Final Report
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Evaluation of the Community and Acute Respiratory Excellence (CARE) Virtual Ward

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Executive Summary

This report summarises findings from an independent evaluation conducted of the Community and Acute Respiratory Excellence (CARE) Virtual Ward (CVW) in co Donegal for high-risk Chronic Obstructive Pulmonary Disease (COPD) patients over the period November 2023 – May 2025. This community-based model of care used continuous Respiratory Rate (cRR) monitoring, to detect early signs of clinical deterioration of patients, with the aim of providing remote monitoring of patients, reducing hospital admissions and empowering patients to manage their condition proactively in partnership with their community-based clinical team.

The CVW was delivered through two models:

Model 1: PMD provided a Managed Service Model with RespiraSense and myPatientSpace (MPS) (November 2023 – December 2024)

In this model, PMD provided chest-worn RespiraSense cRR monitoring devices, and dedicated technology nursing support for patient on-boarding, troubleshooting and patient off-boarding. The clinical dashboard, patient application and data integration with RespiraSense was managed by MPS. The CARE clinical staff focused exclusively on patient care and monitoring, facilitating coordinated care by organising daily multidisciplinary huddles.

During a transition period due to operational change, January 2025 – March 2025, the CVW was temporarily paused, as alternative technology was sourced.

Model 2: HSE-Managed Service with MPS and Crosano (March 2025 – May 2025)

In this model, MPS continued to provide end-to-end virtual ward service directly to the HSE. This included the integration and provision of the new Crosano wrist-worn device, capable of continuous RR monitoring and continued data integration on the MPS platform.

The overall evaluation highlighted significant cost savings, health benefits and positive patient and staff experiences associated with the use of the two CARE virtual ward models of care, managed by the myPatientSpace (MPS) virtual care platform with two continuous monitoring devices: RespiraSense (Model 1) and Corsano (Model 2), over the evaluation period.

Economic evaluation findings:

- **Cost Savings**: The CVW was cost saving to the HSE with potential cost savings of €4,218,727.50. Model 1 led to average healthcare savings of €192,257 per patient (p-value: 0.06), while Model 2 saved €177,742 per patient (p-value: 0.04). Both models with continuous RR devices also improved quality-adjusted life years (QALYs), with increasing mean QALYs by 0.10 (Model 1) and by 0.12 (Model 2). While the CVW

Model 1 demonstrated greater cost savings, these results may be impacted by the larger sample size of patients compared to the smaller patient sample size admitted under Model 2.

- **Resource Use**: The CVW led to 250 admissions under Model 1 and 23 admissions under Model 2, saving a total of 934 bed days. The average cost per patient admitted under Model 1 was €2,851.50 and €1,607.14 under Model 2.
- **Cost-Effectiveness**: The CVW was a more cost-effective model of care compared to hospitalisation, indicating a high probability of cost-effectiveness (63.8% for Model 1 and 96.6% for Model 2) and positive incremental net benefits for both models of care.
- **Quality of Life Improvements**: During care under Model 1, patients had a non-significant increase in health status, while during care provided under Model 2, patients reported a significant improvement in quality of life (mean discharge score of 67.3, $p = 0.03$).

Patient experience insights:

- **Interviews Conducted**: Ten semi-structured interviews with COPD patients and carers highlighted the importance of family support in using the continuous RR technology during admission to the CVW.
- **Accessibility**: Initial apprehension diminished with staff and family support. Some found the Model 1 continuous RR device (RespiraSense) uncomfortable, while Model 2 continuous RR device (Corsano) users had no issues.
- **Acceptability**: Participants valued the reassurance of being monitored, quick access to clinical staff, and the CVW ensuring avoidance of hospital admissions.
- **Impact on Disease Management**: Patients reported increased symptom awareness and earlier access to care.
- **Suggestions for Improvement**: Recommendations included more flexible questionnaire responses, daytime monitoring options, and better feedback post-admission.

Staff perspectives

- **Positive Experience**: A survey of 15 CARE staff indicated strong collaboration and high satisfaction (73.3%) with the virtual ward experience.
- **Impact on Patient Quality of Life**: Staff noted improved patient management and reduced hospital admissions, with 66.7% rating their influence on patient quality of life as moderate to high.
- **Recommendations for Improvement**: Suggested enhancements included better engagement strategies, clearer communication among staff and patients regarding digital tools and devices, and improved patient co-production.

Overall, the CVW model offers a promising community-based approach to COPD management, in line with Sláintecare initiative to enhance integrated care and improve patient outcomes while reducing healthcare costs. Insights from patients and staff highlight successes and opportunities for further service enhancements.

Background

Strain on Irish Healthcare: Ageing Population and Rising Demand

Ireland faces an unprecedented healthcare crisis driven by rapid population aging, escalating chronic disease burden, and unsustainable system pressures. Over the period 2015-2024, the population aged 65 years and older increased by 36.5% (1). This poses a significant challenge for the Irish healthcare system, as demand for public hospital services is projected to grown substantially. Inpatient bed days could increase by up to 37% (2), putting even more strain on an already stretched system. Additionally, emergency departments are experiencing a 9% annual increase in patient visits (3), highlighting potentially unsustainable pressures on the healthcare system in Ireland. Currently, approximately 1 million people in Ireland live with diabetes, asthma, Chronic Obstructive Pulmonary Disease (COPD), or cardiovascular disease, with 64.8% of the population aged over-65 years living with co-morbidity (4). Chronic diseases contribute to 40% of all public hospital admissions and 75% of the total bed days used (5). Additionally,10% of all acute hospital discharges and 21% of all acute hospital bed days used are for treating diabetes, asthma, COPD, and cardiovascular diseases (5).

Chronic Obstructive Pulmonary Disease (COPD)

Chronic Obstructive Pulmonary Disease (COPD) is a common preventable and treatable disease characterised by persistent respiratory symptoms and airflow limitation due to airway /or alveolar abnormalities (6). Nationally and internationally, the rising prevalence of COPD is responsible for significant healthcare use and patient morbidity and mortality (7, 8). In the European Union, €38.6 billion is spent annually on COPD, which represents for 6% of total healthcare expenditures in Europe (9).

The economic and social burden of COPD in Ireland is quite substantial. Compared to the overall average across other Organisation for Economic Co-operation and Development (OECD) countries, Ireland continues to have the highest rates of COPD hospitalisations (10). An estimated 380,000 people in Ireland are living with COPD, with over 15,000 people requiring hospital admission for this condition annually (11). Of those living with COPD, approximately 22% are living with additional comorbidities, resulting in increased risk of hospitalisations, additional medications and mortality (12). Under the current standard of care in Ireland, patients experiencing exacerbations of COPD typically receive treatment in hospitals or manage their condition through outpatient services. Many complex and high-risk patients, often require multiple hospital admissions and readmissions for effective management of their condition. Individuals with severe COPD may suffer frequent exacerbations requiring medical attention, potential hospitalisation, and significant disruption to their quality-of-life. While exacerbations can be treated with antibiotics and steroid medications, many patients often require hospitalisation for closer monitoring or more intensive respiratory support (13).

In 2021 data from the Hospital In-Patient Enquiry (HIPE) indicated that respiratory

admissions accounted for 38% of all emergency department admissions at Letterkenny University Hospital (LUH), which also recorded the highest national rate of COPD readmissions within 30 days of discharge (14). This cycle of exacerbation and readmission highlighted the need for an alternate care pathway, away from the acute services, for COPD patients in co Donegal.

Implementation of the CARE Virtual Ward (CVW)

Following the successful proof-of-concept undertaken in Donegal between May – August 2022 (14) and allocation of Sláintecare funding, the CARE Virtual Ward (CVW) was implemented on the 16th November 2023 in co Donegal. The CVW offers an alternative care pathway for high-risk individuals with COPD, which is firmly rooted in the community and delivered by Respiratory Integrated Care (RIC) service governed by respiratory consultants (14).

The CVW uses continuous RR monitoring, particularly during rest periods (e.g. overnight), to detect early signs of clinical deterioration. The CVW provides remote monitoring of patients with COPD living in the community, with clinical oversight from the RIC team. The core component of the CVW is provision of individualised education and empowerment to patients with COPD living in the community to help improve self-management of their COPD from home, in partnership with their clinical care team, and where appropriate, avoid hospital admission, ultimately, improving their health outcomes. This community model is the primary focus of the Irish national health policy "Sláintecare", aimed at developing and progressing an integrated model of care across all health settings (15, 16).

Design Thinking workshops were undertaken with patients, GPs, respiratory consultants, advanced nurse practitioners (ANPs), and technology partners. During these workshops, four primary clinical pathways under which the CVW operates were developed:

1. **High-Acuity COPD Patients ("Academy"):** Patients with ≥2 hospital admissions or ≥3 General Practitioner (GP) visits in the previous year for COPD exacerbations undergo structured on-boarding, education, and familiarisation with the virtual care model to prevent future admissions.
2. **GP-Referred Active Exacerbation / Emergency Department (ED) Avoidance:** Patients actively exacerbating are referred by their GP as an alternative to hospital admission.
3. **Assisted Discharge:** Patients discharged early from Letterkenny University Hospital (LUH) under the oversight of the acute respiratory team, are supported by the virtual ward.
4. **Admission Avoidance (ED-Initiated/ Acute Medical Assessment Unit (AMAU):** Patients meeting inclusion criteria are referred by ED clinicians to the virtual ward instead of being admitted.

