

EXCEL 2022 Annual Report



Prepared by:

**The EXCEL Registry
Management Committee**

EXCEL Registry

553 St Kilda Road
Melbourne, Australia
ANZIC-RC
Monash University



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Australian and New Zealand Intensive
Care Research Centre (ANZIC-RC)

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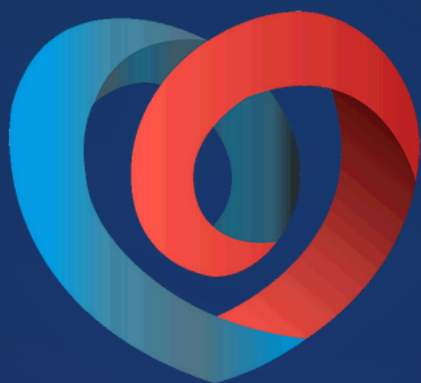


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Foreword

We are delighted to present the Australian and New Zealand Extracorporeal Membrane Oxygenation (EXCEL) Report covering January 1st to December 31st 2022. This report is designed to provide feedback to Australian and New Zealand ECMO sites about patient outcomes and to inform healthcare providers about the national use and outcomes of ECMO. In 2019, 153 patients were added to the registry; which grew by 284 patients in 2020. A total of 495 patients were enrolled in 2021, followed by a further 439 in 2022. This shows the increased growth of the registry over the last four years.

A Management Committee oversees EXCEL and includes broad stakeholder representation from clinicians, researchers, funders, end-users and consumers. We thank all research coordinators and clinicians who have continued to support the EXCEL Registry through the completion of data collection throughout this period. We thank all those people who support the registry through the provision of their clinical and Patient Reported Outcome (PROMs) information.

EXCEL provides biannual reports to sites, including risk-adjusted mortality, complications, healthcare utilisation, hospital outcomes and patient-reported outcomes. Data follows the patient journey, so data is not duplicated if a patient is transferred from one hospital to another and it is directly aligned with the international Extracorporeal Life Support Organization (ELSO) registry. EXCEL provides ELSO direct data upload for 20 sites which has increased Australian and New Zealand ELSO participation. We currently have five registry-embedded clinical trials, including three randomised controlled trials that are funded by the MRFF, with three more in planning for 2023. From 2019-2022, we have had 26 requests for data from the EXCEL registry, all from clinician-researchers at sites participating in the registry. EXCEL encourages secondary use of data from external stakeholders including researchers, clinicians, government agencies and industry.

As we have a waiver of consent for hospital data, there is no missing data due to opt-out. The overwhelming majority of ECMO runs reported to the registry occur in tertiary hospitals, which perform over 90% of all ECMO procedures in Australia and New Zealand. Most patients were admitted to hospital from home (51%) and the most common ICU admission source was from another hospital ICU (27%). For VV-ECMO, VA-ECMO and ECPR respectively, the most common indications were acute respiratory distress syndrome (ARDS) (68.7%), acute decompensated heart failure (23.1%) and acute myocardial infarction (AMI) (50%). The most common complications were renal (73%) with half of patients receiving continual renal replacement therapy. Cardiovascular complications occurred in 54.5% of patients on ECMO, and bleeding complications in 36.2%.

Unique to EXCEL are detailed patient-reported outcome measures (PROMS) at 6 and 12 months. In 2022 we published data available on the incidence of death and new disability at 6 months after ECMO in The Lancet Respiratory Medicine. Death or disability was reported in 260 of 391 (66%) patients at 6 months and was higher in patients receiving ECPR. Of the cohort, 198 (50.6%) patients had died at 6 months after ECMO initiation. Of the survivors, 62 of 193 (32.1%) reported disability at 6-months. Disability was common in physical, psychological and cognitive functioning, and over one-quarter of people who were working prior to their illness had not returned to work due to poor health. These findings demonstrate the ongoing need for high quality ECMO data as we strive to improve outcomes for patients in the future.

EXCEL has shared research findings at the EXCEL Symposium (2022), ELSO Conference (2022), International ECMO Network (2022) and presented over 20 times at national and international conferences.

The EXCEL website provides a large amount of information, including recent publications and consumer stories. <https://www.monash.edu/medicine/sphpm/excel/home>

We hope that you find the EXCEL Registry's 2022 Report interesting and informative reading.



Professor Carol Hodgson
EXCEL Registry Chief Principal Investigator
Head of the Division of Clinical Trials and Cohort Studies, Monash University
Deputy Director of the Australian and New Zealand Intensive Care-Research Centre, Monash University

Acknowledgements

The EXCEL Registry would like to acknowledge the support of funding partners for their continued support, ensuring the ongoing success of this important registry. This includes the National Health and Medical Research Council, the Heart Foundation, the Dicker Family, the International ECMO Network, the Critical Care Research Group (QLD), the Alfred Hospital (VIC), The University Hospital Geelong (VIC), St Vincent's Hospital (NSW) and Royal Prince Alfred Hospital (NSW). We would like to acknowledge in-kind support from the Australian and New Zealand Intensive Care Research Centre, Monash University, the Australian and New Zealand Intensive Care Society and Fiona Stanley Hospital (WA).



We are grateful for the contributions made by the EXCEL Registry Management Committee. We acknowledge the leadership of the chair of the Management Committee, who is also the EXCEL Registry chief principal investigator and academic lead (Prof Carol Hodgson). We would like to acknowledge the contributions of the EXCEL Registry project team (Mr Bentley Fulcher and Ms Natalie Linke) including our Data Analyst (Dr Andrew Stephens). We also gratefully acknowledge the dedication of the steering committee members, clinician researchers including: Professors Stephen Bernard, Daniel Brodie, Jamie Cooper, Eddy Fan, John Fraser, David Pilcher, Dion Stub, Andrew Udy; A/Professors Aidan Burrell, David Gattas, Ingrid Hopper, Priya Nair, Neil Orford, Rachael Parke and Vin Pellegrino; Drs Lisa Higgins, Ed Litton, Shay McGuinness and Ben Reddi; Research Coordinators Heidi Buhr, Jasmin Board, Sue Huckson, Annalie Jones, Tony Trapani and consumers; Ms Shannah Anderson and Mr Craig Dicker.

This work would not have been possible without the ongoing efforts of the many intensive care specialists, nurses, research coordinators and other hospital staff who contribute data to the EXCEL Registry, including the Principal Investigators for their sites. We would like to thank them for their commitment. We would also like to thank the patients who allow the EXCEL Registry to retain their data and recognise the importance of the EXCEL Registry. Thank you to our follow up assessors who interview participants at six and 12 months. This report is presented on behalf of the members of the EXCEL Management Committee, with thanks to Dr Andrew Stephens, Department of Mechanical and Aerospace Engineering at Monash University.

Consumer Impact Statement

Consumers hold an important role within EXCEL as they contribute to designing processes surrounding data capture within healthcare and research systems. The valuable experience brought by consumers is well recognised in Australia and internationally. In our effort to further the impact of consumers within clinical quality registries (CQRs), EXCEL has committed to the following objectives:

- Provide a platform of research-based activities that answers questions and examines outcomes that consumers and carers have identified as important for ECMO patients
- Produce findings that will be used to support clinical care and health policy in line with consumer feedback and evaluation
- Enhance registry communication with consumers, including through its outputs, ensuring that they are consumer-friendly and relevant to consumers

The EXCEL Registry would like to thank the commitment and dedication of the consumers involved with the registry itself, and various sub studies. The feedback, lived experience and knowledge provided by these individuals is invaluable. In particular, our thanks to the Dicker Family for their ongoing support, as well as Ms Shannah Anderson for providing us with her time and effort.

Thank you to our two consumer representatives, Mr Craig Dicker and Ms Shannah Anderson.



Mr Craig Dicker



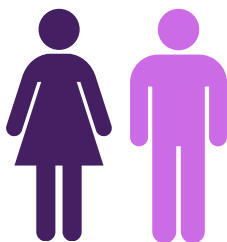
Ms Shannah Anderson

2022 Year in Review - A snapshot



439

ECMO patients
admitted to hospital in
Australia and New Zealand



63%

Were male ECMO
patients



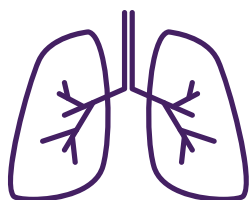
49.5

Mean age (years) of
ECMO patients



48%

Patients received
ECMO for
cardiac support



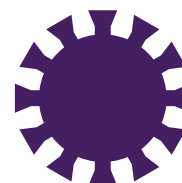
34%

Patients received
ECMO for
respiratory support



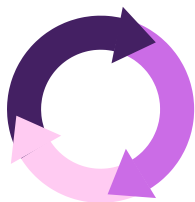
18%

Patients received
ECMO CPR



15%

Patients received
ECMO due to
COVID-19



5.4 days

Median
ECMO treatment



15.0 days

Median
ICU stay



25.8 days

Median
hospital stay



56.1%

Patients survived
ECMO

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ABBREVIATIONS AND ACRONYMS

Table 1: Abbreviations and Acronyms

AMI	Acute myocardial infarction
ANZICS	Australian and New Zealand Intensive Care Society
ARDS	Acute respiratory distress syndrome
CNS	Central nervous system
COVID-19	Coronavirus disease of 2019
CPR	Cardiopulmonary resuscitation
DVT	Deep vein thromboembolism
ECPR	Extracorporeal cardiopulmonary resuscitation used for advanced resuscitation
ED	Emergency Department
ELSO	Extracorporeal Life Support Organisation
GI	Gastrointestinal
ICU	Intensive Care Unit
IQR	Interquartile range
LA	Left atrium
LOS	Length of stay
LVD	Left ventricular distention
NHMRC	National Health and Medical Research Council
PA	Pulmonary artery
REDCap	Research Electronic Data Capture
RESP	Respiratory ECMO survival prediction
SD	Standard deviation
TBI	Traumatic brain injury
VA	Venoarterial ECMO used for cardiac indication
VAD	Ventricular assist device
VF	Ventricular fibrillation
VV	Venovenous ECMO used for a respiratory indication
WHODAS 2.0 12L	World Health Organisation Disability Assessment Schedule 2.0 12 Level

SITE ENROLMENT

The EXCEL Registry continues to engage eligible sites in Australia and New Zealand to contribute data to the registry. An eligible site is defined as a site currently undertaking ECMO as identified by Australian modification of the International statistical classification of diseases and health related problems, 10th revision (ICD-10-AM) coding data provided by the Australian Government Department of Health, or as reported by external sources (internet search, surgeons or site staff).

The list of eligible sites is dynamic and updated regularly based on information obtained from intensive care clinicians and site staff, and information gleaned from internet search engines and websites. The EXCEL Registry maintains a 'watch list' of sites identified as having the potential to undertake occasional ECMO. A participating site is defined as any site that has been granted ethics and governance approval and data collection for the registry has commenced. As of 31 December 2021, 91% of total eligible ECMO runs were captured in the EXCEL Registry.

Engagement is the proportion of eligible sites that are currently participating. The most common reason that eligible sites are not participating is that the implementation process has not yet been completed. The total number of participating sites throughout 2022 was 30. Of the 30 sites, 5% were private and 95% were public hospitals (Figure 1).

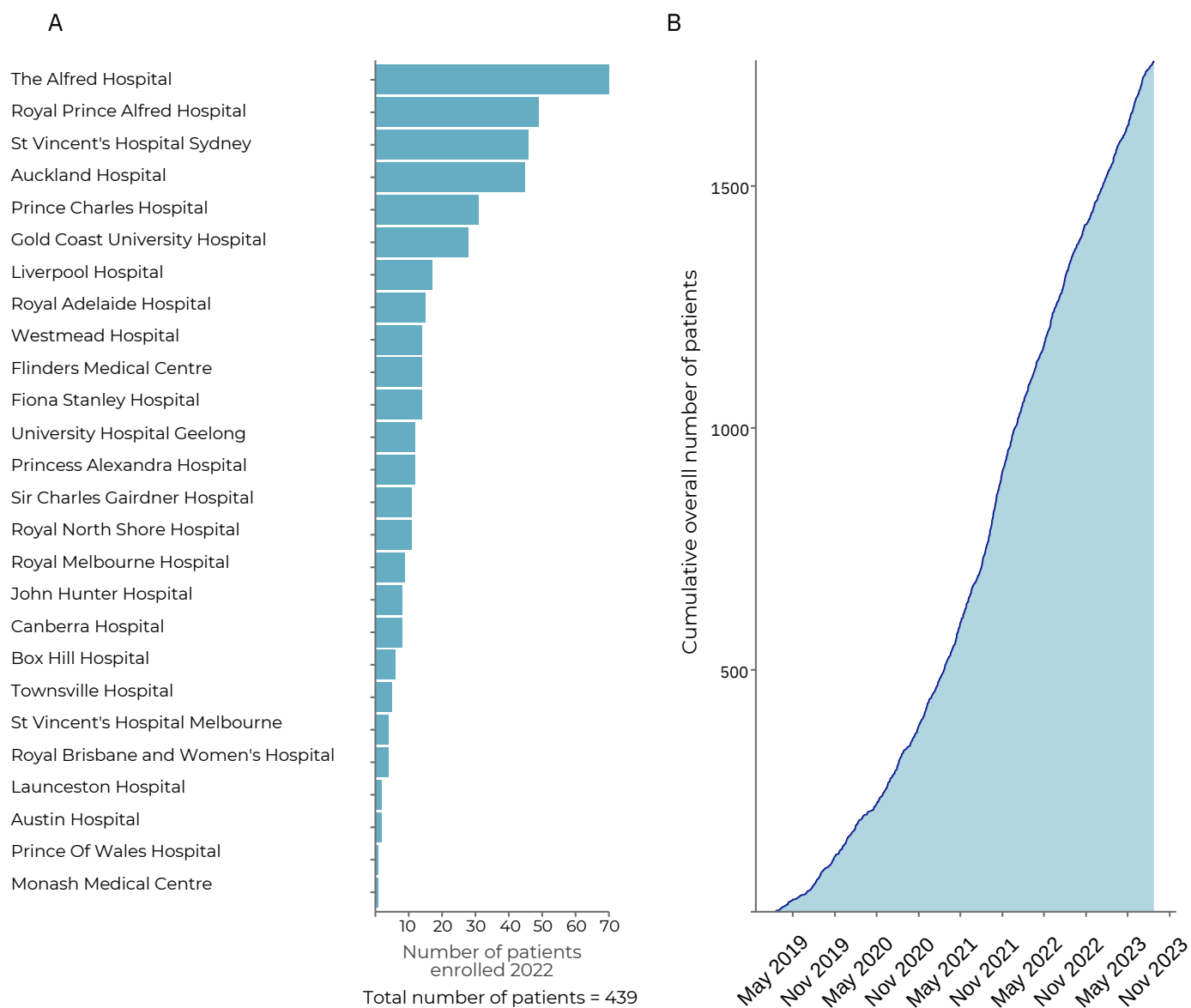


Figure 1: (A) Number of patients enrolled 2022
 (B) Cumulative overall site enrolment to date (February 2019 to October 2023)

