The EXCEL Registry

The Australian and New Zealand ECMO Registry

EXCEL Registry Report
Annual report
January 2019 to December 2019

Proudly funded by:

07 October 2020

Contents

1 Introduction

Aim

The aim of the Australian ECMO Registry (EXCEL) is to generate a binational multidisciplinary network of integrated care for patients suffering acute cardiac or respiratory failure requiring extracorporeal membrane oxygenation (ECMO) to monitor long term outcomes and identify best practice. This report is designed to provide feedback to Australian and New Zealand ECMO sites about patient outcomes.

Population

Patients aged 18 years and older who received ECMO in ICU are included in the EXCEL Registry. The demographic, admission, ECMO and hospital discharge data represent patients admitted to this ICU during the reporting period. This includes patients who have been retrieved to and from the site. The Kaplan-Meier survival curve and follow up data represents all EXCEL patients at the site entered into the database.

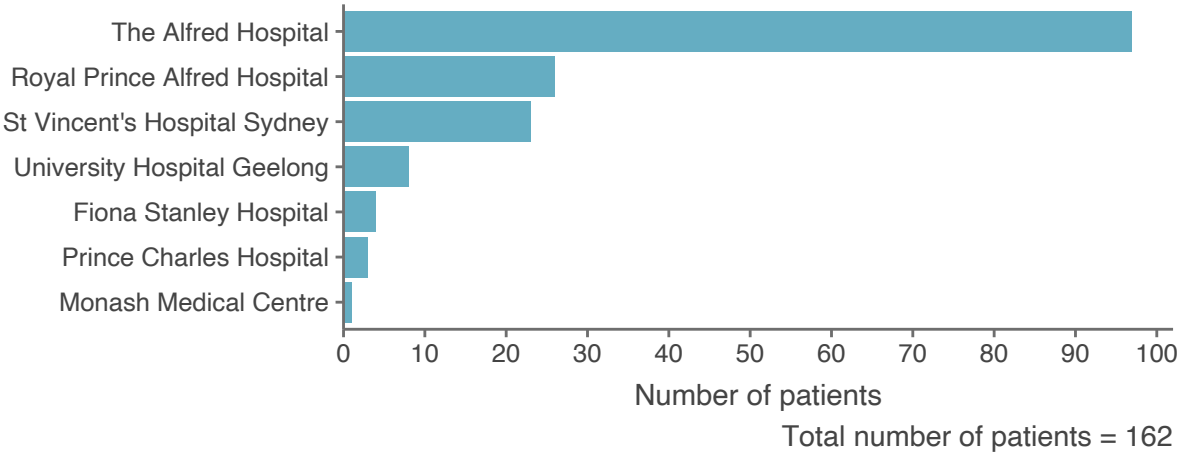

Figure 1: Number of patients per site

Data

All data entered in this report has been collected by Investigators and Research Coordinators at each of the participating sites. Data is available to download by the Principal Investigator via the EXCEL REDCap database. Data is provided confidentially to the EXCEL Registry. Site investigators and data collectors will receive the report and it should be shared with hospital staff including members of the hospital executive committee. The report should not be reproduced without permission from the EXCEL Management Committee.

Data completion reflects the data entered for the reporting period 01 January 2019 to 31 December 2019. Data was extracted on 07 September 2020 and any data entered after this date is not represented in this report. If the report contains less than five patients please be cautious in using this data to inform practice as the data is not generalisable.

Information

Further information about the EXCEL Registry can be found on the EXCEL website:
https://www.monash.edu/medicine/sphpm/anzicrc/research/excel

Participating Sites

Alfred Hospital, Austin Hospital, Box Hill Hospital, Canberra Hospital, Epworth Hospital, Fiona Stanley Hospital, Gold Coast University Hospital, John Hunter Hospital, Launceston General Hospital, Liverpool Hospital, Monash Medical Centre, Prince Charles Hospital, Princess Alexandra Hospital, Royal Adelaide Hospital, Royal Brisbane and Women's Hospital, Royal Melbourne Hospital, Royal North Shore Hospital, Royal Prince Alfred Hospital, St Vincent's Hospital Melbourne, St Vincent's Hospital Sydney and University Hospital Geelong.
Thank you to the data collectors and sites.

EXCEL Management Committee Members

Carol Hodgson, Shannah Anderson, Jasmin Board Daniel Brodie, Heidi Buhr, Aidan Burrell, Jamie Cooper, Eddy Fan, John Fraser, David

Gattas, Lisa Higgins, Ingrid Hopper, Sue Huckson, Natalie Linke, Ed Litton, Shay McGuiness, Priya Nair, Neil Orford, Rachael Parke Vin Pellegrino, David Pilcher, Benjamin Reddi, Sion Stub, Tony Trapani and Andrew Udy.

Contact

If you have any questions please contact EXCEL Chief Investigator Professor Carol Hodgson. This report is presented on behalf of the members of the EXCEL Management Committee, with thanks to Farhad Salimi, Senior Data Analyst, Registry Science and Research.

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2 Abbreviations and Acronyms

Table 1: Abbreviations and Acronyms

AMI	Acute myocardial infarction
ARDS	Acute respiratory distress syndrome
CNS	Central nervous system
CPR	Cardiopulmonary resuscitation
DVT	Deep vein thromboembolism
ECPR	Extracorporeal cardiopulmonary resuscitation used for advanced resuscitation
GI	Gastrointestinal
LVD	Left ventricular distention
TBI	Traumatic brain injury
VA	Venoarterial ECMO used for cardiac indication
VV	Venovenous ECMO used for a respiratory indication

