

# Inpatient Rehabilitation after Spinal Cord Injury Is Associated with Reduced Immobility-Associated Complications Compared to Skilled Nursing Facility Care

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## Background

- Spinal cord injury (SCI) affects 300,000 in U.S.A.
- Disability is due to sensory and motor deficits
- Post-acute care occurs at an inpatient rehabilitation facility (IRF) or skilled nursing facility (SNF)
- IRF care includes significantly more physician-led rehabilitation (>3 hours/day) than SNF care which may improve mobility outcomes
- Hypothesis** - IRF care is associated with fewer immobility-associated complications than SNF care

## Methods

- Quasi-Causal Retrospective Cohort Study Design
- Fine-Gray Competing Risk Survival Models
  - Exposure:** IRF vs. SNF
  - Outcome:** Immobility-associated complications (Sepsis, Type 2 Diabetes, Venous Thromboembolism, Lower Respiratory Tract Infection, Pressure Ulcer, Urinary Tract Infections)
  - Measures:** Cumulative Incidence at 3-years, subdistribution hazard ratio (sHR) within survivors
- Causal-Inference Framework
  - Inverse Probability of Treatment Weights (IPTW)
  - Direct inclusion of covariates in Fine-Gray models
  - Covariates:** 29 variables pertaining to patient demographics, injury characteristics, hospital course, and hospital characteristics
  - Ridge penalization using Akaike's Information Criterion for identifying most parsimonious model