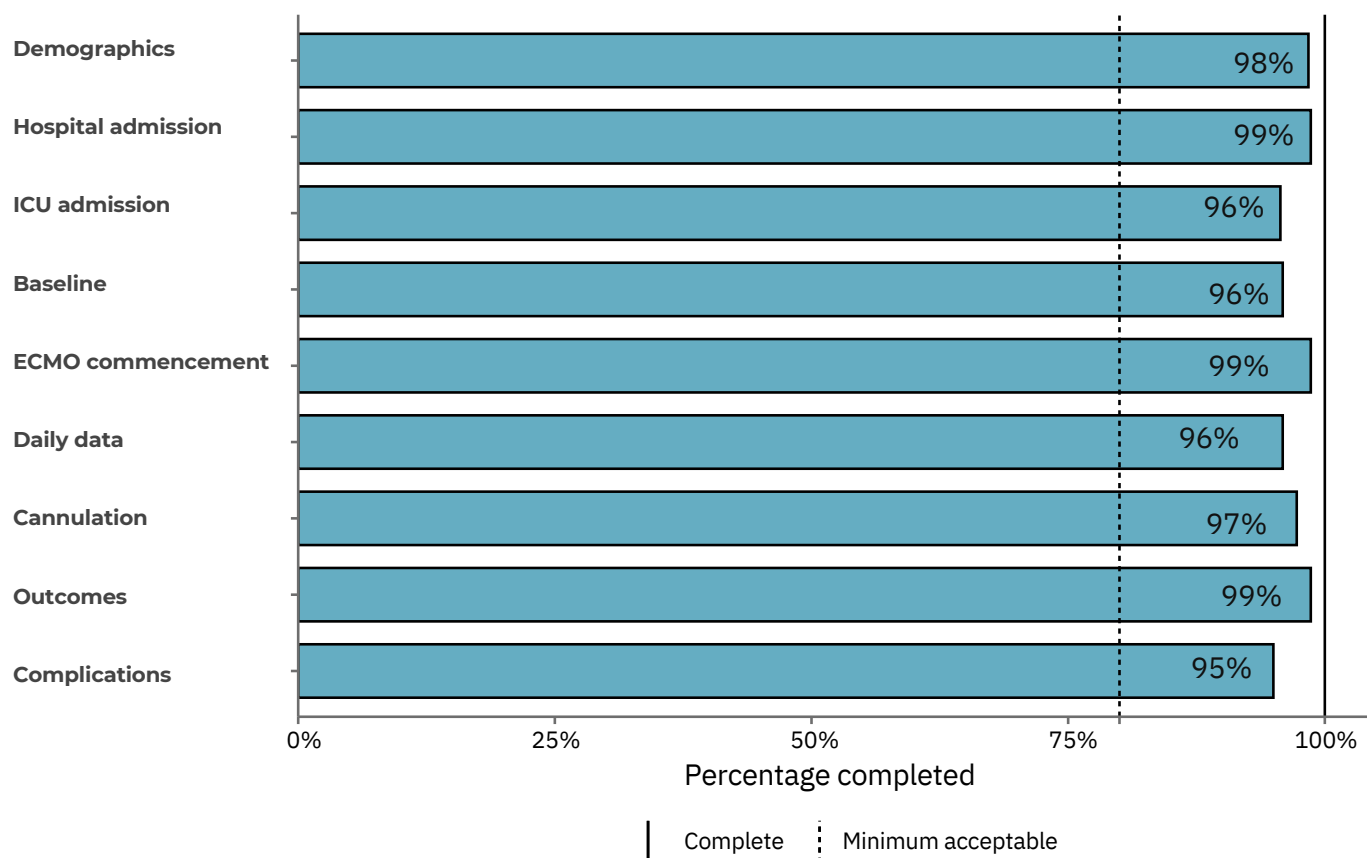


Figure 2: Data completion: EXCEL registry forms

DATA COMPLETION

All data entered in this report have 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.

Over 80% of data was completed for all forms within the registry, with over 95% of data completed for most forms. This work would not have been possible without the ongoing efforts of the many intensive care specialists, nurses, research coordinators and other hospital staff who contribute data to the EXCEL Registry. We would like to thank them for their commitment. We would also like to thank the patients who allow the EXCEL Registry to retain their data (Figure 2).

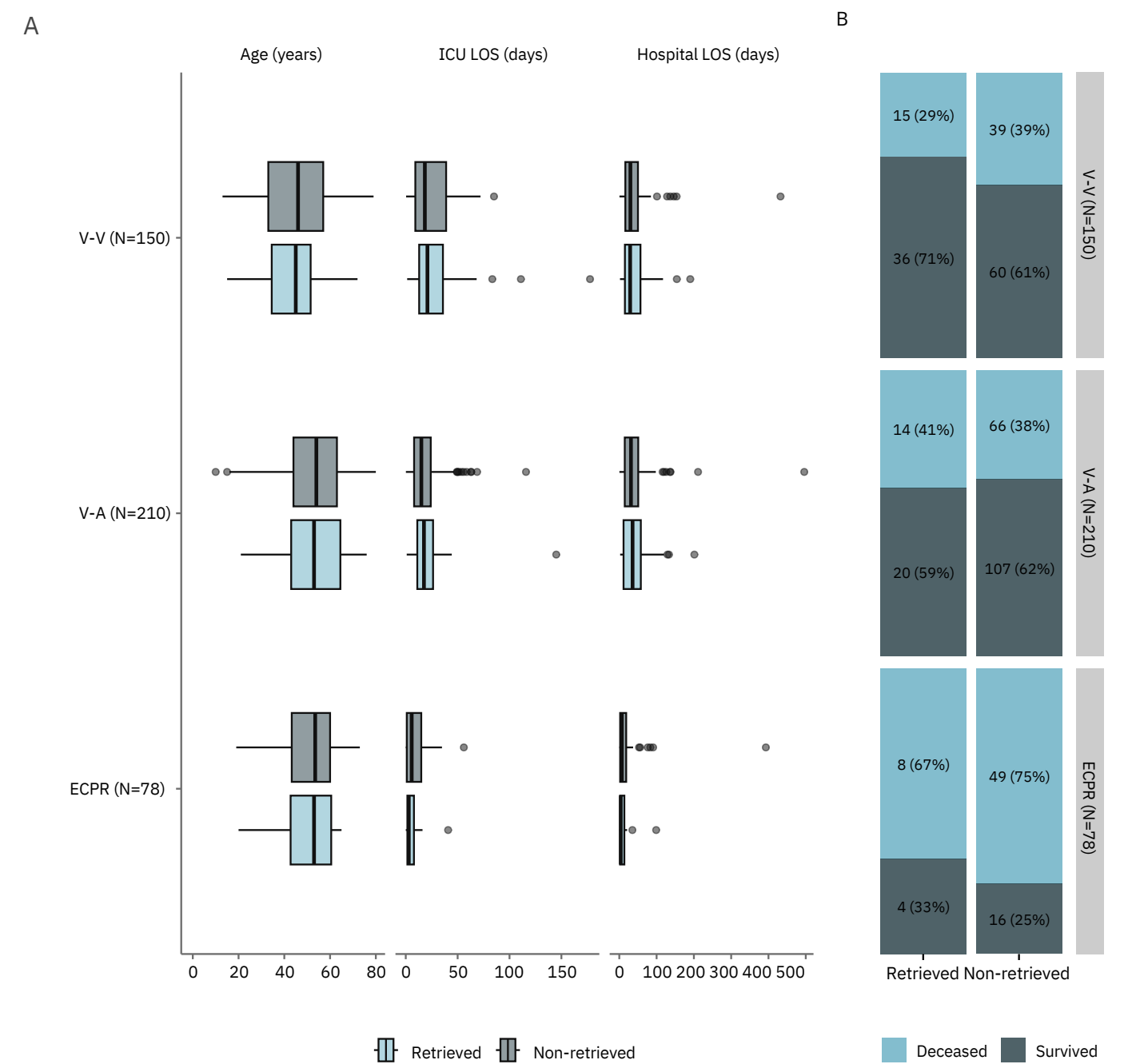
SUMMARY DATA

Table 2 shows the summary data across all sites, separated for the type of ECMO (VV-ECMO, VA-ECMO and ECPR). There were 67 (15.3%) patients who were diagnosed with COVID-19 who received ECMO in this period.

Table 2: Summary information by ECMO mode

	V-V (N=150)	V-A (N=211)	ECPR (N=78)	Total (N=439)
COVID-19 status				
- Confirmed COVID-19 patients	46 (30.7%)	13 (6.2%)	8 (10.3%)	67 (15.3%)
- Other patients	104 (69.3%)	196 (93.8%)	70 (89.7%)	370 (84.7%)
- Total	150	209	78	437
- Missing	0	2	0	2
Age				
- Mean (SD)	44.6 (15.0)	52.4 (14.3)	50.8 (13.4)	49.5 (14.8)
- Median (IQR)	45.0 (33.2, 56.0)	54.0 (44.0, 63.0)	53.5 (43.0, 60.0)	51.0 (39.5, 61.0)
- Range	13.0 - 79.0	10.0 - 80.0	19.0 - 73.0	10.0 - 80.0
- Missing	0	0	0	0
ECMO commencement location				
- Bedside	125 (83.3%)	89 (42.2%)	52 (66.7%)	266 (60.6%)
- Operative theatre	22 (14.7%)	98 (46.4%)	3 (3.8%)	123 (28.0%)
- Cath lab	3 (2.0%)	24 (11.4%)	18 (23.1%)	45 (10.3%)
- At scene	0 (0.0%)	0 (0.0%)	5 (6.4%)	5 (1.1%)
- Total	150	211	78	439
- Missing	0	0	0	0
ECMO outcome				
- Deceased	54 (36.0%)	80 (38.3%)	57 (74.0%)	191 (43.9%)
- Survived	96 (64.0%)	129 (61.7%)	20 (26.0%)	244 (56.1%)
- Total	150	208	77	435
- Missing	0	3	1	3
ECMO duration				
- Mean (SD)	12.6 (12.6)	8.0 (25.8)	4.3 (4.6)	8.9 (19.6)
- Median (IQR)	8.2 (4.1, 17.1)	4.9 (2.9, 7.8)	2.7 (0.9, 6.1)	5.4 (2.7, 9.7)
- Range	0.3 - 70.1	0.2 - 36.9	0.0 - 23.7	0.0 - 70.1
- Missing	0	3	1	4
ICU length of stay (days)				
- Mean (SD)	26.2 (23.3)	19.5 (17.9)	9.3 (11.1)	20.0 (19.9)
- Median (IQR)	19.1 (10.7, 38.8)	15.7 (8.7, 24.4)	5.4 (1.0, 14.3)	15.0 (7.0, 26.9)
- Range	0.3 - 177.6	0.1 - 145.0	0.0 - 56.0	0.0 - 177.6
- Missing	0	3	1	4
Hospital length of stay (days)				
- Mean (SD)	38.3 (33.3)	40.0 (47.1)	19.5 (48.8)	35.8 (38.4)
- Median (IQR)	29.4 (15.9, 50.5)	31.6 (14.2, 51.8)	6.4 (2.2, 19.2)	25.8 (10.1, 48.4)
- Range	0.4 - 190.2	0.3 - 211.2	0.1 - 393.0	0.1 - 393.0
- Missing	9	8	3	20

Figure 3 shows the age, ICU length of stay and hospital length of stay between patients who received ECMO at one centre (non-retrieved) and patients who were transported from one hospital to another for ECMO while receiving ECMO (retrieved). It also shows the outcome of these patients separated for type of ECMO (VV-ECMO, VA-ECMO and ECPR). Of the retrieved patients, 71%, 59% and 33% survived respectively after VV-ECMO, VA-ECMO and ECPR.