3 Data Completion

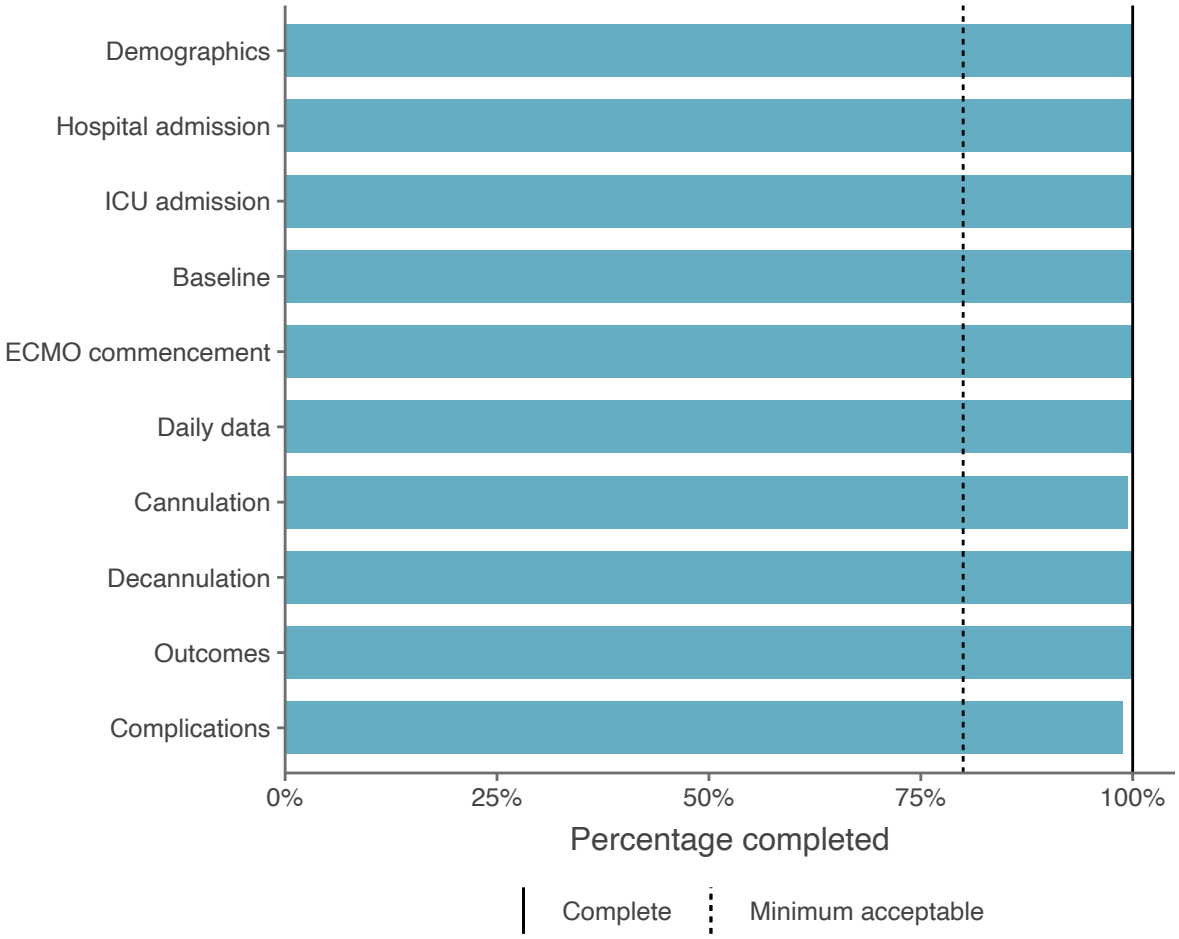

Figure 2: Data completion: EXCEL registry forms

4 Summary Data

Table 2: Summary information by ECMO mode

	V-V (N=55)	V-A (N=81)	ECPR (N=26)	Total (N=162)
Age				
Mean (SD)	45.4 (15.2)	49.6 (14.4)	50.8 (13.6)	48.3 (14.6)
Median (IQR)	46.0 (31.5, 59.0)	52.0 (41.0, 61.0)	53.0 (41.2, 58.5)	50.0 (38.0, 61.0)
Range	19.0 - 72.0	18.0 - 73.0	18.0 - 70.0	18.0 - 73.0
Missing	0	0	0	0
ECMO commencement location				
Bedside	44 (80.0%)	33 (40.7%)	20 (76.9%)	97 (59.9%)
Operative theatre	9 (16.4%)	42 (51.9%)	2 (7.7%)	53 (32.7%)
Cath lab	2 (3.6%)	6 (7.4%)	4 (15.4%)	12 (7.4%)
Total	55	81	26	162
Missing	0	0	0	0
ECMO outcome				
Died	18 (32.7%)	35 (43.2%)	16 (61.5%)	69 (42.6%)
Survived	37 (67.3%)	46 (56.8%)	10 (38.5%)	93 (57.4%)
Total	55	81	26	162
Missing	0	0	0	0
ICU length of stay				
Mean (SD)	29.3 (28.2)	22.0 (20.0)	10.4 (9.4)	22.6 (22.8)
Median (IQR)	20.5 (12.3, 33.2)	15.0 (8.9, 30.5)	9.5 (1.6, 18.5)	15.4 (8.0, 28.8)
Range	0.9 - 141.0	0.5 - 97.5	0.1 - 35.6	0.1 - 141.0
Missing	1	3	0	4
Hospital length of stay				
Mean (SD)	44.6 (44.9)	44.1 (47.0)	17.4 (15.0)	40.0 (43.7)
Median (IQR)	31.9 (17.0, 50.4)	29.3 (14.1, 54.4)	16.7 (2.2, 31.6)	28.9 (12.7, 47.4)
Range	1.1 - 203.9	0.2 - 280.9	0.2 - 42.2	0.2 - 280.9
Missing	0	0	0	0

Table 3: Summary data for patients who are retrieved on ECMO

Type of ECMO		Retrieved (N=47)	Non-retrieved (N=115)	Total (N=162)
ECPR (N=26)	**Age**			
	Mean (SD)	63.0 (8.5)	49.8 (13.6)	50.8 (13.6)
	Median (IQR)	63.0 (60.0, 66.0)	52.0 (39.0, 57.5)	53.0 (41.2, 58.5)
	Range	57.0 - 69.0	18.0 - 70.0	18.0 - 70.0
	Missing	0	0	0
	ECMO commencement location			
	Bedside	1 (50.0%)	19 (79.2%)	20 (76.9%)
	Operative theatre	1 (50.0%)	1 (4.2%)	2 (7.7%)
	Cath lab	0 (0.0%)	4 (16.7%)	4 (15.4%)
	Total	2	24	26
	Missing	0	0	0
	ECMO outcome			
	Died	2 (100.0%)	14 (58.3%)	16 (61.5%)
	Survived	0 (0.0%)	10 (41.7%)	10 (38.5%)
	Total	2	24	26
	Missing	0	0	0
	ICU length of stay			
	Mean (SD)	9.9 (13.1)	10.5 (9.4)	10.4 (9.4)
	Median (IQR)	9.9 (5.2, 14.5)	9.5 (1.9, 17.3)	9.5 (1.6, 18.5)
	Range	0.6 - 19.2	0.1 - 35.6	0.1 - 35.6
	Missing	0	0	0
	Hospital length of stay			
	Mean (SD)	10.5 (13.8)	17.9 (15.3)	17.4 (15.0)
	Median (IQR)	10.5 (5.6, 15.4)	16.7 (2.2, 32.5)	16.7 (2.2, 31.6)
	Range	0.7 - 20.3	0.2 - 42.2	0.2 - 42.2
	Missing	0	0	0
V-A (N=81)	**Age**			
	Mean (SD)	47.1 (15.1)	50.5 (14.1)	49.6 (14.4)
	Median (IQR)	49.0 (39.0, 61.5)	53.0 (43.2, 61.0)	52.0 (41.0, 61.0)
	Range	22.0 - 67.0	18.0 - 73.0	18.0 - 73.0
	Missing	0	0	0
	ECMO commencement location			
	Bedside	11 (47.8%)	22 (37.9%)	33 (40.7%)
	Operative theatre	9 (39.1%)	33 (56.9%)	42 (51.9%)
	Cath lab	3 (13.0%)	3 (5.2%)	6 (7.4%)
	Total	23	58	81
	Missing	0	0	0
	ECMO outcome			
	Died	10 (43.5%)	25 (43.1%)	35 (43.2%)
	Survived	13 (56.5%)	33 (56.9%)	46 (56.8%)
	Total	23	58	81
	Missing	0	0	0
	ICU length of stay			
	Mean (SD)	27.1 (28.5)	20.0 (15.4)	22.0 (20.0)
	Median (IQR)	14.6 (5.2, 43.4)	15.0 (9.8, 27.6)	15.0 (8.9, 30.5)
	Range	0.7 - 97.5	0.5 - 65.8	0.5 - 97.5
	Missing	1	2	3
	Hospital length of stay			

Type of ECMO		Retrieved (N=47)	Non-retrieved (N=115)	Total (N=162)
	Mean (SD)	46.0 (51.6)	43.4 (45.5)	44.1 (47.0)
	Median (IQR)	29.0 (9.5, 68.2)	30.0 (14.3, 54.4)	29.3 (14.1, 54.4)
	Range	0.8 - 183.2	0.2 - 280.9	0.2 - 280.9
	Missing	0	0	0
V-V (N=55)	**Age**			
	Mean (SD)	48.3 (16.6)	43.5 (14.2)	45.4 (15.2)
	Median (IQR)	52.5 (32.2, 62.8)	45.0 (30.0, 54.0)	46.0 (31.5, 59.0)
	Range	21.0 - 72.0	19.0 - 65.0	19.0 - 72.0
	Missing	0	0	0
	ECMO commencement location			
	Bedside	20 (90.9%)	24 (72.7%)	44 (80.0%)
	Operative theatre	1 (4.5%)	8 (24.2%)	9 (16.4%)
	Cath lab	1 (4.5%)	1 (3.0%)	2 (3.6%)
	Total	22	33	55
	Missing	0	0	0
	ECMO outcome			
	Died	9 (40.9%)	9 (27.3%)	18 (32.7%)
	Survived	13 (59.1%)	24 (72.7%)	37 (67.3%)
	Total	22	33	55
	Missing	0	0	0
	ICU length of stay			
	Mean (SD)	27.6 (25.6)	30.5 (30.2)	29.3 (28.2)
	Median (IQR)	19.0 (13.9, 27.2)	22.5 (11.5, 38.6)	20.5 (12.3, 33.2)
	Range	0.9 - 89.6	1.2 - 141.0	0.9 - 141.0
	Missing	0	1	1
	Hospital length of stay			
	Mean (SD)	46.3 (48.4)	43.5 (43.0)	44.6 (44.9)
	Median (IQR)	31.3 (18.2, 51.3)	33.4 (15.8, 47.7)	31.9 (17.0, 50.4)
	Range	1.1 - 187.0	1.8 - 203.9	1.1 - 203.9
	Missing	0	0	0

5 Pre-ECMO Data

Data collected immediately prior to ECMO commencement.

