Supplementary Information

Multisystem disease accumulation in routine claims reveals dynamic multimorbidity and mortality risk in older adults: a multicentre retrospective cohort study

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All substantive methods descriptions are provided in the main manuscript. Supplementary Table S14 lists the operational disease-system label keywords used for transparent mapping.

Supplementary Tables

Table S0. Landmark attrition and comparison of landmark versus non-landmark patients.

S0a. Landmark attrition by care-setting stratum

Care-setting stratum	First age-eligible admissions	Reached landmark	Not in cohort	Death at/before landmark	No post-landmark follow-up	Landmark cohort 12-month deaths
Acute care	1,238	896	342	132	210	132 (14.7%)
Chronic care	5,404	4,122	1,282	740	542	811 (19.7%)
Total	6,642	5,018	1,624	872	752	943 (18.8%)

S0b. Descriptive comparison of landmark and non-landmark patients

Group	N	Age, median [IQR], years	Male, %	D0 burden / CCI median [IQR]
Reached 6-month landmark	5,018	83.7 [77.5–89.0]	33.6	D0: 8 [5–11] / CCI: 2 [1–4]
Did not reach landmark estimand	1,624	85.9 [80.5–90.7]	47.7	D0: 9 [7–12] / CCI: 3 [2–4]
— Death at/before landmark	872	—	—	—
— No positive post-landmark follow-up	752	—	—	—

The 6-month landmark estimand intentionally differs from an admission-time prediction model. Non-landmark patients who died before or at the landmark or lacked positive post-landmark follow-up are described here to make early attrition visible. D0 = Month 0 active disease burden; CCI = Charlson Comorbidity Index.

Table S1. D0 disease-system profile by care setting.

Disease system	Acute-care arm (N=896)			Chronic-care arm (N=4,122)		
	N assessed	D0 active, n (%)	D0 count, median [IQR]	N assessed	D0 active, n (%)	D0 count, median [IQR]
Cardiovascular	896	592 (66.1)	1.0 [0.0–3.0]	4,122	3,060 (74.2)	1.0 [0.0–3.0]
Gastrointestinal	896	347 (38.7)	0.0 [0.0–1.0]	4,122	2,143 (52.0)	1.0 [0.0–1.0]
Metabolic/endocrine	896	399 (44.5)	0.0 [0.0–1.0]	4,122	2,046 (49.6)	0.0 [0.0–1.0]
Musculoskeletal	896	263 (29.4)	0.0 [0.0–1.0]	4,122	1,910 (46.3)	0.0 [0.0–1.0]
Neurological	896	282 (31.5)	0.0 [0.0–1.0]	4,122	1,804 (43.8)	0.0 [0.0–1.0]
Respiratory	896	204 (22.8)	0.0 [0.0–0.0]	4,122	1,385 (33.6)	0.0 [0.0–1.0]
Renal/urologic	896	192 (21.4)	0.0 [0.0–0.0]	4,122	1,103 (26.8)	0.0 [0.0–1.0]
Infectious	896	66 (7.4)	0.0 [0.0–0.0]	4,122	852 (20.7)	0.0 [0.0–0.0]

Haematological	896	100 (11.2)	0.0 [0.0–0.0]	4,122	513 (12.4)	0.0 [0.0–0.0]
Oncological	896	92 (10.3)	0.0 [0.0–0.0]	4,122	596 (14.5)	0.0 [0.0–0.0]

D0 burden = Month 0 active disease-category count. D0 active = at least one active disease-category code within the system at Month 0. IQR = interquartile range. The 10 disease-system domains are mapped from source claims-system labels as documented in Supplementary Table S14 and the main Methods. Proportions are of the arm-specific 6-month landmark cohort.

Table S2. Index-facility patient characteristics and within-group facility heterogeneity.

Facility	Type	N	Age, median [IQR]	Male, n (%)	CCI, median [IQR]	D0, median [IQR]	Net, median [IQR]	12-month death, n (%)
A	Acute	596	80.5 [73.3–86.2]	238 (39.9)	1.0 [0.0–2.0]	5.0 [1.8–8.0]	3.0 [0.0–7.0]	88 (14.8)
B	Acute	300	84.0 [76.4–89.5]	117 (39.0)	2.0 [1.0–5.0]	8.0 [5.0–11.0]	2.0 [0.0–6.0]	44 (14.7)
C	Chronic	1,683	84.5 [78.8–89.5]	535 (31.8)	2.0 [1.0–4.0]	9.0 [6.0–12.0]	2.0 [0.0–5.0]	374 (22.2)
D	Chronic	1,665	83.9 [77.8–89.1]	567 (34.1)	3.0 [2.0–4.0]	7.0 [5.0–10.0]	1.0 [0.0–3.0]	322 (19.3)
E	Chronic	774	83.9 [77.7–88.8]	230 (29.7)	2.0 [1.0–3.0]	8.0 [3.0–11.0]	3.0 [0.0–7.0]	115 (14.9)

Facility labels are anonymised. A and B are acute-care facilities; C, D, and E are chronic-care facilities. CCI = Charlson Comorbidity Index; D0 = Month 0 active disease burden; net = six-month net active disease accumulation. 12-month death is among landmark-cohort patients (i.e., those who reached the 6-month landmark with positive post-landmark follow-up) within each facility. Median [IQR] observed post-landmark care-system time, months: A 18.0 [5.0–63.0]; B 30.0 [10.0–74.0]; C 16.0 [5.0–37.0]; D 19.0 [6.0–45.0]; E 32.0 [10.0–81.0].

Table S3. Disease-system-specific net-accumulation models: added discrimination and hazard ratios beyond demographics + CCI + D0.

Disease system (ranked by ΔC)	ΔC beyond CCI + D0 (95% CI)	p	HR per SD (95% CI)	HR p	Arm	Reference model
Acute-care arm (N=829, events=132) — ranked by ΔC						
Infectious	+0.042 (+0.011, +0.074)	0.016*	1.575 (1.322–1.875)	<0.001	Acute	Demog + CCI + D0
Haematological	+0.026 (+0.003, +0.052)	0.028*	1.397 (1.236–1.580)	<0.001	Acute	Demog + CCI + D0
Renal/urologic	+0.026 (+0.004, +0.047)	0.020*	1.283 (1.148–1.433)	<0.001	Acute	Demog + CCI + D0
Respiratory	+0.025 (−0.004, +0.055)	0.10	1.385 (1.218–1.575)	<0.001	Acute	Demog + CCI + D0
Metabolic/endocrine	+0.010 (+0.000, +0.021)	0.038*	1.148 (1.024–1.287)	0.018	Acute	Demog + CCI + D0
Oncological	+0.003 (−0.004, +0.011)	0.35	1.110 (0.984–1.253)	0.09	Acute	Demog + CCI + D0

Gastrointestinal	+0.003 (−0.003, +0.010)	0.32	1.061 (0.948–1.186)	0.30	Acute	Demog + CCI + D0
Neurological	+0.002 (−0.010, +0.013)	0.63	0.897 (0.757–1.062)	0.21	Acute	Demog + CCI + D0
Musculoskeletal	0.000 (−0.000, +0.001)	0.75	1.004 (0.836–1.205)	0.97	Acute	Demog + CCI + D0
Cardiovascular	−0.000 (−0.001, +0.001)	0.61	1.005 (0.898–1.124)	0.93	Acute	Demog + CCI + D0
Chronic-care arm (N=3,942, events=807) — ranked by ΔC						
Respiratory	+0.021 (+0.012, +0.031)	<0.001*	1.422 (1.336–1.514)	<0.001	Chronic	Demog + CCI + D0
Metabolic/endocrine	+0.013 (+0.006, +0.022)	<0.001*	1.280 (1.207–1.358)	<0.001	Chronic	Demog + CCI + D0
Infectious	+0.011 (+0.003, +0.018)	<0.001*	1.244 (1.166–1.327)	<0.001	Chronic	Demog + CCI + D0
Renal/urologic	+0.006 (+0.001, +0.010)	0.014*	1.156 (1.087–1.229)	<0.001	Chronic	Demog + CCI + D0
Haematological	+0.003 (−0.001, +0.007)	0.10	1.125 (1.051–1.205)	0.001	Chronic	Demog + CCI + D0
Oncological	+0.003 (+0.000, +0.005)	0.06	1.111 (1.048–1.178)	<0.001	Chronic	Demog + CCI + D0
Gastrointestinal	+0.002 (−0.001, +0.004)	0.23	1.086 (1.022–1.155)	0.008	Chronic	Demog + CCI + D0
Cardiovascular	+0.001 (−0.001, +0.002)	0.48	1.066 (1.003–1.133)	0.041	Chronic	Demog + CCI + D0
Musculoskeletal	−0.000 (−0.001, +0.001)	0.98	0.977 (0.916–1.041)	0.47	Chronic	Demog + CCI + D0
Neurological	−0.000 (−0.001, +0.001)	0.84	1.026 (0.962–1.094)	0.44	Chronic	Demog + CCI + D0

*Each row reports the result of adding a single system-specific net-accumulation variable to the reference model (demographics + CCI + D0) within the corresponding arm. ΔC = paired change in C-statistic; 95% CI from 1,000 bootstrap iterations for rows where convergence was achieved. HR per SD = hazard ratio per standard-deviation increase in the system-specific net variable from a Cox proportional-hazards model with the same reference. Systems ranked by ΔC within each arm. * p < 0.05.*

Table S4. Utilisation-component models: added discrimination and hazard ratios beyond CCI + D0 + total net.

