were extracted and are presented as point estimates, together with standard errors and 95% confidence intervals, in Tables 7–9. Readers are reminded that these results were obtained without recalibrating the palliative-care variable.

The odds ratios can be interpreted as the effect of the presence of each modelled characteristic on the likelihood that an episode in hospital will end with in-hospital death, after allowing for all of the other variables in the model. For example, considering the high-risk group (Table 7), elective admissions were associated with a little over one-quarter (0.281 times) the likelihood of in-hospital death compared with emergency admissions (used as the reference group). Similarly, the presence of two or more Charlson comorbidity categories was associated with odds of fatal outcome that were more than 6 times higher (6.048 times) than if no Charlson comorbidity was present.

Table 7: Odds ratios for the effect of each of the included covariates on 80% in-hospital mortality

	Odds ratio	95% CI	p-value
Age (years)	1.045	(1.044–1.046)	<0.001
Sex (Male=1, Female=2)	1.007	(0.984–1.031)	0.556
Length of stay			
1 day	1	–	–
2 days	1.035	(0.991–1.082)	<0.122
3–9 days	0.633	(0.613–0.652)	<0.000
10–15 days	0.66	(0.634–0.687)	<0.000
16–21 days	0.831	(0.789–0.874)	<0.000
22–365 days	1.106	(1.058–1.157)	<0.000
Urgency admission			
(Emergency=1, Elective=2)			
1	1	–	–
2	0.281	(0.271–0.291)	<0.001
Canadian Charlson category			
0	1	–	–
1	2.756	(2.637–2.880)	<0.001
2	6.048	(5.780–6.330)	<0.001
Transferred patient	1.578	(1.519–1.639)	<0.001

Logistic regression	Number of obs	=	1103275
	LR chi2(78)	=	7748.16
	Prob > chi2	=	0.0000
Log likelihood = –120028.66	Pseudo R^2	=	0.2440

Table 8: Odds ratios for the effect of each of the included covariates on 20% in-hospital mortality

	Odds ratio	95% CI	p-value
Age (years)	1.031	(1.030–1.032)	<0.000
Sex (Male=1, Female=2)	0.929	(0.890–0.970)	<0.001
Length of stay			
1 day	1	–	–
2 days	1.493	(1.365–1.632)	<0.000
3–9 days	1.467	(1.378–1.562)	<0.000
10–15 days	1.994	(1.845–2.155)	<0.000
16–21 days	2.943	(2.689–3.221)	<0.000
22–365 days	3.808	(3.528–4.111)	<0.000
Urgency admission			
(Emergency=1, Elective=2)			
1	1	–	–
2	0.322	(0.305–0.340)	<0.000
Canadian Charlson category			
0	1	–	–
1	2.696	(2.2.542–2.860)	<0.000
2	7.155	(6.742–7.593)	<0.000
Transferred patient	1.819	(1.705–1.939)	<0.000

Logistic regression	Number of obs	=	4949902
	LR chi2(20)	=	45312.60
	Prob > chi2	=	0.0000
Log likelihood = –43931.126	Pseudo R^2	=	0.3402

Table 9: Odds ratios for the effect of each of the included covariates on 100% in-hospital mortality

	Odds ratio	95% CI	p-value
Age (years)	1.036	(1.035–1.037)	<0.000
Sex (Male=1, Female=2)	0.955	(0.936–0.974)	<0.000
Length of stay			
1 day	1	–	–
2 days	1.02	(0.982–1.060)	<0.299
3–9 days	0.686	(0.668–0.705)	<0.000
10–15 days	0.783	(0.756–0.811)	<0.000
16–21 days	1.054	(1.009–1.101)	<0.017
22–365 days	1.466	(1.413–1.522)	<0.000
Urgency admission			
(Emergency=1, Elective=2)			
1	1	–	–
2	0.301	(0.293–0.309)	<0.000
Canadian Charlson category			
0	1	–	–
1	2.165	(2.095–2.236)	<0.000
2	4.571	(4.422–4.726)	<0.000
Transferred patient	1.77	(1.715–1.827)	<0.000

Logistic regression	Number of obs	=	6053177
	LR chi2(20)	=	189758.61
	Prob > chi2	=	0.0000
Log likelihood = –171379.69	Pseudo R^2	=	0.3563

5.3 Discriminatory and explanatory power

Tables 10 to 12 display the c-statistic, pseudo R^2, and the change in pseudo-R^2 for subsets of the independent variables included in the RACM model for the three groups.

The generally high values of the c-statistic largely reflect the large size of the data set analysed. The R^2 values are larger with the fuller models, indicating a reduction in unexplained variance with the addition of the covariates shown.

Although these models are not exactly comparable with any of the results from the literature that are summarised in Table 1, it is worth noting that the values presented in Table 10 of the measures of discrimination and explanatory power for the full models are certainly not low in relation to the ranges of values in Table 1.

Table 10: c-statistic, pseudo R^2, and the change in pseudo R^2 for subsets of the independent variables included in the RACM model for 80% in-hospital mortality

Included variables	c-statistic	Pseudo R^2	∆ Pseudo R^2
Age	0.7058	0.0581	
Age, sex	0.7068	0.0586	0.0005
Age, sex, LOS group,	0.7289	0.0727	0.0141
Age, sex, LOS group, urgency	0.767	0.1017	0.029
Age, sex, LOS group, urgency, pdiag_aihw3	0.8583	0.2186	0.1169
Age, sex, LOS group, urgency, pdiag_aihw3, cancharlson	0.8751	0.2424	0.0238
Age, sex, LOS group, urgency, pdiag_aihw3, cancharlson, transfer	0.8764	0.244	0.0016

Model Un-stratified, 80% mortality *N* = 1,103,275

Table 11: c-statistic, pseudo R^2, and the change in pseudo R^2 for subsets of the independent variables included in the RACM model for 20% in-hospital mortality

Included variables	c-statistic	Pseudo R^2	∆ Pseudo R^2
Age	0.79	0.0795	
Age, sex	0.7911	0.0799	0.0004
Age, sex, LOS group,	0.8767	0.187	0.1071
Age, sex, LOS group, urgency	0.9147	0.2205	0.0335
Age, sex, LOS group, urgency, riskcat	0.9554	0.3045	0.084
Age, sex, LOS group, urgency, riskcat, cancharlson	0.9625	0.338	0.0335
Age, sex, LOS group, urgency, riskcat, cancharlson, transfer	0.9632	0.3402	0.0022

Model Un-stratified,20% mortality *N* = 4,949,902

Table 12: c-statistic, pseudo R^2, and the change in pseudo R^2 for subsets of the independent variables included in the RACM model for 100% in-hospital mortality

Included variables	c-statistic	Pseudo R^2	∆ Pseudo R^2
Age	0.8073	0.1114	
Age, sex	0.8084	0.112	0.0006
Age, sex, LOS group,	0.8603	0.1693	0.0573
Age, sex, LOS group, urgency	0.8997	0.2154	0.0461
Age, sex, LOS group, urgency, riskcat	0.9491	0.3357	0.1203
Age, sex, LOS group, urgency, riskcat, cancharlson	0.9548	0.3542	0.0185
Age, sex, LOS group, urgency, riskcat, cancharlson, transfer	0.9555	0.3563	0.0021

Model Un-stratified,100% mortality *N* = 6,053,177

5.4 Goodness of fit

Tables 13 to 15 display Hosmer–Lemeshow deciles of risk and the observed and expected numbers of cases (and non-cases) of in-hospital mortality for the high-risk case group (80% of deaths), analysed using the RACM model, and the lower risk and the all-deaths groups. The tables are collapsed on deciles of estimated probabilities of death. Figures 4 to 6, accompanying the tables, show the percentages of in-hospital mortality for each decile of risk for both the observed data and the data predicted by the logistic regression model for the mortality outcomes. The predicted values for the high-risk group were derived from the RACM model, using principal diagnoses at the three character ICD-10-AM level (Appendix 1). The predicted values for the other two groups were derived using principal diagnoses assigned to deciles of risk, as described above (Section 4.5.2).

The Hosmer–Lemeshow test did not demonstrate good fit for any of the RACM models. However, as has been discussed previously, the Hosmer–Lemeshow goodness of fit method is sensitive to the very large sample sizes used here. Moreover, the RACM model does not include data transformations or allow for possible interactions between covariates—issues which were tackled when developing the ERM model. The tables and graphical plots of deciles of observed and expected risks show that the RACM model fit is closer for the deciles of higher risk than for the lower deciles, where the model seems to somewhat 'over-call' expected mortality (see tables 13 to 15).

The goodness of fit for the ERM model is discussed in Section 5.7.1.

Table 13: Hosmer–Lemeshow deciles of risk and the observed and expected numbers of cases (and non-cases) of in-hospital mortality for the high-risk group of deaths (using the RACM model)

Decile of risk group	Prob	Obs 1	Exp1	Obs 0	Exp 0	Total
1	0.001	30	61.2	110,306	110,274.8	110,336
2	0.002	69	152	110,455	110,372	110,524
3	0.003	159	282.3	110,180	110,056.7	110,339
4	0.006	271	484.1	109,845	109,631.9	110,116
5	0.009	554	786.4	109,789	109,556.6	110,343
6	0.015	1165	1304.3	109,164	109,024.7	110,329
7	0.026	2412	2230.8	107,894	108,075.2	110,306
8	0.046	4111	3837.4	106,227	106,500.6	110,338
9	0.089	7655	7013	102,704	103,346	110,359
10	0.980	19620	19894.4	90,665	90,390.6	110,285

Note: Obs1 and Exp1 = expected cases; Obs 0 and Exp0 = expected non-cases, Hosmer–Lemeshow $Chi^2(8) = 396.37$, $p > 0.000$

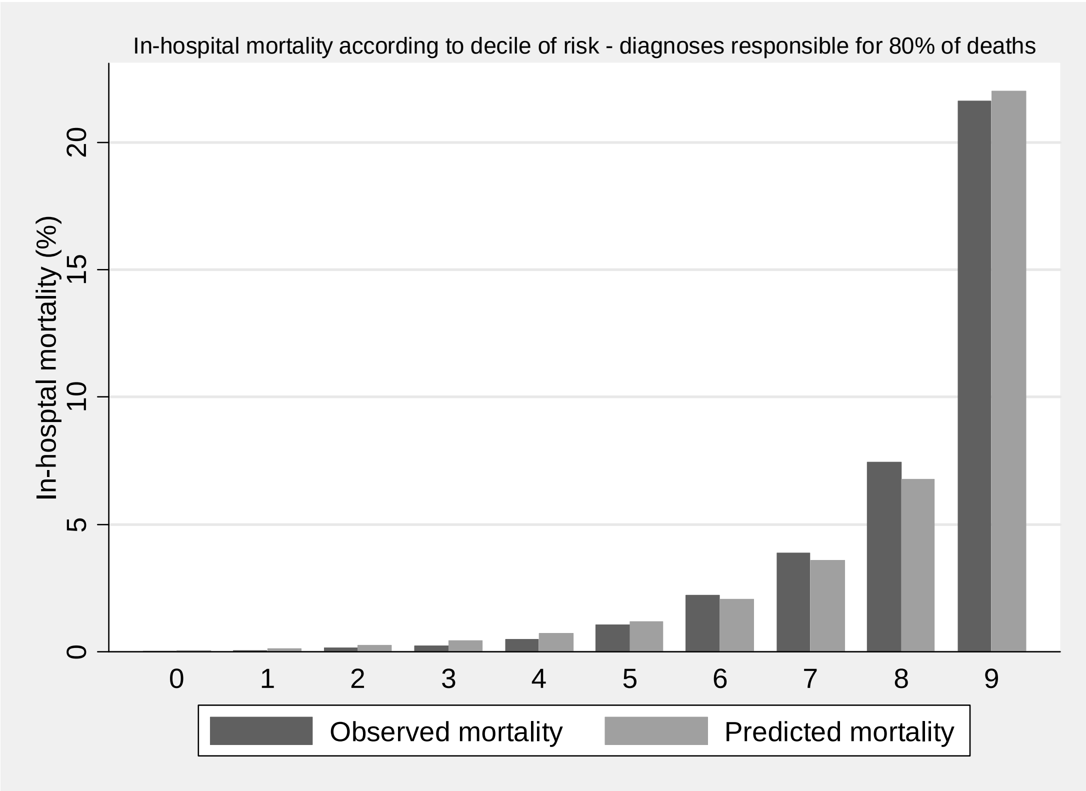


Figure 4: Percentages of in-hospital mortality for each decile of risk for both the observed data and the data predicted by the logistic regression model for the high-risk group of cases accounting for 80% of in-hospital deaths