These pathways are underpinned by cross-sector collaboration among GPs, LUH staff, National Ambulance Service (NAS), Community Intervention Teams (CIT), and respiratory specialist's optimising patient experience and outcomes, with clinical governance provided by the Acute Respiratory Consultant at LUH. A daily huddle meeting between acute and community respiratory clinicians, supported by a weekly multidisciplinary team (MDT) session with a respiratory consultant, enhances clinical decision-making and improves communication and coordination. This collaborative approach leads to structured communication, proactive care planning, timely patient discharges, reduced duplication of care, and optimised resource use, ensuring seamless and responsive patient care.

CVW Technology

An online platform based within the RIC service in co Donegal supported patients with COPD by offering a blended care pathway between November 2023 – December 2024, which was further extended from March 2025 – May 2025. MyPatientSpace (MPS) was the chosen platform provider for the CVW programme. This programme used digital technology, including a patient app and Bluetooth-enabled equipment, to monitor respiratory rate (RR) trends, oxygen saturation levels, and pulse oximetry with data collated on a healthcare platform. The platform provider, (MPS), worked in partnership with the RIC Donegal team to co-design and develop the bespoke COPD app, which was utilised throughout the entire project duration (November 2023 - May 2025).

The digital platform collates daily data on a staff-facing dashboard, enabling real-time monitoring and observation of clinical compromise and /or patient deterioration, thus supporting clinical decision-making. Notifications within the app have been developed to prompt patients to complete daily questionnaires and tasks assigned by the clinical team. If a task remains incomplete, an automated follow-up is initiated to the clinical team to follow-up with patients to ensure they are completed. A Red, Amber, Green (RAG) status on the clinician dashboard categorises, flags and escalates patients for clinical intervention based on the care pathway, providing an early warning of exacerbations. This allows for timely interventions, such as issuing a rescue prescription and educating patients on recognising early signs of deterioration.

Patients identified as deteriorating, had immediate access to a 'rescue' prescription of steroids and/or antibiotics. They also had access to educational materials through the dedicated patient app to facilitate development of self-management skills. This service operated Monday to Friday (08:00 to 16:00) with out of hours escalation processes developed and provided by the National Ambulance Services (NAS).

The key aims of the CARE Virtual Ward were to:

1. Empower patients to manage their chronic condition in the community
2. Identify exacerbations earlier
3. Reduce hospital admissions for COPD.

Objectives

This report summarises the key findings from the evaluation of the CARE Virtual Ward (CVW) in co Donegal. Specifically:

- Changes in health and clinical outcomes
- Results from an economic evaluation of the cost-effectiveness of the CVW
- Cost implications of implementing the CVW
- Assessment of stakeholder experiences during the CVW implementation

Transition, Recovery and Advancement of the CARE Virtual Ward

In January 2025, the CARE virtual ward was temporarily paused for operational reasons. During the period, from January 2025 to March 2025, an alternative technology for continuous monitoring device was sourced, resulting in the replacement of the RespiraSense device with the Corsano device. Alongside this, there was a significant change in the clinical pathway: the managed service model previously supporting the project was withdrawn. As a result, responsibility for both the clinical and technology management of the CARE pathway — including patient onboarding, offboarding, and troubleshooting — was assumed by the HSE clinical team. Throughout this transition, MPS continued to support the clinical pathway by providing technical expertise. MPS collaborated closely with the CARE team to navigate changes in clinical care models and technology, including changes from the RespiraSense to Crosano cRR devices. This collaboration enabled the full successful relaunch of the CARE Virtual Ward clinical pathway in March 2025.

Due to these operational changes mid-project, two delivery models were used:

Model 1: PMD provided a Managed Service Model with RespiraSense and myPatientSpace (MPS) (November 2023 – December 2024)

In this model, PMD provided chest-worn RespiraSense continuous RR monitoring devices (Image 1), and dedicated technology nursing support for patient on-boarding, troubleshooting and patient off-boarding. The clinical dashboard, patient application and data integration with RespiraSense was managed by MPS. The CARE clinical staff focused exclusively on patient care and monitoring, facilitating coordinated care by organising daily multidisciplinary huddles.

This model of care enabled early identification of exacerbations, supported timely discharges from acute settings, expanded COPD outreach across Donegal, and offered an effective alternative to hospitalisation.

Transition Period (January 2025 – March 2025)

During this period, the managed service model was withdrawn and alternative technology for patient monitoring was sourced. MPS continued to provide their digital platform and technology, which provided spot RR monitoring of patients via Massimo/Nonin device. The HSE clinical team assumed full responsibility for on-boarding, monitoring, troubleshooting and off-boarding of patients.

Challenges included limited monitoring capabilities that hindered the detection of respiratory rate trends, restricting early exacerbation identification. Patient selection was confined to lower acuity cases, reducing effectiveness in preventing admissions and supporting early discharges. Additionally, the inability to track respiratory trends limited patient education on self-management.

As a result, a decision was made by the CARE working group to not include data from January – March 2025 in this report, as it did not reflect the CARE Virtual Ward pathway or meet the required clinical care standards.

Model 2: HSE-Managed Service with MPS and Crosano (March 2025 – May 2025)

In this model, MPS continued to provide end-to-end virtual ward service directly to the HSE. This included the integration and provision of the new Crosano wrist-worn device (Image 2), capable of continuous RR monitoring and continued data integration on the MPS platform. The new device and delivery model marked the full reopening of the CARE Virtual Ward and restoring proactive, high-acuity care capacity.

As a result, the CVW service quality returned to levels achieved during the initial model. This facilitated early identification of exacerbations and supported timely patient discharges from acute care. This also allowed for expanded COPD outreach across all areas of Donegal, providing an effective alternative to hospitalisation.

For patients, the transition to a new monitoring device brought noticeable differences in how the technology was worn and experienced. From November 2023 to December 2024, patients were monitored using the RespiraSense device, which is attached to the side of the chest via an adhesive mount that remains in place between uses. In contrast, the Corsano device — implemented on the CVW from March to May 2025 — is worn on the wrist, resembling a fitness tracker, offering a different user experience and monitoring approach.

Image 1. RespiraSense continuous monitoring device used during the CVW Model 1 (November 2023 – December 2024)

Image 2. Corsano continuous monitoring device used during the CVW Model 2 (March 2025 – May 2025)

This report presents the evaluation findings from both care delivery models, during which two continuous monitoring devices were used, as part of the CVW's overall assessment.

Methods

Economic Evaluation

Economic evaluation explores cost-effectiveness by relating the mean difference in cost between alternative treatment options to their mean difference in effectiveness, and by quantifying the uncertainty surrounding these incremental point estimates. The economic evaluation consisted of a cost-effectiveness analysis which estimated the incremental costs and benefits of the CVW compared to usual care (i.e. hospital admission) for the group of COPD patients located in co Donegal.

The initial evaluation was conducted over the period from November 2023 to December 2024, focusing on Model 1 (the managed service model and the use of RespiraSense continuous monitoring device).

A second evaluation was conducted over the period from March 2025 to May 2025, focusing on Model 2 (the HSE-managed model and the use of the Corsano continuous monitoring device).

With the introduction of the new technology, some challenges emerged that affected the ability to consistently on-board patients during the testing period for Model 2 using the Corsano cRR monitoring device, in contrast to the earlier project phase commencing in November 2023 under Model 1 with the RespiraSense cRR monitoring device, which had been fully tested and refined through a dedicated proof-of-concept phase in 2022 (14).

Baseline information on outcomes and costs was collected prior to patient admission to the CVW, representing the standard care for COPD patients. To ensure precise comparability, we captured usual care data, reflected by COPD patient hospitalisations, over the period from 2022 to 2023. This data was used to assess the cost-effectiveness of the CVW under Model 1.

Similarly, to facilitate the comparison of the cost-effectiveness of the CVW under Model 2, baseline information for usual COPD patient care over a 3-month period in 2022 to 2023 was used as comparison. The data representing ‘usual care’ was derived from aggregate HIPE data from Letterkenny University Hospital, patient generic health status completed at baseline and associated costs of hospitalisation (cost per bed day, ambulance transfers).

Estimates from both evaluations were reported in terms of cost and health outcome differences.

Health outcomes were expressed in terms of clinical effects and generic health status. The outcome data used in this analysis were collected and recorded routinely via the interactive bespoke app. Both patient-reported outcomes (generic health status, understanding COPD, daily wellbeing questionnaire) and objective (clinical) outcome measures (respiratory rate, SpO2, pulse oximetry) were captured. The objective outcome measures were captured via the continuous monitoring devices (RespiraSense and Corsano*).* Data captured by both cRR devices for all patients who were admitted to the CVW were analysed.

Individual patient healthcare expenses were also collected (rescue scripts). Considering the duration of the CARE virtual ward, and the period of change between devices, neither the costs nor the outcomes were discounted.

Costing was based on the perspective of the publicly funded health and social care system (HSE) for intervention provision. This perspective was chosen as any potential savings would be in the acute sector and costs in the intermediate/community care sector. The evaluation followed the recommended national guidelines (17, 18).

Cost analysis

The cost components consisted of the following:

- **Cost of implementing the CVW and relevant resources:** patient recruitment, data collection, technology/equipment, application, educational resources.
- **Costs of primary and secondary health services over the course of the CVW:** costs of running the CVW, community staff costs, medications, acute hospital length of stay, ambulance transfers.