Utilisation component (ranked by ΔC)	ΔC beyond CCI + D0 + net (95% CI)	p	HR per SD (95% CI)	HR p	Arm	Reference model
Acute-care arm (N=829, events=132) — ranked by ΔC						
Injections	+0.061 (+0.021, +0.098)	0.006*	3.193 (2.274–4.482)	<0.001	Acute	Demog + CCI + D0 + net
Billing lines	+0.052 (+0.019, +0.085)	<0.001*	7.563 (3.762–15.202)	<0.001	Acute	Demog + CCI + D0 + net
Imaging	+0.042 (+0.015, +0.071)	0.002*	1.633 (1.400–1.905)	<0.001	Acute	Demog + CCI + D0 + net
Medications	+0.031 (−0.001, +0.061)	0.054	2.373 (1.774–3.174)	<0.001	Acute	Demog + CCI + D0 + net

Rehabilitation	+0.015 (−0.009, +0.038)	0.22	1.883 (1.369–2.592)	<0.001	Acute	Demog + CCI + D0 + net
Hospitalisations	+0.003 (−0.022, +0.026)	0.85	0.784 (0.669–0.919)	0.003	Acute	Demog + CCI + D0 + net
Surgeries/procedures	0.000 (−0.007, +0.008)	0.96	1.047 (0.933–1.176)	0.43	Acute	Demog + CCI + D0 + net
Chronic-care arm (N=3,942, events=807) — ranked by ΔC						
Imaging	+0.040 (+0.028, +0.051)	<0.001*	1.656 (1.537–1.785)	<0.001	Chronic	Demog + CCI + D0 + net
Injections	+0.037 (+0.024, +0.050)	<0.001*	1.771 (1.619–1.937)	<0.001	Chronic	Demog + CCI + D0 + net
Billing lines	+0.020 (+0.012, +0.028)	<0.001*	5.827 (3.927–8.647)	<0.001	Chronic	Demog + CCI + D0 + net
Hospitalisations	+0.019 (+0.010, +0.027)	<0.001*	0.653 (0.589–0.724)	<0.001	Chronic	Demog + CCI + D0 + net
Medications	+0.018 (+0.008, +0.027)	<0.001*	1.695 (1.522–1.888)	<0.001	Chronic	Demog + CCI + D0 + net
Surgeries/procedures	+0.004 (−0.001, +0.009)	0.11	0.782 (0.693–0.883)	<0.001	Chronic	Demog + CCI + D0 + net
Rehabilitation	−0.000 (−0.003, +0.003)	0.92	1.099 (1.010–1.197)	0.029	Chronic	Demog + CCI + D0 + net

*Each row reports the result of adding a single M0–M6 utilisation component (log1p-transformed, z-standardised) to the reference model (demographics + CCI + D0 + total net) within the corresponding arm. ΔC = paired change in C-statistic; 95% CI from 1,000 bootstrap iterations. HR per SD = hazard ratio per SD increase in the utilisation component. Components are ordered by ΔC within each arm. * p < 0.05.*

Table S5. Spearman correlations between disease-system net accumulation and utilisation components.

Disease system (net accumulation)	Hosp.	Surg.	Rehab.	Imaging	Medic.	Inject.	Bill.
Acute-care arm							
Cardiovascular	0.31	0.17	0.20	0.21	0.22	0.25	0.23
Gastrointestinal	0.24	0.13	0.21	0.17	0.21	0.23	0.19
Metabolic/endocrine	0.22	0.13	0.11	0.17	0.17	0.30	0.20
Musculoskeletal	0.21	0.05	0.13	0.11	0.17	0.14	0.15
Neurological	0.20	0.14	0.14	0.13	0.18	0.13	0.14
Respiratory	0.11	0.02	0.11	0.15	0.18	0.22	0.24
Renal/urologic	0.15	0.06	0.15	0.17	0.21	0.22	0.21
Infectious	0.05	0.10	0.20	0.20	0.27	0.29	0.35
Haematological	0.07	0.14	0.12	0.16	0.14	0.23	0.22
Oncological	0.20	0.15	-0.04	0.10	0.02	0.13	-0.03
Chronic-care arm							
Cardiovascular	0.26	0.09	0.11	0.17	0.17	0.12	0.17
Gastrointestinal	0.22	0.10	0.01	0.16	0.17	0.20	0.14
Metabolic/endocrine	0.14	0.05	0.09	0.16	0.17	0.13	0.16

Musculoskeletal	0.11	-0.03	0.17	0.13	0.17	0.07	0.09
Neurological	0.19	0.06	0.02	0.07	0.14	0.09	0.09
Respiratory	0.08	-0.03	0.02	0.12	0.11	0.11	0.12
Renal/urologic	0.08	0.01	0.06	0.13	0.12	0.09	0.11
Infectious	0.02	0.03	0.11	0.26	0.13	0.10	0.21
Haematological	0.06	0.01	0.06	0.12	0.14	0.07	0.14
Oncological	0.05	0.04	0.09	0.10	0.10	0.00	0.07

Values shown are Spearman rank-correlation coefficients (ρ) between system-specific six-month net accumulation and each utilisation component, computed separately within each care arm among patients with a non-missing final count (acute-care N=829, chronic-care N=3,942; 4,771 combined). Shading intensity increases with ρ (darkest ρ ≥ 0.30; intermediate ρ ≥ 0.20; unshaded ρ < 0.20); the corresponding heatmap in Supplementary Figure S6 uses a sequential colour scale. All correlations with |ρ| ≥ 0.10 had p < 0.005 in both arms. Abbreviations: Hosp. = hospitalisations; Surg. = surgeries/procedures; Rehab. = rehabilitation units; Medic. = medications; Inject. = injections; Bill. = billing lines.

Table S6. Net-definition sensitivity analyses.

Net-accumulation definition	N	Events	C (CCI + D0 + net)	ΔC vs CCI + D0	Care arm
Acute-care arm					
Primary: last available M1–M6 count minus D0	829	132	0.720	0.042	Acute
M6 count minus D0 only	632	124	0.664	0.042	Acute
Negative net truncated at 0	829	132	0.718	0.040	Acute
Complete M0–M6 cases only	554	114	0.646	0.042	Acute
Absolute net categories (≤0, +1, +2, ≥3)	896	132	0.759	0.057	Acute
Chronic-care arm					
Primary: last available M1–M6 count minus D0	3,942	807	0.696	0.019	Chronic
M6 count minus D0 only	3,538	789	0.677	0.016	Chronic
Negative net truncated at 0	3,942	807	0.693	0.015	Chronic
Complete M0–M6 cases only	3,373	769	0.671	0.014	Chronic
Absolute net categories (≤0, +1, +2, ≥3)	4,122	811	0.717	0.027	Chronic

Each row reports the C-statistic for the CCI + D0 + net model and the ΔC beyond CCI + D0 using an alternative net-accumulation definition. Primary definition = last available M1–M6 active disease count minus D0. For the absolute net-categories variant only, patients without an available final M1–M6 count were classified in the ≤0 category, so that variant uses the full landmark cohort (acute N=896; chronic N=4,122) and is not directly comparable with the complete-case rows. All alternatives preserved positive incremental value over CCI + D0 in both arms. Primary definitions are shown in bold.

Table S7. Facility-adjusted models.

