Patterns and Seasonality of ECMO Referrals in the UK: A Descriptive Analysis Using Refer-a-Patient and Royal Brompton Hospital Data (2019–2025)

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Abstract

Background: Adult Extracorporeal Membrane Oxygenation (ECMO) in the UK is delivered by an eight-centre network (1) with their catchment areas based on population density. The primary method for referral to ECMO by hospitals in the UK is through an online portal – Refer-a-Patient (2).

Methods: A retrospective, descriptive study of monthly ECMO referrals using two sources: *Refer-a-Patient*; (03/2020–06/2025) and *Royal Brompton Hospital (RBH) ECMO commissioning data*; (04/2019–06/2025). Volumes, temporal trend, seasonality using STL (Seasonal-Trend decomposition using LOESS) and geospatial flows to RBH were analysed using Python.

Results: Network referrals surged during COVID-19 waves, then settled to a lower baseline with recurrent winter peaks. Excluding 2020–2021, STL showed moderate–strong seasonality (seasonality strength = 0.64; seasonal signal-to-noise ratio = 3.29) and a modest increasing trend since 2022. In RBH (n = 2,831 referrals; January 2019 - June 2025), 16.1% (n = 455) proceeded to ECMO, and 3.8% (n = 108) patients were transferred but not cannulated. Geospatially, flows were clustered locally around London, with fewer long-distance and cross-catchment.

Conclusions: ECMO referrals in the UK showed seasonality, two main decision-making stages post-referral, and higher volumes of referrals to RBH from local hospitals. Cross-catchment flows were also observed.

Keywords: ECMO, No-ECMO, cannulation, referrals, Refer-a-Patient, time-series, STL, seasonality, geospatial analysis, health equity, critical care networks, UK.

1 Introduction

ECMO (Extracorporeal Membrane Oxygenation) is a form of advanced life-support that provides temporary cardiac and/or respiratory support for patients with severe cardiac or respiratory failure. There are two principle configurations of ECMO, veno-venous (VV) ECMO used in severe acute respiratory failure (SARF), and veno-arterial (VA) ECMO used for cardiac support for example in cardiogenic shock (3).

In the United Kingdom, adult ECMO is delivered through a nationally commissioned network established in 2011 (4). The configuration of ECMO centres and their catchment areas was based on population density at time of its inception, enabling geographic coverage aligned with demand at the time. The network is currently comprised of eight centres – Bristol Royal Infirmary, Royal Brompton Hospital, Guy's & St Thomas' Hospital, Royal Papworth Hospital, Glenfield Hospital, Wythenshawe Hospital and St Bartholomew's Hospital, and Aberdeen Royal Infirmary (1).

Since the network's inception, both demographic and epidemiological landscapes have changed. The 2021 Census revealed shifts in population density, age structure and health burden across regions (5), while the COVID-19 pandemic accelerated demand for advanced respiratory support and ECMO, prompting the introduction of the national ECMO referral portal, *Refer-a-Patient* (RaP), in March 2020 (6). This enabled real-time referral coordination across centres.

These demographic changes and the addition of new ECMO centres since 2011 implies that the pressures on the ECMO network may have changed. It is therefore uncertain whether the current network configuration and catchment areas remain optimal for ensuring equitable access and efficient resource distribution. Understanding how referral patterns have evolved in the post-pandemic period is therefore essential to evaluating whether the UK ECMO network continues to meet population need.

2 Aims

1. Provide a longitudinal and seasonal analysis of all ECMO referrals recorded on *Refer-a-Patient* (RaP) to the entire network from 03/2020 to 06/2025.

2. Conduct a pooled analysis of ECMO referrals to the Royal Brompton Hospital (RBH) from 04/2019 to 06/2025.

3 Methods

3.1 Data Sources

- **Refer-a-Patient (RaP):** A national referral platform used by clinicians to refer patients for ECMO. Using the in-built data analysis tool on RaP, the following statistical reports were generated: number of referrals per hospital, total number of referrals, referral distribution, and acceptance per referring hospital for the period 03/2020–06/2025.
- **Royal Brompton Hospital (RBH) ECMO commissioning dataset (Tracker):** contains all ECMO referrals to RBH with referral decisions, and transfer and cannulation outcomes (04/2019–06/2025).
- **NHS England:** provided a complete data set with details of all commissioned adult critical care (ACC) beds in NHS hospitals in England, adult critical care network (ACCN) membership, and coordinates (accurate as of June 2025). Data were obtained via personal request to NHS England.
- **Spatial Hub Scotland:** Scottish hospital coordinates were sourced from Spatial Hub Scotland. A data collection service run throughout Scotland by the Improvement Service (7).