Note: Non-retrieved patients received ECMO at one centre and were not transported from one ECMO centre to another

Figure 3: Summary data for patients who were retrieved on ECMO



Wards 5-6

Intensive Care Unit

PRE-ECMO DATA

Data collected immediately prior to ECMO commencement.

Indications

Tables 3, 4 and 5 show the indication for ECMO. For VV-ECMO, VA-ECMO and ECPR respectively, the most common indication was ARDS (68.7%), acute decompensated heart failure and acute myocardial infarction (AMI) (22.6%, 50.0%). VV-ECMO was used post lung transplant (6.8%) and VA-ECMO was used post heart transplant (5.8%).

Table 3: ECMO indication (V-V)

Overall (N=150)	
Respiratory indication	
- ARDS (risk factor)	101 (68.7%)
- Asthma	9 (6.1%)
- Chronic end stage lung disease	8 (5.4%)
- Direct lung trauma	4 (2.7%)
- Drug/toxin pulmonary disease	3 (2.0%)
- Focal lung disease (not ARDS)	6 (4.1%)
- Post lung transplant	10 (6.8%)
- Pulmonary vasculitis/haemorrhage	6 (4.1%)
- Total	147
- Missing	3

Table 4: ECMO indication (V-A)

Overall (N=211)	
Cardiac indication	
- Acute decompensated heart failure	48 (23.1%)
- Acute myocardial infarction (AMI)	47 (22.6%)
- Peri-operative support	45 (21.6%)
- Pulmonary embolism	16 (7.7%)
- Myocarditis	15 (7.2%)
- Post heart transplant	12 (5.8%)
- Chronic cardiomyopathy	10 (4.8%)
- Septic shock	6 (2.9%)
- Advanced pulmonary hypertension	3 (1.4%)
- Congenital heart disease	2 (1.0%)
- Primary arrhythmia (Channelopathy)	2 (1.0%)
- Chronic graft (heart) dysfunction	1 (0.5%)
- Toxic	1 (0.5%)
- Total	208
- Missing	3

Table 5: ECMO indication (ECPR)

Overall (N=78)	
ECPR Indication	
- Acute myocardial infarction (AMI)	39 (50.0%)
- Pulmonary embolism	10 (12.8%)
- Acute decompensated heart failure	8 (10.3%)
- Primary arrhythmia (Channelopathy)	6 (7.7%)
- Myocarditis	5 (6.4%)
- Toxic	5 (6.4%)
- Congenital heart disease	2 (2.6%)
- Chronic cardiomyopathy	1 (1.3%)
- Peri-operative support	1 (1.3%)
- Advanced pulmonary hypertension	1 (1.3%)
- Total	78
- Missing	0

Admission

Patients entered into the EXCEL Registry from an EXCEL participating hospital were mostly admitted to that hospital from home (51.3%). Patients admitted to ICU at the ECMO commencing hospital were mostly admitted from the ICU at another hospital (27.3%).

Table 6: Hospital and ICU admission source

Overall (N=439)	
Hospital admission source	
- Home	225 (51.3%)
- Other acute hospital ICU	138 (31.4%)
- Other acute hospital (not ICU/ED)	51 (11.6%)
- Other hospital ED (like ICU above)	25 (5.7%)
- Total	439
- Missing	0
ICU admission source	
- ICU, other hospital	120 (27.3%)
- Operative theatre/recovery	106 (24.1%)
- ED	92 (21.0%)
- Ward	46 (10.5%)
- Catheter lab	44 (10.0%)
- Other hospital	25 (5.7%)
- ICU, same hospital	5 (1.1%)
- Direct ICU admission (from home)	1 (0.2%)
- Total	439
- Missing	0



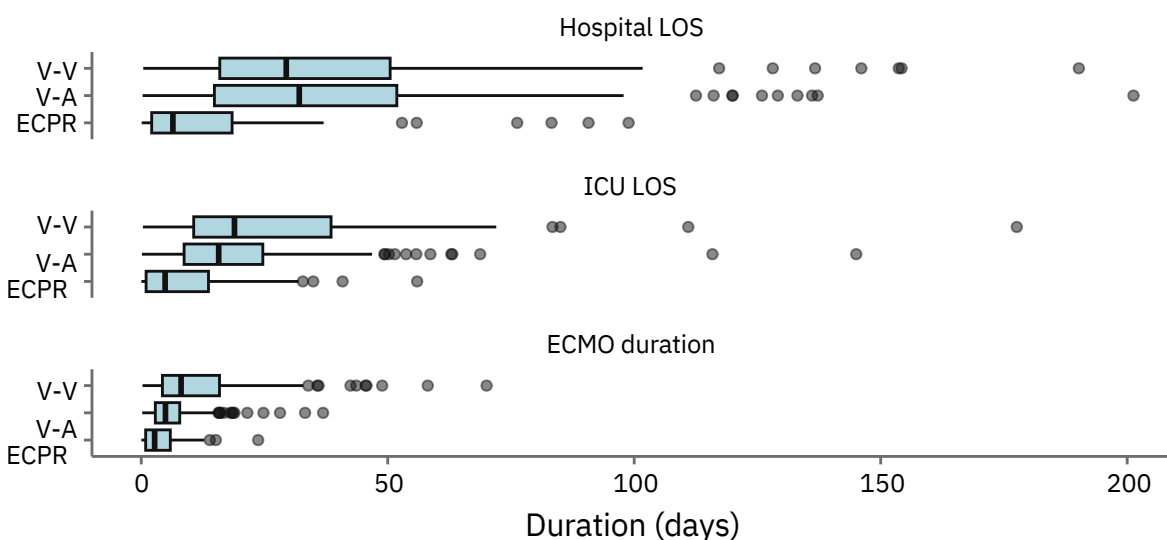
ECMO DATA

Length of stay

Table 8 describes the length of stay stratified by transfer status (retrieved versus non-retrieved patients). Patients who were retrieved had a longer duration on ECMO (median 7.5 days versus 4.9 days) and a longer ICU length of stay (median 17.7 versus 14.6 days).

Table 7: Length of stay (days) stratified by transfer status

Type of ECMO	Retrieved (N=97)	Non-Retrieved (N=341)	Total (N=438)
V-V ECMO duration			
- Median (IQR)	9.5 (5.8, 18.7)	6.7 (3.0, 15.9)	8.2 (4.1, 17.1)
- Total	51	99	150
- Missing	0	0	0
ICU length of stay (days)			
- Median (IQR)	20.9 (12.9, 35.8)	18.4 (9.2, 38.9)	19.1 (10.7, 38.8)
- Total	51	99	150
- Missing	0	0	0
Hospital length of stay(days)			
- Median (IQR)	29.1 (15.0, 56.8)	29.8 (16.1, 50.0)	29.4 (15.9, 50.5)
- Total	44	97	141
- Missing	7	2	9
V-A ECMO duration			
- Median (IQR)	6.4 (4.3, 11.1)	4.9 (2.8, 6.9)	4.9 (2.9, 7.7)
- Total	34	173	207
- Missing	0	3	3
ICU length of stay (days)			
- Median (IQR)	17.5 (11.1, 26.3)	15.1 (8.0, 23.9)	15.7 (8.7, 24.3)
- Total	34	173	207
- Missing	0	3	3
Hospital length of stay (days)			
- Median (IQR)	35.6 (11.4, 57.7)	31.3 (14.7, 50.8)	31.6 (14.0, 51.5)
- Total	34	168	202
- Missing	0	8	8
ECPR ECMO duration			
- Median (IQR)	2.8 (1.6, 4.5)	2.7 (0.9, 6.3)	2.7 (0.9, 6.1)
- Total	12	65	77
- Missing	0	1	1
ICU length of stay (days)			
- Median (IQR)	2.9 (1.6, 7.9)	5.7 (1.0, 14.9)	5.4 (1.0, 14.3)
- Total	12	65	77
- Missing	0	1	1
Hospital length of stay (days)			
- Median (IQR)	4.0 (2.1, 13.6)	7.0 (2.3, 19.2)	6.4 (2.2, 19.2)
- Total	12	63	75
- Missing	0	3	3



To improve clarity, patients with a hospital LOS longer than 200 days have been excluded from figure 4. These included:

- Three V-A ECMO patients (201 days, 211 days and 392 days).

Figure 4: Distribution of length of stay stratified by ECMO mode

ECMO trips

Table 8: Number of trips while on ECMO stratified by ECMO type

	V-V (N=150)	V-A (N=211)	ECPR (N=78)	Total (N=439)
Number of operative theatre trips¹				
- Mean(SD)	1.3 (0.8)	2.5 (1.5)	1.8 (1.1)	2.0 (1.4)
- Range	1.0-6.0	1.0-11.0	1.0-6.0	1.0-11.0
- Missing	4	2	1	7
Number of radiology trips¹				
- Mean(SD)	2.3 (1.9)	1.7 (1.5)	2.1 (1.4)	2.3 (1.9)
- Range	1.0-8.0	1.0-8.0	1.0-9.0	1.0-9.0
- Missing	4	4	1	9

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

ECMO discontinuation

The most common reason for clinicians discontinuing ECMO was because the patient was expected to recover (60.8%).

Table 9: ECMO discontinuation reason stratified by ECMO type

	V-V (N=150)	V-A (N=211)	ECPR (N=78)	Total (N=439)
ECMO discontinuation reason				
- Expected recovery	97 (64.7%)	135 (65.9%)	30 (39.5%)	262 (60.8%)
- Poor prognosis	29 (19.3%)	27 (13.2%)	25 (32.9%)	80 (18.6%)
- ECMO mortality	22 (14.7%)	23 (11.2%)	20 (26.3%)	65 (15.1%)
- Bridge to VAD	0 (0.0%)	12 (5.9%)	1 (1.3%)	13 (3.0%)
- ECMO complication	0 (0.0%)	5 (2.4%)	0 (0.0%)	5 (1.2%)
- Bridge to heart transplant	0 (0.0%)	4 (2.0%)	0 (0.0%)	4 (0.9%)
- Bridge to lung transplant	2 (1.3%)	0 (0.0%)	0 (0.0%)	2 (0.5%)
- Total	150	205	76	431
- Missing	0	6	2	8

ICU therapies

A second ECMO run was defined as ECMO commenced more than 12 hours after the previous ECMO run and within the index hospital admission. This occurred rarely.

Table 10: ICU therapies

	V-V (N=150)	V-A (N=211)	ECPR (N=78)
Second ECMO Run			
- Yes	2 (1.3%)	6 (2.9%)	1 (1.3%)
- No	148 (98.7%)	204 (97.1%)	76 (98.7%)
- Missing	0	1	1
Renal Replacement Therapy			
- Yes	72 (48.3%)	119 (58.0%)	45 (58.4%)
- No	77 (51.7%)	86 (42.0%)	32 (41.6%)
- Missing	1	6	1



COMPLICATIONS

Table 11: Proportion of patients with complications

Complications category	
Renal	73.0%
Cardiovascular	54.5%
Infection	49.5%
Bleeding	36.2%
Mechanical	19.8%
Neurological	13.0%
Pulmonary	8.7%

Major complications are reported to the registry under seven main categories, renal, cardiovascular, bleeding, infection, mechanical, neurological and pulmonary (Table 12). The most common complications were Renal (73.0%), Cardiovascular (54.5%), Infection (49.5%) and Bleeding (36.2%).

Figures 6, 7 and 8 report complications for each type of ECMO (VV-ECMO, VA-ECMO and ECPR). Renal replacement therapy was the most common complication across all types of ECMO, but for VV-ECMO lung infection was reported for over 40% of cases, and for VA-ECMO and ECPR cardiac arrhythmia were among the most common complications. Figure 9 describes the differences in major complications between patients who were retrieved and non-retrieved. Blood stream infection and hyperbilirubinaemia were more common in retrieved patients.