Model	N	Events	C	Incremental ΔC vs preceding nested model	Arm
Acute-care arm					
CCI + D0	829	132	0.678	—	Acute
CCI + D0 + net	829	132	0.720	0.042	Acute
CCI + D0 + net + utilisation	829	132	0.755	0.034	Acute
Facility-adjusted: CCI + D0	829	132	0.705	—	Acute
Facility-adjusted: CCI + D0 + net	829	132	0.733	0.028	Acute
Facility-adjusted: CCI + D0 + net + utilisation	829	132	0.759	0.026	Acute
Chronic-care arm					
CCI + D0	3,942	807	0.677	—	Chronic
CCI + D0 + net	3,942	807	0.696	0.019	Chronic
CCI + D0 + net + utilisation	3,942	807	0.718	0.021	Chronic
Facility-adjusted: CCI + D0	3,942	807	0.680	—	Chronic
Facility-adjusted: CCI + D0 + net	3,942	807	0.703	0.022	Chronic
Facility-adjusted: CCI + D0 + net + utilisation	3,942	807	0.723	0.020	Chronic

Facility-adjusted models include anonymised index-facility indicator variables as additional covariates. C-statistics are apparent internal estimates. Incremental ΔC is relative to the immediately preceding nested model: +net rows are compared with the corresponding CCI + D0 model, and +net + utilisation rows with the corresponding CCI + D0 + net model. Facility adjustment did not materially attenuate the incremental value of net accumulation or utilisation in either arm.

Table S8. Utilisation-score definition sensitivity analyses.

Utilisation-score definition	ρ vs net	N	Events	C (CCI+D0+net +utilisation)	ΔC vs CCI+D0+net (point estimate)	Arm
Acute-care arm (N=829, events=132)						
Primary utilisation score	0.55	829	132	0.755	+0.034	Acute
Billing lines excluded	0.53	829	132	0.749	+0.029	Acute
Medications/injections excluded	0.52	829	132	0.733	+0.013	Acute
PCA utilisation score	0.46	829	132	0.783	+0.062	Acute
Hospitalisation-only	0.28	829	132	0.723	+0.003	Acute
Cost/points variables included	0.54	829	132	0.759	+0.039	Acute
Chronic-care arm (N=3,942, events=807)						
Primary utilisation score	0.45	3,942	807	0.718	+0.021	Chronic
Billing lines excluded	0.43	3,942	807	0.715	+0.019	Chronic
Medications/injections excluded	0.40	3,942	807	0.698	+0.002	Chronic

PCA utilisation score	0.41	3,942	807	0.739	+0.042	Chronic
Hospitalisation-only	0.21	3,942	807	0.715	+0.019	Chronic
Cost/points variables included	0.45	3,942	807	0.717	+0.021	Chronic

Each row reports C-statistics and incremental ΔC for the final combined model (CCI + D0 + net accumulation + utilisation) under alternative utilisation-score definitions. Primary definitions are shown in bold. ρ = Spearman rank correlation between the alternative utilisation score and total net accumulation. C (CCI+D0+net+utilisation) = C-statistic of the final model combining CCI, D0 burden, total net accumulation, and the stated utilisation-score variant. ΔC vs CCI+D0+net = paired increment in C-statistic when the utilisation-score variant is added to the CCI + D0 + net reference model. Bootstrap confidence intervals were not computed for alternative definitions; point estimates are shown. PCA = first principal component of the seven component scores. Hospitalisation-only = score derived from the hospitalisation component alone; this variant omits imaging, injections, medications, billing lines, surgeries, and rehabilitation. Cost/points = primary score augmented with claim-total and points billing variables.

Table S9. Outcome sensitivity analyses.

Outcome	N	Events	Arm	ΔC: net beyond CCI + D0	ΔC: utilisation beyond CCI + D0 + net
Acute-care arm					
Primary: death within 12 months after landmark	829	132	Acute	+0.042	+0.034
All-cause mortality over observed follow-up	829	303	Acute	+0.017	+0.039
Early care-system exit	829	555	Acute	+0.043	+0.071
Chronic-care arm					
Primary: death within 12 months after landmark	3,942	807	Chronic	+0.019	+0.021
All-cause mortality over observed follow-up	3,942	1,911	Chronic	+0.011	+0.032
Early care-system exit	3,942	2,915	Chronic	+0.020	+0.048

Primary outcome = death within 12 months after the 6-month landmark. All-cause mortality over observed follow-up = death at any point after the landmark. Early care-system exit = absence of prolonged observed care-system presence, defined as being alive with fewer than 18 months of observed post-landmark care-system time. ΔC = paired change in apparent C-statistic. This outcome-sensitivity analysis reports point estimates only; inferential 95% CIs and P values for the primary outcome are given in Tables 3 and 4, which use the identical models and analysis sets. Net accumulation and utilisation intensity retained positive ΔC across all outcomes.

Table S10. Combined claims-trajectory model calibration by risk decile.

Risk decile	Predicted risk range	N	Observed events	Mean predicted 12-month risk	Observed 12-month event rate
Acute-care arm (N=829, apparent C=0.755)					
1	(0.012–0.054]	83	0	0.036	0.0%
2	(0.054–	83	3	0.067	3.6%

	0.079]				
3	(0.079–0.106]	83	3	0.093	3.6%
4	(0.106–0.137]	83	5	0.122	6.0%
5	(0.137–0.172]	83	11	0.153	13.3%
6	(0.172–0.201]	82	15	0.187	18.3%
7	(0.201–0.243]	83	22	0.221	26.5%
8	(0.243–0.296]	83	22	0.266	26.5%
9	(0.296–0.372]	83	26	0.328	31.3%
10	(0.372–0.863]	83	25	0.496	30.1%
Chronic-care arm (N=3,942, apparent C=0.718)					
1	(0.011–0.078]	395	3	0.053	0.8%
2	(0.078–0.109]	394	21	0.094	5.3%
3	(0.109–0.139]	394	36	0.124	9.1%
4	(0.139–0.168]	394	61	0.154	15.5%
5	(0.168–0.202]	394	74	0.186	18.8%
6	(0.202–0.238]	394	93	0.221	23.6%
7	(0.238–0.280]	394	105	0.258	26.6%
8	(0.280–0.337]	394	122	0.308	31.0%
9	(0.337–0.426]	394	130	0.377	33.0%
10	(0.426–0.933]	395	162	0.541	41.0%

Calibration evaluated using the combined final model (CCI + D0 + net accumulation + utilisation intensity) applied within the derivation sample (apparent calibration). Risk deciles are based on the final model linear predictor. Observed event rate = proportion of patients in each decile who died within 12 months after the landmark. Decile 10 shows high-risk overprediction in both arms, and the highest acute-care decile did not exceed the preceding decile in observed event rate. Calibration should therefore be described as broad internal ordering with local non-monotonicity and high-risk overprediction, not as strict monotonic calibration or external absolute-risk readiness.

Table S10A. Combined claims-trajectory model apparent C-statistics.

Care arm	N	Events	Apparent C-statistic
Acute care	829	132	0.755

Chronic care	3,942	807	0.718

Apparent C-statistics are reported from the combined final model (CCI + D0 + net accumulation + utilisation intensity) applied within the full available derivation sample. These are not corrected for optimism and have not been validated in an independent external cohort. They support internal risk ordering only. The full-sample apparent risk-ordering visualisation derived from this analysis is shown in Supplementary Figure S10 for context, whereas Main Figure 6 and Table S12 provide the primary facility-held-out transport analysis.

Table S11. Breadth/depth component sensitivity in CCI- and D0-adjusted simplified models without demographic covariates.

Model	N	Events	C-statistic	ΔC vs CCI + D0	ΔC vs CCI + D0 + net
Acute-care arm (N=829, events=132) — simplified CCI + D0 models without age/sex					
CCI + D0	829	132	0.666	—	-0.045
CCI + D0 + net	829	132	0.711	+0.045	—
CCI + D0 + breadth	829	132	0.695	+0.029	-0.016
CCI + D0 + depth	829	132	0.691	+0.025	-0.020
CCI + D0 + breadth + depth	829	132	0.698	+0.032	-0.013
Chronic-care arm (N=3,942, events=807) — simplified CCI + D0 models without age/sex					
CCI + D0	3,942	807	0.621	—	-0.039
CCI + D0 + net	3,942	807	0.660	+0.039	—
CCI + D0 + breadth	3,942	807	0.653	+0.032	-0.007
CCI + D0 + depth	3,942	807	0.643	+0.022	-0.017
CCI + D0 + breadth + depth	3,942	807	0.654	+0.033	-0.006

Each row reports the apparent C-statistic from a Cox model that included only CCI, D0, and the specified component(s); age and sex were intentionally omitted so that the table compares the relative information content of total net accumulation, breadth, depth, and breadth plus depth within a simplified CCI- and D0-adjusted framework. Delta C vs CCI + D0 = apparent C-statistic difference from the simplified CCI + D0 reference. Delta C vs CCI + D0 + net = difference from the simplified total-net model. This table is a component-comparison sensitivity analysis and underlies Supplementary Figure S9; it is not intended to replace or be directly compared with the main age/sex-adjusted model hierarchy.

Table S12. Facility-held-out validation of trajectory-only and utilisation-enriched claims-trajectory models.

S12a. Transported-discrimination summary.