3.2 Inclusion/Exclusion Criteria

Included: All ECMO referrals for cardiac, respiratory or mixed organ support recorded on *RaP* or *Tracker* from 01/04/2019 to 30/06/2025. **Excluded:** Referrals requested by other means (e.g. telephone).

3.3 Variables and Preprocessing

For each dataset, the following variables were extracted: date of referral, referring hospital, ECMO decision (initiated vs not initiated), and transfer status. Data were aggregated into monthly counts for time-series analysis.

Both the *RaP* and *Tracker* datasets were provided in a cleaned and pre-formatted form, having undergone routine validation and curation prior to analysis. Accordingly, no duplicate entries were identified within the extracted data, and missing values were limited to a small number of records used for Sankey diagram generation. The Sankey diagram integrated both *RaP* and *Tracker* datasets. Data on the breakdown of the 'Not Accepted' flow was sourced from *RaP*, all other data were sourced from *Tracker*. 90 patients had missing information about the circumstances they were deemed unsuitable for ECMO, mitigated by adding 'Unknown' category (grey) to maintain completeness and transparency of reporting.

Hospital identifiers were manually standardised using look-up codes provided by NHS England to ensure consistent hospital naming and spatial alignment across datasets and outputs.

3.4 Sample Size and Power

As this was a retrospective, descriptive study, no formal power calculation was undertaken.

3.5 Dataset Usage

The analysis utilised two complementary datasets, each addressing a distinct analytical aim. The network-level dataset (March 2020 – June 2025; n = 64 months) captured aggregated referral volumes across all UK adult ECMO centres, enabling longitudinal assessment of national referral trends following the introduction of the *RaP* system. In contrast, the *Tracker* dataset (April 2019 – June 2025; n = 2,831 referrals) provided granular, hospital-level information suitable for examining referral decision patterns and generating descriptive visualisations of referral flows.

A subset of the network dataset corresponding to the post-pandemic period (January 2022 – June 2025; n = 42 months) was used for STL decomposition to evaluate seasonal variation under stable operational conditions.

3.6 Analytical Techniques

All analyses were conducted in Python (version 3.11.13; Python Software Foundation, USA) (8) within Visual Studio Code (version 1.100.3; Microsoft Corporation, USA). The analytical environment comprised the following packages: *pandas* (v2.3.0) , *numpy* (v2.2.6), *scipy* (v1.15.2), *statsmodels* (v0.14.5), *matplotlib* (v3.10.3), *plotly* (v6.3.0), *geopandas* (v1.1.0), *shapely* (v2.1.1), *folium* (v0.20.0), and *contextily* (v1.6.2).

Analyses were implemented through modular pipelines, ensuring version control and reproducibility. The Sankey diagram was generated using the web-based application *SankeyDiagram.ai* (9). Underlying code and a reproducible computational environment will be made publicly available in a repository upon completion of subsequent analyses.

3.6.1 Seasonality Analysis

To examine seasonality in ECMO referrals, data from 2019–2021 were excluded due to pandemic-associated impacts on the network that markedly altered routine referral behaviour. Monthly referral counts from January 2022 to June 2025 (n = 42 months) were analysed using Seasonal and Trend decomposition using LOESS (STL) implemented using Statsmodels v0.14.5. STL is a non-parametric time-series technique that decomposes longitudinal data into three additive components: long-term trend, recurring seasonal pattern, and an irregular residual component. This approach enables the identification of underlying cycles, as well as long term trajectories within a timeframe.