All costs were expressed in Euros (€) adjusted at the 2024 price level (19).

Effectiveness analysis

Health outcomes were expressed in terms of clinical and generic health status. Clinical outcomes included respiratory rate, pulse oximetry and SP02 which were recorded continuously via the monitoring device during patient admissions on the CVW. These outcomes were analysed and their trends reported in graphical form.

Generic health status was expressed in terms of Quality Adjusted Life Years (QALYs), calculated based on patient responses to the EQ-5D-5L (20) instrument for Ireland. The EQ-5D-5L scores at baseline and at discharge from the CVW were used to calculate patient-specific QALYs during admission under Model 1 and Model 2. The QALY is a widely used outcome in economic evaluations (which combines the quality and quantity of life) to quantify the overall health effects of interventions / alternative treatments (17, 18).

Outcomes from the patient-reported Understanding COPD Questionnaire were also analysed using descriptive statistics. Statistical significance of differences in these outcomes was assessed using t-tests, to identify changes in patient understanding of their condition before admission and at discharge from the CVW.

In economic evaluation, a treatment is defined as more cost-effective than its comparator based on one of the following conditions:

(1) If it is less costly and more effective;
(2) If it is costlier and more effective, but its additional cost per additional unit of effect is considered worth paying by decision-makers; and
(3) If it is less costly and less effective, but the additional cost per additional unit of effect generated by the comparator is not considered worth paying by decision-makers.

The incremental analysis approach was adopted, which combines both the costs and effectiveness into a single measure, the incremental cost-effectiveness ratio (ICER), to determine which of the three conditions applies. The incremental net benefit (INB) statistic was calculated, which takes into account the cost-effectiveness threshold value per additional benefit gained (€45,000 in Ireland (17, 18)). A positive INB indicates that the intervention is cost-effective, and if INB is negative, the intervention is not cost-effective, relative to the usual care provided.

Analyses were performed using Stata v.18.5 and Microsoft Excel with statistical significance set at p <0.05.

Results from the economic evaluation were used to generate a list of recommendations, reported at the end of this report.

Stakeholder experiences

Patients

Individual, semi-structured interviews were conducted with patients who were admitted to the CVW, and/or their carers, to capture their experiences. The aim and objectives of the semi-structured interviews with patients were as follows:

Aim: To assess the experience of patients and their carers during their admission to the CVW to inform improvement and development of the service

Objectives:

1. Explore the fidelity of the patient experience of the CVW to the proposed project design
2. Explore the acceptability of CVW to patients
3. Explore the accessibility of the CVW
4. Explore patient suggestions for improvement of the CVW

Participant recruitment and interview process

Semi-structured interviews were carried out with patients who had previously been admitted to the CVW, and/ or their carers. A purposive sampling approach was used to identify participants: CARE clinical staff identified potential participants, who were contacted by phone by researchers to discuss participation. Following the transition of the CVW from Model 1 with the RespiraSense cRR monitoring device to Model 2 with the Corsano cRR monitoring device, additional patients were recruited to facilitate a comparison of their experiences. Patients admitted to the CVW for at least 3 days since the inception of the programme were eligible to take part in the interviews. Exclusion criteria included patients who lacked capacity to consent or those who were unable to take part due to illness.

All participants were provided with patient information leaflets and consent forms. All participants provided verbal consent on the day of the interview. All interviews took place in person with one interviewer present in the room (NB) and another joining online (GV or HC). A topic guide was used to guide the interview questions, with topic headings including fidelity, accessibility, acceptability, impact on disease and suggestions for change. Open questions were used, with further prompts available when required.

Data collection and analysis

Interviews were video recorded and data were captured on Microsoft Teams, with transcripts generated automatically using the in-built software function. Interview transcripts were checked for accuracy and corrected where needed. Interview transcripts were analysed in line with the framework analysis approach (21). This was chosen as it allows both for exploration of pre-identified themes and the emergence of new themes from the interview participants' experiences. The framework matrix also allows for comparison across cases by theme, valuable for comparing the experiences of the different participants admitted to the CVW.

The researchers followed the steps as described by Spencer and Richie (21) consisting of: familiarisation; identifying a framework; indexing; charting; and mapping and interpretation. Familiarisation was carried out through reading transcripts, viewing video recordings and discussion among the research team. The team discussed the a priori themes to establish a shared understanding of the key themes and sub-themes.

Where participant insights did not clearly align with the pre-identified themes, the researchers discussed and consensus was reached on whether these insights represented a separate, new or could be linked to the existing themes. Any new themes identified in this process were incorporated into the final analysis framework.

Indexing of the data was carried out through coding of the transcripts using Microsoft Excel and NVIVO software. Participant quotations which aligned with the identified themes were highlighted and categorised, with relevant quotations extracted into a data collection tool in Microsoft Excel. Initially, data was charted per participant, and then summarised and grouped into themes. The interview data was mapped and

interpreted to identify relationships between themes, clarify concepts and develop explanations. This process involved discussions and reviews among the researchers, and was used to generate additional recommendations for this report.

Research team

The research team consisted of three independent researchers (HC, NB and GV), with a multidisciplinary background: GV is a health services researcher, HC is a public health medical doctor, and NB is a digital support analyst with the CVW, but not involved in direct patient contact.

Staff

A project closure survey was sent to all staff who were involved (directly and indirectly) in the delivery of care to patients admitted to the CVW. The survey was anonymous and was aimed to capture the experiences of staff during their involvement in the CVW.

Aim: To assess the overall experiences of staff during the CVW.

Survey data analysis

Staff survey responses were analysed using descriptive statistics and short descriptive summaries to capture the key staff experiences during the CVW.

Ethics

Ethical approval was obtained from the Letterkenny University Hospital Research Ethics Committee.

Results

Clinical Outcomes

The results from the CVW under Model 1 and Model 2 are provided below.

Figures 1-3 below summarise the clinical outcomes as captured continuously via the remote monitoring device (RespiraSense and Corsano). A consistent trend across all measures was observed during patient admission to the CVW, allowing clinical staff to accurately monitor patients and identify potential patient exacerbations using the Clinical Dashboard within the MPS application.

Figure 1a. Respiratory Rate trends - clinical dashboard (MPS App) - November 2023 – December 2024 (Model 1 – RespiraSense monitoring device)

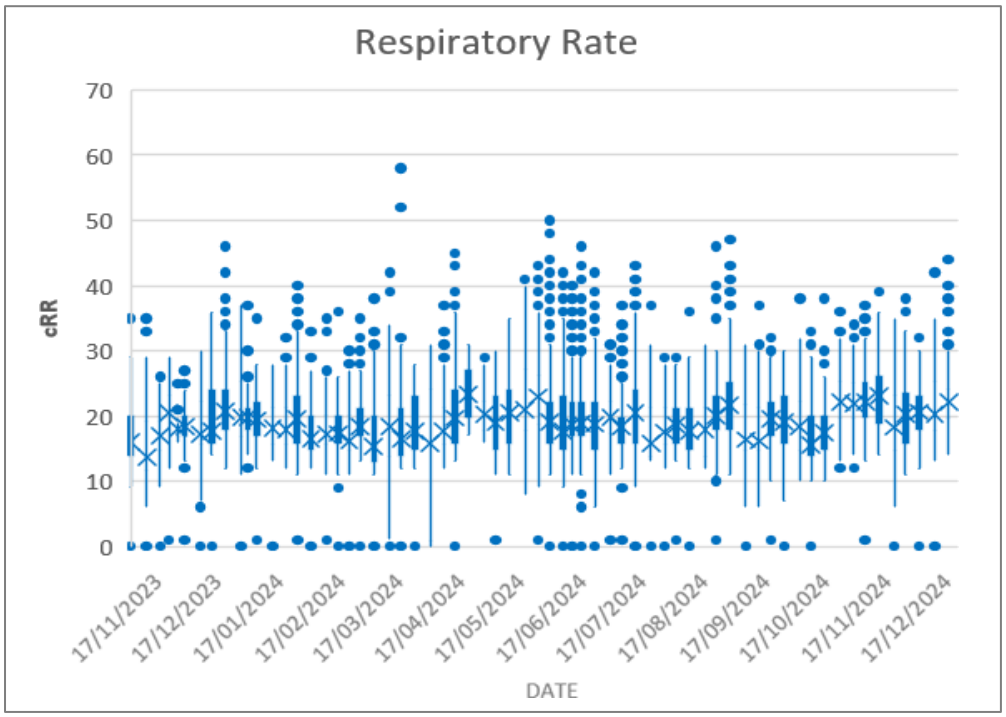


Figure 1b. Respiratory Rate trends - clinical dashboard (MPS App) - March 2025 – May 2025 (Model 2 – Corsano monitoring device)