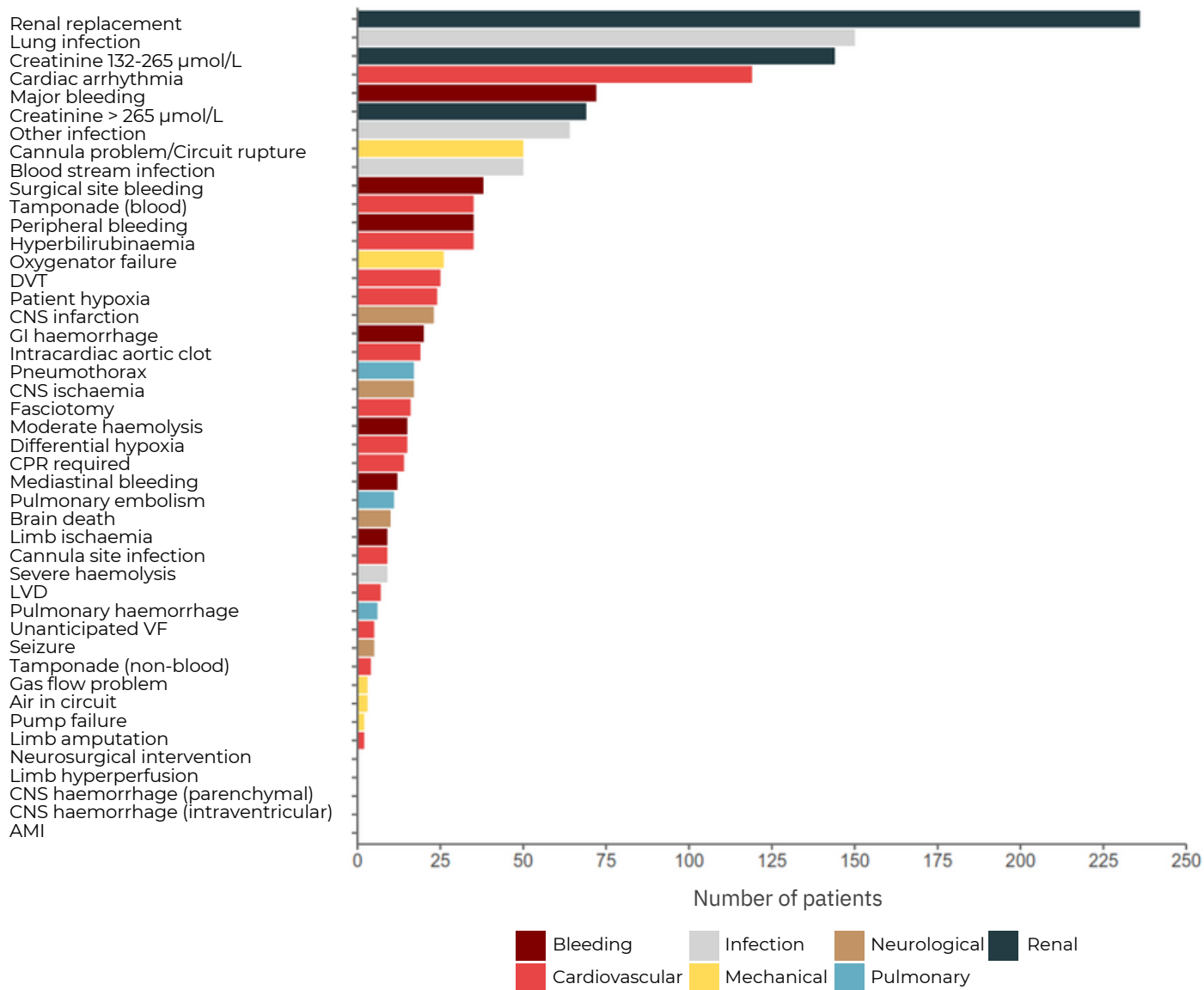


Figure 5: Distribution of ECMO complications



Figure 6: Distribution of ECMO complications stratified by ECMO mode (V-V and V-A)

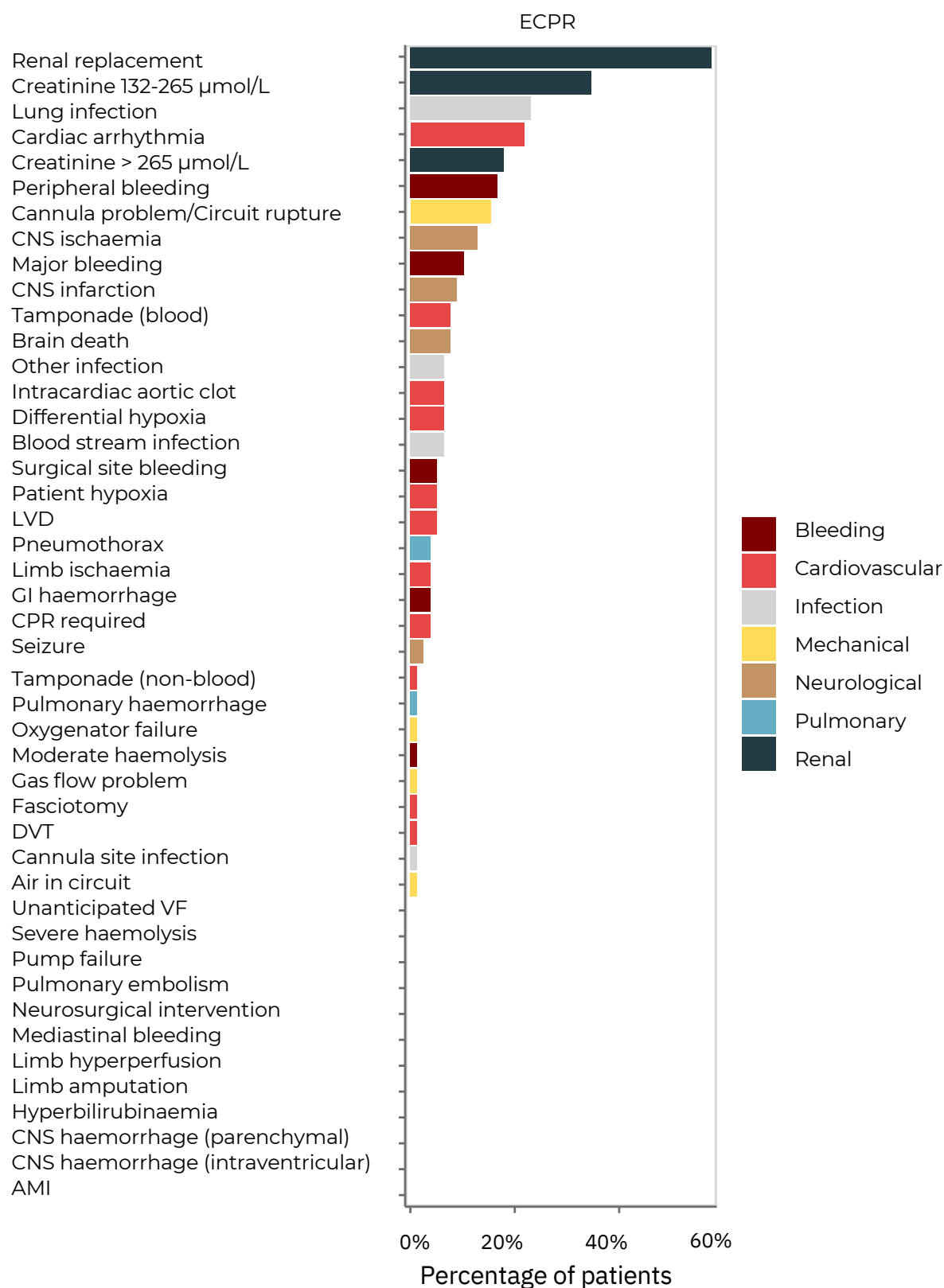


Figure 7: Distribution of ECMO complications stratified by ECMO mode (ECPR)

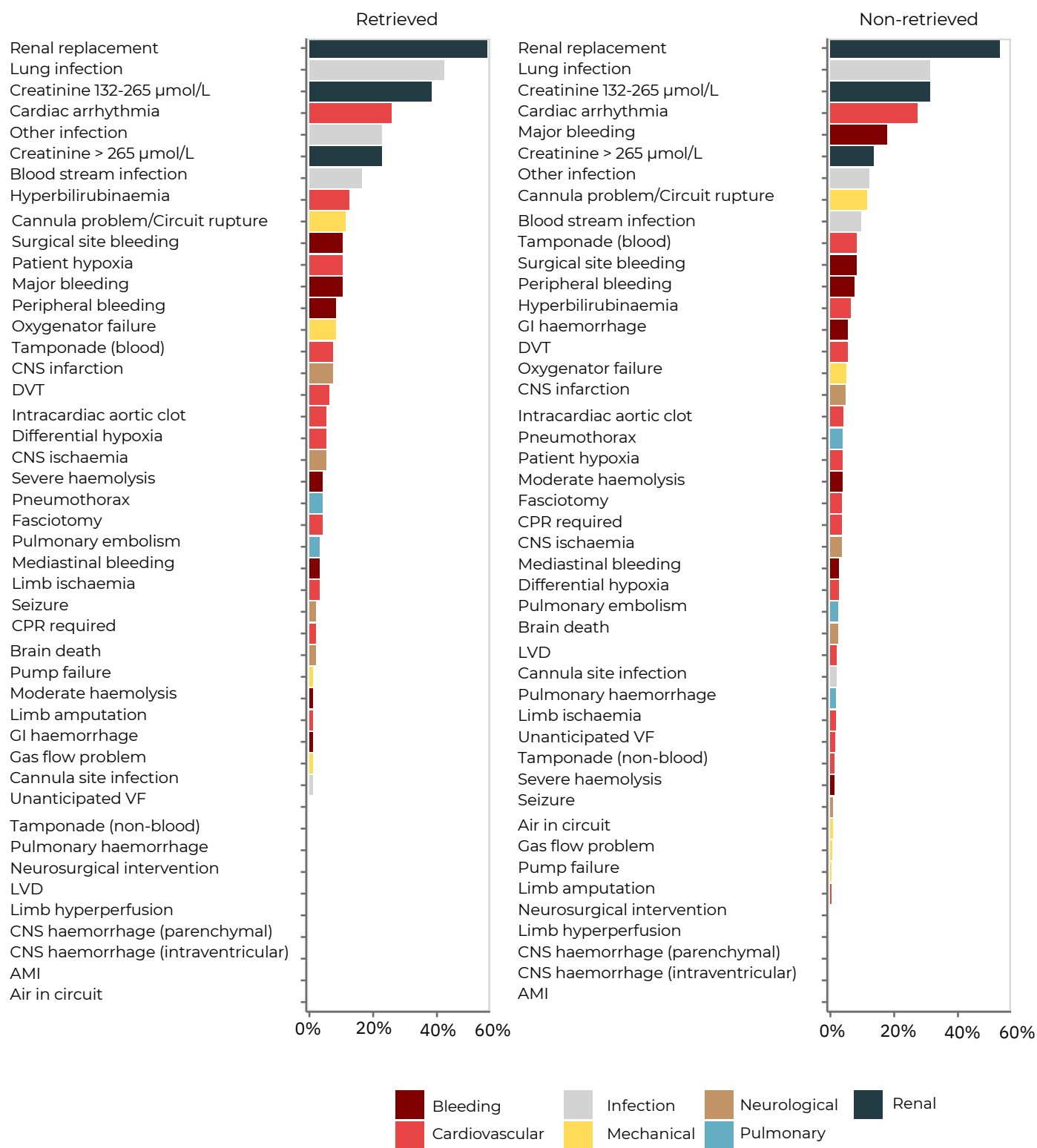


Figure 8: Distribution of ECMO complications stratified by transfer status

OUTCOME DATA

Proximate cause of death

Table 12: Proximate cause of death stratified by ECMO type

	V-V (N=150)	V-A (N=211)	ECPR (N=78)	Total (N=439)
- Cardiogenic shock	0 (0.0%)	40 (50.6%)	23 (40.4%)	62 (32.6%)
- Distributive(septic) shock	19 (35.2%)	11 (13.9%)	3 (5.3%)	33 (17.4%)
- Neurological no TBI without brain death	5 (9.3%)	7 (8.9%)	13 (22.8%)	25 (13.2%)
- Other	7 (13.0%)	10 (12.7%)	3 (5.3%)	21 (11.1%)
- Neurological no TBI with brain death	3 (5.6%)	5 (6.3%)	9 (15.8%)	17 (8.9%)
- Hypoxic respiratory failure	14 (25.9%)	0 (0.0%)	1 (1.8%)	15 (7.9%)
- Arrhythmia	1 (1.9%)	2 (2.5%)	5 (8.8%)	8 (4.2%)
- Hypovolaemic shock	2 (3.7%)	2 (2.5%)	0 (0.0%)	4 (2.1%)
- Metabolic	2 (3.7%)	2 (2.5%)	0 (0.0%)	4 (2.1%)
- Neurological TBI without brain death	1 (1.9%)	0 (0.0%)	0 (0.0%)	1 (0.5%)
- Total	54	79	57	190

The most common cause of death was cardiogenic shock (32.6%) and distributive shock (17.4%). There were 17 (8.9%) patients who suffered a neurological event that resulted in brain death during or after ECMO. A further 25 (13.2%) died because of a neurological event that did not cause brain death.

Discharge destination

Table 13: Discharge destination post-ECMO stratified by ECMO type

	V-V (N=150)	V-A (N=211)	ECPR (N=78)	Total (N=439)
ICU discharge destination				
- Ward	80 (53.3%)	120 (57.4%)	19 (24.7%)	219 (50.2%)
- Deceased	53 (35.3%)	78 (37.3%)	56 (72.7%)	187 (42.9%)
- Other hospital ICU	16 (10.7%)	10 (4.8%)	2 (2.6%)	28 (6.4%)
- Home	1 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.2%)
- Other ICU, same hospital	0 (0.0%)	1 (0.5%)	0 (0.0%)	1 (0.2%)
- Total	150	209	77	436
- Missing	0	2	1	3
Hospital discharge destination				
- Deceased	54 (36.0%)	80 (38.8%)	57 (74.0%)	191 (44.0%)
- Home	46 (30.7%)	69 (33.3%)	8 (10.4%)	123 (28.3%)
- Transferred to another hospital	31 (20.7%)	29 (14.1%)	7 (9.1%)	67 (15.5%)
- Transferred to rehab	19 (12.7%)	29 (14.1%)	4 (5.2%)	52 (12.0%)
- Other	0 (0.0%)	0 (0.0%)	1 (1.3%)	1 (0.2%)
- Total	150	206	77	434
- Missing	0	4	1	5

Overall, most patients were discharged from ICU to the ward (50.2%), 187 (42.9%) died and 28 (6.4%) were discharged to the ICU in another hospital. After hospital discharge, only 123 (28.3%) were discharged home while 52 (12.0%) were transferred to a rehabilitation facility.