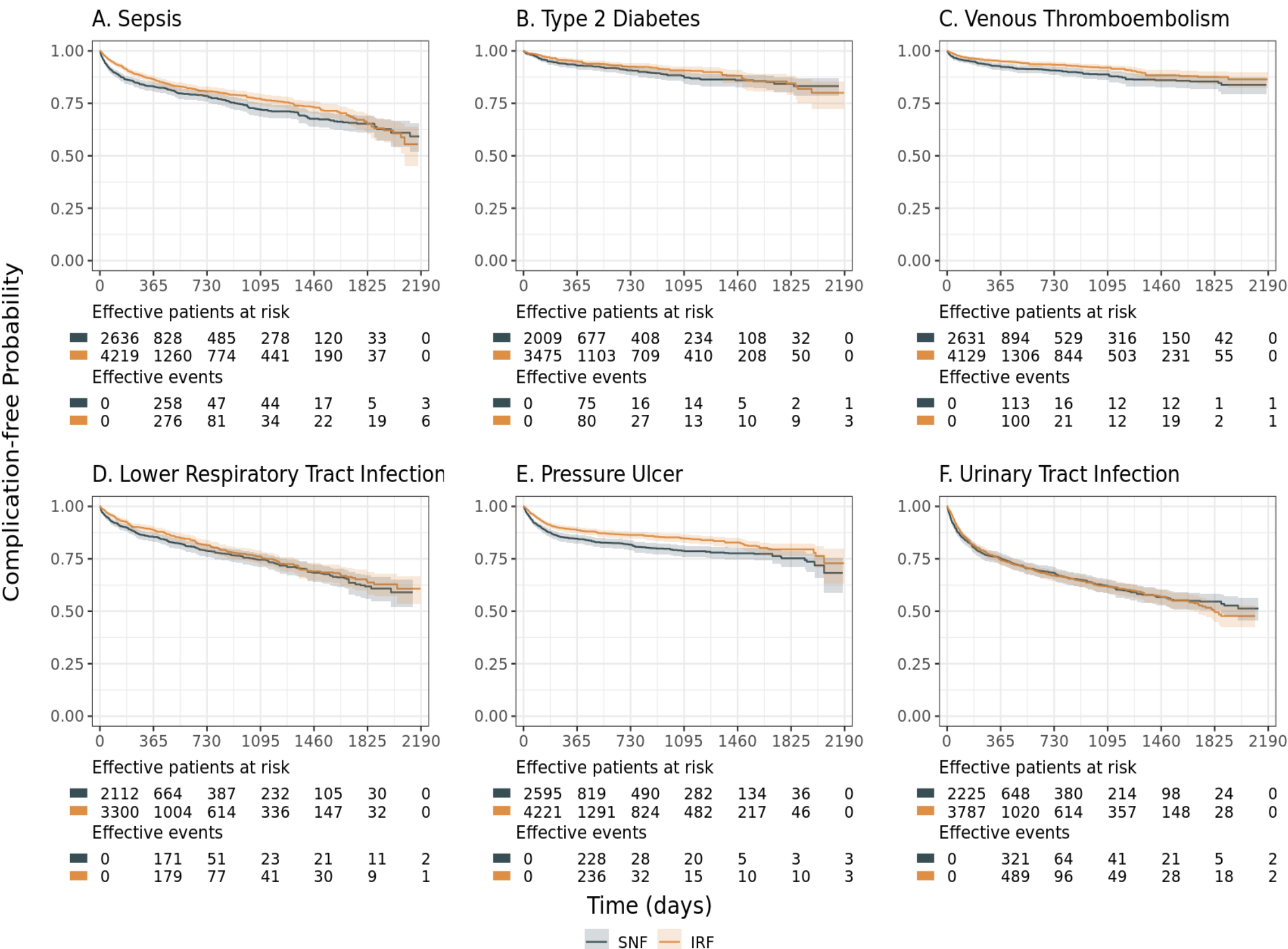
## Inclusion Criteria

- Population:** newly diagnosed adult SCI patients
- Data Source:** multi-institutional cohort (HCUP SID, SEDD)
- States:** AR, FL, MA, ME, NY, WI
- Years:** 2016-2021
- ICD-10 codes,** any in at least one inpatient encounter:
  - S14XXA – cervical SCI, initial encounter
  - S24XXA – thoracic SCI, initial encounter
  - S34XXA – lumbosacral SCI, initial encounter

## Results

Characteristic	Skilled Nursing N = 3,319	Inpatient Rehabilitation N = 5,223
Age (Median [Q1,Q3])	72 (50,82)	58 (38,70)
Sex, n (%)		
Female	1,311 (39)	1,467 (28)
Male	2,008 (61)	3,756 (72)
Race, n (%)		
White	2,269 (68)	3,354 (64)
Black	567 (17)	1,030 (20)
Hispanic	232 (7)	378 (7)
Asian/Pacific Islander	72 (2)	110 (2)
Other Race	149 (4)	298 (6)
Unknown	30 (1)	53 (1)
Primary Payer, n (%)		
Private	556 (17)	2,006 (38)
Medicaid	406 (12)	890 (17)
Medicare	2,191 (66)	1,800 (34)
Other Payer	166 (5)	527 (10)
ZIP Income Quartile, n (%)		
1 (Lowest)	925 (28)	1,527 (29)
2	867 (26)	1,424 (27)
3	787 (24)	1,152 (22)
4 (Highest)	740 (22)	1,120 (21)
Elixhauser Comorbidity Index, n (%)		
<0	437 (13)	905 (17)
0-10	260 (8)	442 (8.5)
11-15	617 (19)	1,065 (20)
16-20	660 (20)	1,176 (23)
21-25	576 (17)	876 (17)
>25	800 (24)	759 (15)
Mechanism		
Fall, n (%)	2,194 (66)	2,660 (51)
Firearm, n (%)	66 (2.0)	320 (6.1)
Assault, n (%)	71 (2.1)	247 (4.7)
MVC, n (%)		
Non-Vehicle Injury	2,429 (73)	3,252 (62)
MVC Occupant	273 (8.2)	784 (15)
MVC Ped or Cycle	123 (3.7)	304 (5.8)
MVC Role Unspecified	76 (2.3)	224 (4.3)
Non-Traffic Vehicle Injury	416 (13)	659 (13)
Spinal Injury Level, n (%)		
Cervical	2,291 (69)	3,660 (70)
Thoracic	626 (19)	1,068 (20)
Lumbosacral	402 (12)	495 (9)
Spinal Injury Lesion, n (%)		
Paraneural Injury	3,078 (93)	4,968 (95)
Edema-only	241 (7.3)	255 (4.9)
AIS, General, n (%)		
None	3,206 (97)	4,939 (95)
Minor/Moderate	45 (1.4)	97 (1.9)
Serious+	68 (2.0)	167 (3.2)