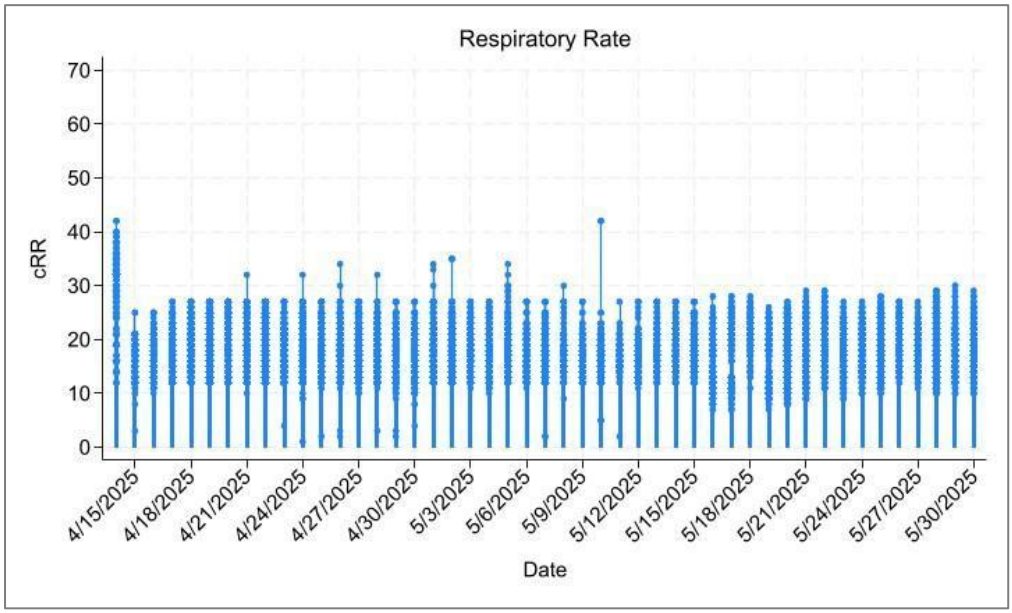


Figure 2a. SP02 trends - clinical dashboard (MPS App) - November 2023 – December 2024 (Model 1 – RespiraSense monitoring device)

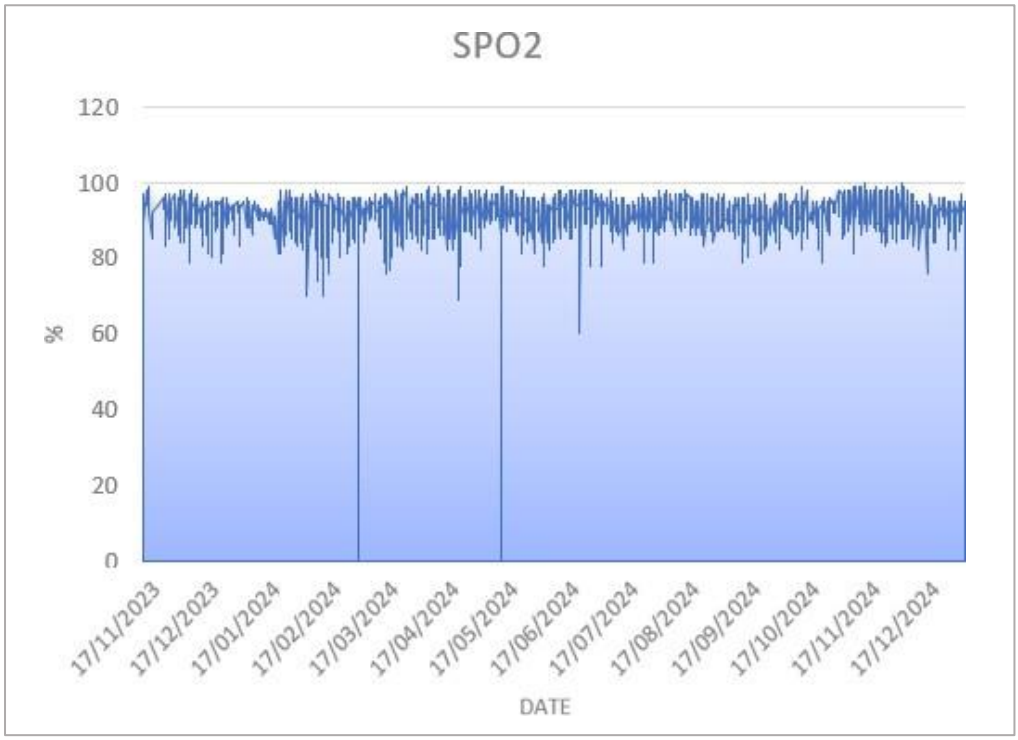


Figure 2b. SP02 trends - clinical dashboard (MPS App) - March 2025 – May 2025 (Model 2 – Corsano monitoring device)

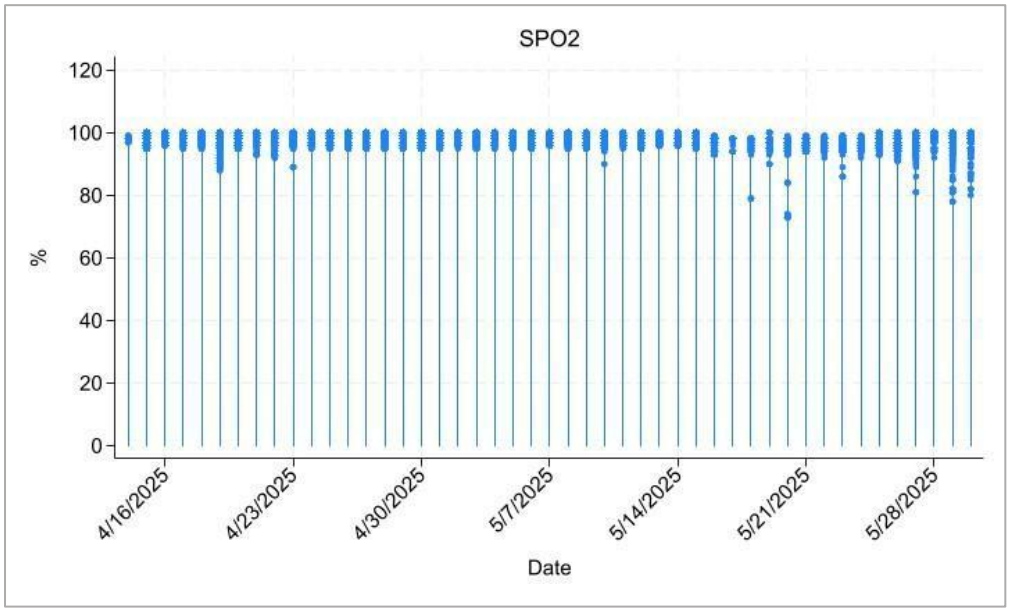


Figure 3a. Pulse Oximetry trends - clinical dashboard (MPS App) - November 2023 – December 2024 (RespiraSense)

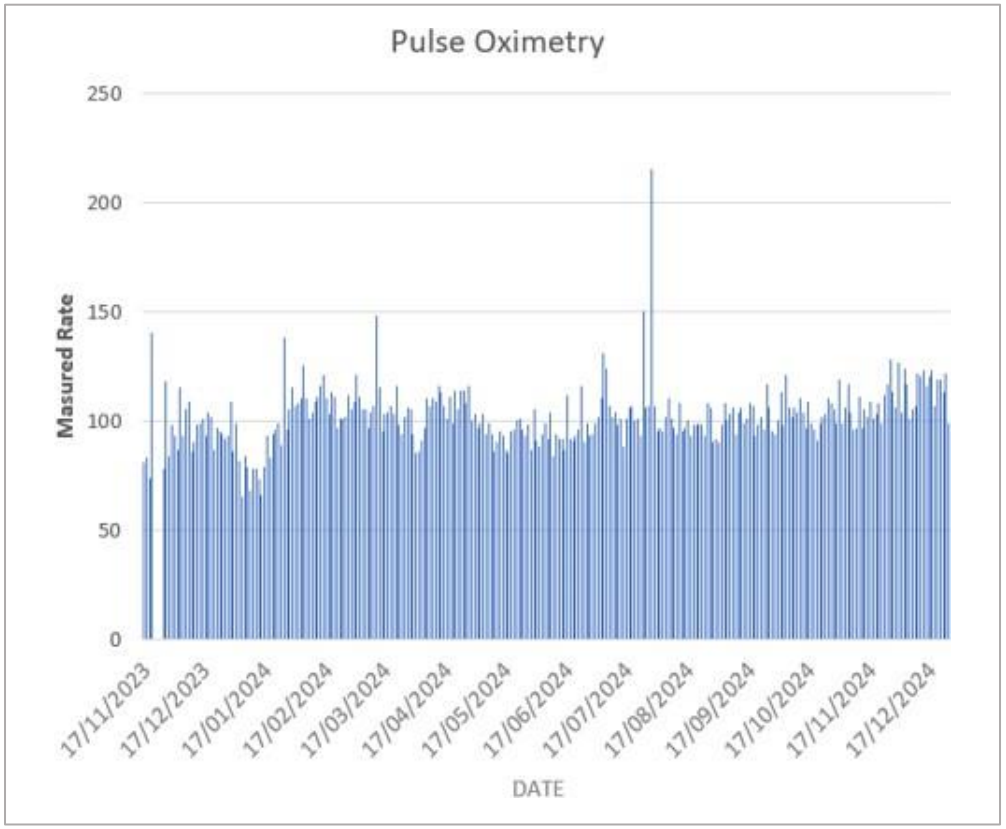
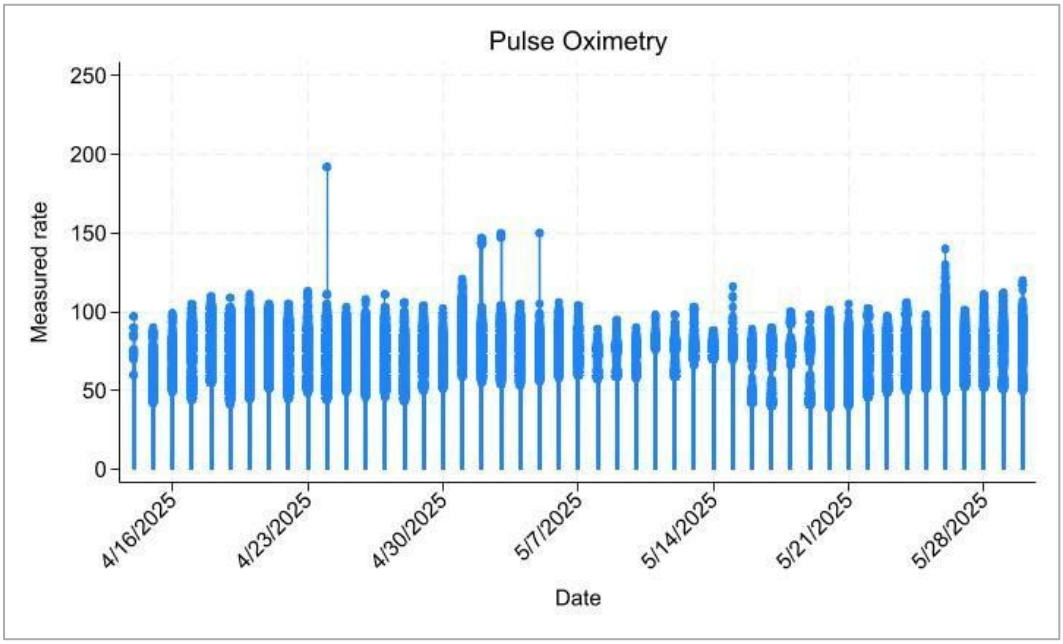