Table 14: Hosmer–Lemeshow deciles of risk and the observed and expected numbers of cases (and non-cases) of in-hospital mortality for the lower risk group of deaths (using the RACM model)

Decile of risk group	Prob	Obs 1	Exp1	Obs 0	Exp 0	Total
1	1	0	6	5.3	500,313	500,313.8
2	2	0	7	9.9	489,655	489,652.1
3	3	0	8	16.3	495,031	495,022.7
4	4	0.000	14	26.2	496,719	496,706.8
5	5	0.000	20	43.8	497,137	497,113.3
6	6	0.000	23	71.5	491,491	491,442.5
7	7	0.000	53	123.7	495,029	494,958.3
8	8	0.001	126	235.9	494,567	494,457.1
9	9	0.002	547	616.4	494,318	494,248.6
10	10	0.720	8324	7979.1	486,514	486,858.9

Note: Obs1 and Exp1 = expected cases; Obs 0 and Exp0 = expected non-cases, Hosmer–Lemeshow Chi^2(8) = 171.29, p > 0.000

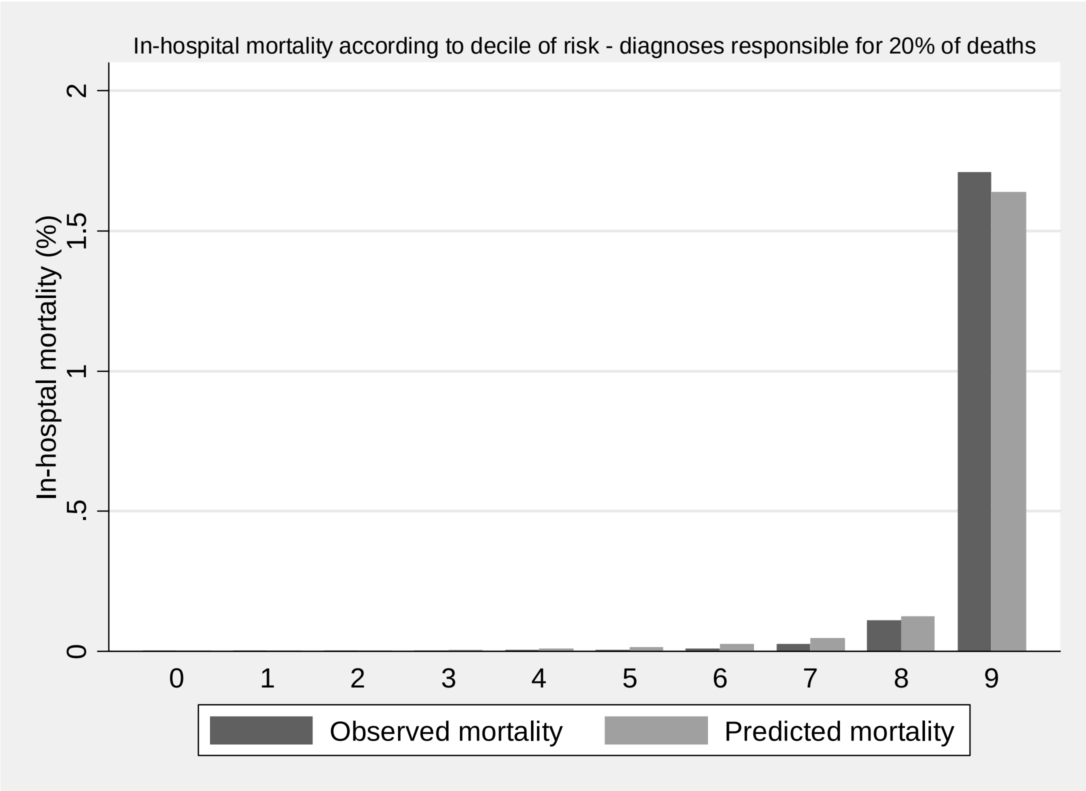


Figure 5: Percentages of in-hospital mortality for each decile of risk for both the observed data and the data predicted by the logistic regression model for the lower risk group including the remaining 20% of in-hospital deaths

Table 15: Hosmer–Lemeshow deciles of risk and the observed and expected numbers of cases (and non-cases) of in-hospital mortality for the group including all in-hospital deaths (using the RACM model)

Decile of risk group	Prob	Obs 1	Exp1	Obs 0	Exp 0	Total
1	0	8	7.3	605,391	605,391.7	605,399
2	0	12	16.4	606,090	606,085.6	606,102
3	0.000	21	30.5	604,450	604,440.5	604,471
4	0.000	26	55.4	612,694	612,664.6	612,720
5	0.000	49	99.9	600,665	600,614.1	600,714
6	0.001	100	203.2	602,952	602,848.8	603,052
7	0.001	259	469.1	604,648	604,437.9	604,907
8	0.004	924	1270.6	604,253	603,906.4	605,177
9	0.014	4021	4483.8	601,364	600,901.1	605,385
10	0.617	39754	38537.7	565,496	566,712.3	605,250

Note: Obs1 and Exp1 = expected cases; Obs 0 and Exp0 = expected non-cases, Hosmer–Lemeshow $Chi^2(8) = 376.26$, $p > 0.000$

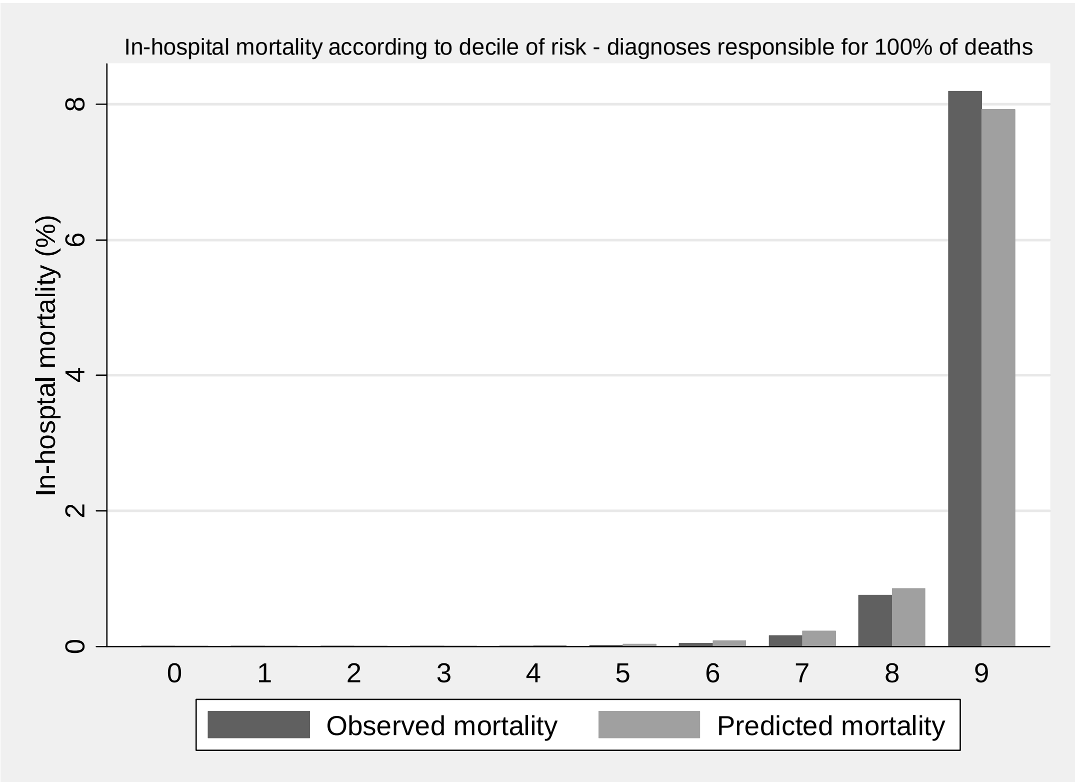


Figure 6: Percentages of in-hospital mortality for each decile of risk for both the observed data and the data predicted by the logistic regression model for the group including all in-hospital deaths

5.5 Individual HSMRs and their 95% confidence intervals

One of the three modes of presentation of HSMRs described in Section 2.9.1 is 'league tables'. This section presents some results of our analysis in this format. Because of the large number of hospitals analysed, we have selected one peer group, A1, to illustrate the approach (equivalent tables of recalibrated risk-adjusted HSMRs for peer groups B1, C2 and D1 are in Appendix 2).

Table 16 shows, for peer group A1, the observed and expected numbers of deaths, the HSMRs (after recalibration) and 95% confidence intervals, and the peer group rankings for the case groups including 80%, 20% and 100% of in-hospital deaths. Readers are reminded that these demonstration values have been recalibrated in order to protect the confidentiality of individual institutions.

Results are arranged in ascending order of risk-adjusted HSMR for the high-risk group of cases (which includes 80% of in-hospital deaths).

Table 16: Observed and expected number of deaths, HSMRs, 95% CIs, and the peer rankings for 80%, 20% and 100% of in-hospital deaths for peer group A1

Study		80%		20%		100%		HSMRs			Rank		
assigned ID	cwaseps	O	E	O	E	O	E	80%(LCI–UCI)	20%(LCI–UCI)	100%(LCI–UCI)	80%	20%	100%
A1001	44965.51	226	321.25	54	100.89	280	379.70	70.35 (61.5–80.1)	53.52 (40.2–69.8)	73.74 (65.4–82.9)	1	1	3
A1002	46593.44	161	224.57	33	49.24	194	267.46	71.69 (61.0–83.7)	67.02 (46.1–94.1)	72.53 (62.7–83.5)	2	3	2
A1003	56580.62	321	444.35	84	104.59	405	544.52	72.24 (64.6–80.6)	80.31 (64.1–99.4)	74.38 (67.3–82.0)	3	12	4
A1004	20299.45	133	180.47	23	36.68	156	229.17	73.70 (61.7–87.3)	62.70 (39.7–94.1)	68.07 (57.8–79.6)	4	2	1
A1005	74787.9	559	701.25	136	154.17	695	845.75	79.72 (73.2–86.6)	88.21 (74.0–104.3)	82.18 (76.2–88.5)	5	15	6
A1006	66842.18	576	717.05	154	177.22	730	885.59	80.33 (73.9–87.2)	86.90 (73.7–101.8)	82.43 (76.6–88.6)	6	14	7
A1007	80017.26	617	739.08	136	187.79	753	927.60	83.48 (77.0–90.3)	72.42 (60.8–85.7)	81.18 (75.5–87.2)	7	5	5
A1008	20061.79	99	117.68	29	28.48	128	144.61	84.12 (68.4–102.4)	101.82 (68.2–146.2)	88.51 (73.8–105.2)	8	33	11
A1009	30667.47	171	199.64	48	44.00	219	242.17	85.65 (73.3–99.5)	109.09 (80.4–144.6)	90.43 (78.9–103.2)	9	42	14
A1010	44398.09	435	507.72	84	89.23	519	565.82	85.68 (77.8–94.1)	94.14 (75.1–116.6)	91.73 (84.0–100.0)	10	21	20
A1011	81502.59	553	639.58	164	147.47	717	747.03	86.46 (79.4–94.0)	111.21 (94.8–129.6)	95.98 (89.1–103.3)	11	44	24
A1012	19691.53	142	162.31	37	37.73	179	195.93	87.49 (73.7–103.1)	98.07 (69.0–135.2)	91.36 (78.5–105.8)	12	26	18
A1013	27462	192	217.15	35	47.77	227	266.71	88.42 (76.4–101.8)	73.27 (51.0–101.9)	85.11 (74.4–96.9)	13	6	8
A1014	25276.55	167	188.29	44	40.87	211	232.79	88.69 (75.7–103.2)	107.65 (78.2–144.5)	90.64 (78.8–103.7)	14	38	15
A1015	43771.57	434	481.53	80	108.35	514	599.19	90.13 (81.8–99.0)	73.83 (58.5–91.9)	85.78 (78.5–93.5)	15	7	9
A1016	37992.91	287	318.22	65	60.64	352	385.69	90.19 (80.1–101.3)	107.18 (82.7–136.6)	91.27 (82.0–101.3)	16	37	16
A1017	20106.52	144	158.08	39	38.58	183	200.07	91.09 (76.8–107.2)	101.08 (71.9–138.2)	91.47 (78.7–105.7)	17	31	19
A1018	22186.01	209	228.79	43	56.15	252	281.49	91.35 (79.4–104.6)	76.58 (55.4–103.2)	89.52 (78.8–101.3)	18	9	13
A1019	82247.16	424	462.66	157	133.67	581	576.71	91.64 (83.1–100.8)	117.45 (99.8–137.3)	100.74 (92.7–109.3)	19	51	32
A1020	35695.89	133	144.43	49	49.55	182	193.91	92.08 (77.1–109.1)	98.90 (73.2–130.8)	93.86 (80.7–108.5)	20	28	23