Care arm	Model	Derivation facilities	Validation facility	Derivation N/events	Validation N/events	Derivation C (95% CI)	Validation C (95% CI)	Validation log-rank p
Acute care	Trajectory-only	A	B	N=540; events=88	N=289; events=44	0.762 (0.723–0.803)	0.660 (0.579–0.739)	0.009
Acute care	Utilisation-enriched	A	B	N=540; events=88	N=289; events=44	0.779 (0.737–0.816)	0.693 (0.624–0.764)	<0.001
Chronic care	Trajectory-only	C and D	E	N=3,245; events=694	N=697; events=113	0.692 (0.675–0.709)	0.746 (0.706–0.786)	<0.001
Chronic care	Utilisation-enriched	C and D	E	N=3,245; events=694	N=697; events=113	0.714 (0.696–0.730)	0.758 (0.719–0.794)	<0.001

S12b. Validation tertile risk-group event rates after transporting derivation beta coefficients and cutoffs.

Care arm	Model	Low risk	Intermediate risk	High risk
Acute care	Trajectory-only	2/52 (3.8%)	14/96 (14.6%)	28/141 (19.9%)
Acute care	Utilisation-enriched	3/81 (3.7%)	13/92 (14.1%)	28/116 (24.1%)
Chronic care	Trajectory-only	5/219 (2.3%)	31/197 (15.7%)	77/281 (27.4%)
Chronic care	Utilisation-enriched	3/240 (1.2%)	39/211 (18.5%)	71/246 (28.9%)

Facility labels are anonymised as in Table S2. Models were fitted only in the derivation facility/facilities; Cox beta coefficients and derivation-sample linear-predictor tertile cutoffs were then applied to validation patients without refitting. Trajectory-only model = age + sex + CCI + D0 burden + six-month net accumulation. Utilisation-enriched model = trajectory-only model + M0-M6 utilisation-intensity score. Derivation and validation C-statistics are shown with bootstrap 95% CIs; validation CIs were estimated by resampling the held-out validation cohort while keeping

transported beta coefficients and tertile cutoffs fixed.

Table S13. Descriptive landmark-window sensitivity analyses.

S13a. Acute-care arm

Window	N	Events	Event, %	C: CCI + D0	C: + net	C: + net + utilisation	Delta C: net	Delta C: utilisation
M0-M3	1004	101	10.1	0.682	0.698	0.735	+0.016	+0.038
M0-M6 (primary)	**829**	**132**	**15.9**	**0.678**	**0.720**	**0.755**	**+0.042**	**+0.034**
M0-M12	542	66	12.2	0.732	0.762	0.776	+0.030	+0.014

S13b. Chronic-care arm

Window	N	Events	Event, %	C: CCI + D0	C: + net	C: + net + utilisation	Delta C: net	Delta C: utilisation
M0-M3	4850	687	14.2	0.674	0.678	0.700	+0.005	+0.022
M0-M6 (primary)	**3942**	**807**	**20.5**	**0.677**	**0.696**	**0.718**	**+0.019**	**+0.021**
M0-M12	2832	426	15.0	0.678	0.705	0.744	+0.027	+0.038

Point estimates are shown without inferential intervals. The M0-M6 window is the prespecified primary specification. M0-M3 and M0-M12 are descriptive robustness checks and were not used to choose or optimise the primary trajectory window. N indicates the common-N analysis set available for the corresponding landmark window and model comparison; patients were required to have observed time beyond the corresponding landmark. Event, % denotes death within 12 months after the corresponding landmark. Delta C: net = incremental C-statistic for adding net accumulation beyond CCI + D0. Delta C: utilisation = incremental C-statistic for adding utilisation intensity beyond CCI + D0 + net accumulation. CCI = Charlson Comorbidity Index; D0 = Month 0 active disease burden.

Table S14. Operational disease-system mapping used in manuscript-facing outputs.

Manuscript disease-system domain	Source monthly label keyword(s) used for matching
Cardiovascular	循環器; cardio; circulatory
Gastrointestinal	消化器; gastro
Metabolic/endocrine	内分泌; 代謝; metabolic; endocrine
Musculoskeletal	筋骨格; musculo
Neurological	神経; neuro
Respiratory	呼吸器; resp
Renal/urologic	腎; 尿路; urolog; renal
Infectious	感染; infect
Haematological	血液; 免疫; haemat; hemat
Oncological	腫瘍; oncolog; cancer; malign

The matching rule, candidate-column restriction (names beginning with diseases_), first-available-column rule, and system-specific feature definitions are described in the main Methods. This table lists the prespecified label keywords used for transparent operational mapping.

Supplementary Figure S1

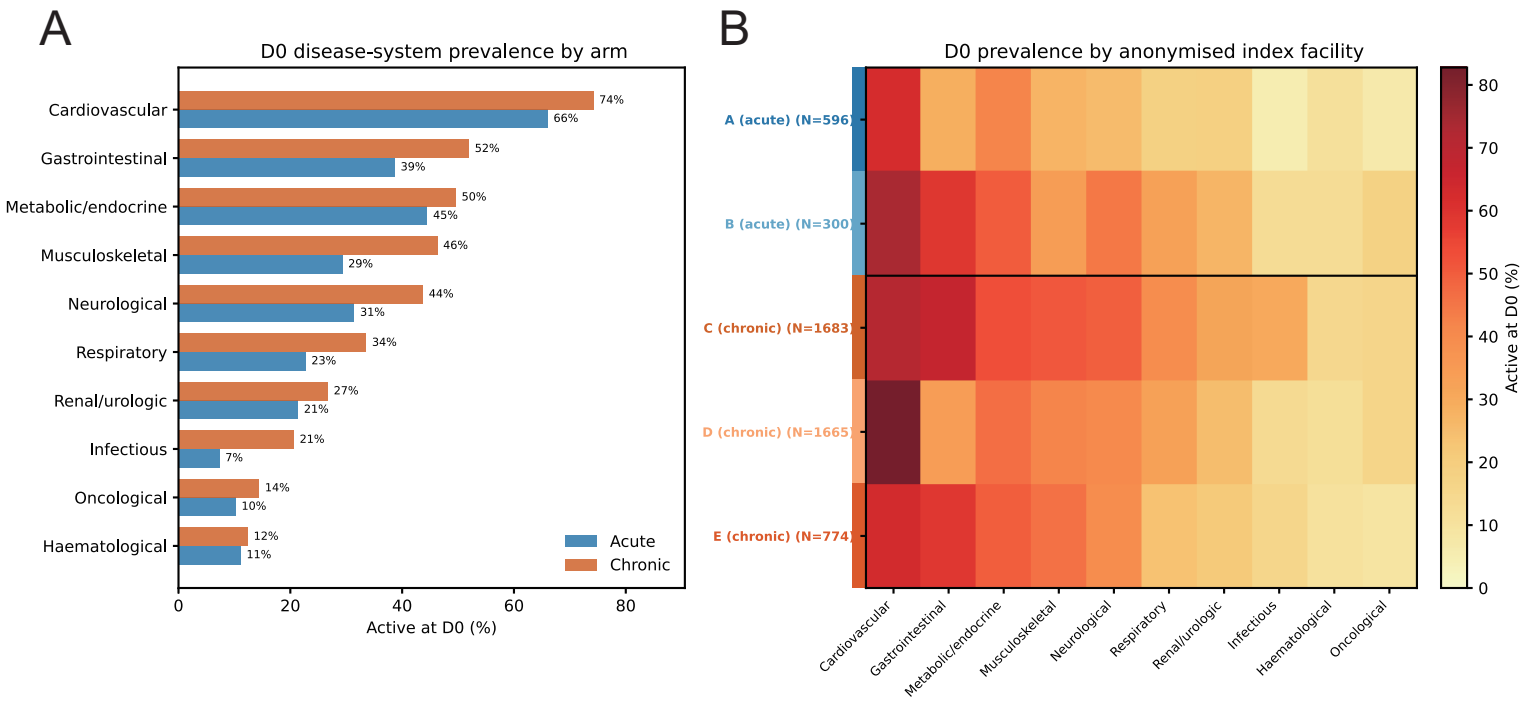


Figure S1. D0 disease-system burden by care setting and anonymised index facility.

(A) Percentage of patients in the 6-month landmark cohort with at least one active disease-category count within each of the 10 disease-system domains at Month 0 (D0), shown separately for acute-care and chronic-care arms. (B) The same D0 prevalence by anonymised index facility; the heatmap scale is the percentage active at D0. Facility labels are anonymised as in Table S2 (A and B, acute care; C-E, chronic care). D0 denotes Month 0 active disease burden.