Figure 3b. Pulse Oximetry trends - clinical dashboard (MPS App) - March 2025 – May 2025 (Corsano)



Patient-reported outcomes

Understanding COPD

Understanding COPD Questionnaire scores showed a statistically significant improvement among patients at discharge from the CVW (Table 1). During Model 1 admissions, the mean score relating to patients' overall 'Understanding COPD' increased by 19.2 ($p < 0.01$). The greatest improvement was in exercise participation by a mean score increase of 26.4 (p< 0.01) followed by an improvement in breathing techniques with a mean score increase of 25.7 (p<0.01).

In comparison, during Model 2 admissions, the mean score related to patient's overall 'Understanding of COPD' increased by 2.3 (p<0.01). The greatest and statistically significant improvements were reported in understanding 'positions of ease' and 'participation in exercise' with a mean score increase of 2.5 (p<0.01) across both questions.

All patients reported significant improvements across the remaining questions, except for 'Understanding how to get aids and appliances' (Model 2) which was not statistically significant (p=0.09) (Table 1).

Table 1. *Summary of COPD Questionnaire Scores at CVW admission and discharge*

CVW delivery model	**Model 1^**				**Model 2***			
Outcomes	**Admission**	**Discharge**	**Overall change**	**Significance**	**Admission**	**Discharge**	**Overall change**	**Significance**
Understanding COPD	77.5 (23.1)	96.8 (8.8)	19.2 (3.8)	p <0.01	6.1 (1.4)	8.4 (1.4)	2.3 (0.4)	p <0.01
Changes over time	75.8 (25.9)	95.7 (11.4)	19.8 (4.4)	p <0.01	6.3 (1.5)	8.3 (1.1)	2.0 (0.4)	p <0.01
Recognising Exacerbation	81.2 (21.6)	94.1 (9.6)	12.9 (3.7)	p <0.01	6.9 (1.8)	8.3 (1.6)	1.4 (0.6)	p=0.01
Therapy During Exacerbation	74.7 (25.8)	92.7 (13.0)	17.9 (1.8)	p<0.01	6.1 (1.9)	7.9 (1.3)	1.8 (0.5)	p=0.01
Seeking Help During Exacerbation	78.4 (25.3)	95.4 (10.7)	17.0 (4.3)	p<0.01	6.8 (2.2)	8.9 (1.2)	2.1 (0.6)	p=0.01
COPD Medication: How?	86.3 (19.5)	98.4 (3.7)	12.1 (3.2)	p<0.01	6.9 (1.9)	8.5 (1.5)	1.6 (0.6)	p=0.01
COPD Medication: Why?	85.9 (19.9)	98.9 (3.1)	13.0 (3.3)	p<0.01	6.5 (1.6)	8.3 (1.4)	1.8 (0.5)	p <0.01

Breathing Techniques	53.7 (27.8)	79.5 (24.9)	25.7 (4.9)	p<0.01	5.6 (1.8)	7.5 (1.3)	1.9 (0.5)	p=0.01
Conserving Energy	57.7 (29.3)	79.7 (24.3)	21.9 (5.2)	p<0.01	5.4 (1.5)	7.5 (1.2)	2.1 (0.5)	p <0.01
Positions of Ease	57.0 (25.6)	76.5 (27.3)	19.4 (4.7)	p<0.01	4.9 (1.8)	7.4 (1.4)	2.5 (0.5)	p <0.01
Exercise Benefits	75.8 (25.7)	96.5 (12.7)	20.7 (4.4)	p<0.01	5.5 (1.5)	7.8 (1.2)	2.3 (0.4)	p <0.01
Exercise Participation	49.8 (25.7)	76.2 (12.7)	26.4 (6.2)	p<0.01	4.8 (1.8)	7.3 (1.9)	2.5 (0.6)	p <0.01
Mood Management	69.8 (27.2)	90.0 (18.7)	20.2 (4.7)	p<0.01	6.4 (2.0)	8.3 (1.4)	1.9 (0.6)	p=0.01
Stress + Anxiety	70.0 (25.1)	91.4 (17.0)	21.4 (4.4)	p<0.01	6.4 (2.3)	8.1 (1.5)	1.7 (0.7)	p=0.01
Aids + Appliances	72.4 (30.3)	95.4 (18.3)	22.9 (5.2)	p<0.01	7.3 (2.3)	8.5 (1.6)	1.2 (0.7)	p=0.09
Welfare + Benefits	70.1 (29.4)	95.9 (16.9)	25.9 (5.0)	p<0.01	7.4 (2.1)	9.1 (1.2)	1.7 (0.6)	p=0.01
Exercise Facilities	49.0 (37.7)	71.1 (41.1)	22.1 (6.9)	p=0.02	6.2 (2.6)	7.9 (1.5)	1.7 (0.7)	p=0.02
Support Groups	54.2 (37.4)	76.8 (39.4)	22.5 (6.9)	p=0.01	6.2 (2.7)	8.3 (2.1)	2.1 (0.8)	p=0.01

Note: Standard deviation reported in brackets.
Model 1: Pre = 59 patients, 161 data entries; post = 37 patients, 37 data entries. ^Questions were based on responses ranked on a scale ranging 10(low understanding) -100 (perfect understanding).
Model 2: pre = 23 patients, 28 data entries; post = 15 patients, 15 data entries. *Questions were based on responses ranked on a scale ranging 1(low understanding) -10 (perfect understanding).

Daily wellbeing

The key summary of findings from the wellbeing questionnaire which patients were notified to complete daily via the MPS app is summarised in Table 2. Among all patients who were monitored during Model 1 admissions, 55 patients had completed the full daily questionnaire regularly, suggesting full compliance with daily reporting of their wellbeing. 49 patients had responded to the daily questionnaire at least once, but did not complete all of the questions. Similarly, among patients who were admitted during Model 2, 9 patients had completed the full daily questionnaire regularly, with 13 patients partially completing the daily questions.

Table 2. Summary of patient completion of the daily wellbeing questionnaire by CVW delivery model

CVW delivery Model	Model 1	Model 2
	% of all responses (n = 1,502)	**% of all responses)** (n=968)
How are you today?	Same as yesterday (49.7%), Worse than yesterday (5.7%)	Same as yesterday (51.2%) Worse than yesterday (3.9%)
How much energy do you have today?	Same as yesterday (70.5%)	Same as yesterday (66.1%)
Have you been able to do your normal daily activities?	Yes (78.1%)	Yes (76.4%)
Have you had night sweats and/or a fever?	Yes (8.4%)	Yes (10.3%)
How is your breathing today?	Same as yesterday (67.8%), Worse than yesterday (6.1%)	Same as yesterday (63.4%), Worse than yesterday (5.6%)
Have you used your (blue) inhaler more than usual?	Yes (17.7%)	Yes (19.0%)
How is your coughing compared to yesterday?	Same as yesterday (67.2%), Worse than yesterday (6.1%)	Same as yesterday (64.2%), Worse than yesterday (4.8%)
What colour is your phlegm today?	White (23.5%), Yellow (19.8%)	White (25.7%), Yellow (17.4%)
Do you have more phlegm (volume) than yesterday?	Yes (11.5%)	Yes (12.2%)
Is your phlegm stickier or thicker than yesterday?	Yes (12.8%)	Yes (14.1%)
Have you taken your rescue medications in line with your Action Plan?	Yes (49.4%)	Yes (47.9%)
Have you taken your prescribed drugs today that are listed in your plan?	Yes (85.4%)	Yes (82.7%)

Overall, most patients appeared to have a generally good understanding of their COPD condition and awareness of their COPD symptoms.