(continued)

Table 16 (continued): Observed and expected number of deaths, HSMRs, 95% CIs, and the peer rankings for 80%, 20% and 100% of in-hospital deaths for peer group A1

Study assigned ID	cwaseps	80% O	80% E	20% O	20% E	100% O	100% E	HSMRs 80%(LCI–UCI)	HSMRs 20%(LCI–UCI)	HSMRs 100%(LCI–UCI)	Rank 80%	Rank 20%	Rank 100%
A1021	29060.4	176	190.94	42	39.48	218	221.39	92.17 (79.1–106.8)	106.39 (76.7–143.8)	98.47 (85.8–112.4)	21	36	29
A1022	57505.83	273	295.15	66	82.28	339	379.52	92.49 (81.8–104.1)	80.22 (62.0–102.1)	89.32 (80.1–99.4)	22	11	12
A1023	23290.99	140	150.48	24	28.55	164	186.39	93.03 (78.3–109.8)	84.06 (53.8–125.1)	87.99 (75.0–102.5)	23	13	10
A1024	43507.94	510	544.63	105	114.04	615	673.66	93.64 (85.7–102.1)	92.07 (75.3–111.5)	91.29 (84.2–98.8)	24	19	17
A1025	51138.63	422	447.44	78	109.72	500	515.17	94.31 (85.5–103.8)	71.09 (56.2–88.7)	97.05 (88.7–105.9)	25	4	27
A1026	92870.13	451	478.02	146	150.62	597	618.88	94.35 (85.8–103.5)	96.93 (81.8–114.0)	96.46 (88.9–104.5)	26	25	25
A1027	23866.06	182	191.07	40	50.93	222	241.17	95.25 (81.9–110.1)	78.54 (56.1–107.0)	92.05 (80.3–105.0)	27	10	21
A1028	16206.31	145	150.83	31	25.81	176	178.66	96.13 (81.1–113.1)	120.12 (81.6–170.5)	98.51 (84.5–114.2)	28	52	30
A1029	49856.89	536	557.39	115	105.55	651	671.73	96.16 (88.2–104.7)	108.95 (89.9–130.8)	96.91 (89.6–104.7)	29	41	26
A1030	54724.37	391	402.17	107	101.32	498	531.72	97.22 (87.8–107.4)	105.60 (86.5–127.6)	93.66 (85.6–102.3)	30	34	22
A1031	85014.36	775	787.03	215	198.44	990	972.39	98.47 (91.7–105.7)	108.35 (94.3–123.8)	101.81 (95.6–108.4)	31	40	33
A1032	82730.06	542	543.17	146	131.10	688	667.68	99.78 (91.6–108.5)	111.37 (94.0–131.0)	103.04 (95.5–111.0)	32	45	36
A1033	22731.9	179	179.28	33	34.68	212	207.38	99.84 (85.8–115.6)	95.16 (65.5–133.6)	102.23 (88.9–117.0)	33	24	35
A1034	61193.27	535	535.71	119	134.62	654	669.68	99.87 (91.6–108.7)	88.40 (73.2–105.8)	97.66 (90.3–105.4)	34	16	28
A1035	16578.69	91	90.91	30	21.82	121	112.72	100.09 (80.6–122.9)	137.48 (92.7–196.3)	107.35 (89.1–128.3)	35	66	44
A1036	63875.61	505	501.42	144	130.66	649	592.88	100.71 (92.1–109.9)	110.21 (92.9–129.8)	109.47 (101.2–118.2)	36	43	47
A1037	32121.94	212	210.46	57	47.43	269	263.45	100.73 (87.6–115.2)	120.17 (91.0–155.7)	102.11 (90.3–115.1)	37	53	34
A1038	69013.7	551	545.70	122	105.78	673	644.19	100.97 (92.7–109.8)	115.34 (95.8–137.7)	104.47 (96.7–112.7)	38	48	40
A1039	42827.35	414	400.38	91	96.05	505	467.68	103.40 (93.7–113.9)	94.75 (76.3–116.3)	107.98 (98.8–117.8)	39	22	45
A1040	18413.09	68	65.07	30	24.25	98	85.80	104.51 (81.1–132.5)	123.69 (83.4–176.6)	114.22 (92.7–139.2)	40	61	54
A1041	41986	323	308.10	75	60.59	398	371.43	104.84 (93.7–116.9)	123.79 (97.4–155.2)	107.15 (96.9–118.2)	41	62	43

(continued)

Table 16 (continued): Observed and expected number of deaths, HSMRs, 95% CIs, and the peer rankings for 80%, 20% and 100% of in-hospital deaths for peer group A1

Study assigned ID	cwaseps	80%		20%		100%		HSMRs			Rank		
		O	E	O	E	O	E	80%(LCI–UCI)	20%(LCI–UCI)	100%(LCI–UCI)	80%	20%	100%
A1042	24986.04	138	131.30	31	34.54	169	169.17	105.10 (88.3–124.2)	89.76 (61.0–127.4)	99.90 (85.4–116.1)	42	17	31
A1043	50525.68	450	428.07	112	112.68	562	542.20	105.12 (95.6–115.3)	99.40 (81.8–119.6)	103.65 (95.3–112.6)	43	29	38
A1044	29232.16	292	272.10	53	53.87	345	333.48	107.31 (95.4–120.4)	98.39 (73.7–128.7)	103.46 (92.8–115.0)	44	27	37
A1045	33567.65	178	165.38	58	42.91	236	207.35	107.63 (92.4–124.7)	135.15 (102.6–174.7)	113.82 (99.8–129.3)	45	65	53
A1046	20557.86	155	143.43	35	28.82	190	174.58	108.07 (91.7–126.5)	121.45 (84.6–168.9)	108.83 (93.9–125.5)	46	57	46
A1047	22311.62	301	278.48	59	58.23	360	345.85	108.09 (96.2–121.0)	101.33 (77.1–130.7)	104.09 (93.6–115.4)	47	32	39
A1048	28272.78	303	275.51	62	54.51	365	324.84	109.98 (97.9–123.1)	113.75 (87.2–145.8)	112.36 (101.1–124.5)	48	47	51
A1049	16978.06	131	119.11	25	27.13	156	147.61	109.98 (92.0–130.5)	92.16 (59.6–136.1)	105.68 (89.7–123.6)	49	20	42
A1050	67976.92	530	480.42	180	145.77	710	598.06	110.32 (101.1–120.1)	123.48 (106.1–142.9)	118.72 (110.1–127.8)	50	60	58
A1051	54906.39	586	529.43	120	119.22	706	635.06	110.68 (101.9–120.0)	100.66 (83.5–120.4)	111.17 (103.1–119.7)	51	30	48
A1052	18835.92	173	155.26	38	35.17	211	188.46	111.43 (95.4–129.3)	108.03 (76.4–148.3)	111.96 (97.4–128.1)	52	39	50
A1053	29670.07	215	192.57	36	34.02	251	222.47	111.65 (97.2–127.6)	105.82 (74.1–146.5)	112.82 (99.3–127.7)	53	35	52
A1054	34145.57	402	359.66	62	67.83	464	404.31	111.77 (101.1–123.3)	91.40 (70.1–117.2)	114.76 (104.6–125.7)	54	18	56
A1055	48204.3	336	293.16	105	73.15	441	358.15	114.61 (102.7–127.5)	143.54 (117.4–173.8)	123.13 (111.9–135.2)	55	67	63
A1056	47210.35	362	315.41	99	82.29	461	400.33	114.77 (103.3–127.2)	120.30 (97.8–146.5)	115.15 (104.9–126.2)	56	54	57
A1057	26682.48	256	221.23	30	39.66	286	272.63	115.71 (102.0–130.8)	75.64 (51.0–108.0)	104.90 (93.1–117.8)	57	8	41
A1058	45401.98	516	445.53	101	83.60	617	551.52	115.82 (106.0–126.3)	120.81 (98.4–146.8)	111.87 (103.2–121.1)	58	56	49
A1059	54452.89	382	323.53	101	81.80	483	398.39	118.07 (106.5–130.5)	123.47 (100.6–150.0)	121.24 (110.7–132.5)	59	59	61
A1060	84337.28	652	546.95	170	147.08	822	679.82	119.21 (110.2–128.7)	115.58 (98.9–134.3)	120.92 (112.8–129.5)	60	49	60
A1061	26753.52	224	187.53	55	43.48	279	233.78	119.45 (104.3–136.2)	126.50 (95.3–164.7)	119.34 (105.7–134.2)	61	63	59
A1062	29043.85	247	205.00	67	55.65	314	274.57	120.49 (105.9–136.5)	120.41 (93.3–152.9)	114.36 (102.1–127.7)	62	55	55

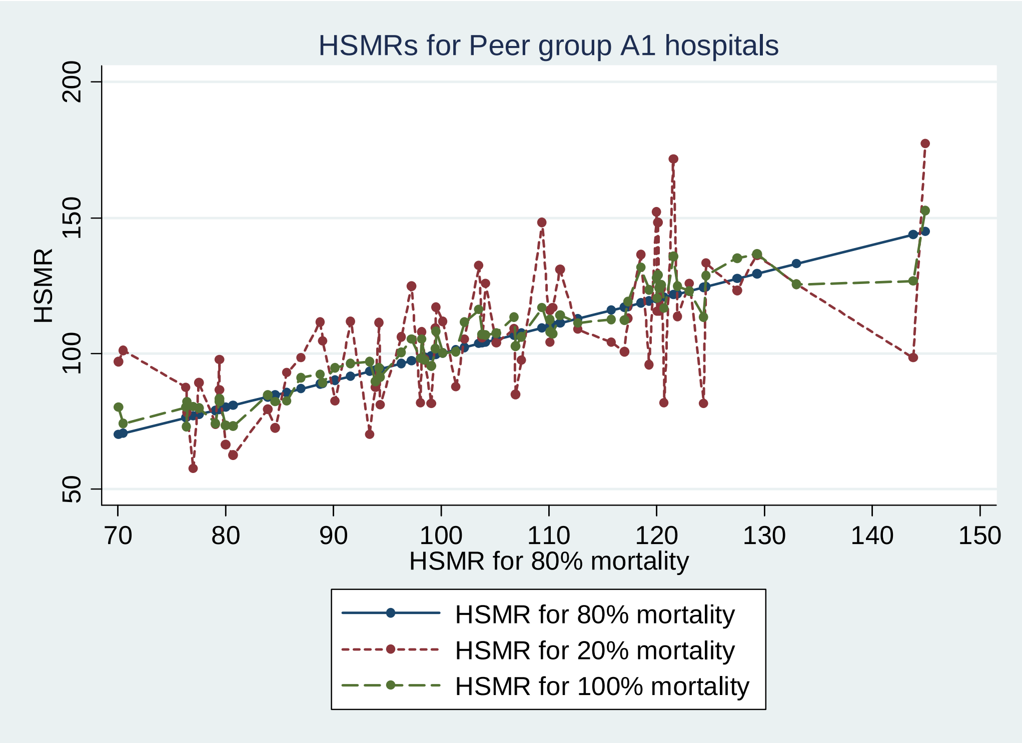
(continued)