AIS, Head and Neck, n (%)		
None	852 (26)	1,122 (21)
Minor/Moderate	479 (14)	784 (15)
Serious+	1,988 (60)	3,317 (64)
AIS, Face, n (%)		
None	2,933 (88)	4,349 (83)
Minor/Moderate	318 (9.6)	707 (14)
Serious+	68 (2.0)	167 (3.2)
AIS, Chest, n (%)		
None	2,141 (65)	3,173 (60)
Minor/Moderate	234 (7.1)	420 (8.1)
Serious+	944 (28)	1,666 (32)
AIS, Abdomen, n (%)		
None	2,512 (76)	3,951 (76)
Minor/Moderate	619 (19)	824 (16)
Serious+	188 (5.7)	448 (8.6)
AIS, Extremities, n (%)		
None	2,669 (80)	3,963 (76)
Minor/Moderate	513 (15)	1,010 (19)
Serious+	137 (4.1)	250 (4.8)
Mobility Impairment, n (%)		
None	2,531 (76)	3,363 (64)
Paraplegia, incomplete or unspecified	209 (6.3)	590 (11)
Paraplegia, complete	34 (1.0)	189 (3.6)
Quadriplegia, incomplete or unspecified	501 (15)	967 (19)
Quadriplegia, complete	44 (1.3)	114 (2.2)
Had TBI, excluding concussion, n (%)	427 (13)	883 (17)
Length of Stay (Days), n (%)		
<8	1,176 (35)	1,747 (33)
8-14	1,001 (30)	1,951 (37)
15-30	712 (21)	1,104 (21)
>31	430 (13)	421 (8.1)
SCI Surgery (e.g., Laminectomy/Spinal Fusion), n (%)	1,467 (44)	3,088 (59)
TBI Surgery (e.g., Craniectomy/Craniotomy), n (%)	63 (1.9)	116 (2.2)
Respiratory Support Interventions, n (%)		
Never ventilated	2,750 (83)	4,143 (79)
Ventilated without new tracheostomy	274 (8.3)	616 (12)
Ventilated with new tracheostomy	295 (8.9)	464 (8.9)
Had Central Venous Catheter, n (%)	625 (19)	1,175 (22)
Had Transfusion, n (%)	447 (13)	697 (13)
Had Urinary Catheter, n (%)	103 (3.1)	134 (2.6)
Hospital GAF Quartile, n (%)		
1 (Lowest)	883 (27)	1,620 (31)
2	696 (21)	1,124 (22)
3	977 (29)	1,522 (29)
4 (Highest)	754 (23)	957 (18)
Hospital State, n (%)		
NY	1,181 (36)	1,544 (30)
AR	88 (2.7)	474 (9.1)
FL	1,260 (38)	1,975 (38)
MA	255 (7.7)	341 (6.5)
MD	196 (5.9)	155 (3.0)
WI	339 (10)	734 (14)
Hospital Volume Quintile, n (%)		
1 (Highest)	483 (15)	1,204 (23)
2	653 (20)	1,144 (22)
3	522 (16)	1,063 (20)
4	733 (22)	1,069 (20)
5 (Lowest)	928 (28)	743 (14)