Supplementary Figure S2

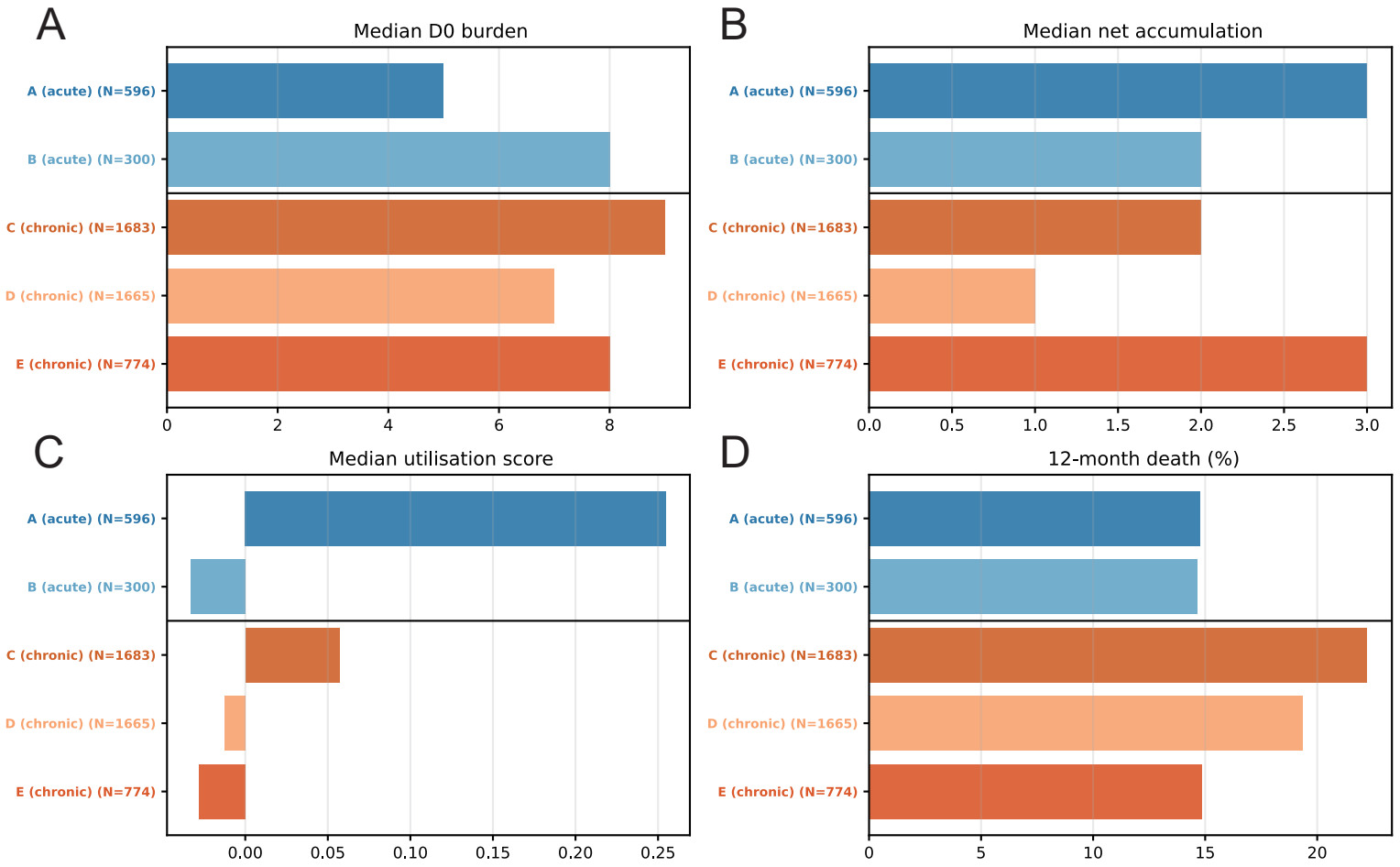


Figure S2. Facility-level heterogeneity in baseline burden, accumulation, utilisation, and mortality.

(A) Median D0 burden. (B) Median six-month net active disease accumulation. (C) Median M0-M6 utilisation-intensity score. (D) Death within 12 months after the 6-month landmark. Bars represent the five anonymised index facilities; facility type is indicated by the figure colour coding. These panels are descriptive and are intended to show within-group heterogeneity rather than to estimate causal facility effects.

Supplementary Figure S3

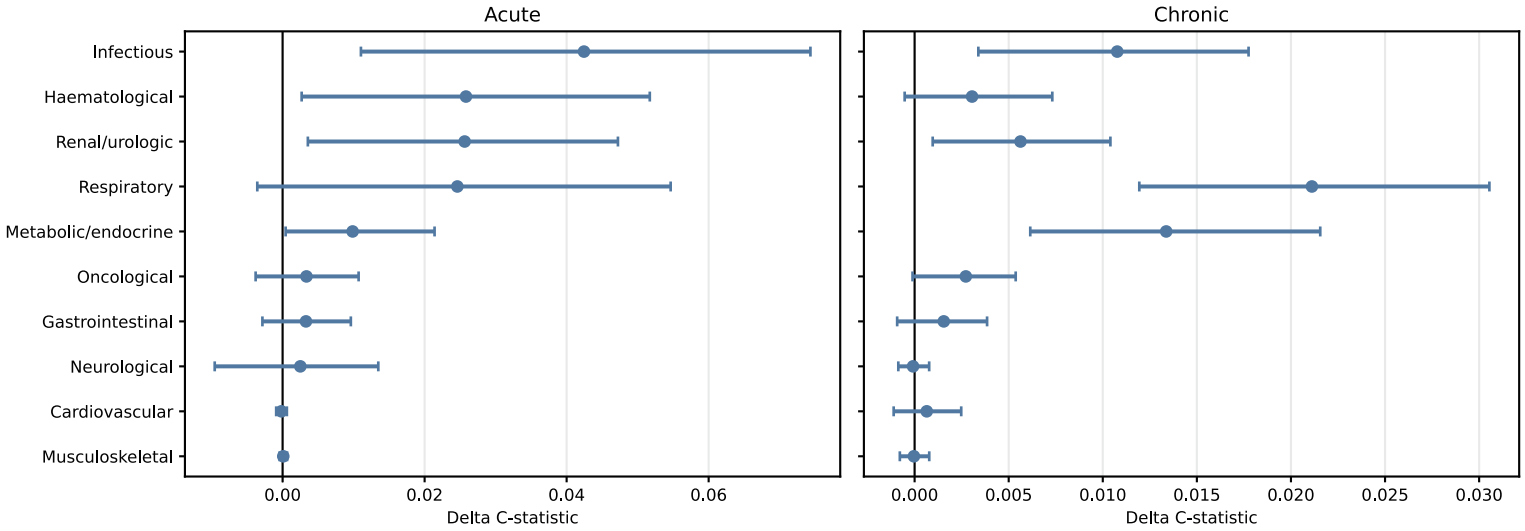


Figure S3. Disease-system-specific net accumulation and added discrimination.

Acute-care results are shown at left and chronic-care results at right. Each point is the change in C-statistic (Delta C) obtained by adding one system-specific M0-M6 net-accumulation variable to a reference Cox model containing age, sex, Charlson Comorbidity Index (CCI), and D0 burden. Horizontal bars show 95% bootstrap confidence intervals (1,000 resamples); the vertical line at zero indicates no added discrimination. Analyses use the common complete-case sets (acute N=829; chronic N=3,942). See Table S3.

Supplementary Figure S4

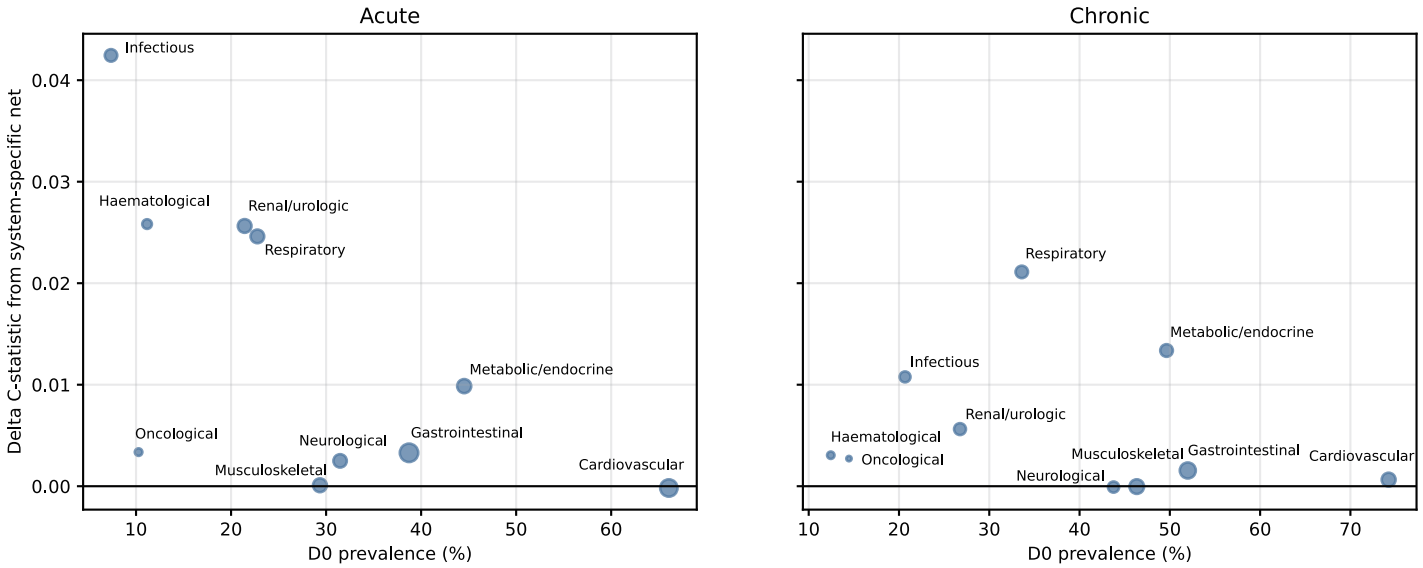


Figure S4. Baseline prevalence versus prognostic contribution of system-specific net accumulation.