Survival

We have shown survival to 180-days in Kaplan-Meier plots stratified by ECMO type (Figure 10) and by retrieval status (Figure 11). Patients receiving VV-ECMO were most likely to survive and patients receiving ECPR were least likely to survive.

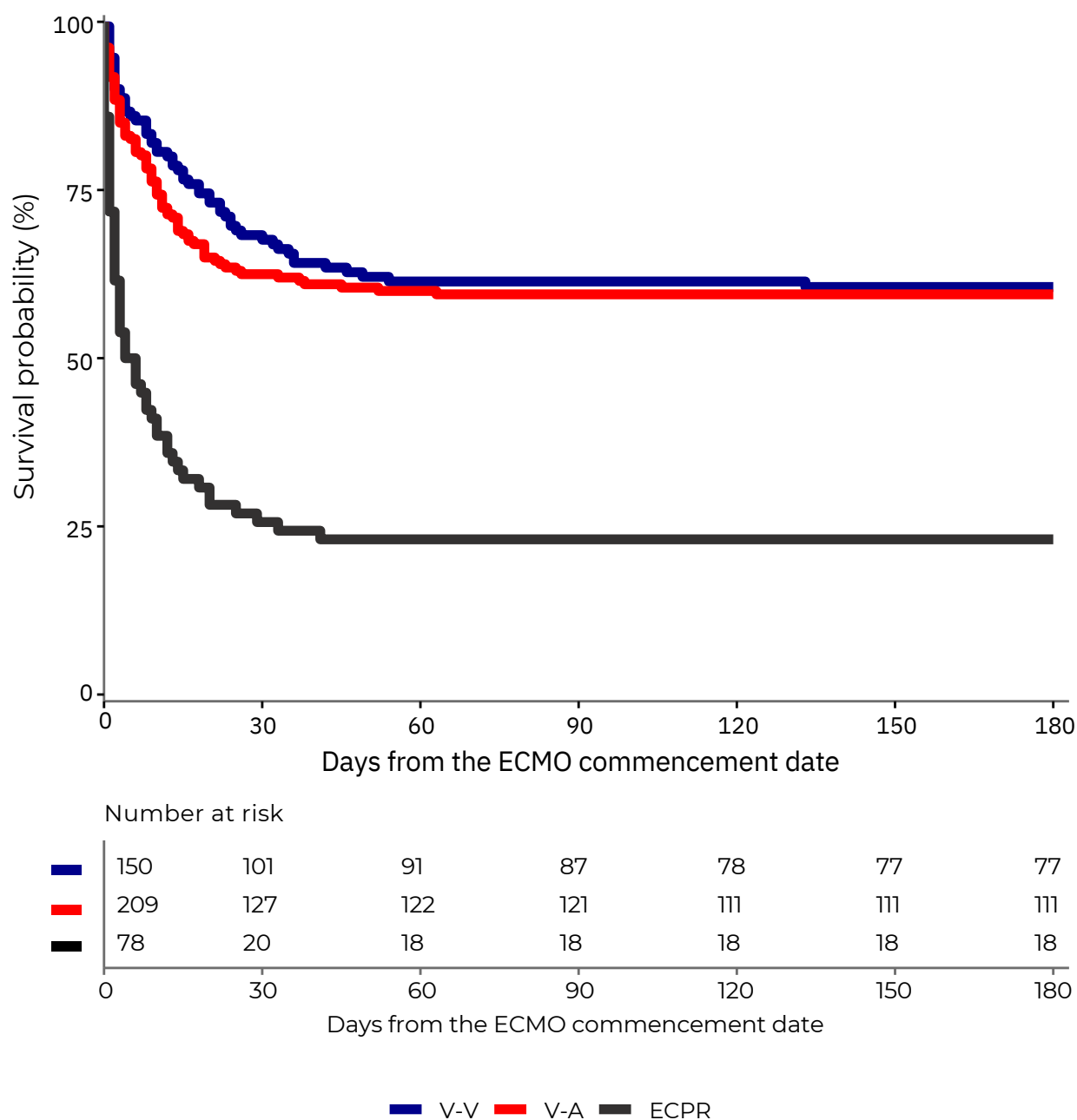


Figure 9: Kaplan-Meier plot of survival stratified by ECMO type

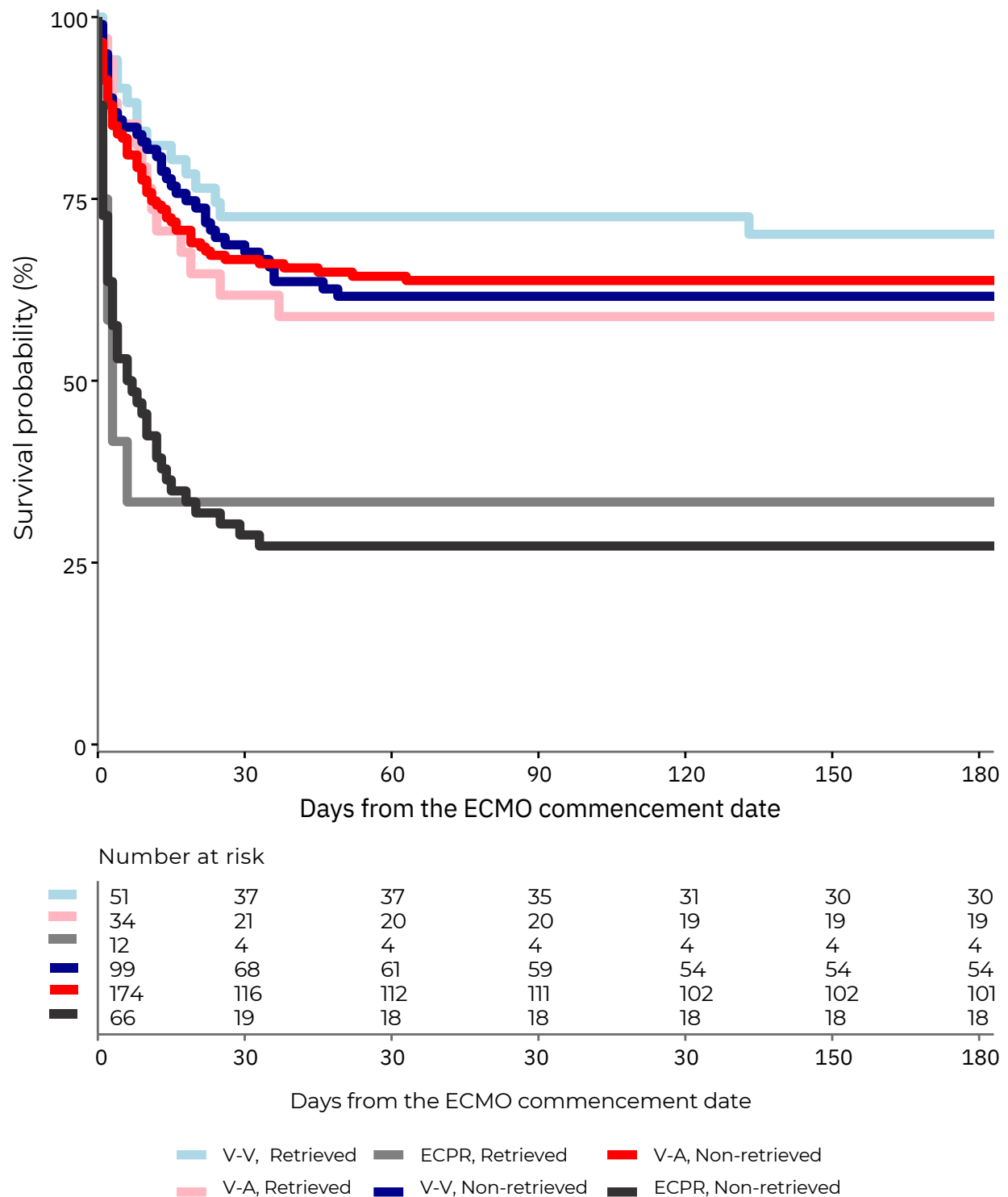


Figure 10: Kaplan-Meier plot of survival stratified by transfer status and ECMO type

Funnel plots

We provide risk-adjusted mortality for VV-patients (using the RESP score), for VA-patients (using the SAVE score) and for ECPR patients (also using the SAVE score). Each dot represents a site, and the shaded areas represent the 95% and the 99.8% control limits. In reports to each site biannually, the site is identified using a different colour to allow interpretation of outliers.