5.1 Indications

Table 4: ECMO indication (V-V)

	Overall (N=55)
Respiratory indication	
ARDS (risk factor)	34 (64.2%)
Asthma	3 (5.7%)
Chronic end stage lung disease	3 (5.7%)
Direct lung trauma	4 (7.5%)
Drug/toxin pulmonary disease	0 (0.0%)
Focal lung disease (not ARDS)	4 (7.5%)
Post lung transplant	4 (7.5%)
Pulmonary vasculitis/haemorrhage	1 (1.9%)
Total	53
Missing	2

Table 5: ECMO indication (V-A)

	Overall (N=81)
Cardiac indication	
Acute decompensated heart failure	10 (12.7%)
Acute myocardial infarction (AMI)	14 (17.7%)
Advanced pulmonary hypertension	1 (1.3%)
Chronic cardiomyopathy	8 (10.1%)
Chronic graft (heart) dysfunction	1 (1.3%)
Congenital heart disease	1 (1.3%)
Myocarditis	6 (7.6%)
Peri-operative support	27 (34.2%)
Primary arrhythmia (Channelopathy)	2 (2.5%)
Pulmonary embolism	4 (5.1%)
Septic shock	3 (3.8%)
Toxic	2 (2.5%)
Total	79
Missing	2

Table 6: ECMO indication (ECPR)

	Overall (N=26)
Indication	
Acute decompensated heart failure	1 (4.2%)
Acute myocardial infarction (AMI)	11 (45.8%)
Advanced pulmonary hypertension	0 (0.0%)
ARDS (risk factor)	0 (0.0%)
Asthma	0 (0.0%)
Chronic cardiomyopathy	0 (0.0%)
Chronic end stage lung disease	0 (0.0%)
Chronic graft (heart) dysfunction	0 (0.0%)
Congenital heart disease	1 (4.2%)
Direct lung trauma	0 (0.0%)
Focal lung disease (not ARDS)	0 (0.0%)
Myocarditis	0 (0.0%)
Peri-operative support	3 (12.5%)
Post lung transplant	0 (0.0%)
Primary arrhythmia (Channelopathy)	7 (29.2%)
Pulmonary embolism	1 (4.2%)
Pulmonary vasculitis/haemorrhage	0 (0.0%)
Septic shock	0 (0.0%)
Toxic	0 (0.0%)
Total	24
Missing	2

5.2 Admission

Table 7: Hospital and ICU admission source

	Overall (N=162)
Hospital admission source	
Home	74 (45.7%)
Other acute hospital (not ICU/ED)	15 (9.3%)
Other acute hospital ICU	61 (37.7%)
Other hospital ED (like ICU above)	12 (7.4%)
Rehabilitation	0 (0.0%)
Total	162
Missing	0
ICU admission source	
Emergency department	36 (22.2%)
ICU, other hospital	55 (34.0%)
ICU, same hospital	0 (0.0%)
Operative theatre/recovery	45 (27.8%)
Other hospital	11 (6.8%)
Ward	15 (9.3%)
Total	162
Missing	0

6 ECMO Data

6.1 Length of stay

Table 8: Length of stay (days) stratified by ECMO type

	V-V (N=55)	V-A (N=81)	ECPR (N=26)	Total (N=162)
ECMO duration				
Median (IQR)	7.8 (4.6, 12.8)	5.7 (3.3, 11.7)	3.9 (1.6, 5.5)	5.7 (3.5, 10.8)
Total	55	81	25	161
Missing	0	0	1	1
ICU length of stay				
Median (IQR)	20.5 (12.3, 33.2)	15.0 (8.9, 30.5)	9.5 (1.6, 18.5)	15.4 (8.0, 28.8)
Total	54	78	26	158
Missing	1	3	0	4
Hospital length of stay				
Median (IQR)	31.9 (17.0, 50.4)	29.3 (14.1, 54.4)	16.7 (2.2, 31.6)	28.9 (12.7, 47.4)
Total	55	81	26	162
Missing	0	0	0	0

Table 9: Length of stay (days) stratified by transfer status

	Retrieved (N=47)	Non-retrieved (N=115)	Total (N=162)
ECMO duration			
Median (IQR)	8.7 (4.3, 15.5)	5.3 (3.0, 8.9)	5.7 (3.5, 10.8)
Total	47	114	161
Missing	0	1	1
ICU length of stay			
Median (IQR)	16.9 (9.0, 33.2)	15.0 (7.9, 28.5)	15.4 (8.0, 28.8)
Total	46	112	158
Missing	1	3	4
Hospital length of stay			
Median (IQR)	29.0 (12.8, 53.6)	28.8 (12.7, 45.9)	28.9 (12.7, 47.4)
Total	47	115	162
Missing	0	0	0

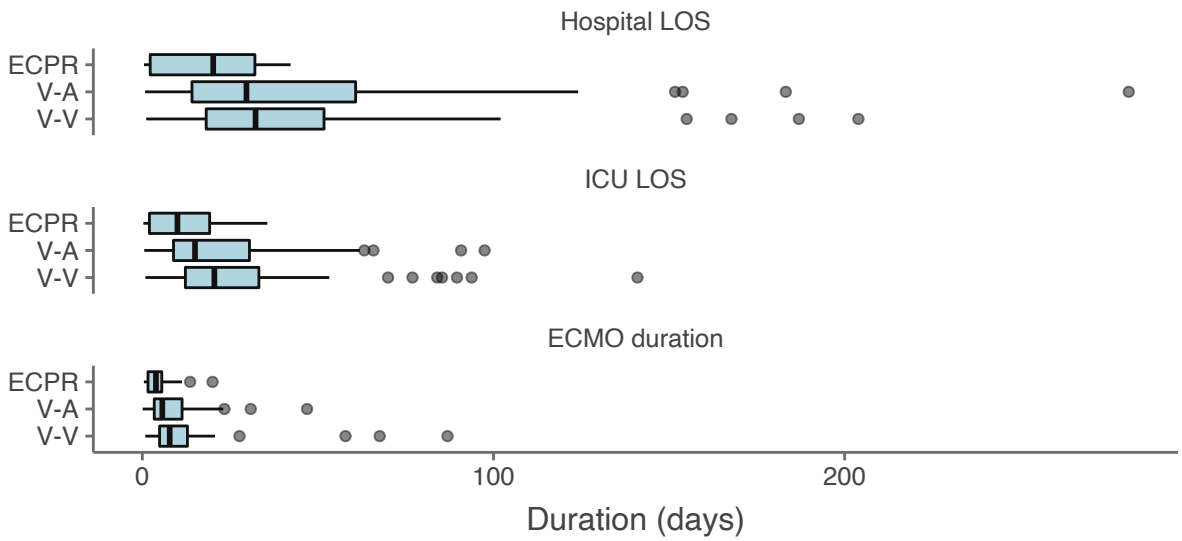

Figure 3: Distribution of length of stay stratified by ECMO mode

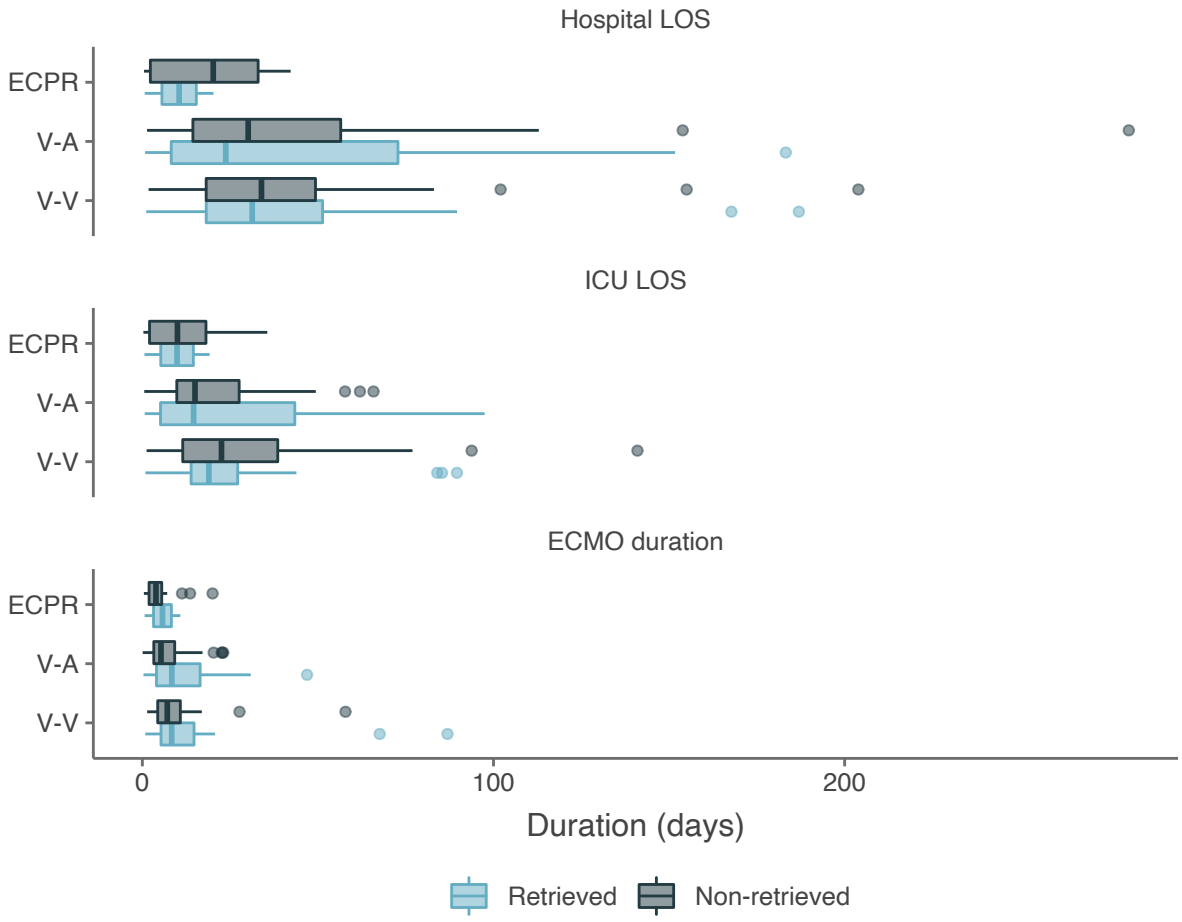

Figure 4: Distribution of length of stay stratified by transfer status

6.2 ECMO trips

Table 10: Number of trips stratified by ECMO type

	V-V (N=55)	V-A (N=81)	ECPR (N=26)	Total (N=162)
Number of operative theatre trips[1]				
Mean (SD)	1.7 (1.3)	2.9 (1.5)	2.5 (1.0)	2.4 (1.5)
Range	1.0 - 8.0	1.0 - 7.0	1.0 - 5.0	1.0 - 8.0
Missing	0	0	0	0
Number of radiology trips[1]				
Mean (SD)	2.3 (1.6)	1.9 (1.6)	2.0 (1.5)	2.1 (1.6)
Range	1.0 - 10.0	1.0 - 9.0	1.0 - 8.0	1.0 - 10.0
Missing	0	0	0	0