Acute-care results are shown at left and chronic-care results at right. The x-axis is the percentage of the landmark cohort with the disease system active at D0. The y-axis is Delta C from adding that system-specific net-accumulation variable to the age-, sex-, CCI-, and D0-adjusted reference model. Point area is proportional to the percentage of patients with a positive net change in the corresponding system. The horizontal line at zero indicates no added discrimination.

Supplementary Figure S5

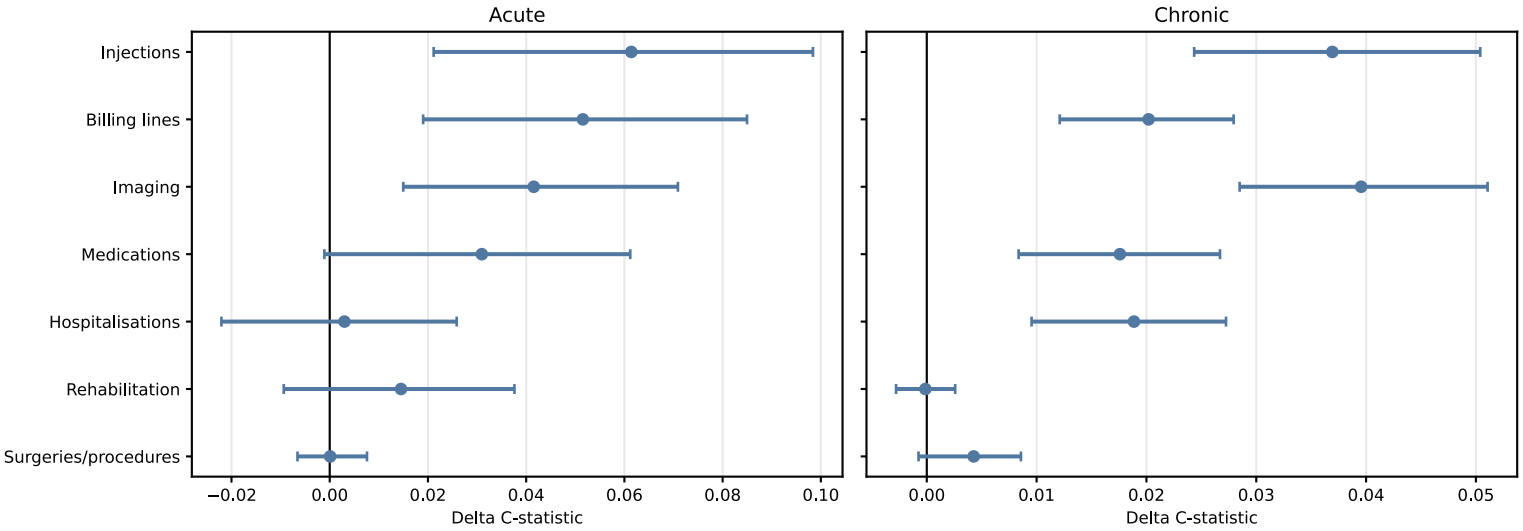


Figure S5. Utilisation-component contribution beyond disease burden and net accumulation.

Acute-care results are shown at left and chronic-care results at right. Each point is Delta C obtained by adding one M0-M6 utilisation component to a reference model containing age, sex, CCI, D0 burden, and total net active disease accumulation. Horizontal bars show 95% bootstrap confidence intervals (1,000 resamples); the vertical line at zero indicates no added discrimination.
Components include hospitalisations, surgeries/procedures, rehabilitation, imaging, medications, injections, and billing-line counts. See Table S4.

Supplementary Figure S6

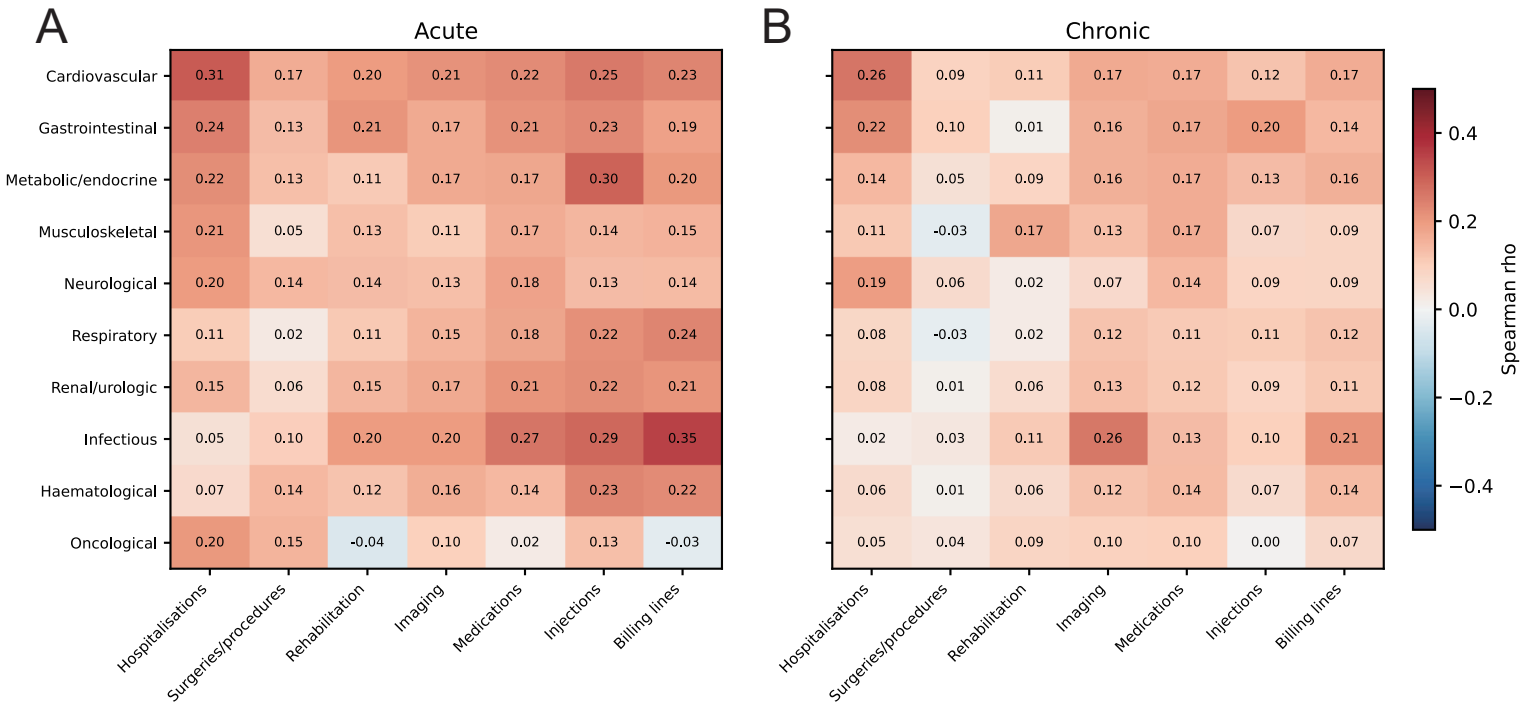


Figure S6. Correlation between disease-system net accumulation and utilisation components.

(A) Acute-care arm. (B) Chronic-care arm. Cells show Spearman correlation coefficients between M0-M6 system-specific net accumulation and each utilisation component; the numeric value is printed within each cell and the colour scale is centred at zero. Correlations are descriptive and are used to assess overlap between the disease-accumulation and care-utilisation signals rather than to imply causal relations. See Table S5.