A seasonal period of 12 months was specified to capture recurring annual fluctuations in referral volumes. The smoothing window lengths for seasonal and trend estimation were determined adaptively according to data length:

$$\text{Seasonal window} = \max(13, \min(25, \lfloor N/6 \rfloor)) \quad \text{Trend window} = \max(13, \min(51, \lfloor N/3 \rfloor))$$

As STL requires odd window lengths to maintain a central reference point, should either of these parameters yield an even number it were to be rounded up to the nearest odd integer. This yielded seasonal = 13 to capture annual cycles, and trend =15, a longer window to ensure gradual structural changes were distinguished from annual variation. Robust fitting was applied (*robust* = *True*) to mitigate the influence of outliers, reducing distortion from anomalous months or residual pandemic effects.

Diagnostics:

- Seasonality strength (Fs: Range = 0-1):

$$F_s = 1 - \frac{\mathrm{Var}(R)}{\mathrm{Var}(S+R)}.$$

  To quantify the proportion of variance attributable to seasonality.

- Signal-to-noise ratio (SNR):

$$\frac{\mathrm{Var}(S)}{\mathrm{Var}(R)}.$$

  To assess how well seasonal variation dominates residual noise.

3.6.2 Geospatial Analysis

Referral origin and destination coordinates were extracted from the *RaP* dataset for the period March 2020 – June 2025 and geocoded using hospital location data from the Adult Critical Care Network (ACCN) commissioning dataset provided by NHS England. Hospital sites were represented as point features, with symbol size scaled to referral volume. Directed flow lines were generated between referring hospitals and the Royal Brompton Hospital (RBH), with line thickness proportional to total referral volume over the time-period studied. For referral acceptance rate graphs, flow line colour was determined by acceptance rate. Conversely for referral volume graphs, flow line colour was determined by referral volumes. Aggregation functions were used to group referrals by hospital in cases where there were different units in the same hospital referring for ECMO, allowing hospital-level analysis of referrals, and more intuitive visualisation. All coordinates were projected to the British National Grid (EPSG: 27700) to ensure accurate distance and area representation. The resulting flow maps were generated as PNG images for publication as well as being rendered using folium to enable interactive visualisation and interrogation of referral patterns.

3.7 Cohort Definitions

- **Died on ECMO**: Patients who died while supported on ECMO
- E**CMO-initiated**: an ECMO referral resulting in cannulation either by during a mobile ECMO retrieval or conventional retrieval.
- **ECMO Survived**: Patients initiated on ECMO, successfully weaned off ECMO
- **No-ECMO**: a referral not resulting in cannulation (declined, deferred, improved, or other).
- **Referral**: any recorded request for ECMO assessment on RaP or Tracker datasets.
- **Transferred-not-cannulated**: subset of No-ECMO that were physically transferred to RBH but received conventional management, not ECMO.

4 Results

4.1 Network-Wide Referral Volumes (03/2020 – 06/2025)

Referral volumes for ECMO in the United Kingdom during the periods analysed showed two main spikes in referral volumes in mid and late 2020 (Figure 1). During the COVID-19 pandemic referrals to UK ECMO centres increased by approximately a factor of five for wave one and two. Post pandemic, referrals reduced to lower levels, with recurrent winter spikes (e.g. late 2022 and 2024), presumably due to seasonality of respiratory pathologies causing severe acute respiratory failure (SARF).

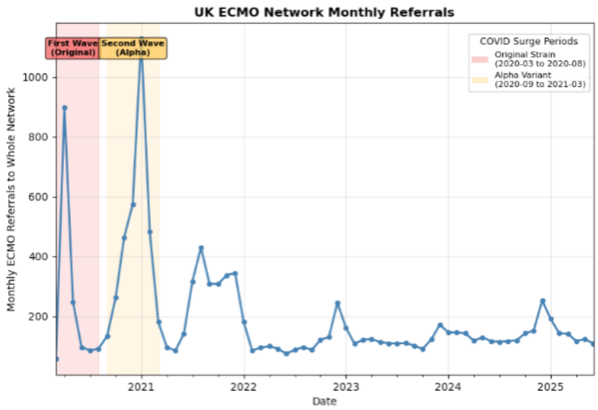

Figure 1: Monthly ECMO referral volumes recorded on RaP (03/2020 – 06/2025) Wave One – Red (03/2020–08/2020), Wave Two – yellow (09/2020–03/2020). *Dates courtesy of NHS England Commissioners*

4.2 Seasonality

After exclusion of referrals during the pandemic period, analysis of ECMO referrals between January 2022 and June 2025 ($n = 42$ months, mean 128 ± 37.6 referrals per month) demonstrated that most variation was attributable to the long-term trend and seasonal components (Figure 2).