**Table 1. Characteristics of patients discharged to SNF and IRF.** AIS = Abbreviated Injury Score, TBI = Traumatic Brain Injury



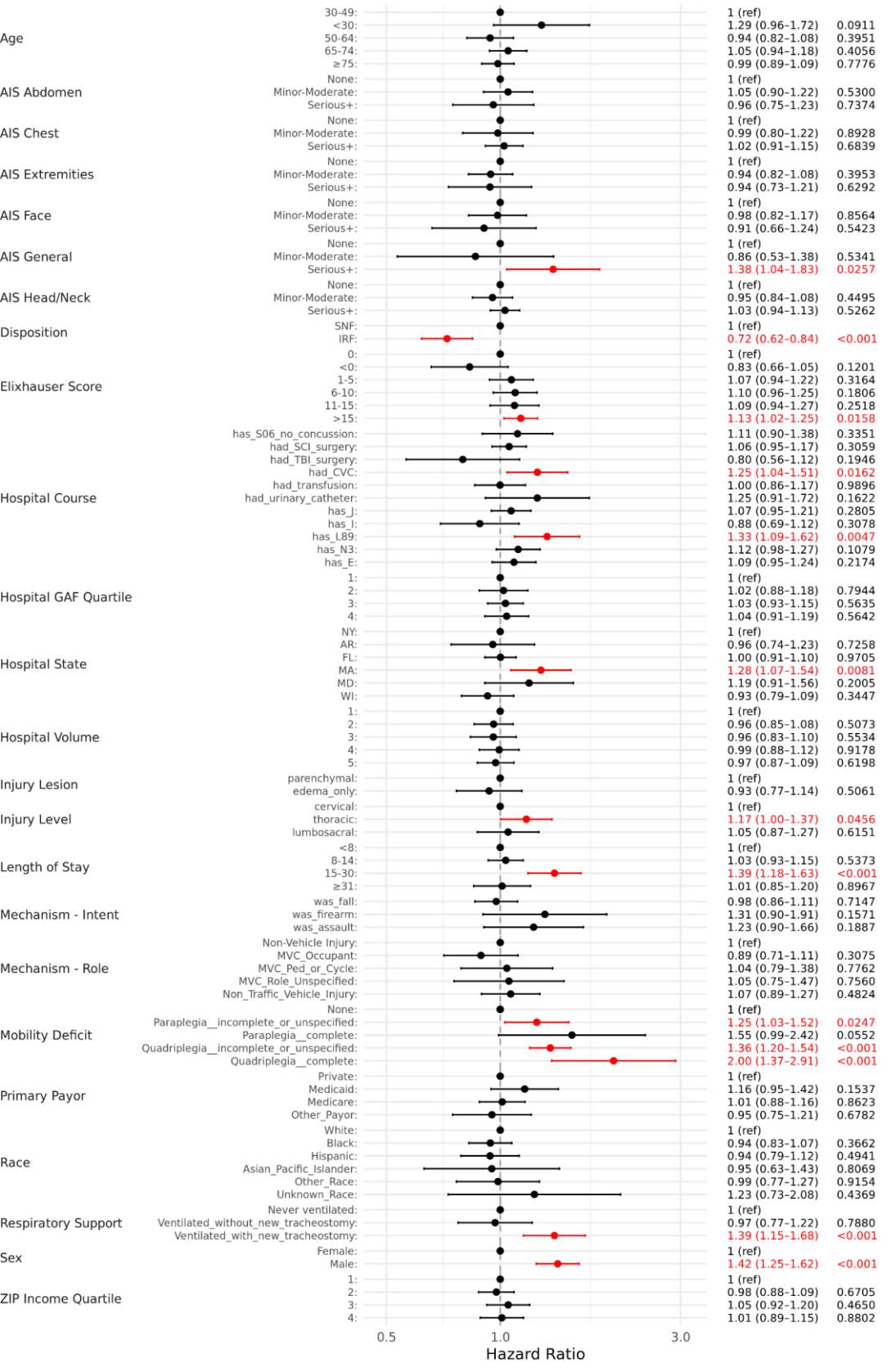
**Figure 1. IPTW Cumulative Incidence of Immobility-Associated Complications After IRF vs SNF Discharge.** IPTW = inverse-probability of treatment weighted

Complication	SNF (%)	IRF (%)	P
Sepsis	27.1	22.3	0.007*
Type 2 Diabetes	13.2	9.5	0.013*
Venous Thromboembolism	11.2	8.3	0.010*
Lower Respiratory Tract Infection	24.4	23.2	0.271
Pressure Ulcer	20.1	15.5	0.001*
Urinary Tract Infection	37.5	37.8	0.468

**Table 2. Cumulative incidence at 3-years of each complication after discharge to IRF vs SNF.** Cumulative incidence for Sepsis, Type 2 Diabetes, Venous Thromboembolism, and Pressure Ulcers were significantly lower after discharge to IRF than SNF. Patients already diagnosed with the complication during their index hospitalization were excluded from the complication-specific analysis.

Complication	Adjusted sHR	P
Sepsis	0.72 (0.62-0.84)	<0.001*
Type 2 Diabetes	0.69 (0.49-0.97)	0.0346*
Venous Thromboembolism	0.72 (0.56-0.93)	0.0123*
Lower Respiratory Tract Infection	0.83 (0.69-1.00)	0.0518
Pressure Ulcer	0.69 (0.58-0.83)	<0.001*
Urinary Tract Infection	0.99 (0.89-1.17)	0.7981

**Table 3. Subdistribution Hazard Ratios for each complication after discharge to IRF vs SNF.** Hazards for Sepsis, Type 2 Diabetes, Venous Thromboembolism, and Pressure Ulcers were significantly lower after discharge to IRF than SNF among patients who were still alive through 3 years after index discharge. sHR = subdistribution hazard ratio.



**Figure 2. Example Fine-Gray Regression Model Output For Sepsis Incidence.** Coefficient estimates are stabilized using ridge penalization.

## Conclusion

- IRF care is associated with significant reductions in Sepsis, T2DM, VTE, and Pressure Ulcers for at least 3 years after index discharge
- These results should inform discharge disposition of SCI patients
- Limitations:** observational design, no direct measure of functional status, likely error in ICD-10 coding, exclusion of outpatient encounters

**Disclosures:** None. **Funding:** Dr. Rao was supported by the Agency for Healthcare Research and Quality (AHRQ) via an individual post-doctoral grant (F32HS029776) as well as by an American College of Surgeons (ACS) 2024-2026 Resident Research Scholarship.