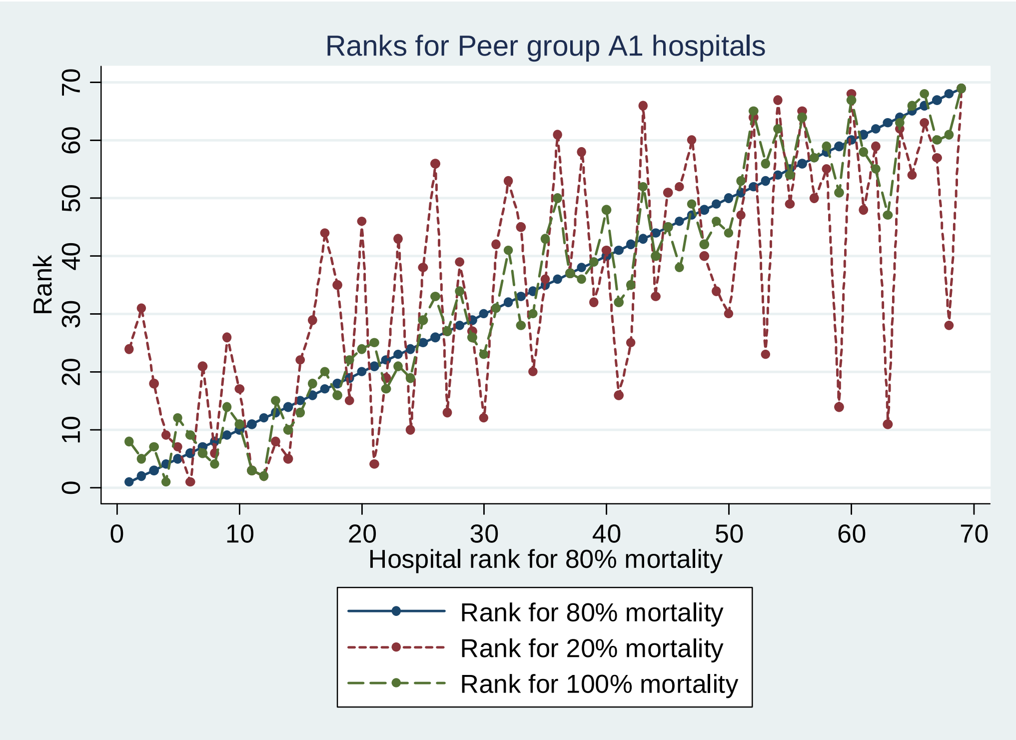
Table 16 (continued): Observed and expected number of deaths, HSMRs, 95% CIs, and the peer rankings for 80%, 20% and 100% of in-hospital deaths for peer group A1

Study assigned ID	cwaseps	80%		20%		100%		HSMRs			Rank		
		O	E	O	E	O	E	80%(LCI–UCI)	20%(LCI–UCI)	100%(LCI–UCI)	80%	20%	100%
A1063	17672.03	209	173.20	47	29.40	256	199.63	120.67 (104.9–138.2)	159.86 (117.4–212.6)	128.24 (113.0–144.9)	63	68	66
A1064	49841.73	614	501.05	152	118.11	766	629.94	122.54 (113.0–132.6)	128.69 (109.0–150.9)	121.60 (113.1–130.5)	64	64	62
A1065	61723.66	563	452.55	147	126.01	710	554.98	124.41 (114.3–135.1)	116.66 (98.6–137.1)	127.93 (118.7–137.7)	65	50	65
A1066	23069.21	266	207.16	44	46.31	310	249.93	128.40 (113.4–144.8)	95.00 (69.0–127.5)	124.03 (110.6–138.6)	66	23	64
A1067	76698.91	556	430.69	135	110.38	691	519.36	129.09 (118.6–140.3)	122.31 (102.5–144.8)	133.05 (123.3–143.4)	67	58	67
A1068	44580.66	260	200.58	84	52.52	344	257.06	129.62 (114.3–146.4)	159.95 (127.6–198.0)	133.82 (120.1–148.7)	68	69	68
A1069	9835.32	129	86.99	24	21.36	153	113.31	148.28 (123.8–176.2)	112.35 (72.0–167.2)	135.03 (114.5–158.2)	69	46	69

Note: In the table 'cwaseps' refers to the case weighted average number of separations; 'O' = observed number of deaths; 'E' = expected number of deaths; 'LCI' = lower confidence interval; 'UCI' = upper confidence interval.

The figures below provide a graphical representation of the HSMRs and ranks for the three case groups analysed, for peer group A1. The differences in rank were most marked between the analyses of the case groups including, respectively, 80% and 20% of in-hospital deaths. The HSMRs for the lower risk group were the most variable.





Figures 7 and 8: HSMRs and ranks for peer group A1 hospitals

5.6 Caterpillar plots

This section presents examples of the use of caterpillar plots to summarise HSMRs. As before, we have limited presentation to several peer groups, which is sufficient for the purposes of demonstration. In this section, we present plots of the hospitals in four peer groups for the high-risk case group accounting for 80% of all in-hospital deaths.

Figures 9 to 12 display the variation of HSMRs in the peer groups A1, B1, C2 and D1. The 95% confidence interval associated with each point estimate indicates the degree of uncertainty of the point estimate and is dependent on both the observed and expected number of deaths (the larger the observed and expected number of deaths the narrower the confidence intervals). The caterpillar plots allow for a quick visual display of the extent of between-hospital variability, and the degree of precision for each of the estimates using the confidence intervals. Those hospitals in which the confidence intervals do not overlap can generally be assumed to be different in terms of HSMRs.

Differences in the distribution of HSMRs between peer groups might represent true differences in risk, but they might also be due to models and available data allowing incomplete adjustment of risk. It is certainly the case that casemix differs substantially between peer groups. Hence, as for other characteristics of hospitals, comparisons within peer groups may be more meaningful than those between peer groups, even after adjustment.

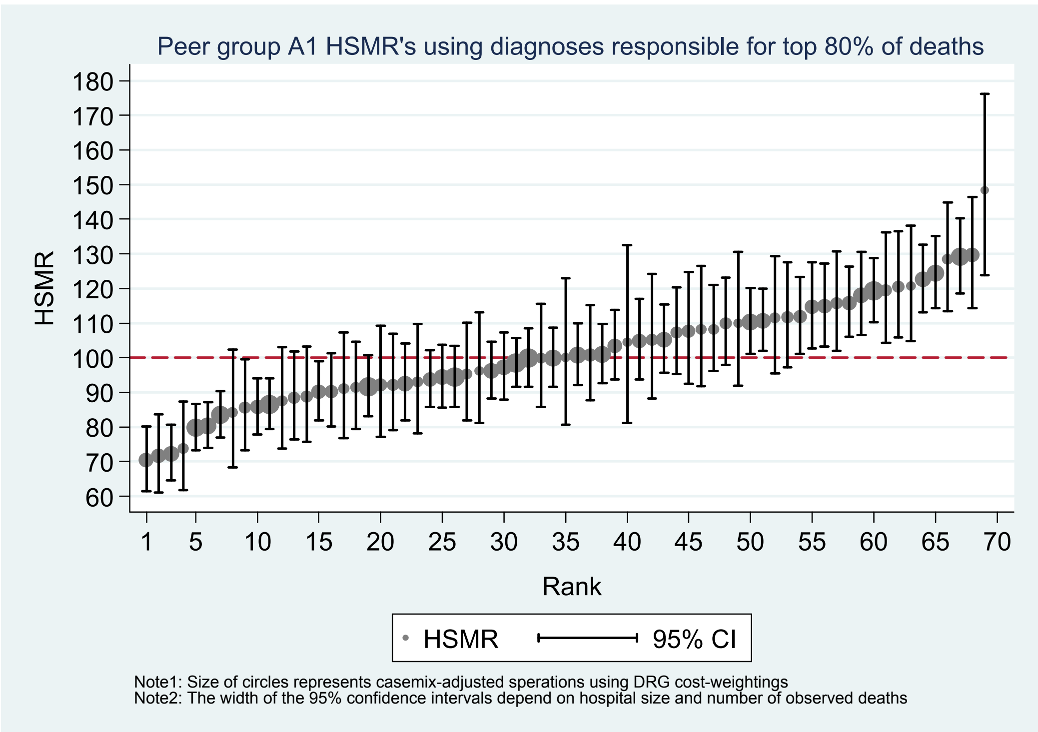


Figure 9: Caterpillar plot of variation in point estimates in HSMR for peer group A1, 80% of in-hospital mortality

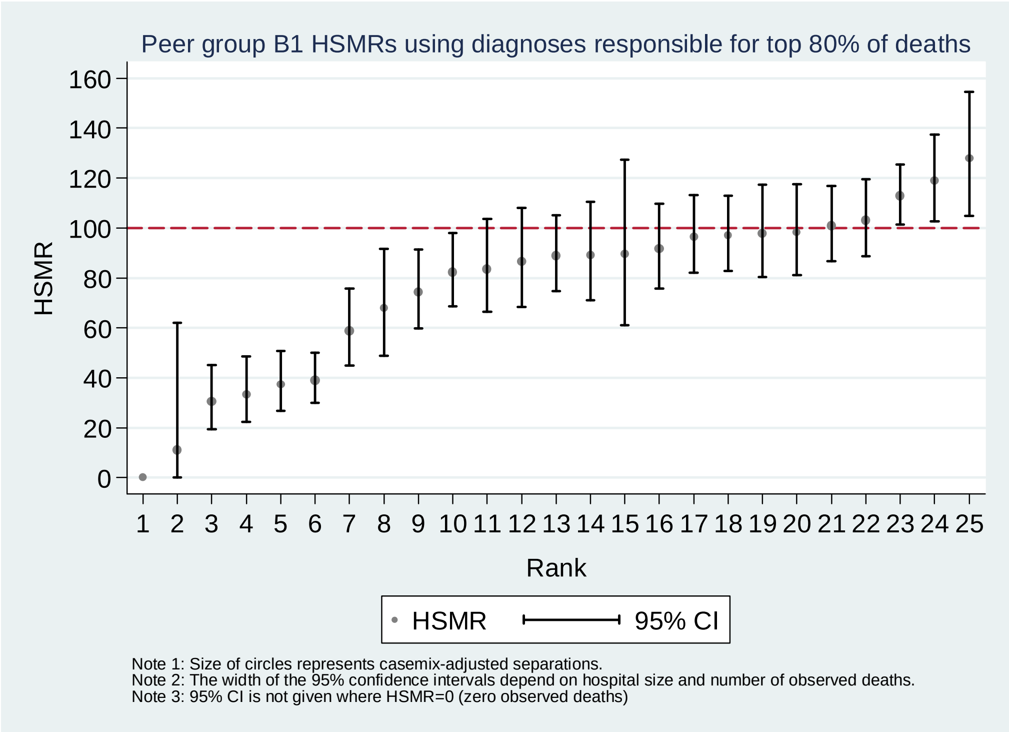


Figure 10: Caterpillar plot of variation in point estimates in HSMR for peer group B1, 80% of in-hospital mortality