The trend component indicated a modest average increase of +0.69 referrals per month, with gradual growth until early 2024 followed by plateau and slight decline. The seasonal component exerted a stronger influence, with a seasonality strength of 0.64 (moderate–strong) and an amplitude of 161.4 referrals. This was characterised

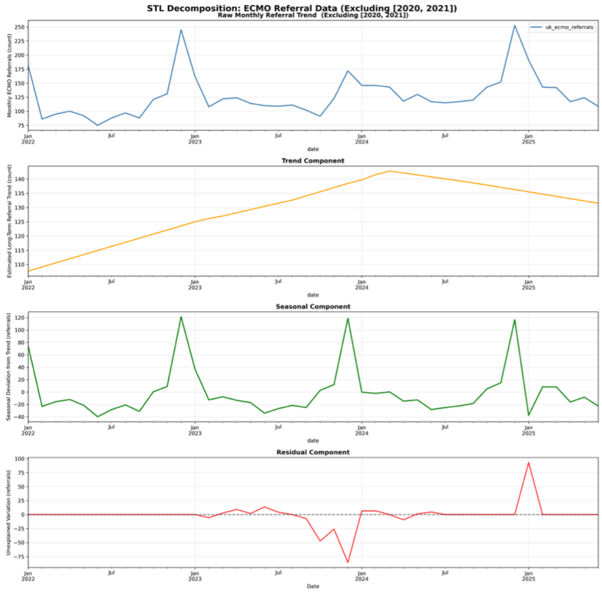

Figure 2: STL decomposition of monthly UK ECMO referrals (01/ 2022–062025). Blue = Raw referrals/month. Yellow = Trend component. Green = Seasonal component. Red = residual variation.

by consistent winter peaks up to 121.4 referrals above baseline and summer troughs approximately 39.9 below.

The residual component accounted for a smaller proportion of total variation (signal-to-noise ratio 3.28; residual SD 21.8). Occasional outliers were observed (range –85.5 to +93 referrals), including notable surges in December 2023 and January 2025.

4.3 Outcomes of ECMO referrals to RBH (04/2019 – 06/2025)

Most referrals did not result in cannulation onto ECMO (n = 2,268; 80.1%), primarily due to perceived futility (n = 896; 31.6%) or being managed at the referring unit (n = 823; 29.1%). Accepted and transferred cases numbered 563 (19.9%); of these, 108 were not cannulated but transferred to an ECMO centre for expert care, while 455 (16.1% of all referrals) started ECMO (Figure 3).

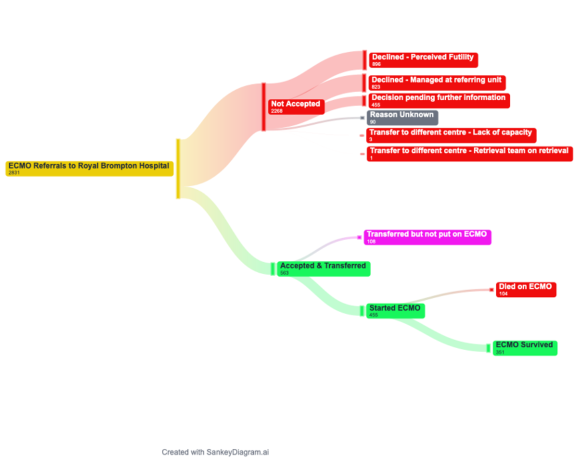

Figure 3: ECMO referral pathway to Royal Brompton Hospital (04/2019 – 06/2025; n = 2,831 referrals)

4.4 Geospatial analysis of ECMO referrals to RBH (03/2020 – 06/2025)

4.4.1 Referral Volumes

109 different hospitals sent 2,831 referrals through *RaP* to RBH for ECMO in the time period 03/2020–06/2025. Geospatial analysis indicates that local hospitals refer higher volumes of patient to RBH for ECMO, whilst there were smaller volumes from peripheral centres found outside the published catchment areas for ECMO (Figures 4 and 5). Larger volumes originate from hospitals in closer proximity to London, while lower-volume referrals are distributed more widely from peripheral regions (Figure 5).