Health-related quality of life

The EQ-5D-5L quality of life instrument reported an overall health status improvement among patients whilst on the CVW under Model 1 between November 2023 – December 2024, with a mean discharge score of 53.9 (SD: 18.2 ($p = 0.57$)) however, this was not statistically significant which was consistent with people who had ongoing exacerbations and significant levels of respiratory disease.

In comparison, the EQ-5D-5L quality of life improved among patients admitted to the CVW under Model 2 during March 2025 – May 2025, with a statistically significant mean discharge score of 67.3 (SD: 17.9, ($p = 0.03$)).

On average, patients admitted to the CVW during care delivery under Model 2 had reported significantly better improvements in their overall general health compared to patients admitted during care delivery under Model 1.

Resource use and costs

CVW implementation costs

Overall, 181 patients were admitted to the CVW during the period November 2023 – May 2025. 159 patients were admitted to the CVW under Model 1 (managed service model), resulting in 250 admissions (including readmissions) between November 2023 to December 2024. The average length of admission to the CVW was 16.9 days.

Under Model 2 (HSE-managed model), 22 patients were admitted, leading to 23 admissions (including readmissions) and an average length of admission of 15.2 days, between March 2025 to May 2025. This led to a combined total of 934 bed days saved from hospital among these patients.

The associated resources and costs incurred during the CVW are summarised in Table 3 for both CVW delivery models.

The total cost of implementing the CVW under Model 1 over the period November 2023 – December 2024 was €453,385.70, giving a mean cost per patient of €2,851.50.

The total cost of implementing the CVW under Model 2 over the period March 2025 – May 2025 was €35,357.12, giving a mean cost per patient of €1,607.14.

The combined total cost of implementing the CVW over the full implementation period, November 2023 – May 2025, was €488,742.82.

On average, patients admitted under Model 2 incurred lower costs compared to patients admitted under Model 1.

Table 3. *Summary of key resources used and costs during admission to the CVW by delivery model*

CVW delivery model	**Model 1 (***November 2023 – December 2024)*				
Description	**Rescue scripts**	**Staff [a]**	**Ambulance**	**Equipment and Technology**	**Total CVW implementation cost**
Number of uses	166	9	106[b]	-[c]	
Total resource Cost	€3,919.26	€63,838.94	€21,862.50	€363,765	**€453,385.70**
Virtual Ward Technology	**Model 2** (March *2025 – May 2025)*				
Number of uses	5	9	8	-[d]	
Total resource cost	€118.05	€ 3,349.07	€1,650	€30,240	**€35,357.12**
Combined total cost (November 2023 – May 2025)	**€2,998.47**	**€67,188.01**	**€10,931.25**	**€303,063.75**	**€488,742.82**
Source	Local GP	HSE Employee Scale	NAS / Study records	Study Records	

[a] Includes Advanced Nurse Practitioner (ANP), Clinical Nurse Specialist (CNS), Physio, Staff nurse, Hub ANP, Hub senior physio, Hub staff nurse, ANP virtual, Staff nurse virtual

[b] Based on the number of journeys for 53 patients. Two journeys were assumed for each patient.

[c] Inclusive of managed service costs, respiratory rate measurement device, additional staff (2 nursing staff), project administrator and support staff

[d] After switching to Model 2 (using the Corsano monitoring device), the managed services were no longer required. MPS provided the complete managed platform, tablets, devices and support directly to the HSE.

[e] Based on the number of journeys for 4 patients. Two journeys were assumed for each patient.

Total costs / Potential cost savings from providing usual COPD care

The total costs of COPD patient hospitalisations which could have led to potential cost savings (to the HSE), due to avoided hospital admissions (in the year prior to CVW implementation) if the CVW was implemented in 2022 were estimated. Additionally, ambulance transfer costs during this period were also calculated.

Representing usual care in 2022-2023 the total number of COPD patient hospital admissions were 601, with 110 COPD patients admitted to the hospital three times or more, including readmissions. The average number of bed days was 7.3 per patient with a total of 3,139 bed days used (Table 4).

The overall average cost per patient (including ambulance transfers) was estimated at €7,019.50. The total potential cost savings to the HSE, if the CVW would have been implemented a year prior in 2022-2023 would have resulted in €4,218,727.50 for these patients. This represents 7.0% of the Sláintecare Community enhancement Fund, which allocated €60 million in 2021 for enhancing community care [20].

Table 4. *Summary of COPD patient hospital admissions and costs in 2022-2023*

	Baseline period (June 2022 – June 2023)	**Baseline period** (November 2022 – January 2023)	**Total**
Number of COPD admissions (three or more) [a]	474	127	**601**
Total number of bed days used	1,753	1,386	**3,139**
Ambulance transfers [b]	956	322	**1,278**
Cost per inpatient stay [c]	€1,260	€1,260	-
Cost per ambulance transfer [b]	€206.25	€206.25	-
Total costs / potential cost savings (2022-2023)	**€2,405,955**	**€1,812,772.50**	**€4,218,727.50**
Average cost per patient	**€6,265.50**	**€14,273.80**[d]	**€7,019.50**

[a] Includes 110 patients who were admitted 3 times or more (including readmissions) during both baseline periods combined.

[b] The number of ambulance transfers and ambulance cost was estimated using cost data per km travelled in co. Donegal provided by the National Ambulance Service (NAS). Two journeys were assumed for each patient.

[c] National bed day hospital cost reported by the Healthcare Pricing Office (HPO)

[d].During this period, there was a rise in hospital admissions for COPD patients, attributed to the challenges posed by the winter season.

Economic evaluation

Table 5 summarises the economic evaluation results for each CVW model of care.

The CVW under Model 1 was associated with savings in mean healthcare costs of €192,257 (p-value: 0.06; 95%CI: -€447,722, €57,208) per patient, and an increase of 0.10 (p-value: 0.13; 95%CI: 0.01, 0.19) in mean QALYs per patient, compared to standard care (hospitalisations) (at the WTP threshold value of €45,000 for Ireland).

Similarly, the CVW under Model 2 was associated with savings in mean healthcare costs of €177,742 (p-value: 0.04; 95%CI: -€359,998, €4,515) per patient, and an increase of 0.12 (p-value: 0.04; 95%CI: 0.02, 0.22) in mean QALYs per patient, compared to standard care (at the WTP threshold value of €45,000 for Ireland).

The probability of the CVW being cost-effective under Model 1 (using the RespiraSense monitoring device and managed service model) was estimated to be at 0.638 (63.8%). The probability of the CVW being cost-effective under Model 2 (using the Corsano monitoring device without the managed service model using MPS as the app provider and technology support) was estimated to be at 0.966 (96.6%). These results were based on assuming a range of different WTP cost-effectiveness thresholds.

Additionally, the incremental analysis suggested that relative to the usual care provided, the CVW under Model 1 was cost-effective, as reflected by a positive Incremental Net Benefit (INB) value of €197,767 (95% CI: -€54,767, €454,302).

Similarly, the incremental analysis for CVW under Model 2 was cost-effective, as reflected by a positive INB value of €183,050 (95% CI: -€1,372, €367,473).

While the CVW Model 1 demonstrated greater cost savings, these results may be impacted by the larger sample size of patients compared to the smaller patient sample size admitted under Model 2.

The cost-effectiveness analysis suggested that, on average, the CVW was both less expensive and more effective than standard COPD care (hospitalisation).

Table 5. Incremental cost-effectiveness results

CVW delivery model	**Model 1**	**Model 2**
Variable/analysis	**Incremental analysis (CVW minus usual care)**	**Incremental analysis (CVW minus usual care)**
Cost analysis		
Difference in mean total cost (95% CI) [p-value]	-€192,257 (-€447,722, €57,208) [0.06]	€-177,742 [-€359,998, €4,515] [0.04]
Electiveness analysis		
Difference in mean QALYs (95% CI) [p-value]	0.10 (0.01, 0.19) [0.13]	0.12 (0.02, 0.22) [0.09]
Incremental Cost-Effectiveness Ratio (ICER)	€-1,948,011	-€1,506,638
Incremental Net Benefit (INB) (95% CI)	€197,767 (-€54,767, €454,302)	€183,050 (-€1,372, €367,473)
Probability (%) that the CVW is cost-effective at the willingness to pay threshold value of €45,000 for Ireland[a]	0.638 (63.8%)	0.966 (96.6%)

[a] Probability was estimated by bootstrapping the key findings 1,000 times and assuming a range of different WTP values.

Patient experiences

Patient Characteristics

Ten interviews were carried out, with nine patients and two carers, between December 2024 and May 2025, lasting an average of 42 minutes. Eight participants were male and three were female, all aged between 60-70 years, except for one carer participant aged 40-50 years. Eight participants were interviewed at the Errigal Chronic Disease Management Hub in Letterkenny, and two were interviewed at a local health facility to facilitate participant travel limitations.

Participants had been admitted to the CVW between September 2024 and April 2025. Five had one previous admission to the CVW, while five had more than one admission. Six participants were admitted under Model 1 and had used the RespiraSense monitoring device for remote monitoring; three were admitted under Model 2 and had used the Corsano monitoring device; and one patient was had separate admissions under Model 1 and Model 2 and had used both monitoring devices. One participant was interviewed with their carer, who had assisted with the app and monitoring device, while another interview was solely with a patient's family caregiver.