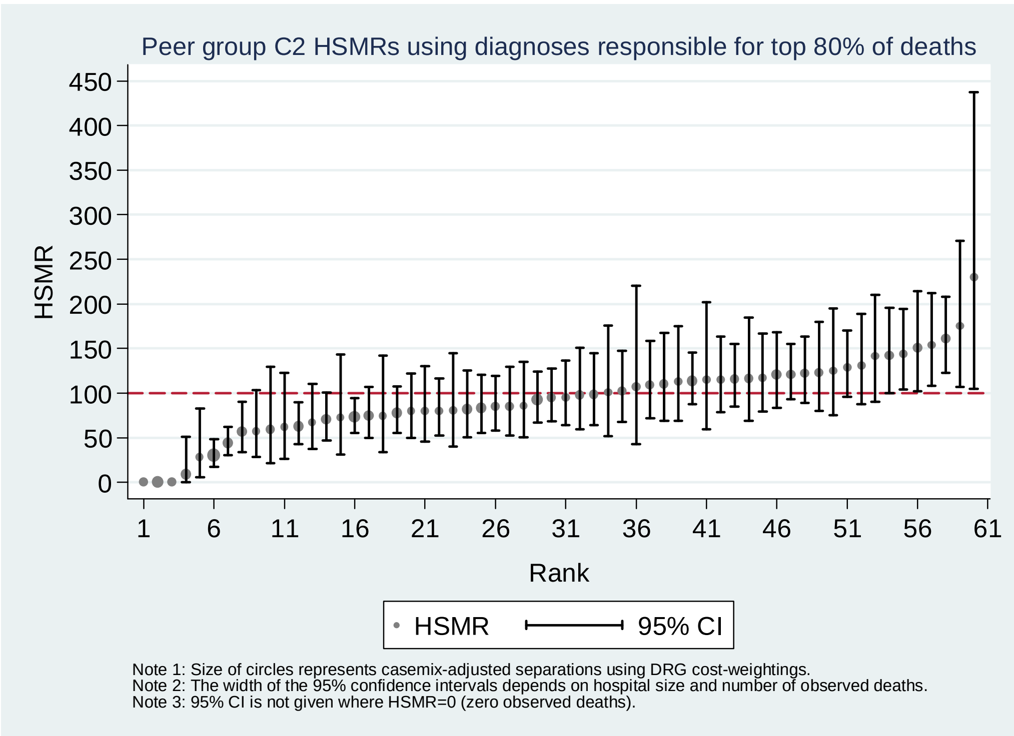


Figure 11: Caterpillar plot of variation in point estimates in HSMR for peer group C2, 80% of in-hospital mortality

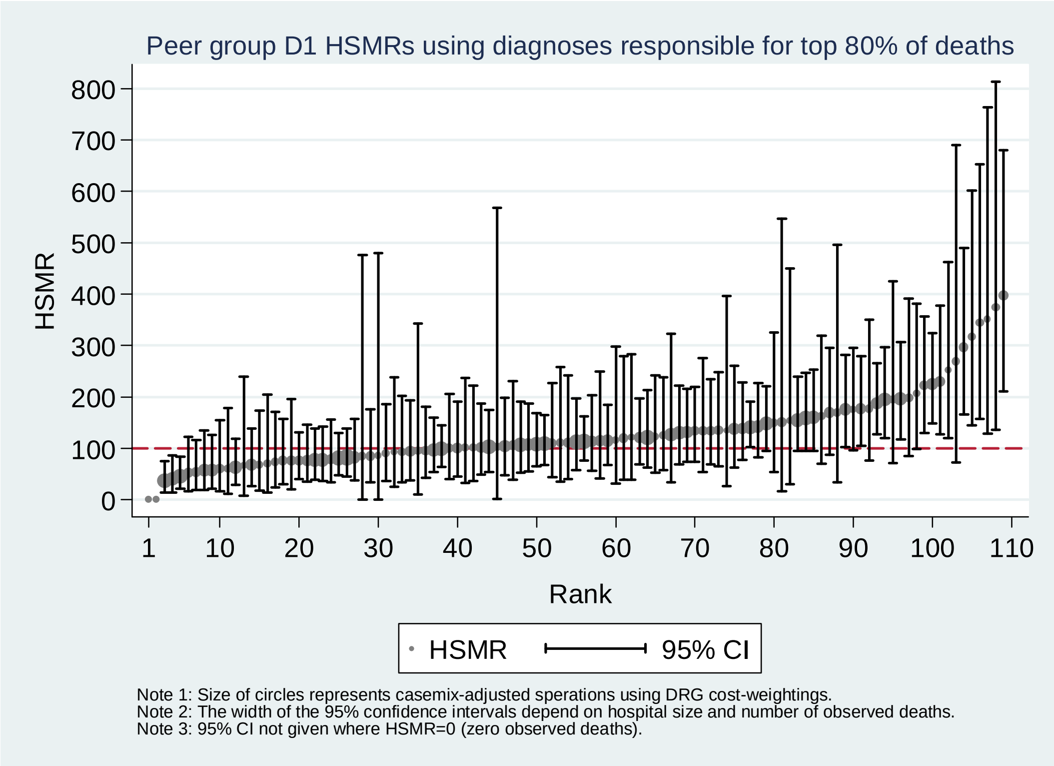


Figure 12: Caterpillar plot of variation in point estimates in HSMR for peer group D1, 80% of in-hospital mortality

5.7 Funnel plots

This section demonstrates the presentation of study data in the form of funnel plots. Compared with tables and caterpillar plots, funnel plots allow graphical information about a large number of hospitals to be presented in only a few figures. We illustrate the approach here by presenting information on peer groups A1, B1 and B2. Funnel plots for other peer groups are provided in Appendix 3.

Figures 13 to 15 display the variation in HSMRs for the A1, B1 and B2 hospitals according to the expected number of deaths and the size of the institution (as assessed by the number of cost-weight adjusted separations). The position of the marker shows the HSMR versus the number of deaths predicted by the model. The size of the marker represents the size of the hospital, measured as casemix-adjusted separations. Each of the figures summarises results for one of the three case sets: high-risk diagnoses accounting for 80% of deaths; the lower risk diagnoses accounting for the remaining 20% of deaths, and all diagnoses.

Funnel plots allow for quick visual detection of ‘out-lying’ institutions, which are represented as points outside the funnel. More than one peer group is shown in each of the figures, coded by colour.

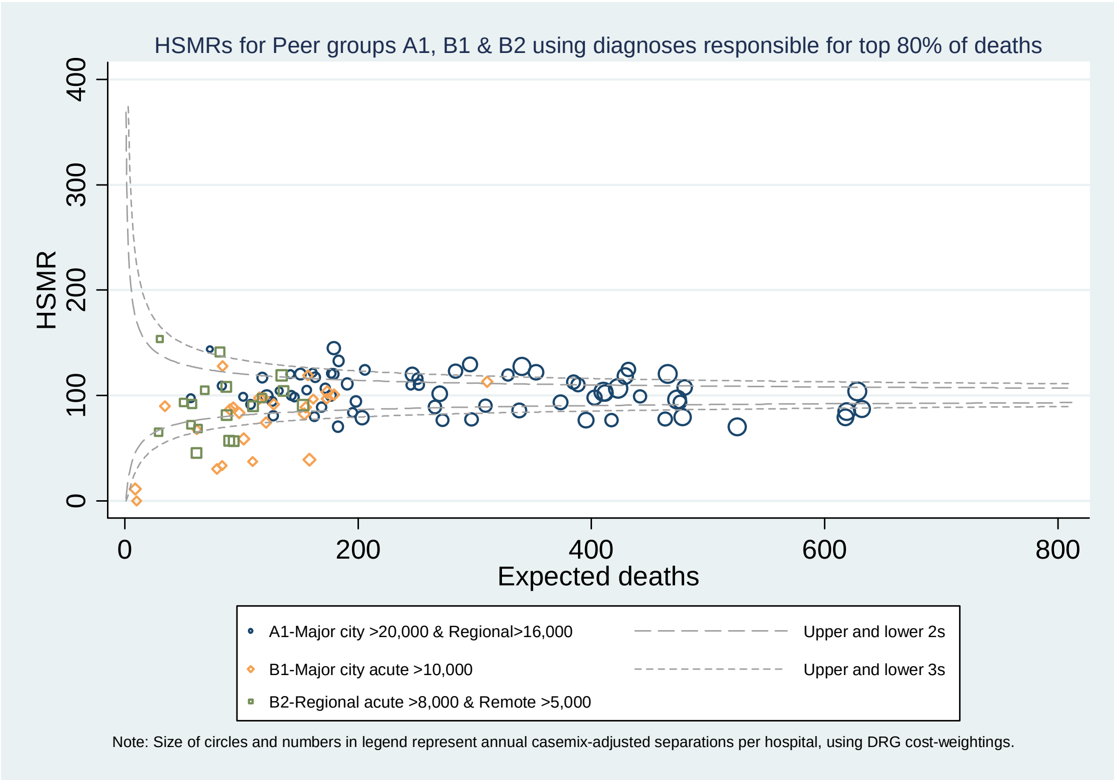


Figure 13: Variation in HSMRs according to the expected number of deaths and the size of the institution, peer group A1, B1 and B2, 80% of in-hospital mortality

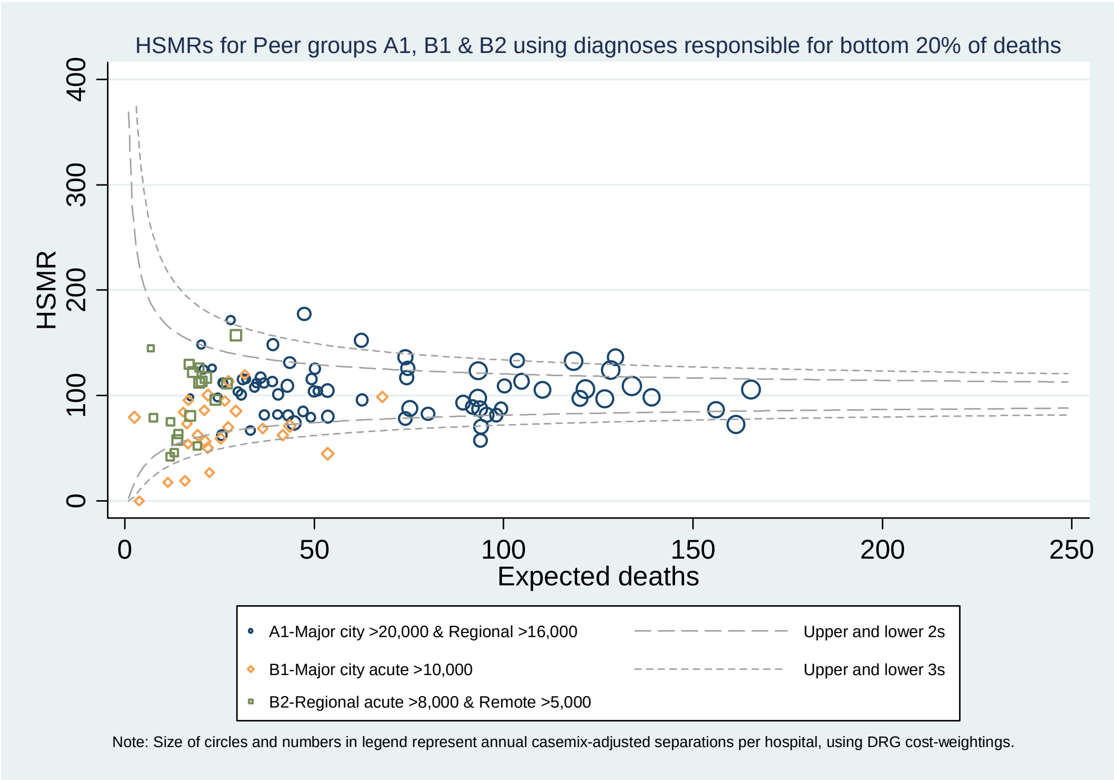


Figure 14: Variation in HSMRs according to the expected number of deaths and the size of the institution, peer group A1, B1 and B2, 20% of in-hospital mortality