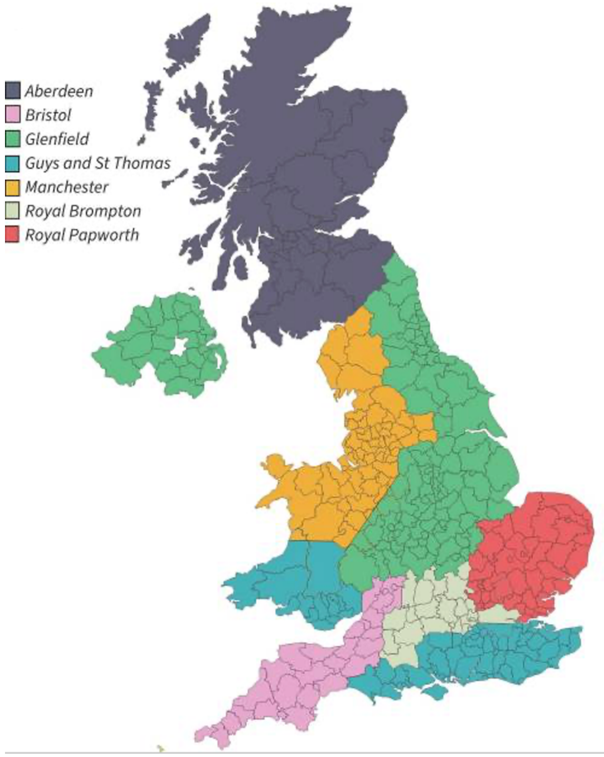

Figure 4: Catchment areas of the centres forming the UK's Adult ECMO network (10) (© Bruce Jones Design 2024)

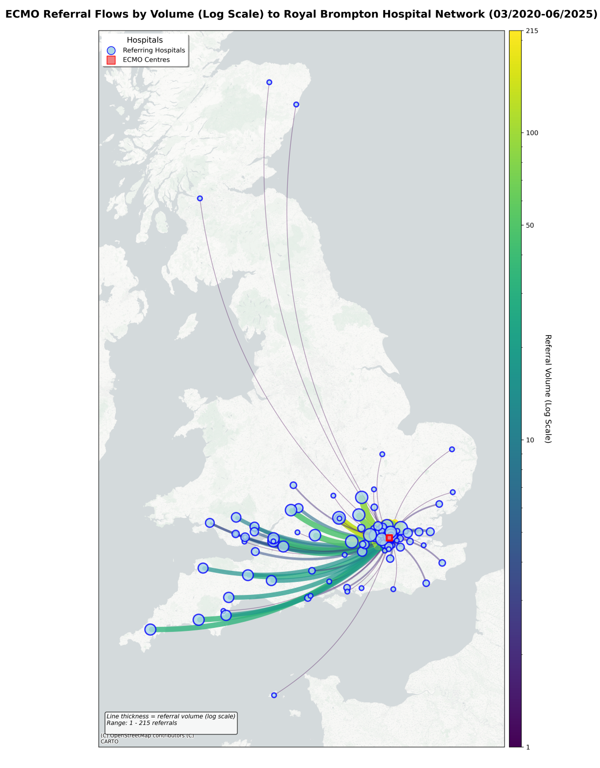

Figure 5: ECMO referral flows to the Royal Brompton Hospital network (04/2019 – 06/2025) by volume (log scale). Referring hospital (blue circles), Royal Brompton Hospital (red square). Line thickness is directly proportional to referral volume, colour indicates referral volume on a logarithmic scale (range 1–215 referrals).

4.4.2 Referral Acceptance

Geospatial mapping of ECMO referrals to RBH shows heterogeneous acceptance rates. Many flows display acceptance rates of <25% (Figure 6), aligning with the Sankey Diagram (Figure 3) visualisation of the RBH ECMO referral outcomes.