Supplementary Figure S7

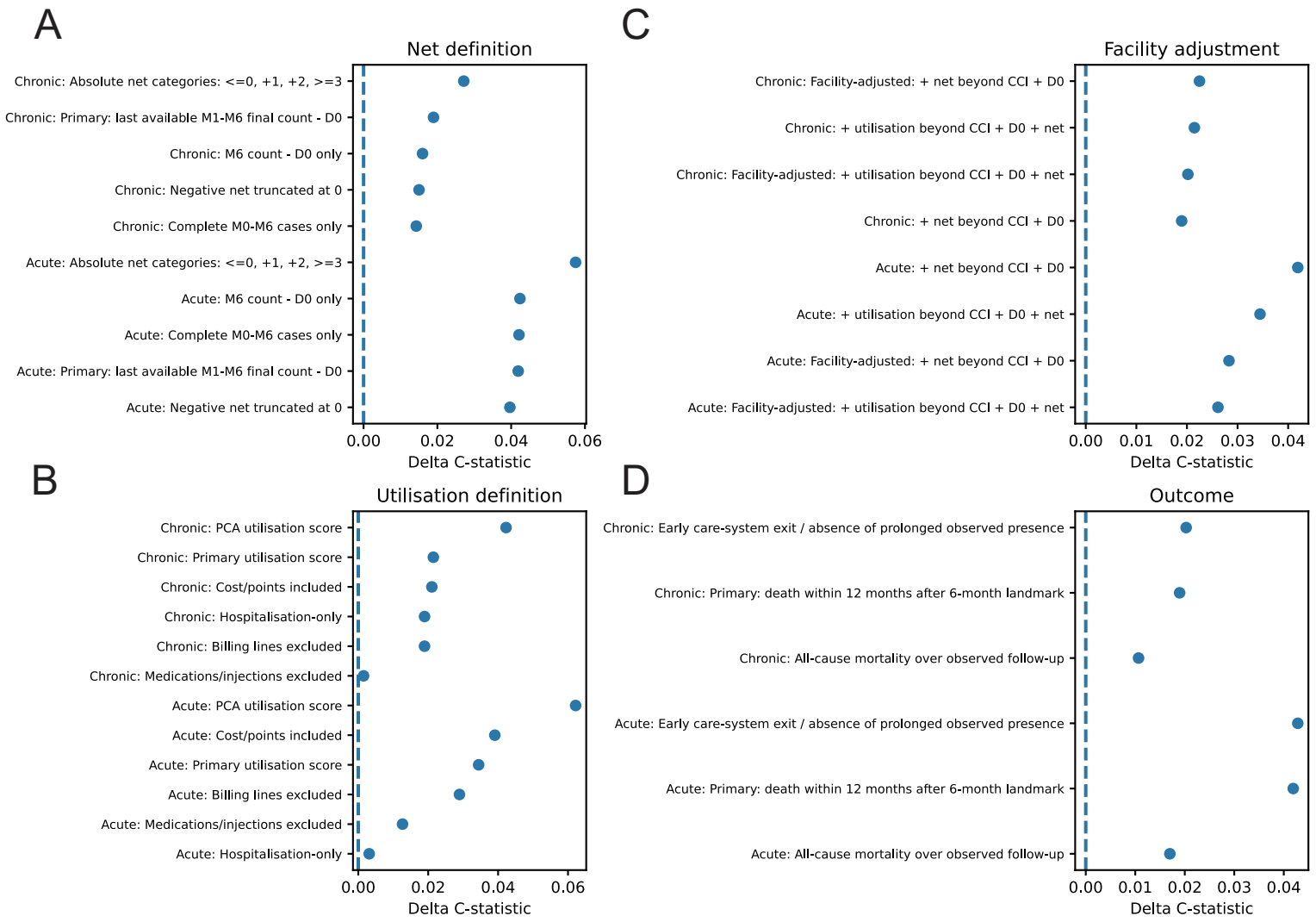


Figure S7. Sensitivity summary for the main Delta-C findings.

(A) Alternative definitions of net accumulation. (B) Alternative utilisation-score definitions. (C) Facility-adjusted model variants. (D) Alternative outcome definitions. Points show the panel-specific Delta C values for acute-care and chronic-care analyses, as labelled on the y-axes; the vertical line at zero indicates no incremental discrimination. These sensitivity panels report point estimates only and are intended as descriptive robustness checks rather than replacements for the prespecified primary analysis.

Supplementary Figure S8

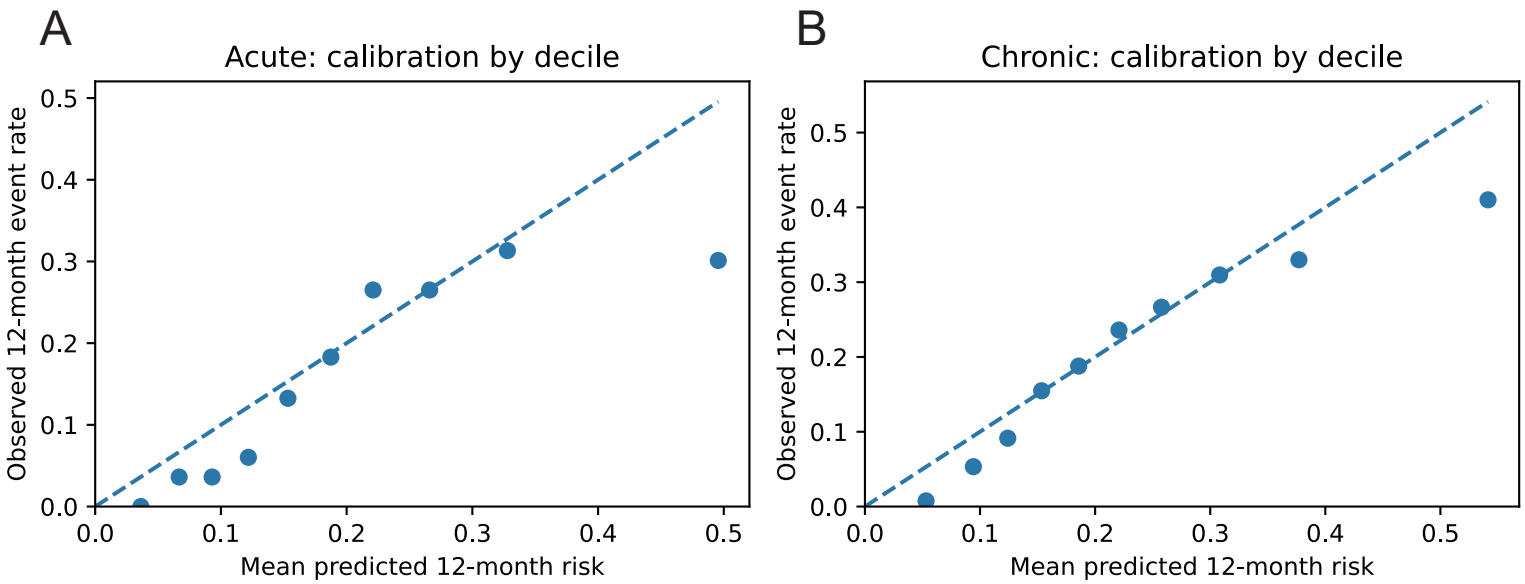


Figure S8. Apparent calibration of the final model by risk decile.

(A) Acute-care arm. (B) Chronic-care arm. Patients were grouped by deciles of predicted 12-month post-landmark mortality risk from the final model (age, sex, CCI, D0 burden, six-month net accumulation, and M0-M6 utilisation intensity). Each point compares mean predicted risk with the observed event proportion in that decile; the dashed diagonal denotes perfect agreement. These are apparent within-sample calibration summaries and should not be interpreted as external calibration.