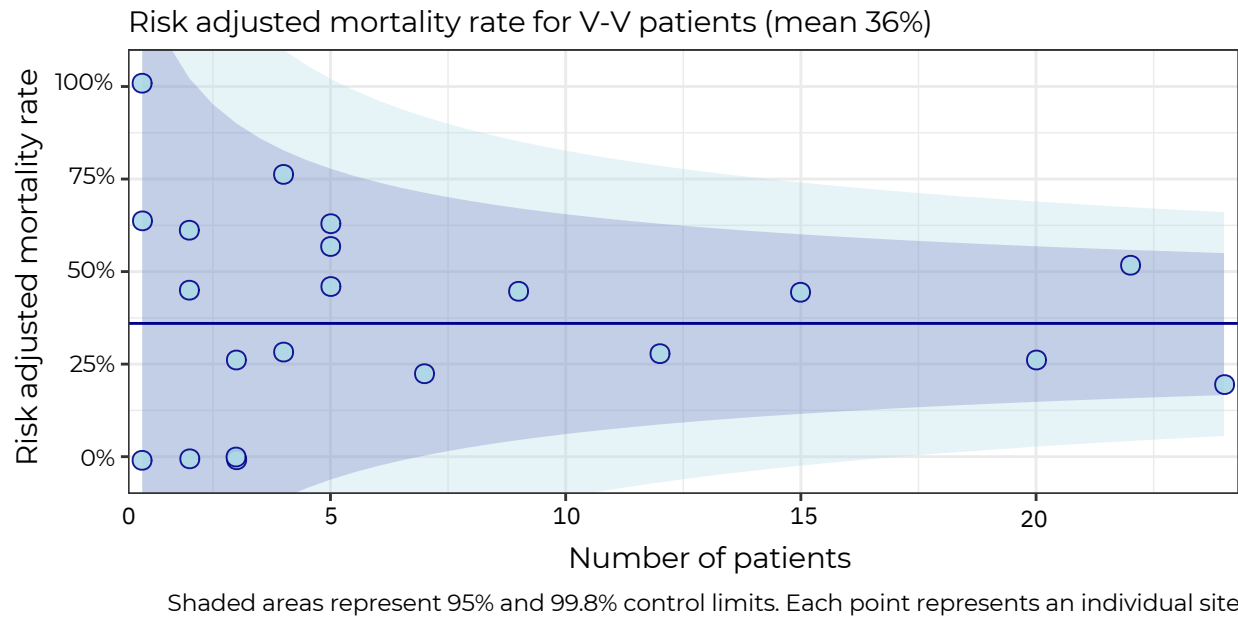


Figure 11: Risk adjusted mortality rate for V-V patients

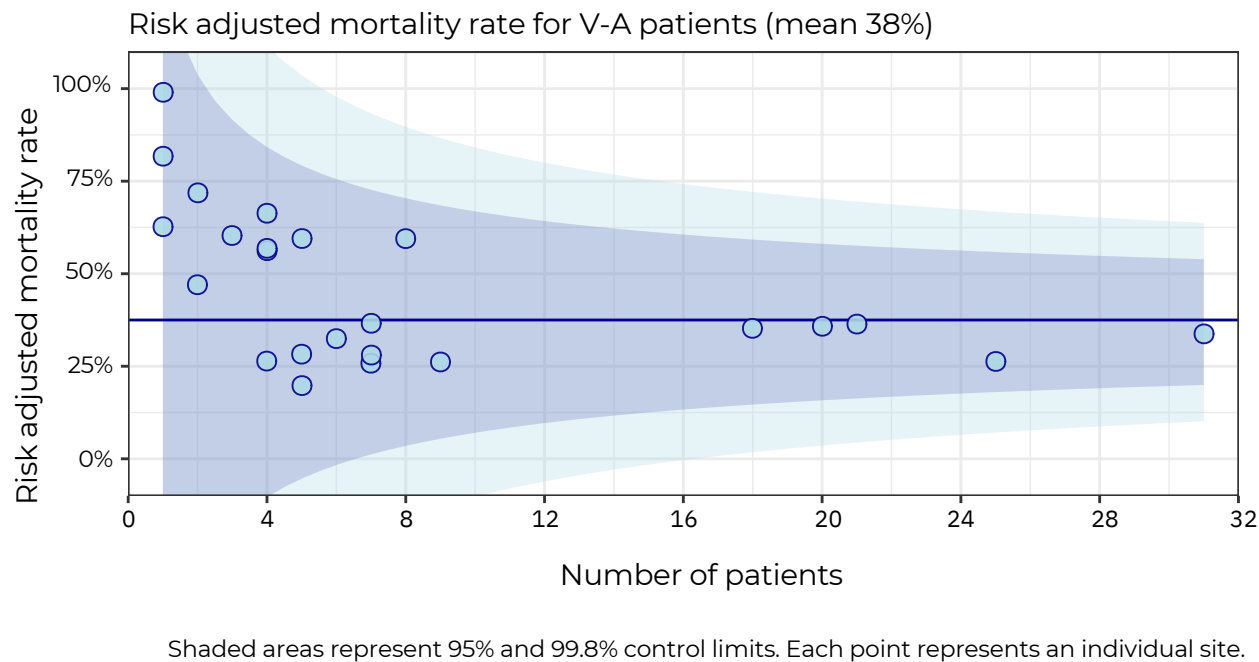


Figure 12: Risk adjusted mortality rate for V-A patients

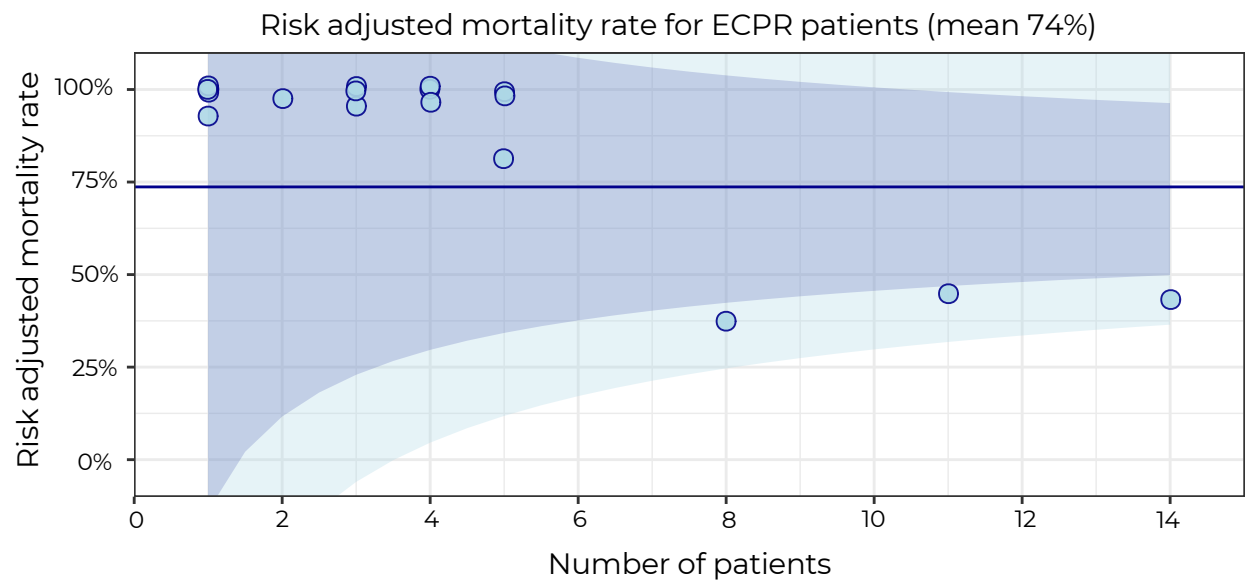


Figure 13: Risk adjusted mortality rate for ECPR patients

FOLLOW-UP 6 MONTHS POST ECMO INITIATION

Each surviving patient is followed up by telephone at 6 and 12 months. In Australia, these calls are performed by the Australian and New Zealand Intensive Care Research Centre. Follow up calls for New Zealand patients are performed by the research coordinators from Auckland City Hospital. The patient reported outcome measures (PROMS) used include:

- The Lawton IADL Scale is a valid and reliable functional assessment instrument which assesses independent living skills across 8 domains of function. A summary score ranges between from 0 and 8 with higher scores indicating greater levels of independence.
- The Barthel Index measures functional disability in 10 ADLs by quantifying patient performance. 5-point increments are used in scoring, with a maximal score of 100 indicating full independence in physical functioning whilst a lowest score of 0 indicating a patient with a complete bed-bound state.
- The EQ-5D-5L is a generic preference-based instrument that measures health related quality of life. It is comprised of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The EQ Visual Analogue Scale provides a single global rating of self-perceived health and is scored on a 0 to 100 scale representing “the worst...” and “the best health you can imagine”, respectively.
- The 12-item WHODAS 2.0 score scores from 0 (no difficulty) to 4 (extreme difficulty) for each item and a total WHODAS score ranges from 0 to 48, with higher scores representing greater disability. The total score is divided by 48 and multiplied by 100 to convert it to a percentage of maximum disability.

Table 14: Follow-up functional outcome measures and ECMO mode

	V-V (N=136)	V-A (N=166)	ECPR (N=87)	Total (N=389)
WHODAS 2.0 12L				
-Mean(SD)	26.0 (22.9)	23.0 (20.7)	23.6 (21.1)	24.2 (21.5)
-Median(IQR)	21.9 (7.8, 41.7)	17.7 (6.2, 35.4)	18.8 (6.2, 36.5)	18.8 (6.2, 37.5)
-Range	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0
-Missing	16	18	8	42
IADL				
-Mean(SD)	6.5 (2.2)	6.6 (2.1)	6.5 (2.2)	6.5 (2.1)
-Median(IQR)	8.0 (6.0, 8.0)	8.0 (6.0, 8.0)	8.0 (6.0, 8.0)	8.0 (6.0, 8.0)
-Range	0.0 - 8.0	0.0 - 8.0	0.0 - 8.0	0.0 - 8.0
-Missing	28	26	17	71
Barthel index				
-Mean(SD)	92.2 (20.1)	94.4 (14.7)	92.6 (19.1)	93.2 (17.7)
-Median(IQR)	100.0 (95.0, 100.0)	100.0 (95.0, 100.0)	100.0 (95.0, 100.0)	100.0 (95.0, 100.0)
-Range	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0	0.0 - 100.0
-Missing	28	26	17	71
Health related quality of life				
-Mean(SD)	68.0 (20.9)	69.5 (19.7)	69.4 (21.4)	69.0 (20.5)
-Median(IQR)	73.5 (59.2, 85.0)	75.0 (60.0, 85.0)	75.0 (60.0, 85.0)	75.0 (60.0, 85.0)
-Range	5.0 - 100.0	5.0 - 100.0	5.0 - 100.0	5.0 - 100.0
-Missing	16	16	8	40

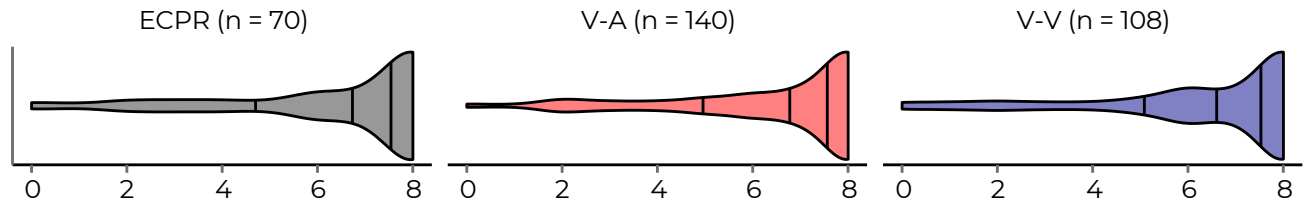
While recovery at 6-months is variable, the majority of survivors report mild to moderate disability. This is despite being able to independently manage their daily activities. Health related quality of life is similar to other survivors of critical illness.

Distribution of 6-month follow-up functional outcome measures

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

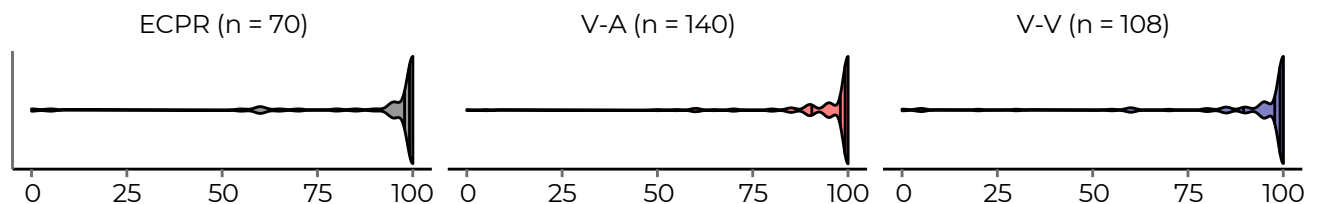
Instrumental Activities of Daily Living (IADL)

The total score may range from 0–8. Higher score indicates a higher level of independence.



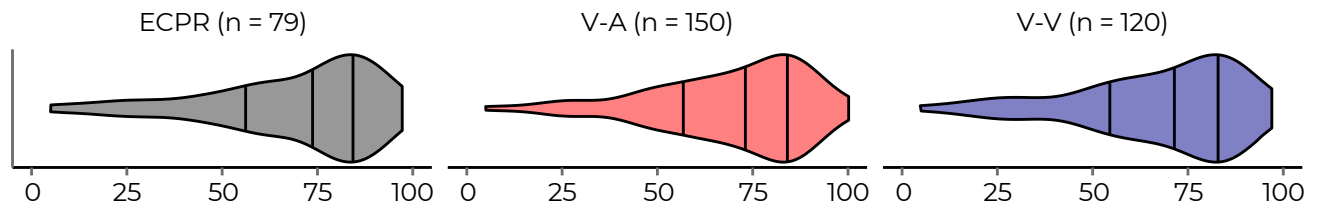
Barthel index

Higher score indicates a higher level of independence.



Health related quality of life

Higher score indicates better health and 100% indicates full health



Global health and disability (WHODAS 2.0 12L)

Higher score indicates increased disability. none (0–4%), mild (5–24%), moderate (25–49%), severe (50–95%) and complete disability (96–100%).

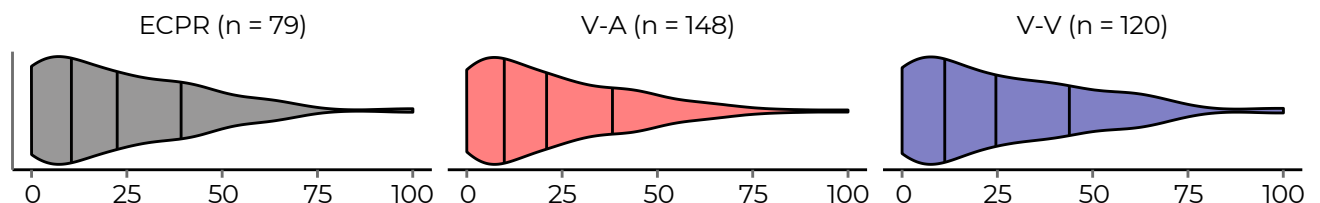


Figure 14: Distribution of follow-up functional outcome measures and ECMO mode

COVID-19 PATIENTS

In 2020 we added additional data points to determine the use of ECMO in patients with COVID-19, aligned with the data in the international registry (ELSO). There were 67 (15%) patients who were diagnosed with COVID-19 who received ECMO in this period. Patients with COVID-19 had a longer duration of ECMO, longer ICU and hospital length of stay (Figure 17). Survival of patients with COVID-19 was lower than other patients on VV-ECMO (Figure 19).