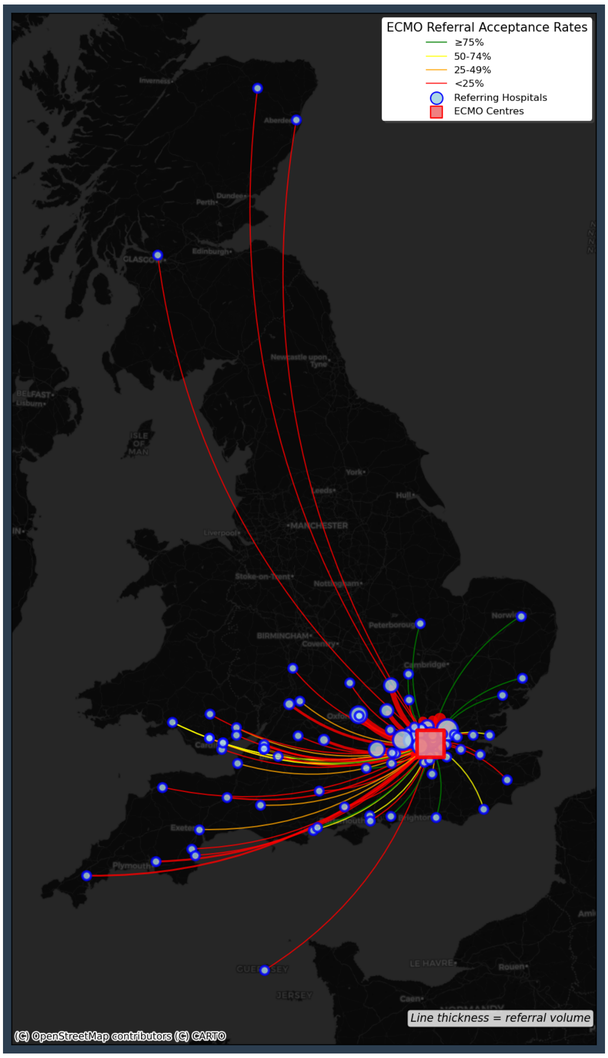

Figure 6: Acceptance rates of referrals to RBH Lines connect referring hospitals (blue circles) to RBH (red square). Line thickness and circle size are proportional to referral volume; line colour indicates acceptance-rate bands: green $\geq 75\%$, yellow 50-74%, orange 25-49%, red $< 25\%$.

5 Discussion

This retrospective database study offers an initial national description of ECMO referral volumes, as well as a preliminary single-centre description of the nuances behind ECMO referral behaviour and may inform further analyses across the network. While seasonality in SARF has been recognised (11), this project quantified its impact on ECMO referrals and introduced geospatial mapping to enhance visualisation of referral patterns beyond traditional numerical reporting. The descriptive nature of this work does not allow causal inferences to be made; however, this project still generates important findings with regards to referral behaviour, motivating further research.

5.1 Referral pathway outcomes at the Royal Brompton Hospital (RBH)

The Sankey diagram demonstrates two key decision stages following referral submission. The first involves an initial assessment of ECMO suitability based on information provided through the Refer-a-Patient (RaP) portal and discussion with the referring team. The second occurs when the ECMO retrieval team arrives at the patient's bedside in the referring hospital to perform a direct clinical assessment before cannulation.

At RBH, 83.8% (n = 2372) of referrals did not progress to cannulation, 108 of these were accepted and transferred. This raises important questions about the purpose of referrals: whether they primarily represent requests for ECMO or, alternatively, for specialist input in advanced ventilatory management and diagnostic work-up. Future analyses incorporating case-mix data, hospital and geographical context for the No-ECMO cohort are essential to evaluate provision of ECMO in the UK.

5.2 Seasonality and temporal variation in referral volumes

The observed seasonal pattern indicates that ECMO referral activity in the post-pandemic period fluctuated predictably, with winter peaks corresponding to established trends in respiratory disease incidence. This finding aligns with the expected seasonality of pathologies underlying severe acute respiratory failure (SARF) (11). The moderate-strong strength of the seasonal component ($F_s = 0.64$) suggests that these fluctuations are stable and recurrent rather than irregular or unexpected.

The modest upward trend in referrals until early 2024, followed by a plateau and slight decline, may reflect a gradual normalisation of service utilisation following the pandemic. As population immunity to SARS-CoV-2 strengthened and public-health restrictions were relaxed, previously suppressed respiratory pathogens likely re-emerged, contributing to the re-establishment of pre-pandemic seasonal patterns.