Summary of Themes

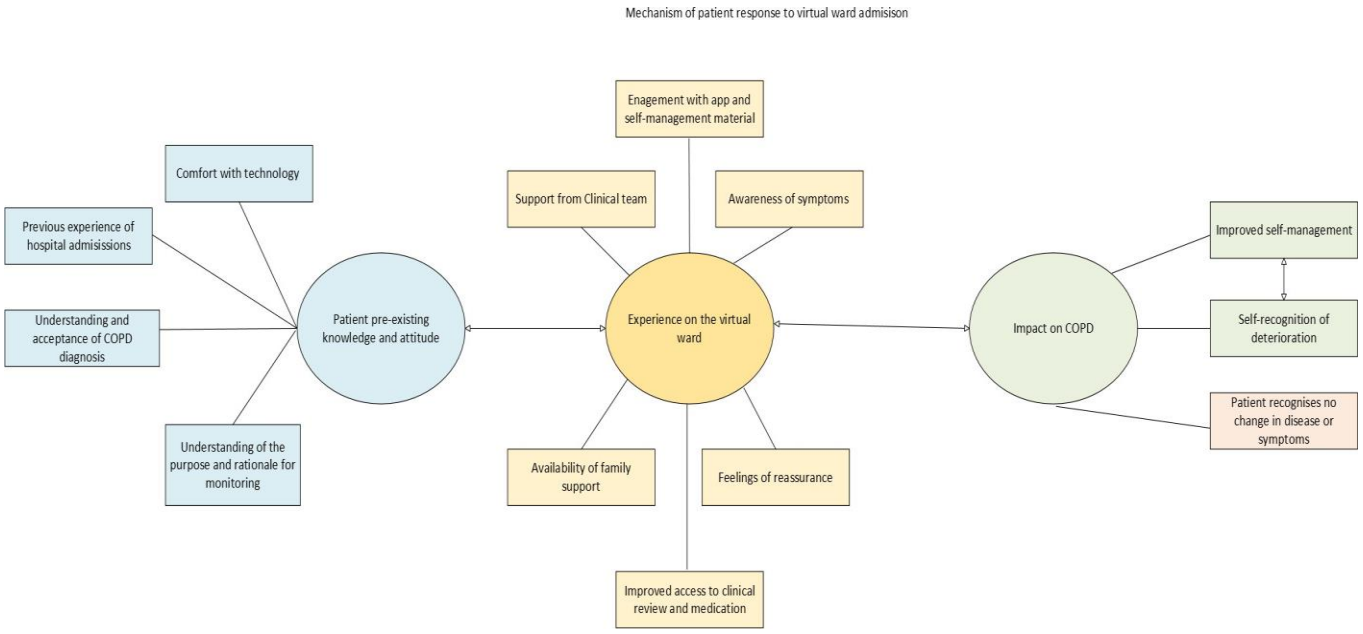
Table 6 below provides a summary of the findings relevant to each theme. Further explanation of each sub-theme is provided below.

Table 6. Summary of themes and sub-themes from patient interviews

Theme	Sub theme
Accessibility - *technology posed some challenges for participants, which improved with use and through support*	Engaging with MPS app and monitoring device was supported by staff and required self-learning, with confidence increasing over time
	Family were a source of support for technology use
	Completing the questionnaires was straightforward, with participants finding the questions easy to understand.
	Previous smart phone or other technology use varied among the participants
	RespiraSense device was uncomfortable for some patients, and there were some challenges in keeping it securely in place with the provided adhesive
	Some concerns about 'getting it wrong', particularly with navigating through the app and uploading the required data
Fidelity – *the patient experience largely included all components of the CVW*	Self-management video/ written content was not accessed by the majority of participants
Acceptability – *participants valued being monitored and having ease of access to staff and medical treatment*	Sense of being monitored, with the assurance that any deterioration would be identified and acted on by staff
	Quick and direct access to clinical staff, facilitating reviews and early access to medication
	Avoidance of hospital admission
	Reduced burden on carers and family
	Close interaction with clinical staff who knew their background
Impact on disease – *improved recognition and understanding of symptoms*	Improved awareness of signs and symptoms
	Increased willingness to access medication or care earlier
	Increased confidence
Suggestions for change – *Enhanced recognition of what matters most to patients regarding their symptoms*	Increased flexibility in questionnaire responses, with option for free text/ explanation of responses
	Option to be monitored and complete surveys during the day, when symptoms are more pronounced
	Dissatisfaction with lack of feedback on the results from remote monitoring, end of admission review
Emergent, explanatory themes – *pre-existing knowledge and attitudes shaped the experience on the ward*	Patient understanding of disease and the CVW
	Patient attitude to health
	Patient previous experience of healthcare

Figure 1 below draws together the findings related to the a priori themes and the emergent themes, to understand what factors may have shaped the patient's experience of the CVW and how this may ultimately influence the impact on the patient's COPD.

***Figure 1**: This figure describes the relationship between the themes generated from the data analysis. Participant's previous experience, knowledge and attitude may influence how they engage and interact with the ward. Patients' experience on the ward is shaped by their own access to help and support, and their emotional and practical reaction to the ward. Each of these components has a bearing on what impact the CVW will ultimately have on the patient's illness experience, potentially leading to improved self-management and recognition of deterioration, or indeed to little change for the patient*.



Detailed description of themes

Accessibility

The accessibility of the monitoring devices and technology required on the CVW can be summarised as posing some challenges for participants, which improved with use and through support, with all participants able to successfully complete the required tasks. Participants reported some apprehension before starting the CVW, and described a **process of learning how to use the technology with the support of staff and family members**, and becoming more confident over time.

> 'I guess at the start it I found it a bit difficult. I didn't even know if had done it. But after three or four days I got used to it myself.' *Participant 5 (Model 1, RespiraSense)*

> 'I was a wee bit apprehensive about it but it came as second nature to me' *Participant 8 (Model 2, Corsano)*

> 'even if you didn't like (technology) its explained that well to you, and if you make a mistake the girls are there for you and it's not hard' *Participant 7 (Model 1, RespiraSense)*

Some participants reported **continued need for technical support throughout their admission**, while others became more confident after a short period. Two participants had a **family member undertake all tasks** (completion of questionnaires and uploading data from the monitoring device) for them, and did not directly engage with the tablet or monitoring device.

> 'that would have been my lad, NAME, like I mean he would have checked it all out in the morning, and he would have been asking me [the questionnaire]' *Participant 10 (Model 1, Corsano)*

> 'then I have grandkids which was able to sort me out too no problem.' *Participant 1(Model 1, RespiraSense)*

Completion of questionnaires within the MPS app was reported to be 'simple', with questions '*straightforward… all was really well explained' (Participant 5 (Model 1, RespiraSense)).* None of the participants reported challenges with reading the text, other than Participant 3 whose carer completed the questionnaire on their behalf. Some reported using the zoom function as effective for reading the app material.

The process of submitting the answers was challenging for some participants, though it became easier over time:

> 'I guess at the start it I found it a bit difficult. I didn't even know if had done it.

But after three or four days I got used to it myself.' *Participant 6 (Model 1, RespiraSense).*

Likewise **uploading of data from the monitoring device posed a challenge** to some participants:

I had difficulty with..with getting the data all up on the screen, all right, and then…ehmm… with the sending [of data]. Sometimes it would send other times it wouldn't.' *Participant 5 (Model 1, RespiraSense)*

There were **varying levels of previous use of technology** - two participants reported being very confident technology users at baseline, and did not report requiring support from the CARE team. Others reported having some use of a smartphone, laptop or tablet but with lower levels of confidence.

Among patients admitted under Model 2, the Corsano monitoring device was described as *'like wearing a watch.. It was very comfortable' (Participant 10),* and the one participant who had used both devices preferred the Corsano device describing it as *'the best thing to ever come in the front door' (Participant 9).*

Among patients admitted under Model 1, there was **mixed feedback on the ease of wearing the RespiraSense** device. Some found it a '*bit uncomfortable'*, while others reported it as '*not bulky'* and '*comfortable enough'*. Some experienced challenges with the adhesive used to keep the RespiraSense device holder in place on the skin when the participant was not wearing the monitor:

'when you put it back on at night again, it's loose' Participant 1 (Model 1,

RespiraSense) 'you forgot it was there, you know' *Participant 4 (Model 1,*

RespiraSense)

'Popping the new one on [gestures to where sensor goes on], it's quite torture to get the stuff together' *Participant 1(Model 1, RespiraSense).*

For some participants, the technology used on the CVW generated some concern about 'getting it wrong', particularly with navigating through the app and uploading required daily data.

'I found anything that went wrong or anything that wasn't on the way that it should have been on was on my behalf' *Participant 3 (Model 1, RespiraSense)*

'I was skeptically going into it, 'cos I was scared if I go into this I might never get back out of it [video content]' *Participant 1 (Model 1, RespiraSense)*

Fidelity

Participants expressed that their experiences with the main components of the CVW closely aligned with the planned care. Participants reported completing the questionnaires and uploading the monitoring data as they had been advised to. One participant reported that when their data did not correctly upload; they were contacted by the clinical team to guide them through the upload.