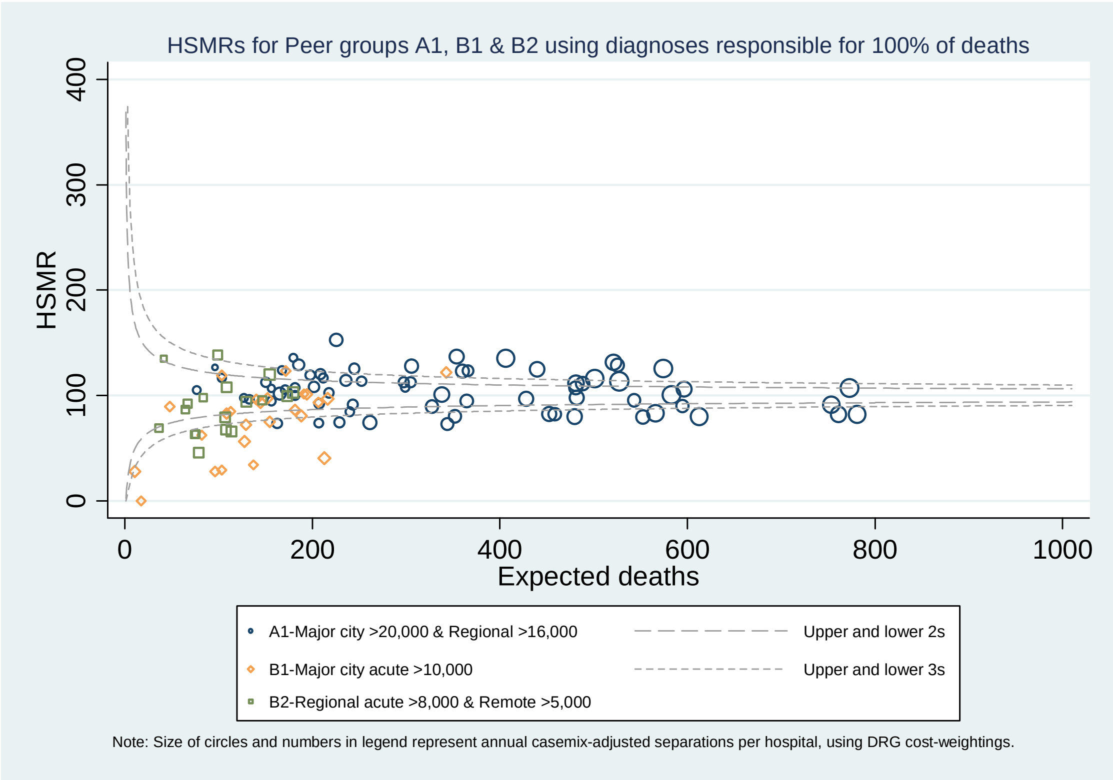


Figure 15: Variation in HSMRs according to the expected number of deaths and the size of the institution, peer group A1, B1 and B2, 100% of in-hospital mortality

5.8 Model development

The RACM model only includes untransformed values of variables and main effects. This is not necessarily the best way to model the data (see Section 4.8).

Fractional polynomials suggested the best powers of age for the transformation of age were age (i.e. a linear term) and age cubed. The Akaike information criterion (AIC) reduced from 266865.8 (80 df) to 266183.2 (79df) ($p < 0.001$). Table 17 displays the observed and expected deciles of risk for three different models: the standard RACM model, the full interaction model using the 50% developmental model data set (random sample of 50% of the 2005–06 data) and the full interaction model using the validation data set (with the remaining 2005–06 data).

Table 17: Observed and expected deciles of risk for 3 different models

	Model without interactions			Full model with interactions			Full model applied to 50% sample		
Decile	Obs	Exp	sqrt((obs-exp)^2/exp)	Obs	Exp	sqrt((obs-exp)^2/exp)	Obs	Exp	sqrt((obs-exp)^2/exp)
1	29	67.9	4.7	2	8.6	2.25	4	3.8	0.08
2	64	167.8	8.0	18	32.3	2.52	8	15.0	1.80
3	164	315.5	8.5	72	89.5	1.85	46	41.7	0.67
4	302	558	10.8	185	221.4	2.45	101	105.6	0.44
5	631	926.5	9.7	504	531.5	1.19	251	261.9	0.67
6	1,418	1,560.4	3.6	1,178	1,221.4	1.24	609	611.5	0.10
7	2,654	2,653.1	0.0	2,640	2,500.7	2.79	1,259	1,259.7	0.02
8	4,874	4,491.9	5.7	5,030	4,897.5	1.89	2,573	2,453.7	2.41
9	9,171	8,112.5	11.8	9,511	9,507.4	0.04	4,755	4,746.8	0.12
10	21,918	22,371.4	3.0	22,306	22,435.7	0.87	11,109	11,177.4	0.65
			65.9			17.08			6.96

The model fit for the standard RACM model was $Chi^2 = 65.9$, 8df, $p < 0.001$ and the fit increased substantially with the ERM model using the 50% 2005–06 validation sample data set ($Chi^2 = 6.96$, 10df, $p = 0.73$). Not only does the ERM produce better fit overall, but the residual differences between observed and expected deaths are spread more evenly over risk deciles than when the RACM model is used (Table 17). Figure 16 demonstrates that that the observed and predicted proportions of mortality fit well for all deciles.

HSMRs were calculated for the 80% mortality outcomes for the A1 hospital peer group. For the sake of comparison, the RACM model was re-run, placing the primary diagnoses in risk decile groups but otherwise leaving the model as is. HSMR plots are provided using the ERM model, the modified RACM model, and the RACM model as previously described (Figure 17).

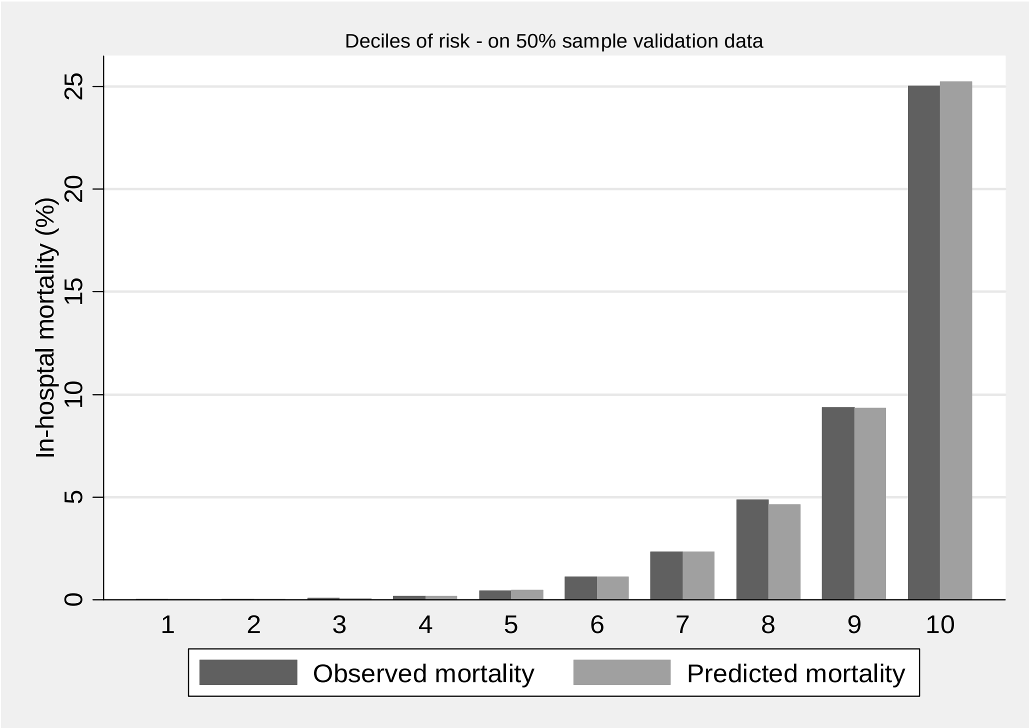


Figure 16: Observed and predicted proportions of mortality by deciles of risk

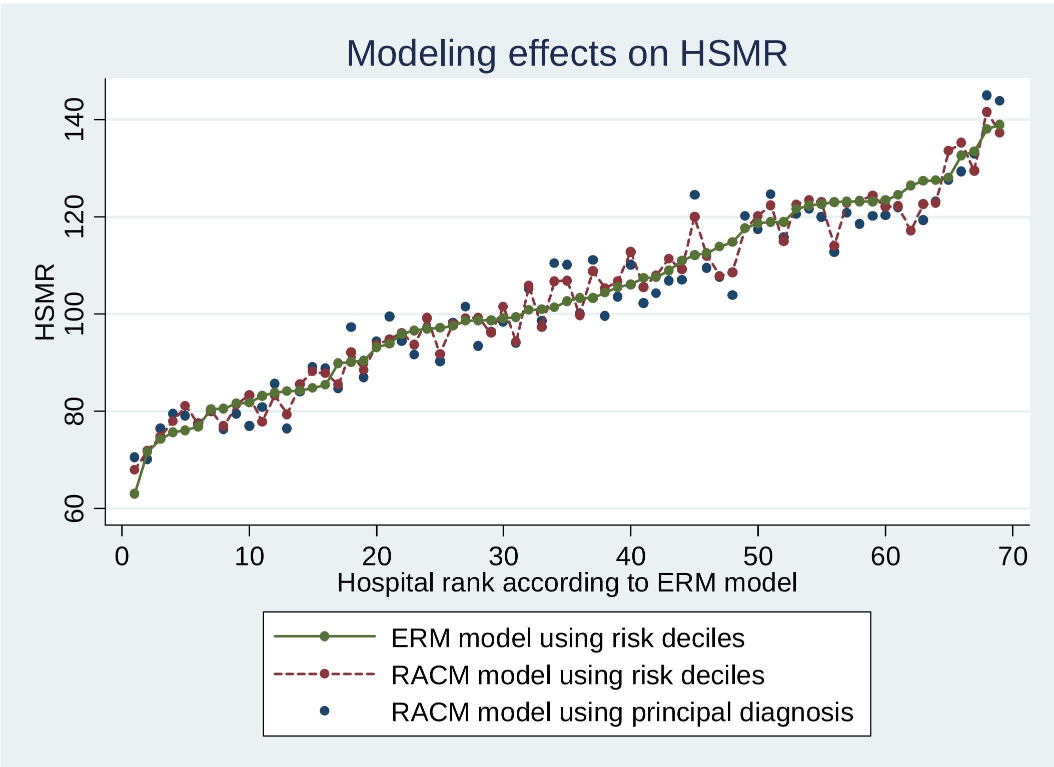


Figure 17: HSMR plots using the ERM model, the modified RACM model, and the RACM model

5.9 Inclusion of SEIFA

When the SEIFA index of socioeconomic status was included as a five-category variable in the standard RACM model, it was found to be a significant predictor of in-hospital mortality (LR test : $Chi^2 = 29.13$, 4df, $p < 0.001$). However, the change in the pseudo R^2 statistic was only marginal (from 0.2459 to 0.2460). The effect of increasing quintiles of SEIFA on the odds of in-hospital mortality compared with the odds for in-hospital mortality for the first SEIFA quintile are shown in Table 18.

Table 18: Effect of increasing quintiles of SEIFA[(a)] on the odds of in-hospital mortality

SEIFA quintile	Odds ratio	Std. Error	z	P	LCI	UCI
Most disadvantaged	1.000	–	–	–	–	–
Second most disadvantaged	1.029	0.016	1.86	0.064	0.998	1.061
Middle quintile	0.992	0.017	–0.46	0.648	0.961	1.025
Second most advantaged	0.971	0.017	–1.71	0.087	0.938	1.004
Most advantaged	0.942	0.017	–3.39	0.001	0.911	0.975

(a) Based on the ABS's SEIFA 2001 Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) score for the statistical local area of the patients area of usual residence (ABS 2004).

5.10 Longitudinal analysis

In addition to applying the RACM and ERM models to a single year of hospital separations data, we undertook a longitudinal analysis of data for that year (2005–06), the year before and the year after. The longitudinal analysis has been undertaken to demonstrate the feasibility of basing this approach on Australian data.