Residual variation was limited, implying that most month-to-month fluctuations in ECMO referral volume can be attributed to predictable seasonal and temporal factors, with only a few months showing atypical surges. Such episodes may represent transient operational pressures or localised epidemiological events rather than systemic instability.

Collectively, these findings demonstrate that ECMO referral activity in the post-pandemic period is governed primarily by predictable seasonal drivers, with minimal unexplained fluctuation. Quantifying these patterns provides an evidence base for evaluating service capacity, supporting proportionate resource planning and preparedness for both routine winter pressures and potential future system shocks.

5.3 Geography

Out-of-area referrals were infrequent, as expected given the defined catchment configuration of the UK ECMO network. Such referrals likely reflect capacity-related transfers between centres or requests for second opinion rather than de novo referrals from outside a centre's usual population base. When local capacity is available, second-opinion cases are rarely transferred. This underscores the value of further network-wide analyses in characterising inter-centre referral dynamics and assessing equity of access.

5.4 Acceptance Rates

Acceptance rates are challenging to evaluate as they are inherently nuanced. Patient factors (e.g. age, comorbidity, severity), referrer factors (population served, local disease burden, thresholds), and centre factors (capacity, consultant receiving referrals) could all play a role in driving these patterns. The Sankey Diagram shows the main steps where patients are accepted or declined well. However, it is important to note that despite strict criteria that guiding ECMO referrals (12) and their acceptance, these decisions are multifactorial and follow a chain of clinical determinants, not a single yes/no rule. The decision not to initiate a patient on ECMO is an outcome of consistent re-evaluation of that patient throughout their journey in the referral pathway and not a single decision point.

Selection criteria also evolved during COVID-19 (13). This too may have impacted acceptance rates during the studied timeframe and indicates the evolving nature of criteria for patient selection. Should a longitudinal analysis of acceptance rates be carried out such changes should be explicitly noted.

5.5 Commissioning framework & international context

In the UK, ECMO is commissioned nationally as a highly specialised service by NHS England as it is a rare intervention associated with high-costs and specialist skillsets (14). Its delivery is governed by a national service specification (5) that outlines eligibility criteria, interdependencies (ECMO centre location, 24/7 retrieval), quality reporting and audit metrics. Operationally the network follows a hub-and-spoke model with eight centres providing cannulation, retrieval, and complex care, while referring hospitals access the network via a standardised referral pathway *Refer-a-Patient* (2). As the UK is formed of devolved nations, the ECMO Network is a cross jurisdictional service with multiple levels of stakeholders across four countries, adding complexity to its delivery with cross-border agreements enabling patients from the other home nations to access ECMO centres in England (15). However, concentrating cases over a finite number of centres is strategically important: current research indicates that there is a volume outcome relationship, with centres with higher caseloads reporting decreased mortality (16–18). Internationally, a nationally coordinated ECMO network such as the UK's is unusual. However, whilst no international comparative studies adjusting for demographic variability were found during an extensive literature review, research indicates that the UK's ECMO network has better ECMO survival to ICU discharge (74%) (19) in comparison to France (64%)(20), Australia and New Zealand (71%)(21), and 57% of patients being alive at hospital discharge in the

USA (22). This may potentially in part be due to the UK's centrally coordinated network structure in combination with the strict case-selection.

The COVID-19 pandemic highlighted how ECMO referral criteria and clinical practice evolved within this national framework. Early in the pandemic, variation in the duration and intensity of non-invasive ventilation prior to referral revealed the risk of delayed escalation in patients with severe hypoxaemic respiratory failure (13). Earlier identification and referral were therefore prioritised, alongside stricter adherence to lung-protective ventilation strategies. These coordinated changes were made possible because ECMO in the UK operates within a centrally commissioned, networked framework. Enabling adjustments to be implemented quickly and uniformly across all centres. This capacity for system-wide learning and adaptation represents a key strength of the UK's model of ECMO provision.

5.6 Why this analysis matters to NHS England

This project has depicted the referral pipeline for ECMO in the UK to one centre. It visualises referral volumes and demonstrates that a substantial proportion of referred patients are not ultimately initiated on ECMO. Understanding where, when, and how patients are referred helps commissioners evaluate equity of access, identify capacity pressures, and optimise network design. Such granular data can inform service planning and catchment delineation, Integrating these referral trends with national ICU and hospital admission data could enable real-time forecasting of capacity needs and support dynamic resource allocation through a national ECMO dashboard, an approach aligned with NHS England's broader digital transformation agenda as part of their 10-year plan (23).