1. Trips occur when a patient is physically transferred to another location to facilitate imaging and/or procedure ECMO discontinuation

6.3 ECMO discontinuation

Table 11: ECMO discontinuation reason stratified by ECMO type

	V-V (N=55)	V-A (N=81)	ECPR (N=26)	Total (N=162)
ECMO discontinuation reason				
Expected recovery	39 (70.9%)	38 (46.9%)	13 (50.0%)	90 (55.6%)
Poor prognosis	13 (23.6%)	18 (22.2%)	8 (30.8%)	39 (24.1%)
Bridge to VAD	0 (0.0%)	16 (19.8%)	0 (0.0%)	16 (9.9%)
ECMO mortality	2 (3.6%)	7 (8.6%)	5 (19.2%)	14 (8.6%)
Bridge to heart transplant	0 (0.0%)	2 (2.5%)	0 (0.0%)	2 (1.2%)
ECMO complication	1 (1.8%)	0 (0.0%)	0 (0.0%)	1 (0.6%)
Total	55	81	26	162
Missing	0	0	0	0

6.4 ICU therapies

Table 12: ICU therapies

	Overall (N=162)
Second ECMO Run	
Yes	2 (1.8%)
No	107 (98.2%)
Total	109
Missing	53
Renal Replacement Therapy	
Yes	93 (65.5%)
No	49 (34.5%)
Total	142
Missing	20
Maximum IMS on ECMO	
Median (IQR)	0.0 (0.0, 0.0)
Total	8
Missing	154
Maximum IMS in ICU	
Median (IQR)	3.0 (0.0, 5.0)
Total	155
Missing	7

7 Complications

Table 13: Proportion of patient with complications

Complications category	
Bleeding	63.3%
Cardiovascular	66.7%
Infection	63.3%
Neurological	20.0%
Renal	77.3%
Mechanical	22.0%
Pulmonary	12.0%