As discussed in the literature review (see Section 2.7.2), longitudinal studies are of considerable importance for confirming the presence of systematic variations in mortality outcomes, and for assessing the extent to which a data source provides information on in-hospital mortality, rather than 'noise'.

Reliance solely on cross-sectional comparisons of performance would miss patterns such as hospitals whose rates remained static although there was a general trend towards improvement, or hospitals whose results improved or deteriorated to an important extent over time, despite the absolute mortality rates for the hospitals not deviating enough form group means to attract attention on cross-sectional study.

This section provides information on the method employed and the results of the analysis of data covering the 3–year period 2004–05 to 2006–07.

We used a method based closely on that reported by Heijink (2008). This is a two-step analysis, outlined here and described fully below.

The first step is logistic regression modelling. As before, this was done to reduce variation among hospitals due to different case profiles (i.e. risk adjustment). We used the same modelling approach used for the single-year study (i.e. RACM).

The second step is two-stage multi-level logistic regression. This was done to explain remaining variation of risk-adjusted HSMRs within and between hospitals—especially variation over time.

Following Heijink, we did this analysis on the high-risk (80%) case group.

5.10.1 Method

Data

This analysis uses data for hospital separations that occurred in Australia from 1 July 2004 to 30 June 2007. As in the single-year analysis, the data were provided by the AIHW from the NHMD.

Institution mapping

A longitudinal analysis of this nature depends on tracking individual hospitals over time. Unfortunately, this is not as simple as it sounds. Hospitals merge, change ownership, change their names, and change from public to private and vice versa. No 'map' was available to track these changes. In the absence of an available map we made one to cover the 3–year period under study.

We obtained from the AIHW website tables that listed, for each data year, hospital names, establishment identifiers and several other characteristics, including average available beds, peer group code and regional designation. We used these tables, in conjunction with establishment identifier codes in the NHMD data, to construct the map. Many hospitals were easy to map: names and establishment IDs remained identical over the 3 years. Many others had some differences, which were assessed carefully. Establishments for which mapping doubt remained were omitted from the analysis. Private hospitals were generally not identified separately in the NHMD, and were not in the tables, and could not be included in this part of the analysis.

Of the 856 hospitals identified in the three data years, 736 were matched across all 3 years and retained for the longitudinal analysis. Each of these hospitals was assigned a study identifier, which was used in this part of the analysis.

Case selection, peer groups and modelling

Exclusion criteria for years 2004–05 and 2006–07 were applied as for the single-year analysis described above (Section 4.5). Records meeting the following criteria were selected from the three annual files:

1. hospital establishment identifier was one of the 736 that were mapped over the 3 years
2. Principal Diagnosis code was one of those in the high-risk group (These codes are listed in Appendix A1.)
3. the hospital was in one of the peer groups A1, A2, B1, B2, C1, C2, D1, D2 or D3.

These exclusions reduced the number of cases for analysis to 2,012,302.

A logistic regression model for in-hospital mortality above was created using the following covariates: age, sex, length of stay, elective/emergency status, principal diagnosis, Charlson index and transfer status. Modelling followed the RACM method described above for the single-year analysis. Model coefficients were determined using the first year of data (2004–05). These coefficients were then applied to each record in each of the data years 2004–05 to 2006–07 to generate a probability of death. The sum of these values for all records belonging to a hospital gave the expected number of deaths for that establishment. This was done separately for each year.

HSMRs for each year were then calculated by dividing the observed number of deaths by the expected number of deaths for each hospital and for each year. An HSMR was calculated for each of the 3 years for 418 hospitals with a peer group of A1, A2, B1, B2, C1, C2, D1, D2 or D3. Overall HSMRs for each of these peer groups were also calculated (Table 19).

Following calculation of annual HSMRs for these 418 hospitals, a two-stage multi-level linear regression model was developed in order to assess any systematic change in HSMRs over time, and also the within-hospital correlation of HSMRs over time.

Multi-level models partition the variance of the data into fixed and random effects. Fixed effects for our models were the overall mean HSMR in 2004–05 and the decrease in HSMR for each of the following 2 years. Random effects were the overall variance in HSMRs across hospitals (denoted in the results as 'random intercept for hospitals'), the variance in the slopes of HSMRs across time ('random slopes for hospitals') and the covariance (i.e. degree of correlation) between the random intercept and the random slopes.

The correlation across time for hospitals was assessed using the intraclass correlation coefficient (ICC), which is defined as the ratio of the (level 2) between-hospital variance (random intercept for hospitals) and the total hospital variance (random intercept for hospitals plus the (level 1) within-hospital variance). A high degree of correlation indicates that compared with between-hospital variation, within-hospital variation across time is small.

Observed and model-predicted HSMRs were also plotted across time to allow visual assessment of the data. The model-predicted HSMRs incorporate the fixed and random effect components of the model, but not the unexplained (level 1) within-hospital variation (i.e. residual variation not explained by the modelling). The model-predicted HSMRs can therefore be thought of as depicting the explained (i.e. systematic) variance in the HSMRs.

5.10.2 Results

The 3–year analysis was done to demonstrate an approach to longitudinal analysis of in-hospital mortality, and to examine the adequacy of Australian hospital morbidity data for this purpose.

The overall HSMRs for the whole data for the first year (2004–05) is, by definition, 100 (95% CI= 99–101). The overall HSMR declined to 98.6 (95% CI= 97–100) for the second year (2005–06) and to 95.5 (95% CI= 94–97) for the third year (2006–07).

The annual mean HSMRs for each peer group are presented in Table 19. Because the logistic regression modelling was built using data from all hospitals combined (rather than being stratified by peer group), the first-year HSMRs are not set to 100—revealing differences between the groups. The effect of applying a model derived from all cases to very different types of hospital is particularly evident for peer group A2, WCHs.

Looking across the rows, it can be seen that there was a tendency for HSMRs to decrease over time for peer groups A1, A2, B1, C2 and D2.

The results of the multi-level modelling of HSMRs are shown in Table 20. Although HSMRs for most groups decreased across time, the only significant decreases in HSMR after 2004–05 were for peer group A1 in 2006–07 (–6.3, 95% CI = –9.9 to –2.6, $p < 0.001$) and for peer group C2 in 2006–07 (–18.0, 95%CI = –35.6 to –0.5).

The ICC values are high for most of the peer groups, indicating that within-hospital variation between the 3 years is small in relation to between-hospital variation.

Table 19: Mean HSMRs (and 95% confidence intervals) by financial year and peer group

	Financial year		
Peer group	2004–05	2005–06	2006–07
A1	104.3 (98.8,109.7)	102.6 (98.0, 107.1)	98.0 (93.0, 103.0)
A2	201.3 (87.8, 314.8)	168.5 (74.3, 262.8)	167.0 (72.5, 261.6)
B1	80.4 (67.2, 93.5)	78.1 (63.9, 92.4)	77.4 (65.0, 89.9)
B2	96.2 (80.4, 112.1)	90.7 (76.7, 104.6)	96.2 (82.6, 109.8)
C1	68.6 (55.3, 81.9)	75.8 (60.4, 91.2)	68.4 (54.1, 82.7)
C2	107.0 (86.5, 127.5)	96.8 (83.9, 109.7)	88.9 (78.3, 99.6)
D1	133.8 (111.7. 156.0)	133.0 (117.3, 148.7)	136.6 (122.0, 151.2)
D2	119.9 (102.8, 136.9)	120.9 (102.3, 139.4)	108.0 (93.5, 122.5)
D3	98.2 (71.0, 125.4)	100.6 (84.1, 117.1)	106.3 (80.5, 132.1)

Another way of presenting this information is provided in Figures 18 to 20.

The pair of charts in each row represents one of the peer groups included in the longitudinal part of the study. The thick line in each chart presents the peer-group mean HSMRs for each year (like the values in Table 19). Each of the dashed lines represents one of the hospitals in the peer group. The chart on the left in each pair ('Observed') shows the risk-adjusted HSMRs as calculated by applying the logistic regression model based on 2004–05 data to this year and to each of the other years. The other chart in each pair ('Predicted') displays the risk-adjusted HSMRs predicted by the multi-level model.

The more linear each hospital line is across the 3 years, the less variation there is within that hospital across time. As a consequence, the relative contribution of between-hospital variation in HSMRs to the total variation is higher and, by definition, the ICC is therefore higher too.

The difference in HSMRs between the two charts demonstrates the amount of residual variation in the HSMRs that cannot be explained by the multi-level models. Note that the vertical scale differs between charts.

These results are generally similar to those reported by Heijink et al. (2008), whose approach we followed. Like them, we found a downward trend in overall risk-adjusted HSMR, and that variation was mostly between-hospitals, not within hospitals.

The main difference between Heijink et al. (2008) and our analysis is their examination of a wider range of covariates as predictors of in-hospital mortality. The satisfactory performance of the method when applied to Australian hospitals data suggests that it will be fruitful to extend our analysis in a similar way. Exact replication is unlikely to be feasible, because some of the covariates used by Heijink et al. may not have direct Australian equivalents, due to differences in health system organisation and health information. However, data on some other potential covariates may exist in Australia.

It should be recognised that that these are results of a demonstration analysis. Although they offer support for the view that Australian hospital morbidity data provide an adequate basis for calculation of indicators of in-hospital mortality, caution should be taken not to over-interpret these results, which have some limitations.

The analysis presented here is based on only 3 years of data. That was enough to allow us to test the extent to which Australian hospitals data provide ‘signal’ rather than ‘noise’ in hospital-level HSMRs. Subsequent analyses will benefit from the use of data for a larger number of years.

The analysis presented here is for only one of the three indicators defined in Section 4.5.2: namely the indicator restricted to the group of Principal Diagnoses associated with the highest number of in-hospital death, and which together account for 80% of all in-hospital deaths.

As explained above, the lack of a ‘map’ led to the omission of some public hospitals. Many private hospitals could not be included, due to the lack of hospital-specific identifiers in the NHMD.

Table 20: Fixed and random effects and intra-class correlation coefficients for the multi-level models

	Hospital peer groups								
	A1	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2[(a)]**	**D3**
	(*n* = 61)	**(*n* = 9)**	**(*n* = 25)**	**(*n* = 18)**	**(*n* = 27)**	**(*n* = 59)**	**(*n* = 103)**	**(*n* = 80)**	**(*n* = 36)**
Fixed effects									
Constant (group mean for 2004–05)	104.3 (2.6)	201.3 (46.8)	80.4 (6.6)	96.2 (7.2)	68.6 (6.7)	107.0 (10.0)	133.8 (10.2)	119.9 (8.4)	98.2 (12.3)
Year									
2004–2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005–2006	–1.7 (1.6)	–32.8 (21.6)	–2.2 (2.8)	–5.6 (4.9)	7.2 (4.3)	–10.2 (5.5)	–0.8 (9.5)	1.0 (8.2)	2.3 (12.9)
2006–2007	–6.3† (1.9)	–34.3 (22.3)	–2.9 (2.8)	0.0 (6.1)	–0.2 (5.0)	–18.0* (9.0)	2.8 (10.1)	–11.9 (8.2)	8.1 (16.0)
Random effects									
Level 1 variance	71.7 (13.)	2,051.4 (725.3)	99.8 (20.4)	177.0 (60.7)	222.8 (61.8)	379.8 (70.5)	4,444.8 (440.1)	2,662.8 (299.6)	2,459.4 (587.9)
Level 2 variances									
Random intercept for hospitals	435.0 (114.1)	20,259.1 (12,363.7)	1,021.5 (357.3)	1,032.1 (515.5)	1,037.7 (455.4)	10,604.5 (2,140.1)	9,745.1 (2,660.9)	3,027.5 (630.9)	6,350.3 (3198.8)
Random slope for hospitals	17.8 (11.8)	90.3 (223.8)	0.5 (2.0)	78.0 (64.7)	56.9 (56.0)	995.3 (222.9)	379.9 (216.3)	–	1,078.3 (625.1)
Covariance of random slope and intercept	–52.3 (31.1)	–1,352.7 (1,981.8)	–21.7 (49.1)	–181.4 (159.4)	–51.7 (129.6)	–3,048.9 (665.2)	–1,924.0 (792.1)	–	–2,239.1 (1,331.7)
Intraclass correlation coefficient	0.86	0.91	0.91	0.85	0.82	0.97	0.69	0.53	0.72
–2 x log-likelihood	1,471.2	282.9	626.4	469.5	734.0	1,791.8	3,582.6	2,672.2	1,189.9

(a) A random-intercept only model was used for peer group D2 due to non-convergence with a random intercepts and random slopes model.
* $p < 0.05$, † $p < 0.001$ versus 2004–2005. Figures in brackets denote standard errors.