Furthermore, there is a drive within NHS England to form more of these highly specialist care networks, for example for cardiogenic shock (24). Analysing ECMO delivery in the UK not only has the potential to improve outcomes within the ECMO network but will be able to inform ground-up development of other services into robust and resilient assets to the NHS.

This project serves as a proof-of-concept for how routinely collected data can strengthen accountability, resilience, and fairness in delivering complex, high-cost critical-care services. It will continue to develop into a larger programme quantifying equity, efficiency, and outcomes across the entire network.

5.7 Limitations

For this analysis several limitations should be acknowledged.

Firstly, the analysis was descriptive, limiting causal inference, and was based on referral-level rather than patient-level data – preventing adjustment for case-mix, comorbidity, or disease severity. The STL decomposition provided valuable quantification of seasonality and trend; however, interpretation of the post-COVID plateau would be strengthened by additional reference years as epidemiological patterns stabilise.

Geospatial analysis in this study represents an initial single-centre analysis within a nationally commissioned service. Findings therefore reflect referral behaviours specific to the Royal Brompton Hospital and may not fully capture variation across the wider ECMO network.

Findings were further constrained by incomplete contextual data, such as referrer intent or inter-centre capacity factors, while acceptance-rate analyses were less stable for low-volume referrers. Moreover, several unmeasured influences, including local thresholds for escalation, temporary capacity pressures, and consultant decision-making, may have affected observed referral outcomes. Finally, this project examined one component of the national ECMO referral pipeline; integration with hospital and ICU admission datasets across all referrers and centres would allow more robust, generalisable conclusions and underpin the development of real-time national monitoring tools in future work.

5.8 Future work

The next phase of this work will focus on how geographic distribution of referrals and acceptance changed over the course of the pandemic and thereafter with the addition of a new ECMO centre (Bristol) to South England.

Subsequent steps will focus on linking referrals to patient-level characteristics and outcomes, estimating per-capita referral and acceptance rates by region, and applying mixed-effects, case-mix-adjusted models to quantify centre- and geography-specific effects. Auditing pathway frictions such as time-to-decision and retrieval distances and times will also be key to evaluating efficiency. In parallel, integrating referral and outcome data with national ICU admission and capacity datasets could enable real-time forecasting and inform service resilience. Together, these analyses will enable a more rigorous evaluation of equity in ECMO access and inform targeted, evidence-based service planning.

6 Conclusions

Referrals to the ECMO network as a whole through Refer-a-Patient increased sharply during the COVID-19 pandemic but have since stabilised into a seasonal pattern, with consistent winter peaks reflecting the seasonality of pathologies causing SARF.

16.1% of referrals progressed to cannulation, with a proportion (n = 108) being accepted and transferred but ultimately not initiated on ECMO. This highlights the complexity of referral decision-making and the importance of clarifying whether referrals are primarily intended for ECMO initiation or for specialist input in advanced respiratory care.

Referral volumes were higher in areas surrounding the Royal Brompton Hospital; however, this pattern likely reflects higher population density in the London periphery rather than proximity alone. Cross-catchment referrals were also observed, suggesting that factors such as local capacity pressures and case complexity may influence referral behaviour. These findings highlight the need for broader, network-wide analyses to disentangle geographic accessibility from demographic and operational determinants of ECMO referral activity.

Seasonal analysis indicated that ECMO referral activity fluctuated throughout the year but followed a consistent and predictable pattern, aligning with established winter peaks in respiratory illness. These results suggest that routine seasonal variation in ECMO demand is stable and expected. Deviations from this pattern, such as those observed during pandemic periods, likely reflect exceptional system-wide pressures rather than underlying changes in referral behaviour. While such events are infrequent, they highlight the need for strategic consideration of how much reserve capacity should be maintained to balance preparedness for future surges against the financial and operational constraints of service delivery.

Together, these findings underscore the need for ongoing evaluation of ECMO delivery in the UK, as well as careful planning of service capacity to ensure resilience in the face of both predictable seasonal pressures and future system shocks.

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