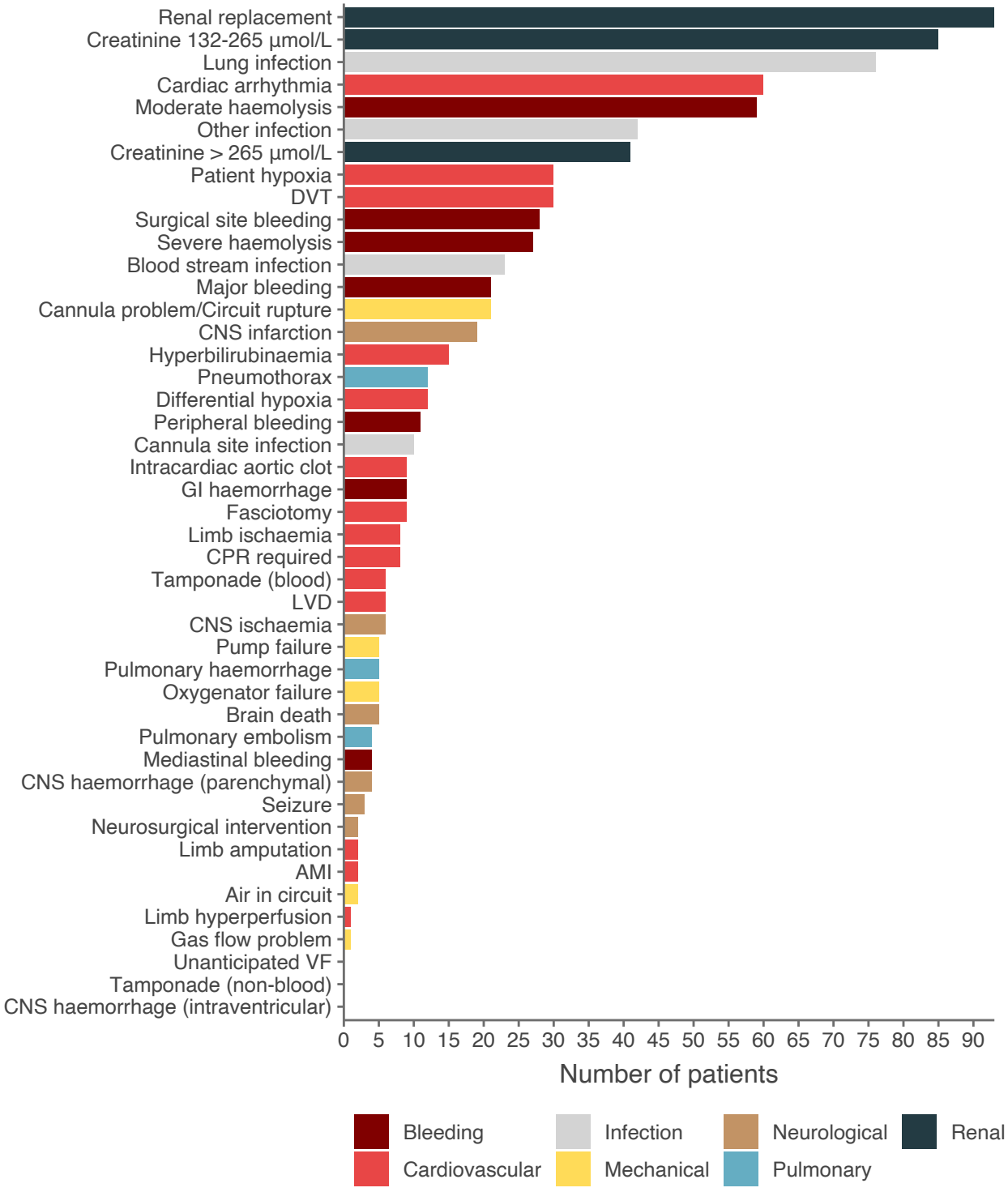

Figure 5: Distribution of post-ECMO complications

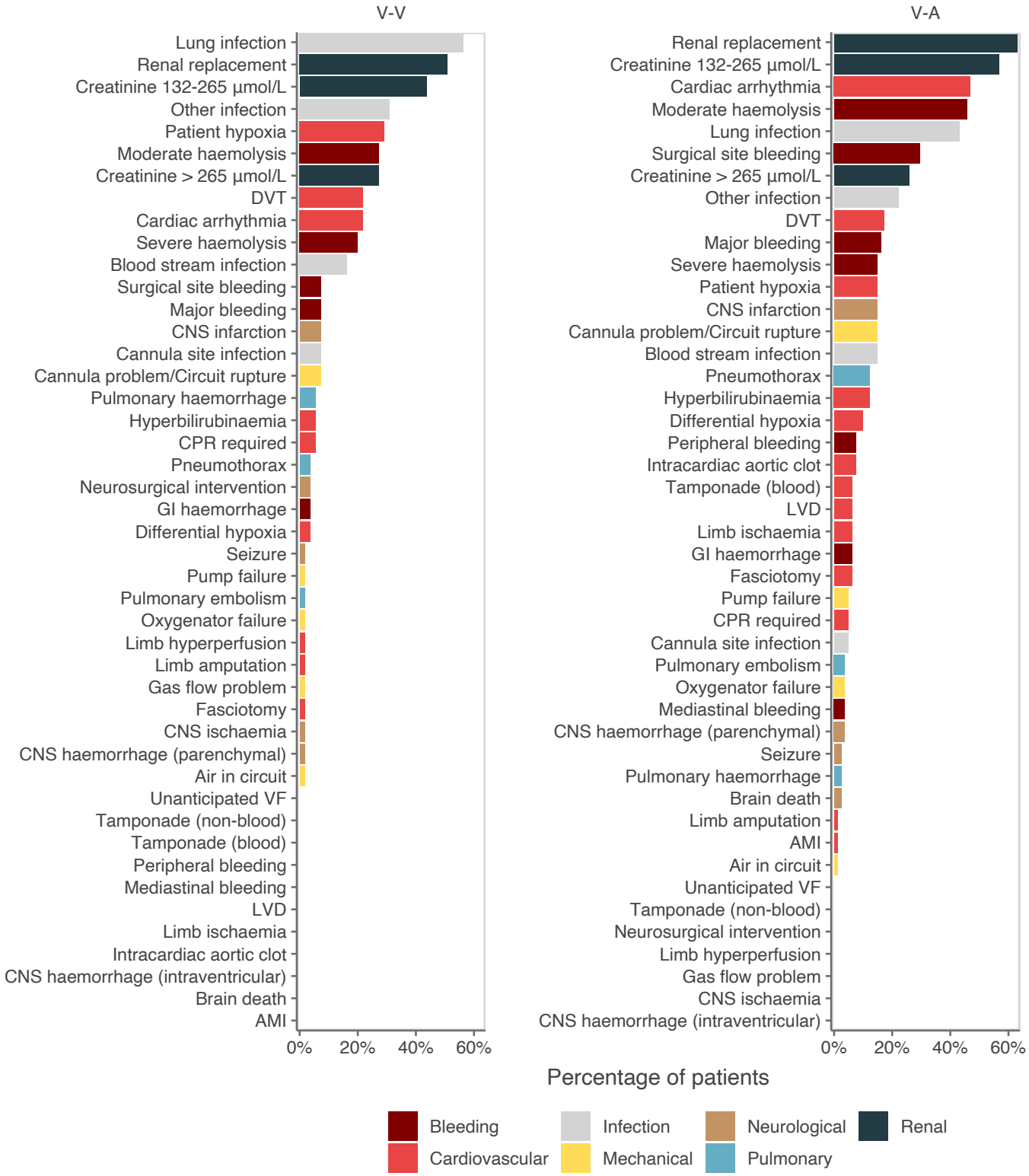

Figure 6: Distribution of post-ECMO complications stratified by ECMO mode (1/2)

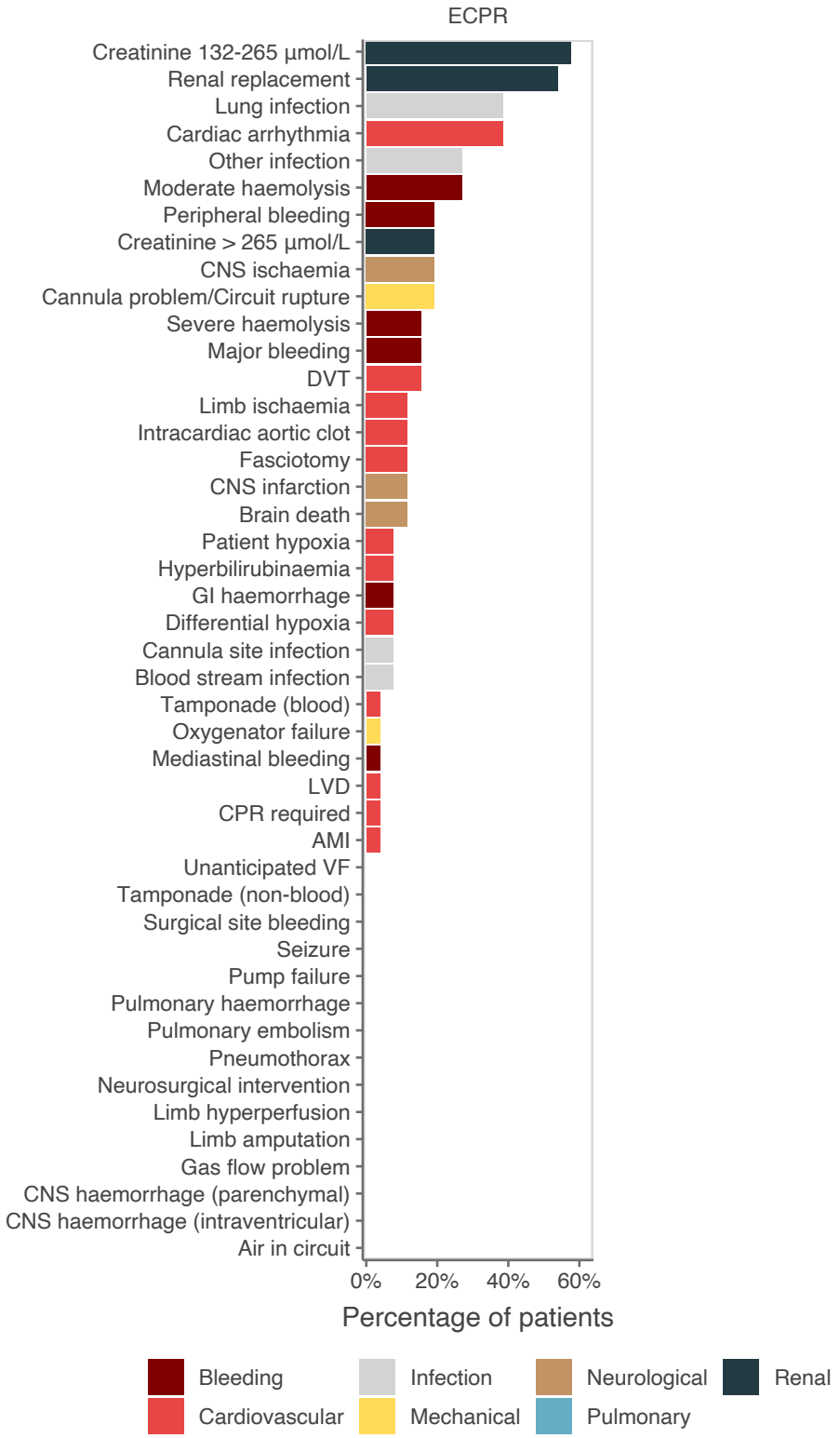

Figure 7: Distribution of post-ECMO complications stratified by ECMO mode (2/2)