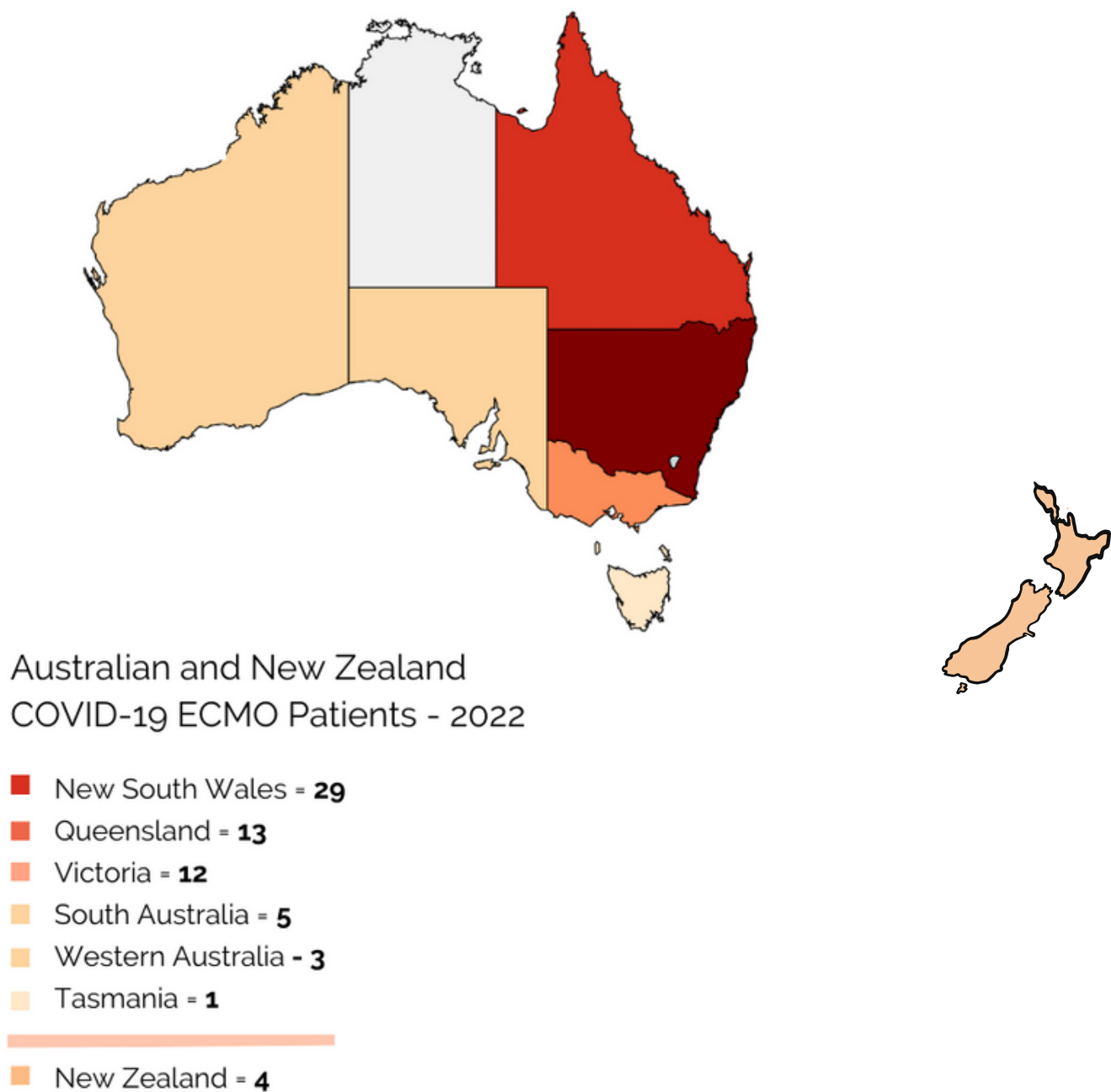


Figure 15: COVID-19 ECMO patients by state and country

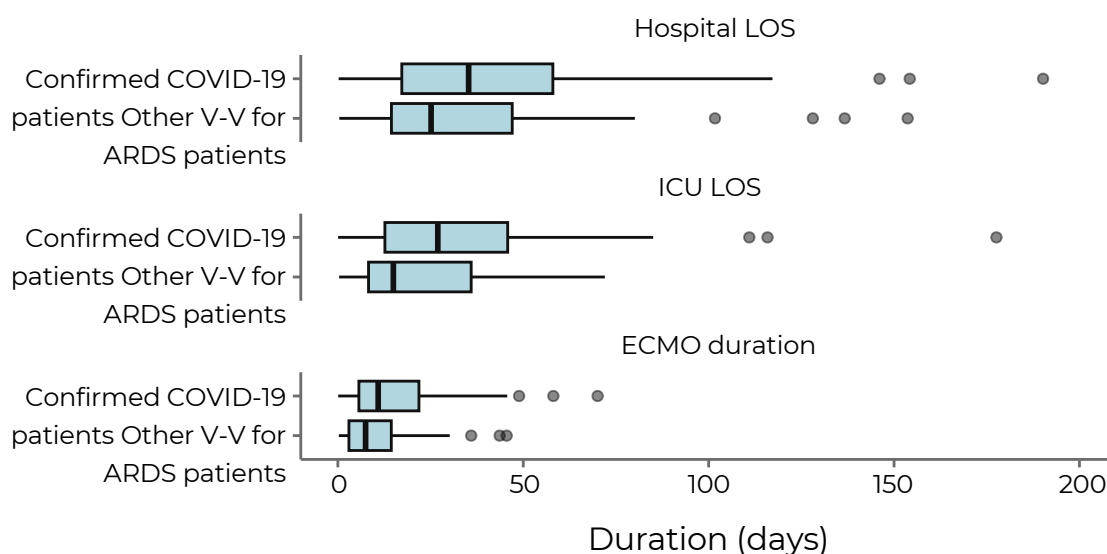


Figure 16: Distribution of length of stay stratified by COVID-19 status

Table 15 : Discharge destination post-ECMO stratified by COVID-19 status

	Confirmed COVID-19 patients (N=67)	Other V-V for ARDS patients (N=63)	Total (N=130)
ICU discharge destination			
- Ward	29 (43.3%)	31 (49.2%)	60 (46.2%)
- Deceased	32 (47.8%)	23 (36.5%)	55 (42.3%)
- Other hospital ICU	6 (9.0%)	9 (14.3%)	15 (11.5%)
- Total	67	63	130
- Missing	0	0	0
Hospital discharge destination			
- Deceased	34 (50.7%)	23 (36.5%)	57 (43.8%)
- Transferred to another hospital	14 (20.9%)	17 (27.0%)	31 (23.8%)
- Home	11 (16.4%)	16 (25.4%)	27 (20.8%)
- Transferred to rehab	8 (11.9%)	7 (11.1%)	15 (11.5%)
- Total	67	63	130
- Missing	0	0	0

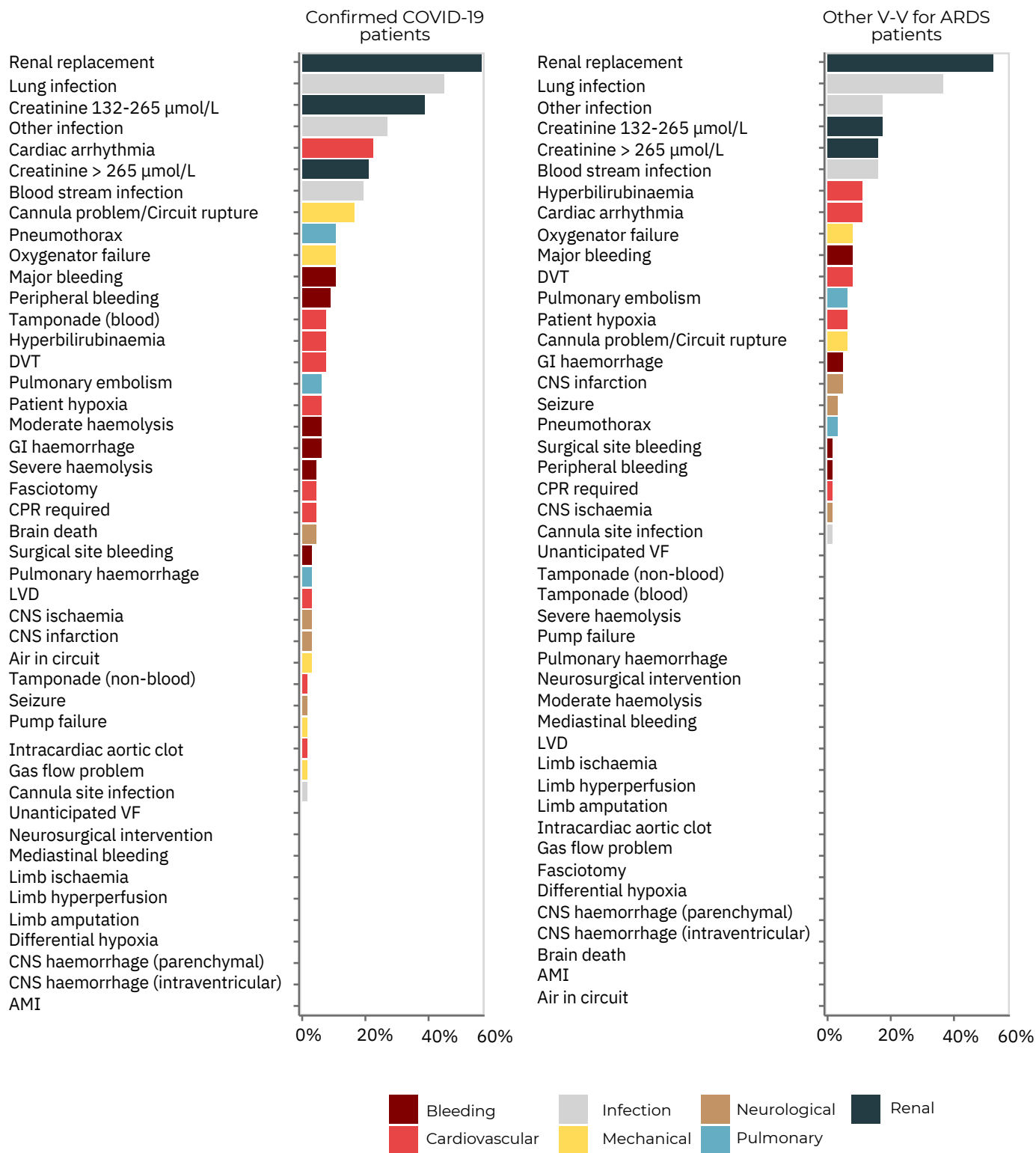


Figure 17: Distribution of ECMO complications stratified by COVID-19 status

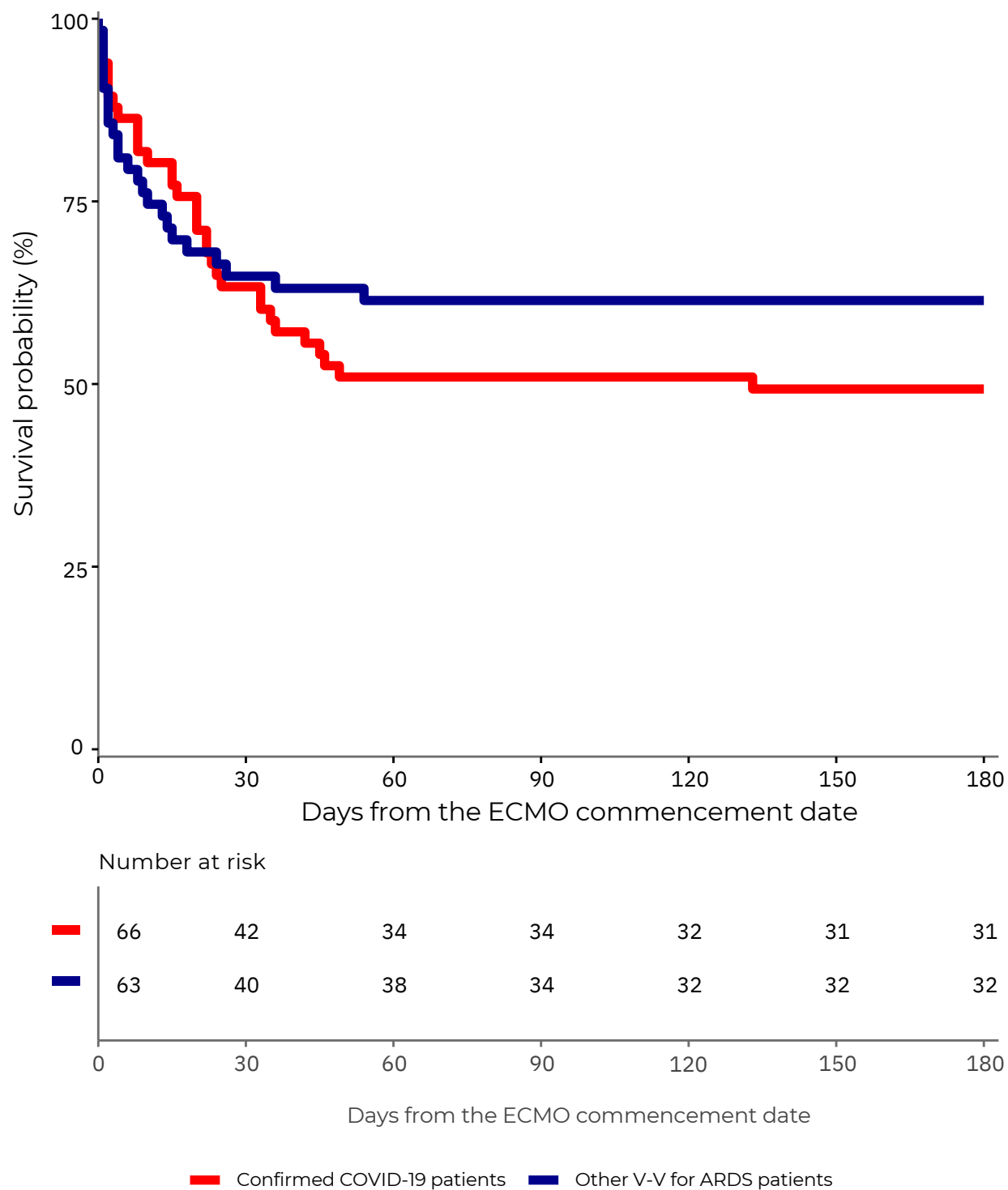


Figure 18: Kaplan-Meier plot of survival stratified by COVID-19 status

REGISTRY EMBEDDED STUDIES

EXCEL supports investigator-led research demonstrated by the completion of 26 data requests from 2019-2022. This research has resulted in publications highlighting ECMO concomitant therapies, long term outcomes and practice in Australia and New Zealand.