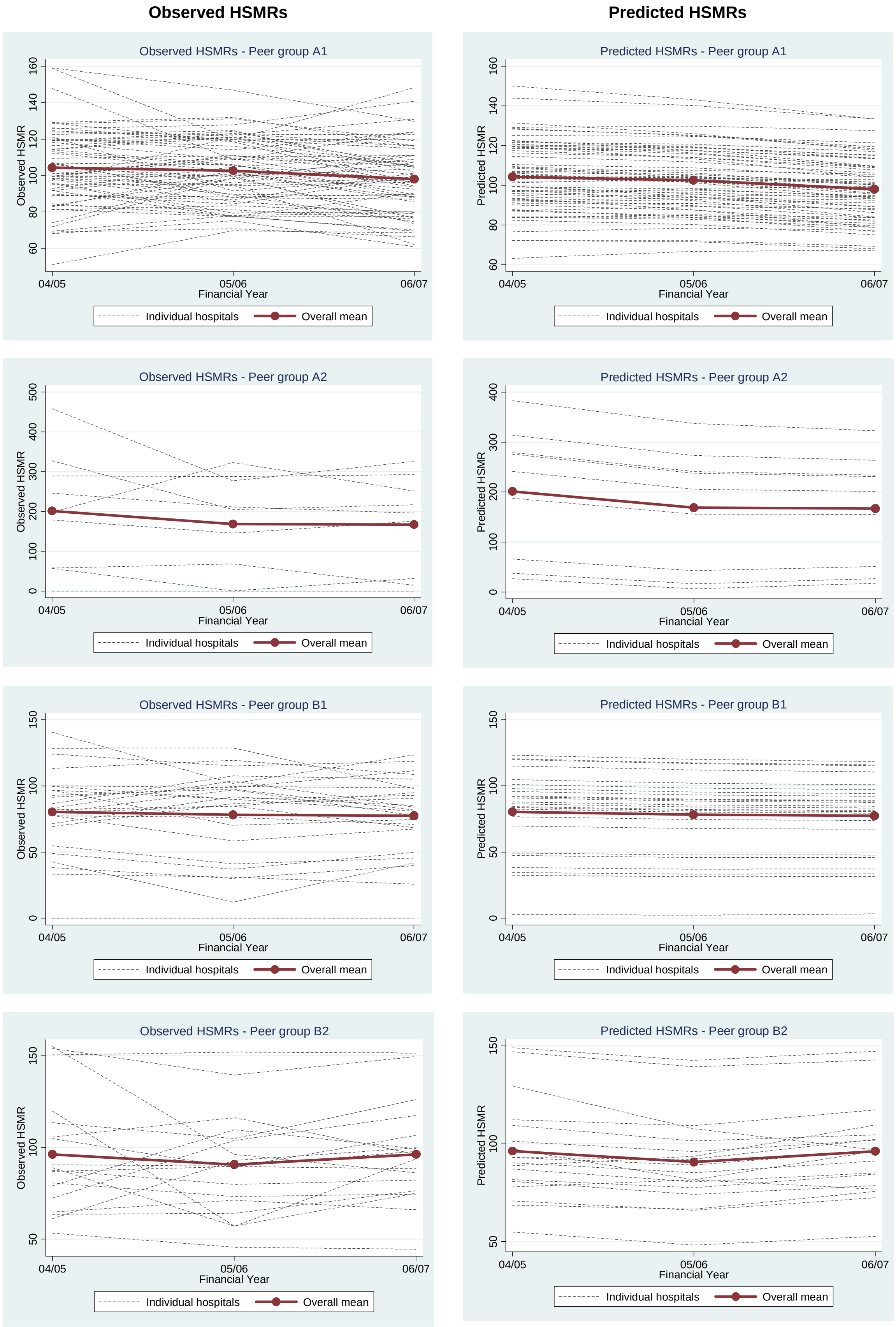


Figure 18: Observed and predicted hospital-specific and group mean HSMRs by financial year and peer group: peer groups A1, A2, B1 and B2

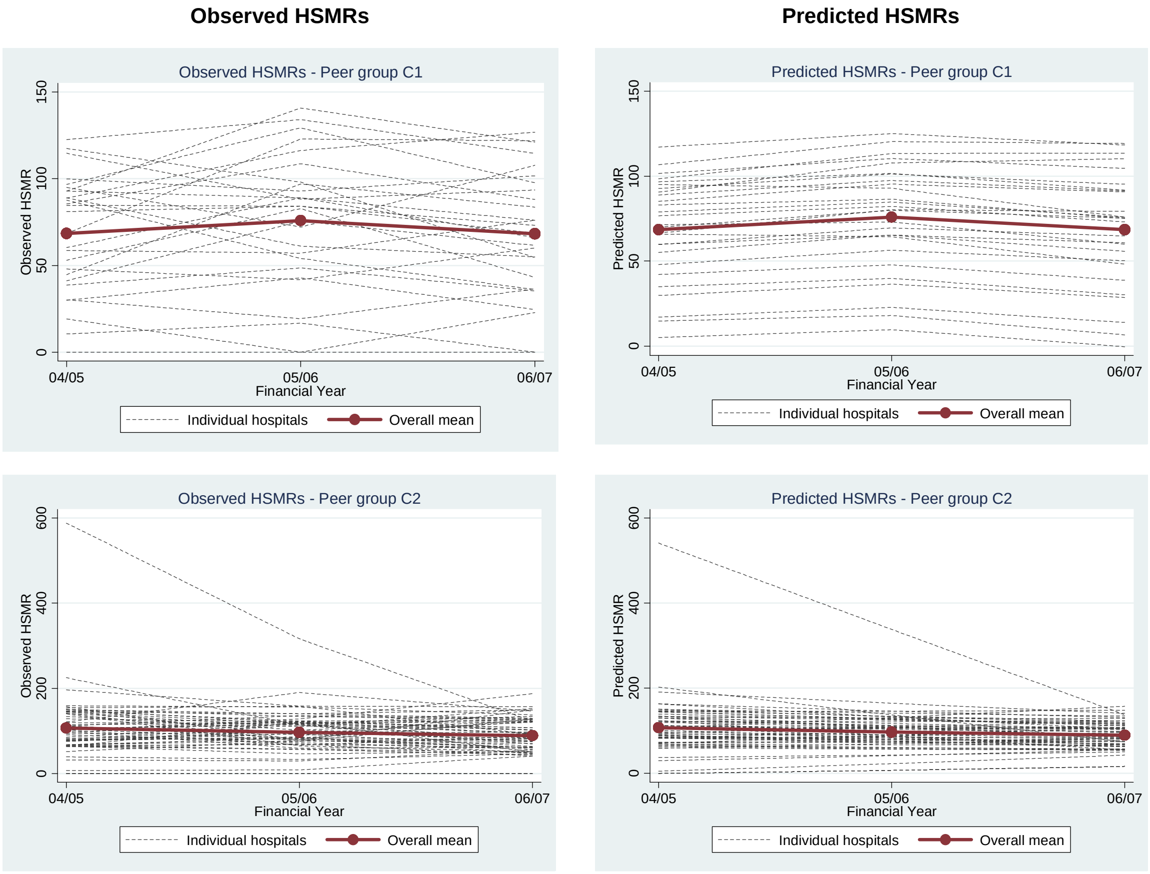


Figure 19: Observed and predicted hospital-specific and group mean HSMRs by financial year and peer group: peer groups C1 and C2

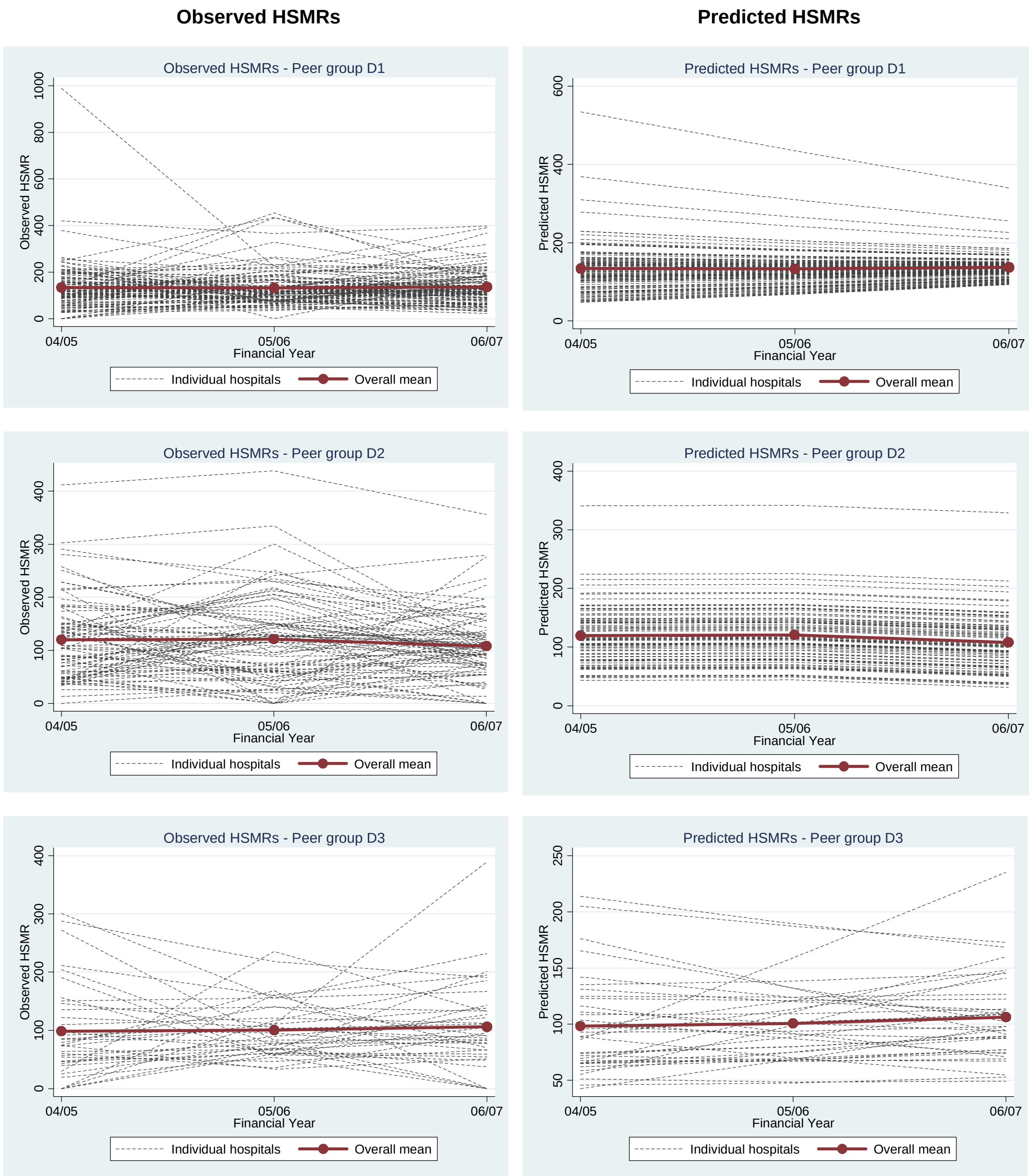


Figure 20: Observed and predicted hospital-specific and group mean HSMRs by financial year and peer group: peer groups D1, D2 and D3