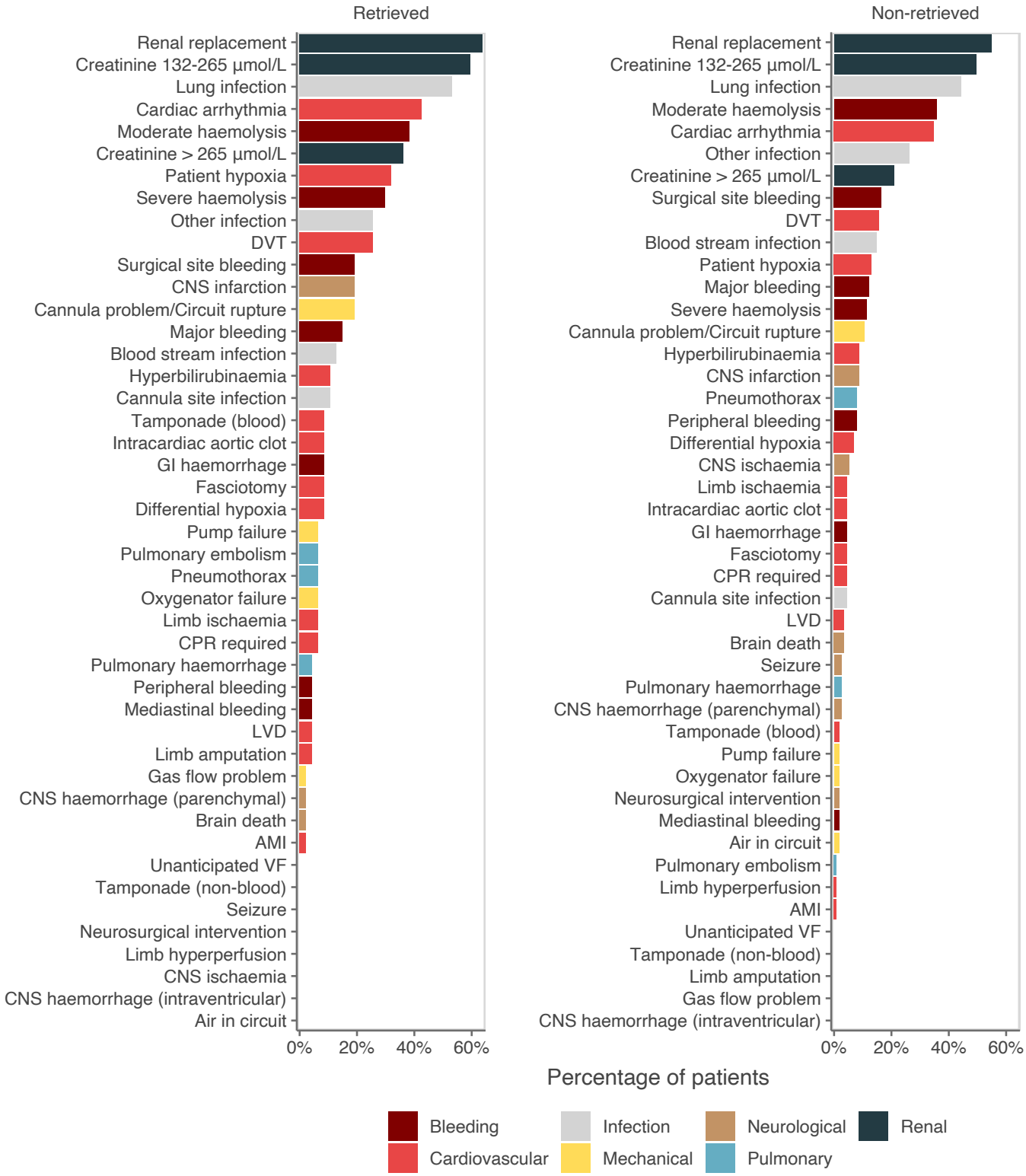

Figure 8: Distribution of post-ECMO complications stratified by transfer status

7.1 Proximate cause of death

Table 14: Proximate cause of death stratified by ECMO type

	V-V (N=55)	V-A (N=81)	ECPR (N=26)	Total (N=162)
Proximate cause of death				
Arrhythmia	1 (5.6%)	0 (0.0%)	1 (6.2%)	2 (2.9%)
Cardiogenic shock	0 (0.0%)	16 (45.7%)	5 (31.2%)	21 (30.4%)
Distributive (Septic) shock	9 (50.0%)	8 (22.9%)	1 (6.2%)	18 (26.1%)
Hypovolaemic shock	0 (0.0%)	1 (2.9%)	0 (0.0%)	1 (1.4%)
Hypoxic respiratory failure	4 (22.2%)	1 (2.9%)	0 (0.0%)	5 (7.2%)
Metabolic	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Neurological no TBI with brain death	0 (0.0%)	2 (5.7%)	1 (6.2%)	3 (4.3%)
Neurological no TBI without brain death	2 (11.1%)	3 (8.6%)	5 (31.2%)	10 (14.5%)
Neurological TBI with brain death	0 (0.0%)	0 (0.0%)	1 (6.2%)	1 (1.4%)
Neurological TBI without brain death	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Other	2 (11.1%)	4 (11.4%)	2 (12.5%)	8 (11.6%)
Total	18	35	16	69

8 Outcome Data

8.1 Discharge destination

Table 15: Discharge destination post-ECMO stratified by ECMO type

	V-V (N=55)	V-A (N=81)	ECPR (N=26)	Total (N=162)
ICU discharge destination				
Died	17 (30.9%)	35 (43.2%)	15 (57.7%)	67 (41.4%)
Home	1 (1.8%)	0 (0.0%)	0 (0.0%)	1 (0.6%)
Other	1 (1.8%)	0 (0.0%)	0 (0.0%)	1 (0.6%)
Ward	31 (56.4%)	43 (53.1%)	11 (42.3%)	85 (52.5%)
Other hospital ICU	4 (7.3%)	3 (3.7%)	0 (0.0%)	7 (4.3%)
Other hospital- normal ward	1 (1.8%)	0 (0.0%)	0 (0.0%)	1 (0.6%)
Total	55	81	26	162
Missing	0	0	0	0
Hospital discharge destination				
Home	16 (29.1%)	25 (30.9%)	6 (23.1%)	47 (29.0%)
Transferred to another hospital	14 (25.5%)	3 (3.7%)	0 (0.0%)	17 (10.5%)
Transfer to LTAC or rehab	6 (10.9%)	16 (19.8%)	4 (15.4%)	26 (16.0%)
Dead	18 (32.7%)	35 (43.2%)	16 (61.5%)	69 (42.6%)
Other	1 (1.8%)	2 (2.5%)	0 (0.0%)	3 (1.9%)
Total	55	81	26	162
Missing	0	0	0	0