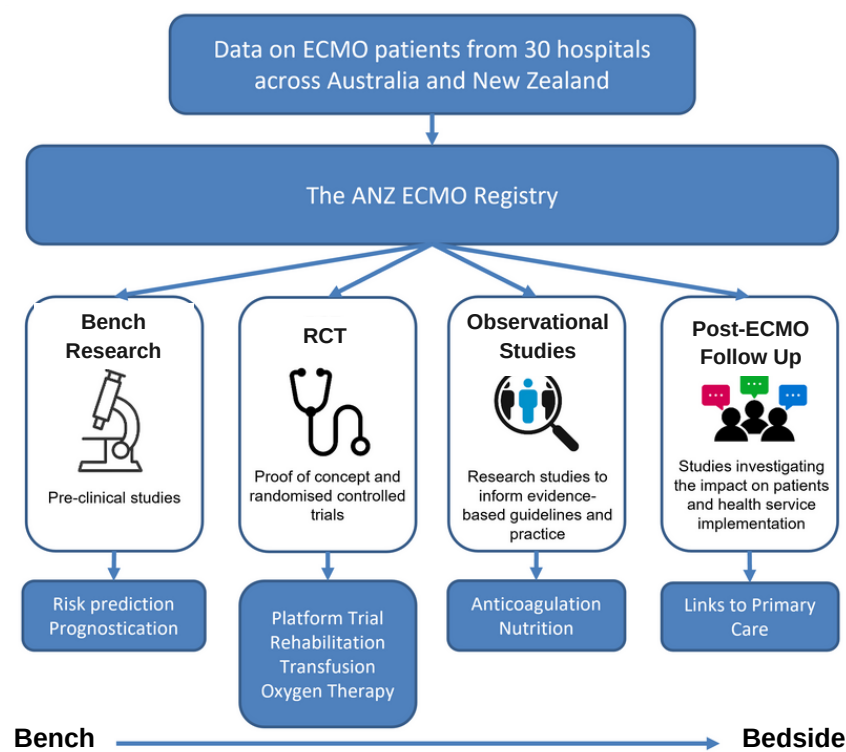


Figure 19: Types of research supported EXCEL

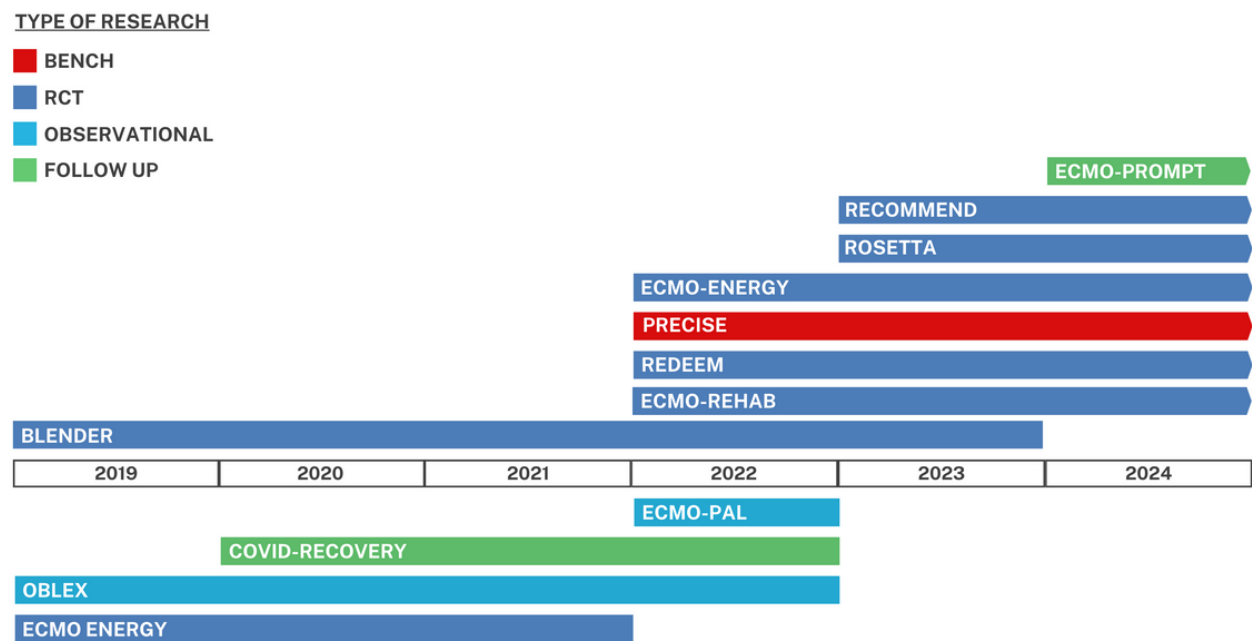


Figure 20: Studies supported by EXCEL 2019-2022

FUTURE INITIATIVES - BEYOND 2022

As the EXCEL Registry moves towards maturity, 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, safety signals, risk prediction and patient outcomes. 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. EXCEL has collaborated with the INDEX Registry for patients on ECMO in North America. In 2023 we will provide regular reports for the NSW Agency for Clinical Innovation (ACI) and Victorian ECMO Service (VECMOS) to compare practices within jurisdictions and outcomes. EXCEL has also had preliminary discussions with the Therapeutic Goods Administration (TGA) regarding data sharing.

We have been fortunate to receive partnership funding from the NHMRC, Heart Foundation, the International ECMO Network, The Dicker Family, Critical Care Research Group (CCRG), and major Australian ECMO sites including The Prince Charles Hospital, The Alfred, St Vincent's Hospital Sydney, The University Hospital Geelong, and Royal Prince Alfred Hospital. We will be exploring alternate funding models within the Commonwealth, and look forward to engaging with stakeholders to measure and report on new models of care. The EXCEL Registry will continue to work with our research collaborators, including the existing studies that are embedded within the registry.

EXCEL has had great success with our embedded clinical trials. This year, we received funding to embed our first platform trial, The RECOMMEND Platform Trial. It will investigate rehabilitation, transfusion thresholds and fluid balance during ECMO. We will continue to share all research findings with the wider community at annual EXCEL symposiums.

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.



EXCEL 2022 Symposium

From left to right:

Back row - Mr Ben Fulcher, Dr Bes Ayre, Ms Natalie Linke, A/Prof Aidan Burrell, Dr Andrew Stephens

Middle row - Dr Tony Dicker, Dr Priya Nair, Dr Lisa Higgins, Prof Carol Hodgson

Front row - A/Prof Vincent Pellegrino, Ms Pamela Butt, Ms Amanda Brown, Prof John Fraser, Mr Ian Dicker AM, Mr Tony Trapani

PUBLICATIONS

1. Hodgson CL, Higgins AM, Bailey MJ, Anderson S, Bernard S, Fulcher BJ, Koe D, Linke NJ, Board JV, Brodie D, Buhr H, Burrell A, Cooper DJ, Fan E, Fraser JF, Gattas DJ, 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, Serpa Neto A, EXCEL Investigators on behalf of the International ECMO Network and the Australian and New Zealand Intensive Care Society Clinical Trials Group (2022). The incidence of death or disability at 6-months after extracorporeal membrane oxygenation: a prospective, multicentre, registry-embedded cohort study. *The Lancet Respiratory Medicine*. 10(11) 1038-1048. doi: 10.1016/s2213-2600(22)00248-x
2. Thiara S, Serpa Neto A, Burrell AJC, Fulcher BJ, Hodgson CL(2022). Association of Respiratory Parameters at Venovenous Extracorporeal Membrane Oxygenation Liberation With Duration of Mechanical Ventilation and ICU Length of Stay: A Prospective Cohort Study. *Critical Care Explorations*. 4(5):e0689. PMID: 35517643
3. Hodgson, C.L., Fulcher, B., Mariajoseph, F.P., Burrell, A., Pellegrino, V., Brodie, D., Fan, E., & SCOPE Study Investigators on behalf of the International ECMO Network (2021). A core outcome set for research in patients on extracorporeal membrane oxygenation. *Critical Care Medicine*, 49(12), e1252–e1254. PMID: 34074857
4. 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, for the EXCEL Investigators (2020). A survey of extracorporeal membrane oxygenation practice in 23 Australian adult intensive care units. *Critical Care Resuscitation*. 22(2):166-70. PMID: 32389109
5. Fulcher BJ, Nicholson AJ, Linke NJ, Berkovic D, Hodgson CL; EXCEL Study Investigators and the International ECMO Network (2020). The perceived barriers and facilitators to implementation of ECMO services in acute hospitals. *Intensive Care Medicine*. 46(11):2115-7. PMID: 32705292
6. Hodgson CL, Burrell AJC, Engeler DM, Pellegrino VA, Brodie D, Fan E, International ECMO Network. Core Outcome Measures for Research in Critically Ill Patients Receiving Extracorporeal Membrane Oxygenation for Acute Respiratory or Cardiac Failure: An International, Multidisciplinary, Modified Delphi Consensus Study. *Crit Care Med* 2019;47(11):1557-63. PMID: 31389837
7. ECMO-PT Study Investigators; International ECMO Network. Early mobilisation during extracorporeal membrane oxygenation was safe and feasible: a pilot randomised controlled trial. *Intensive Care Med* 2020;46(5):1057-9. PMID: 32179935

APPENDIX

Complications

The EXCEL Registry currently collects a range of complications that both clinicians and researchers feel is important to know when a patient undergoes ECMO. This data will help to drive both improvement and identification of complications that present most notability within specific ECMO populations, as well as the ECMO cohort as a whole. The definitions for these complications have recently been updated with regard to new research evidence decided upon by the international ECMO community (e.g. core outcome set - Hodgson et al, Crit Care Med, 2021).

The complications captured by EXCEL are listed below.

Mechanical Complications

Relates directly to components within the ECMO circuit that are used to deliver extracorporeal support.

These include:

- Oxygenator and pump failure requiring exchange of these components
- Cannula problems and circuit rupture.
- Formation of clots within the circuit's components (connectors, bridges, pigtails) or within the haemofilter itself
- Disruption of gas flow and air within the circuit
- Heat exchanger malfunction

Haemorrhagic Complications

Due to the high acuity and often post-operative status of these patients, we collect an extensive range of bleeding complications.

These include:

- GI haemorrhage (upper or lower GI)
- Peripheral and mediastinal site bleeding.
- Surgical site bleeding (other than the cannulation sites)
- Major bleeding which can include fatal or symptomatic bleeds within critical areas or regions, as well as whether a fall in haemoglobin or transfusion has been performed.

Renal Complications

These include:

- Creatinine serum measurement of >132.
- Use of renal replacement therapy

Cardiovascular Complications

A large proportion of ECMO patients undergo intervention based upon a cardiovascular-related diagnosis. The following complications seek to elucidate further development of cardiac conditions.

These include:

- Cardiac arrest requiring CPR
- Cardiac arrhythmia requiring antiarrhythmic medications, overdrive pacing, cardioversion or defibrillation
- Tamponade.
- Acute myocardial infarction.
- Left ventricular distension requiring decompression of the left ventricle after initiation of VA-ECMO
- Unanticipated ventricle fibrillation.
- Intracardiac/aortic clot confirmed by echocardiography

Pulmonary Complications

These include:

- Pneumothorax requiring insertion of chest drain
- Pulmonary haemorrhage requiring a packed red blood cell transfusion
- Pulmonary embolism diagnosed with contrast angiography, ventilation perfusion scan, isotope scanning or CTPA.

Metabolic Complications

ECMO patients are also noted to undergo serious metabolic changes and complications.

These include:

- Hyperbilirubinemia – Based on total bilirubin or conjugated bilirubin, or the need for extracorporeal purification
- Moderate and severe haemolysis – Peaks in plasma haemoglobin sustained for 2 recordings 4 hours apart
- Patient hypoxia – With an oxygen saturation level below 80% lasting more than 5 minutes or requiring an emergency response.
- Differential hypoxia – Lower oxygen saturation readings on one side of the body when compared to the other

Limb Complications

Extended stays within ICU as well as peripheral limb cannulation sites can develop into a number of limb complications for the ECMO patient.

These include:

- Fasciotomy – Performed secondary to compartment syndrome from ECMO cannulation
- Pressure injury – Localised damage to the skin and underlying tissue caused by pressure or shearing force
- Limb amputation – Secondary to complications experienced during ECMO run
- Limb ischaemia requiring limb perfusion cannula – Post peripheral cannulation, requiring addition of limb reperfusion cannula within 6 hours of cannulation
- Deep vein thrombosis – Diagnosed with imaging (ultrasound or venography)
- Limb hyper-perfusion – Caused by the ECMO cannula, causing increased blood flow in a limb

Neurological Complications

These include:

- Brain death or neurological determination of death
- Seizures clinically determined
- Seizures confirmed by EEG
- CNS diffuse ischaemia – CT or MRI demonstrating ischaemic changes
- CNS infarction (US or CT or MRI) OR thrombotic/embolic CVA
- Intracranial haemorrhage – Acute neurological deficit attributable to intracranial haemorrhage
- Neurological intervention performed – For example, intracranial pressure monitor or external ventricular drain inserted

Other Complications

This is a free text field within the database which clinicians can enter any other complication they believe is a result of the patient being on ECMO. This has assisted in identification and addition of new complications that were not previously collected.