Supplementary Figure S9

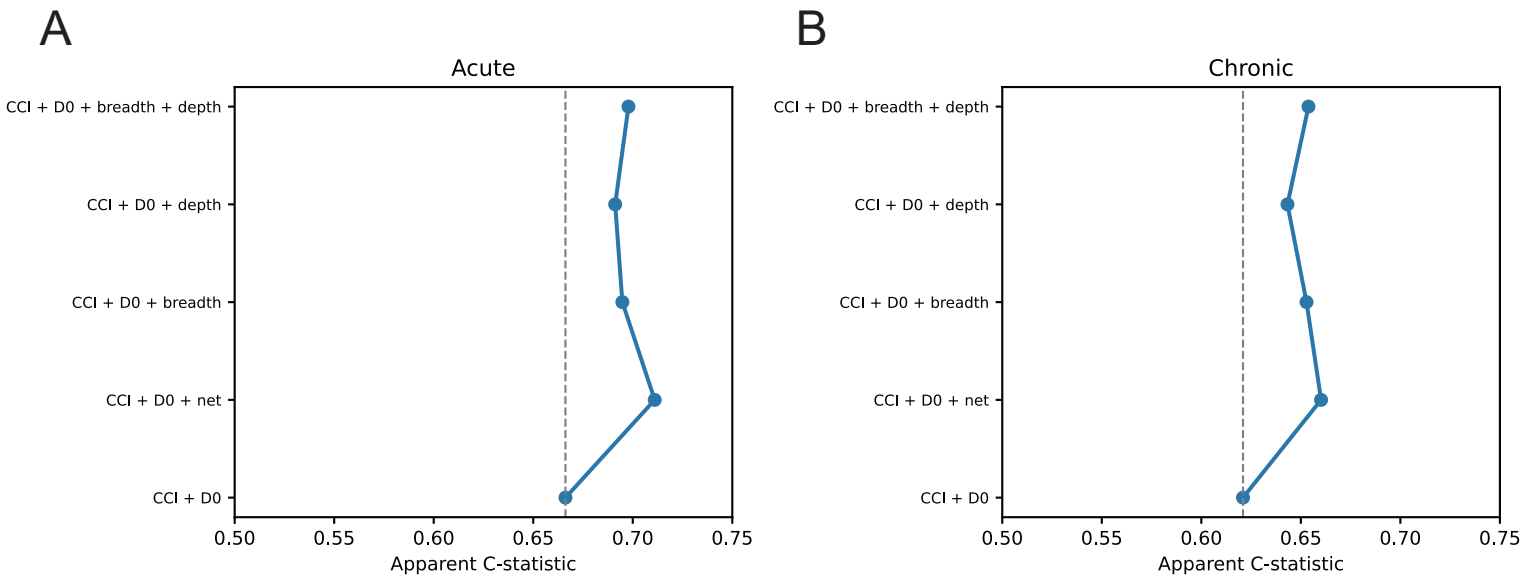


Figure S9. Breadth/depth component sensitivity relative to total net accumulation.

(A) Acute-care arm. (B) Chronic-care arm. Points show apparent C-statistics from simplified Cox models containing CCI and D0 alone or with total net accumulation, breadth, depth, or breadth plus depth. Breadth is the number of newly involved disease systems; depth is the maximum positive net gain within any single disease system. The dashed vertical line marks the CCI + D0 reference. Age and sex were intentionally omitted in this component-comparison sensitivity analysis; see Table S11.

Supplementary Figure S10

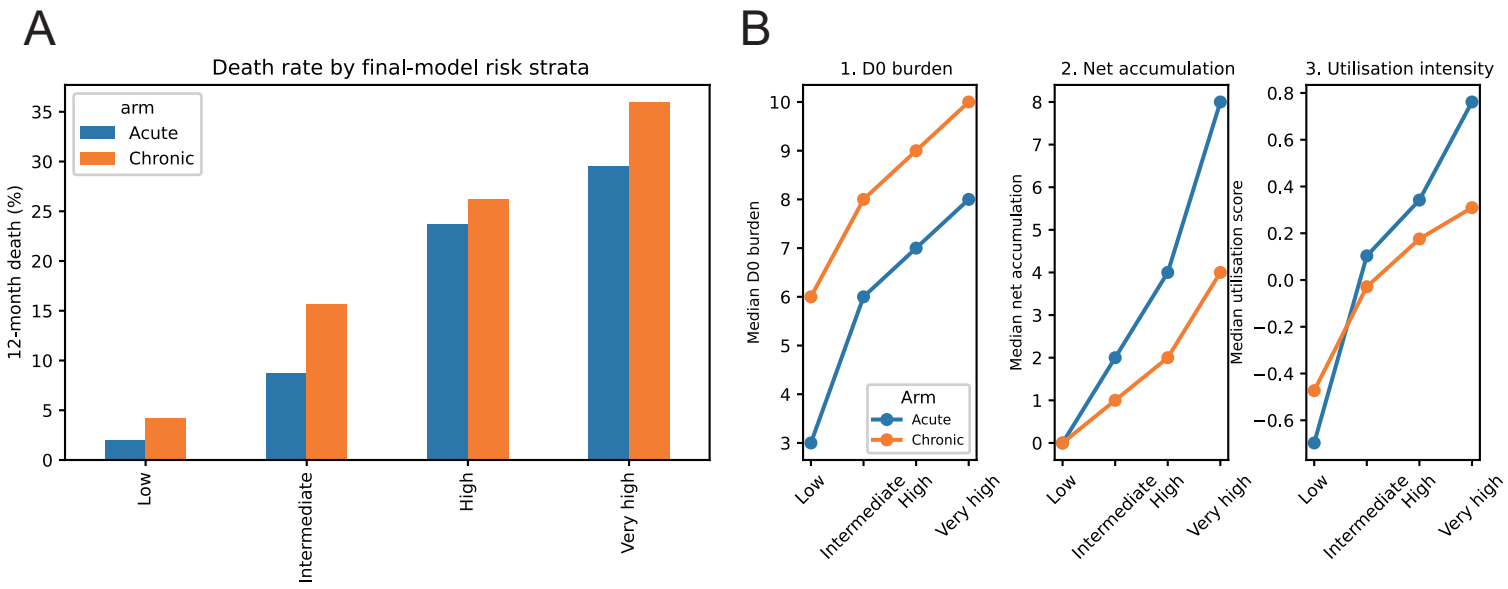


Figure S10. Full-sample apparent risk ordering from the final model.

(A) Observed 12-month post-landmark mortality across four within-arm strata (low, intermediate, high, and very high) defined by quartiles of the final-model linear predictor. (B) Median D0 burden, six-month net accumulation, and utilisation-intensity score across the same strata, shown separately for acute-care and chronic-care arms. The model was fitted and stratified in the same full analysis sample; this display is shown for descriptive risk ordering only and is not a held-out validation result.

Supplementary Figure S11

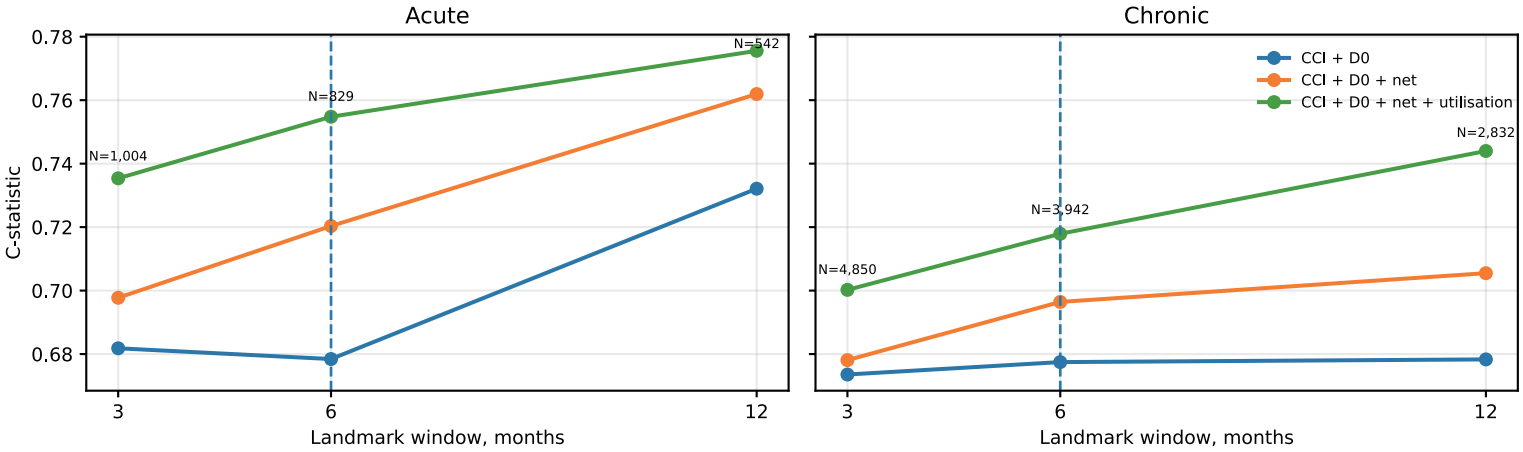


Figure S11. Descriptive landmark-window sensitivity analysis.

Acute-care results are shown at left and chronic-care results at right. Lines show apparent C-statistics for CCI + D0, CCI + D0 + net accumulation, and CCI + D0 + net accumulation + utilisation intensity using 3-, 6-, and 12-month landmark windows. The 6-month window is the prespecified primary specification; the 3- and 12-month windows are descriptive robustness checks. The mortality endpoint was defined as death within 12 months after the corresponding landmark, and patients were required to have observed time beyond that landmark. See Table S13.