8.2 30, 60, 90 and 180-day survival

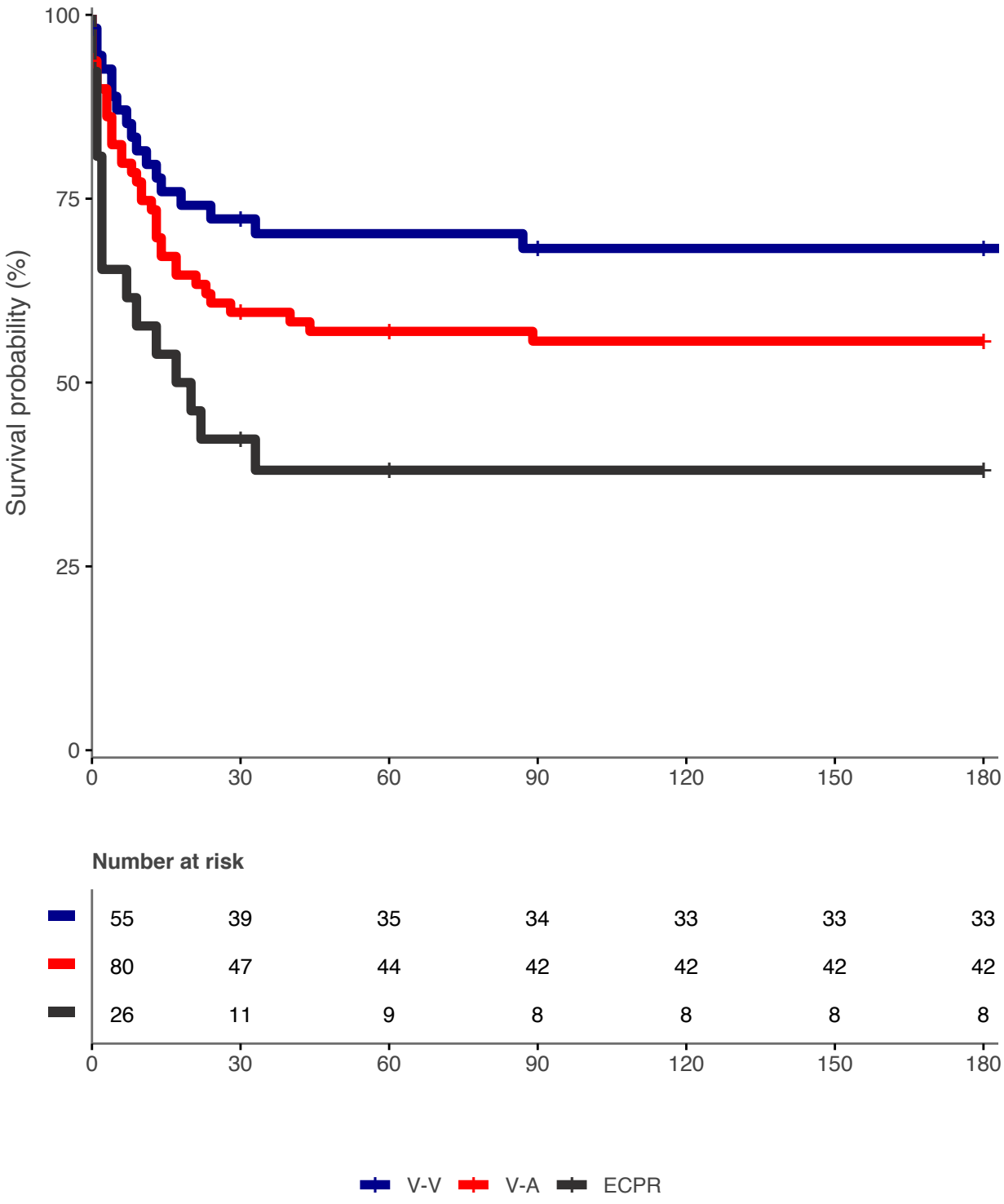

Figure 9: Kaplan-Meier plot of survival stratified by ECMO type

8.3 30, 60, 90 and 180-day survival

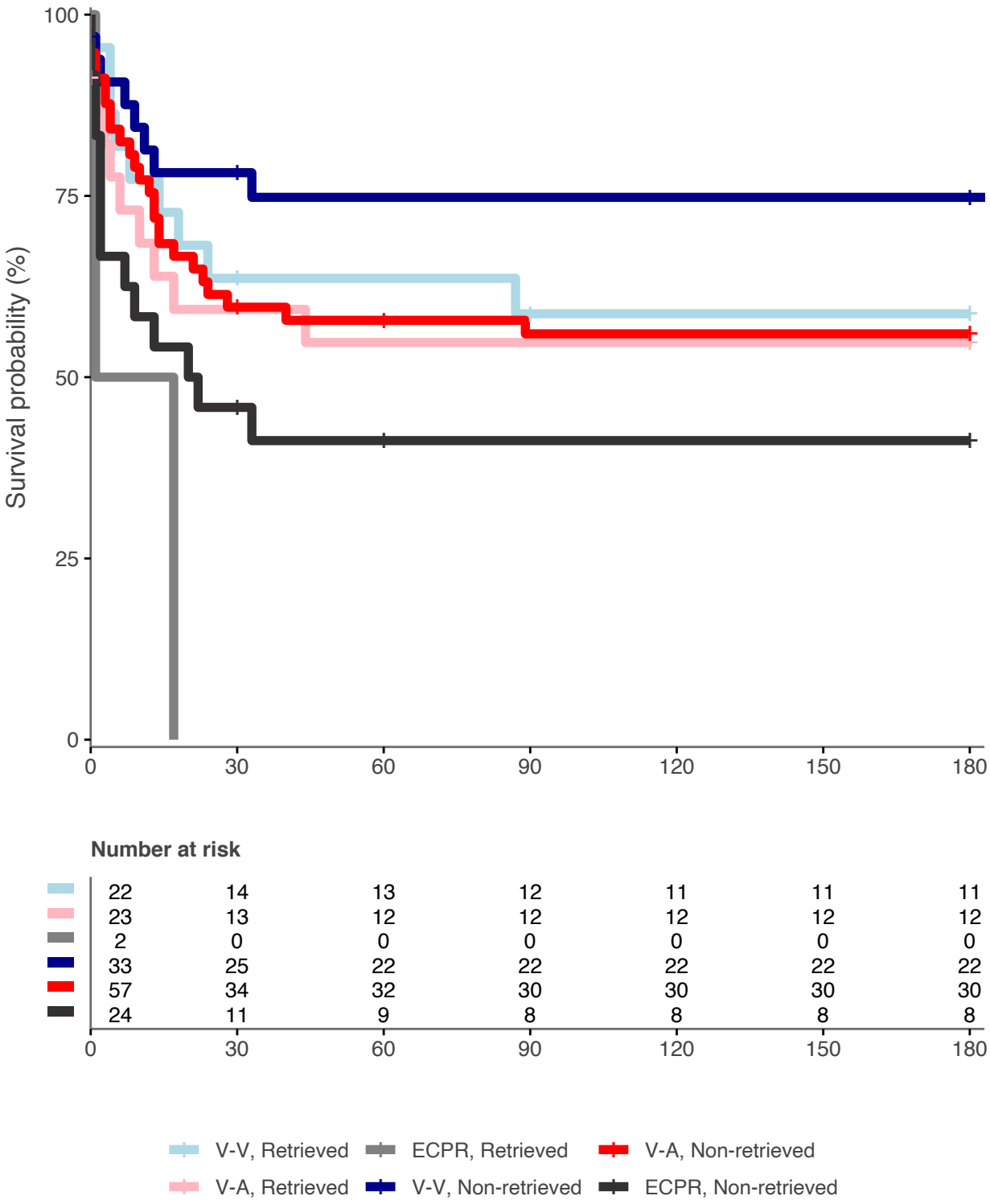

Figure 10: Kaplan-Meier plot of survival stratified by transfer status and ECMO type

8.4 Funnel plots

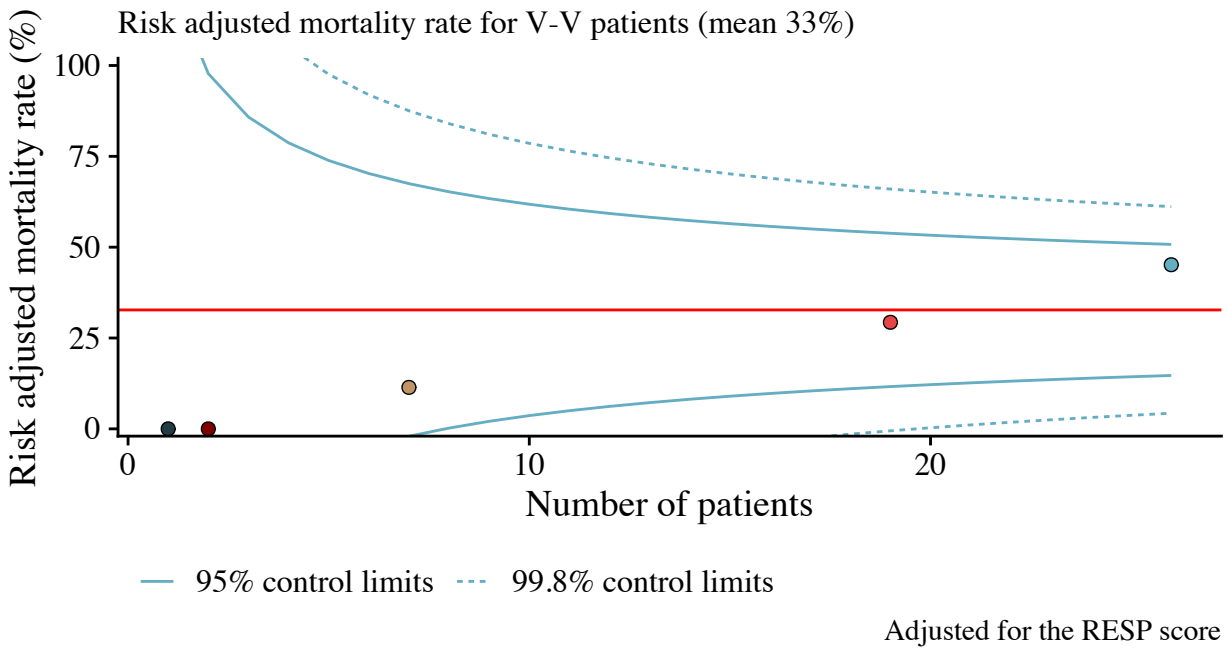

Figure 11: Risk adjusted mortality rate for V-V patients

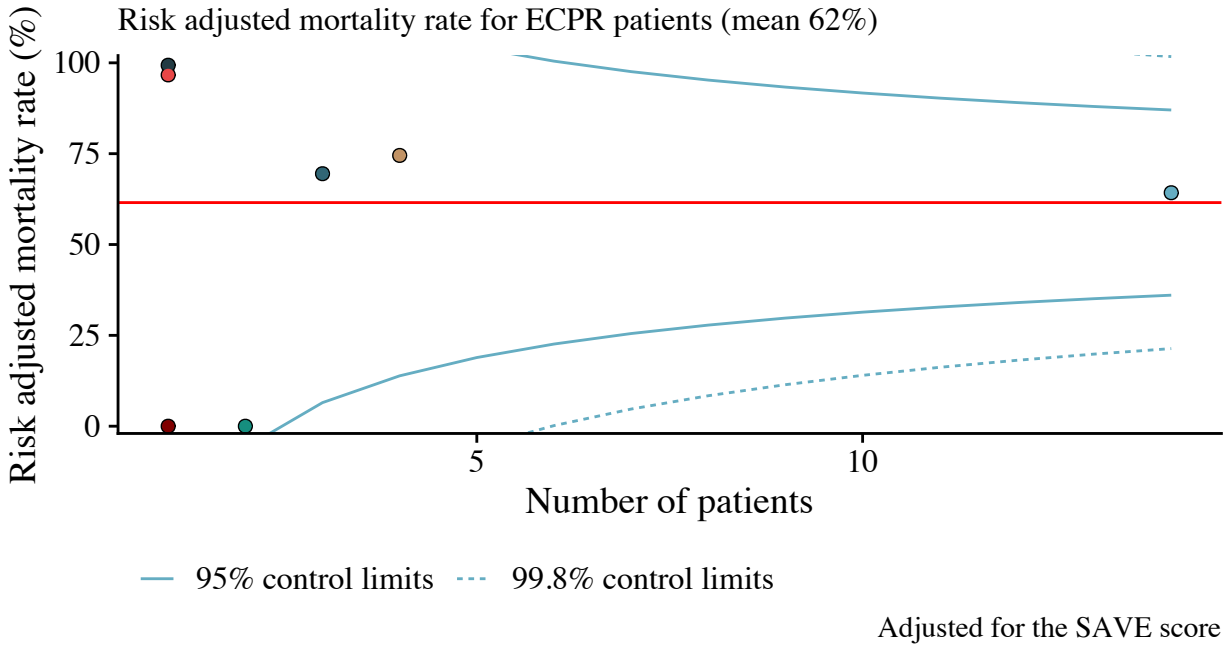

Figure 12: Risk adjusted mortality rate for ECPR patients

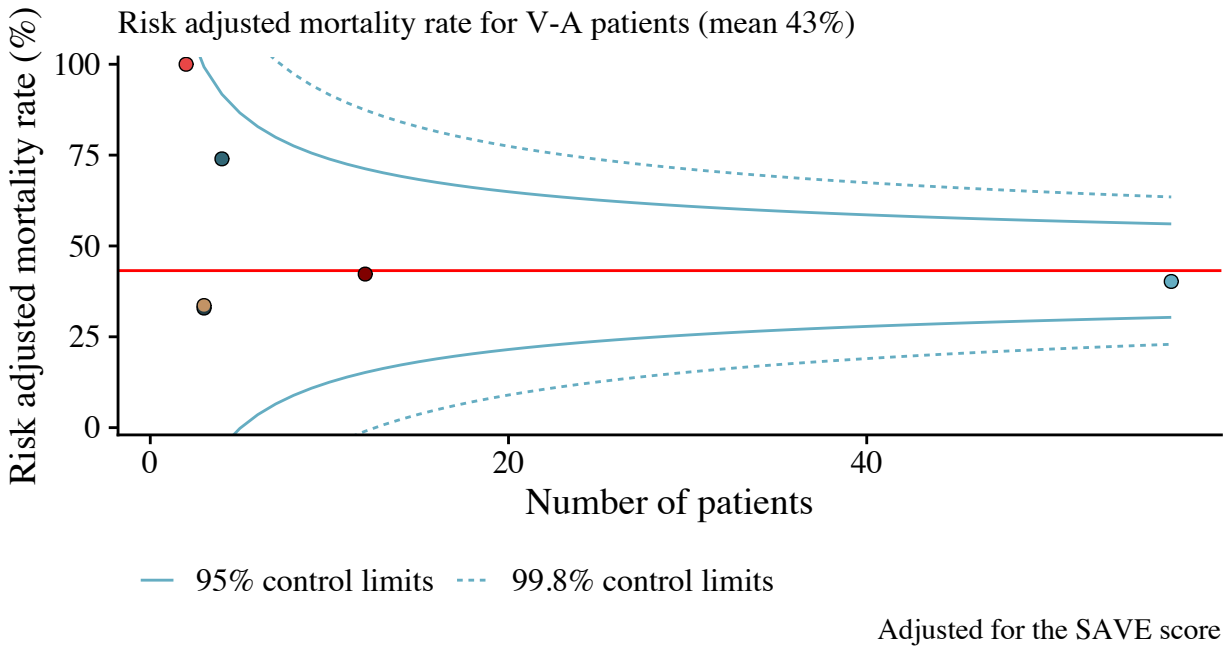

Figure 13: Risk adjusted mortality rate for V-A patients

9 Follow-up (6 months post ECMO)

Distribution of 6-month follow-up functional outcome measures

Vertical lines illustrate 25th, 50th, and 75th percentiles

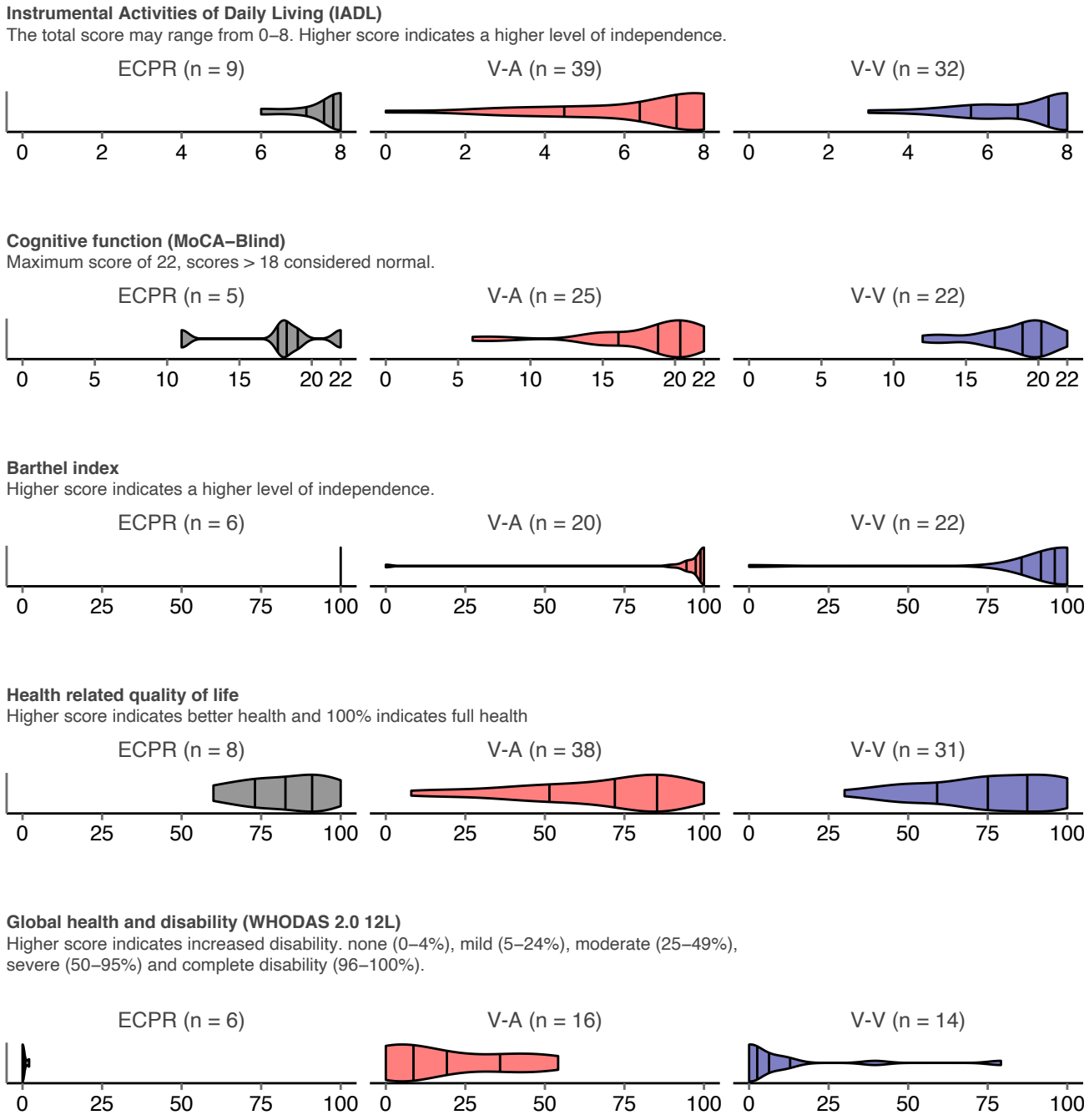

Figure 14: Distribution of follow-up functional outcome measures by site and ECMO mode

10 Future initiatives

As the EXCEL Registry moves towards maturity, the data are becoming more valuable for monitoring ECMO in Australia. We will be undertaking further work on testing and refining algorithms to identify outliers, device performance and safety signals.

We anticipate that data from the EXCEL Registry will become increasingly important to drive continuous quality improvement in healthcare. We plan more detailed reports back to sites and funders including their choice of process measures of care. We will continue to work with stakeholders, including consumers, to raise awareness about the registry within Australia.

We have been fortunate to receive partnership funding from the Heart Foundation, the International ECMO Network, major Australian ECMO sites including The Prince Charles Hospital, The Alfred, St Vincent's Hospital Sydney, The University Hospital Geelong, Royal Prince Alfred Hospital and the NHMRC. We will be exploring alternate funding models within the Commonwealth, and look forward to engaging with stakeholders to find an appropriate model of care.

The EXCEL Registry will continue to work with our research collaborators, including the existing studies that are embedded within the registry: (1) The BLENDER RCT - CIA David Pilcher (2) OBLEX - CIA Hergen Buscher (3) ECMOCARD - CIA John Fraser and (4) ECMO Energy - CIA Arne Diehl. We have two completed publications (see below) and several planned publications on retrievals, decannulation, long term outcomes and costs. We have presented our data at The World Congress of Intensive Care (2019) and the ANZICS Conference on Safety and Quality (2019). Work is also being done with the INDEX Registry in North America, and a planned annual report may eventuate.

On behalf of the EXCEL Management Committee, we look forward to another active year ahead, working with clinicians, hospitals, patients and other stakeholders to improve the health of Australians on ECMO.

11 References

1. Linke NJ, Fulcher BJ, Engeler DM, Anderson S, Bailey MJ, Bernard S, Board JV, Brodie D, Buhr H, Burrell AJC, Cooper DJ, Fan E, Fraser JF, Gattas DJ, Higgins AM, Hopper IK, Huckson S, Litton E, McGuinness SP, Nair P, Orford N, Parke RL, Pellegrino VA, Pilcher DV, Sheldrake J, Reddi BAJ, Stub D, Trapani TV, Udy AA, Hodgson CL; EXCEL Investigators. A survey of extracorporeal membrane oxygenation practice in 23 Australian adult intensive care units. Crit Care Resusc. 2020 Jun;22(2):166-170. PMID: 32389109.

2. Fulcher BJ, Nicholson AJ, Linke NJ, Berkovic D, Hodgson CL; EXCEL Study Investigators and the International ECMO Network. The perceived barriers and facilitators to implementation of ECMO services in acute hospitals. Intensive Care Med. 2020 Jul 23. doi: 10.1007/s00134-020-06187-z. Epub ahead of print. PMID: 32705292.