Two participants were able to access video content on the app, one on exercises and one on correct use of the monitoring device. The remaining **participants were not aware that self-management content was available on the app;** all expressed an interest in using this if available.

Acceptability

When exploring what patients liked about their time on the CVW, their responses showed participants valued being monitored and having ease of access to staff and medical treatment. Participants reported a sense of **reassurance in being monitored,** of knowing that a deterioration would be identified and acted on:

> ‘You knew somebody is watching you. It's like big brother and he knew that you woke up in the morning. If there was a problem, and once we needed help, it was there with a phone call and there was always somebody there in case anything happened, you’re just…you’re being monitored' *Participant 1 (Model 1, RespiraSense)*

> ‘It was nice at the same time, even reassuring to think that you know, whatever was happening with being recorded and then someone was looking at it.' *Participant 3 (Model 1, RespiraSense)*

> ‘I know that there's somebody behind…behind the tablet or behind the questionnaire, you know I know that there’s somebody listening or somebody reading or somebody you know, keeping an eye' *Interview 6 (Model 1, RespiraSense)*

Patients **valued avoiding hospital admission, and delays in accessing medication**:

> 'The health team, they always knew what I was like in the morning, what I was like. They were always there to help me. Instead of going down to the hospital and sitting down there for 12 or 16 hours until I’d be seen' *Participant 5 (Model 1, RespiraSense)*

> 'Anything at all that helps you stay at home like. '*Participant 10 (Model 2, Corsano)*

> ‘So I was getting… I was getting … it seen to before it got to the stage where [patient] was really sick', *Participant 3 (Carer) (Model 1,RespiraSense)*

One participant reported feeling like **less of a burden on family and carers,** and the two carers included in the study reported feeling less worried about their relative while they were being monitored.

'You need somebody to help. You can't do that…. You can't be all your own, and your family's OK. But you really get you're getting on their nerves, you know, and they're fed up listening to you all the time.' *Participant 1 (Model 1, RespiraSense)*

'I knew that someone else was monitoring and going to check her in the morning and they might have picked up something I mightn't have seen …So that was and still is my reassurance' *Participant 9 (Carer)(Model 1, RespiraSense and Model 2, Corsano)*

Participants were appreciative of close interaction with and easy access to clinical staff who knew their background, and compared it favourably to hospital admissions in general:

'I would say almost better than you would in the hospital as you was getting more interaction with who was treating you.' *Participant 7 (Model 1, RespiraSense)*

'the staff you were dealing with understood your condition better than being on a ward full of... illnesses.' *Participant 7 (Model 1, RespiraSense)*

'I felt that I wasn't alone in my illness, and I felt that there was someone there, and all I had to do was make contact' *Participant 8 (Model 2, Corsano)*

Impact on disease

Participants were asked to describe what, if any, impact their time on the CVW had on their knowledge, understanding and control of their COPD condition. Two participants were not able to describe a change from their perspective, one reported a negative impression of the impact on disease, while the seven remaining participants described positive impacts, described below.

Some reported **improved awareness of symptoms:**

'You know I would pick up on it [an exacerbation] now 'cos I've got all the information. Like the sputum colour…' *Participant 1 (Model 1, RespiraSense)*

'I have a better understanding of how Mammy is. I can nearly tell now by looking at her' *Participant 9 (Carer)(Model 1, RespiraSense and Model 2, Corsano)*

Other participants **recognised the value of seeking medical attention sooner** when experiencing an exacerbation:

'Maybe if I fell into that again, you know, where I was really, really bad with my

chest, like, you know, I suppose just to have the medication there and maybe get started earlier. I know I'm going to hang on, which I shouldn't do, you know, that that's part of my problem that I'd probably hang on too long.' *Participant 4 (Model 1, RespiraSense)*

Others did not report experiencing a clear benefit from their time on the CVW, with one reporting an overall negative impression of their time:

‘COPD I would say isn't any better.’ *Participant 1 (Model 1, RespiraSense)*

‘You know, but I just felt at the end of it like I was the running rat on the table and I knew nothing of what's going on’, *Participant 2 (Model 1, RespiraSense)*

Suggestions for change

Participants were asked what they would change about the CVW if they could; three provided no suggestions. Any patient suggestions for change were related to enhanced recognition of what matters most to patients regarding their symptoms.

Participants suggested provision of **increased flexibility in questionnaire responses,** with option for free text for explanation of their responses or the use of simpler language:

‘The questionnaire was not allowing me to say this is how I feel... I felt I couldn't give honest answers to the questions because I felt it wasn't allowing me to compare it with what, with what I need to put down’ *Participant 2 (Model 1, RespiraSense)*

'I probably would have liked maybe something that you could fill in, you know, any for any additional information' *Participant 4 (Model 1, RespiraSense)*

‘You know it’s… the questions that are there are clear enough. Maybe… some of the answers, like NAME says ‘I'm grand’. [laughs]. You know, I don't know

how you'd do it. I'm trying to imagine 'I'm grand' being on the, on the app now' *Participant 3 (Carer) (Model 1, RespiraSense)*

Other participants suggested having the option to be **monitored and complete questionnaires during the day,** when symptoms are more pronounced.

'You know it takes me a while to get going in the morning, because I have the breathing to do.. do you get me? But I try to do what I can, but then just NAME would be asking me the questions and everything would be staying the same' *Participant 3 (Model 1, RespiraSense)*

'I was like how is your breathlessness today Mammy how's your breathing? And she says I'm still sitting on the bed NAME, how do I know how my breathlessness is' *Participant 9 (Carer) (Model 1, RespiraSense and Model 2, Corsano)*

'And I wondered, did that device tell you more, you know, during the day because, you know, you go to your bed, just fall asleep and you're just zonked out.' I just wondered, you know whether it could have been more beneficial… to have that device on during the day' *Participant 4 (Model 1, RespiraSense)*

Two reported some **dissatisfaction with lack of feedback on the results from remote monitoring**, and suggested they would value an end of admission review early after their admission or paper work with further details:

'I wish I'd have known what was found in that two weeks. I really, if I'd have been on the ward literally with all the X-rays and the scanning and everything else, it would have been done. Then I would have been told what the problem was and that would have been fine, but I got none of that. So I I didn't even know what your results were or anything. I don't know what they produced or anything.' *Participant 2 (Model 1, RespiraSense)*

'I suppose when you ask me about that, did I get any information back about all that? I probably, I don't, so I don't know, you know, I'm, I'm, I'm saying then none of those […]. So, I mean then probably thinking about that it probably would have been nice to know.' *Participant 4 (Model 1, RespiraSense)*

Emergent themes

While the themes identified a priori were relevant and suitable for exploring the patient experience with the CVW, they did not fully explore the mechanism by which the CVW had an ultimate impact on patients' COPD. Additional themes generated through the analysis, relevant to explaining and understanding the impact on disease are summarised below.

Patient understanding of disease and the CVW

There was a lack of clarity in some participants' understanding of the CVW. Two did not distinguish their time on the CVW from the rest of the care offered by the IRC team, referring to 'the hub' interchangeably with the CVW. Others were not aware it was a ward: *'I wasn't really aware it was called a virtual ward at the beginning' (Participant 8),* and understood their admission as being an 'experiment', viewing their involvement as a way of helping the HSE rather than the CVW being an alternative care pathway for them.

> Two participants reported not being sure whether or not they had COPD, and highlighted they were given conflicting information about the severity of their disease in the past.

'So when I went to my doctor's for something else [after the CVW admission] …I said by the way, what is wrong with my lungs? She said nothing. She said, you've got COPD.' *Participant 2 (Model 1, RespiraSense)*

Two participants understood the monitoring being part of a diagnostic process:

''You know, I, I wonder if the test that was done with the monitor. Does that show anything there to say you really do have COPD to me.' *Participant 4 (Model 1, RespiraSense)*

'All I know is it [the CVW] must have confirmed to my doctor that I've got COPD'. *Participant 2 (Model 1, RespiraSense)*

Previous experience of healthcare

Patients' previous experiences of healthcare featured throughout the interviews, and in general their experience on the CVW was contrasted favourably against the delays and wait time associated with previous episodes of illness.

'There's been times in my life that I've been sent direct to the hospital. You've been up to A&E. Not the last time, the second last time I was up there something for 36 hours' *Participant 4 (Model 1, RespiraSense)*

'They were always there to help me. Instead of going down to the hospital and sitting down there for 12 or 16 hours until I'd be seen.' *Participant 5 (Model 1, RespiraSense)*

''I had already been with the doctor with it, he sent me up to A&E, A&E sent me home. I knew there was something wrong. Three days later I ended up back in,

two days later they sent me home again' *Participant 7 (Model 1, RespiraSense)*

Patient attitude to health

One participant's willingness to engage with self-management tools may have been shaped by their approach to illness:

'I don't want to know what's going to happen five years or three years or well, nobody knows what I mean if I'm going to be here in five years, but I would just rather try to think positive about it, have a condition and be treated for it .' *Participant 3 (Model 1, RespiraSense)*

Conclusions

The interviews explored the experience of nine patients who were admitted to the CVW and two carers. The main findings include:

Accessibility

This patient cohort includes people with a range of confidence with technology, therefore patient support is crucial to being able to engage with virtual monitoring. The CARE team provided close support to those requiring additional assistance, and family members were also valuable to ensuring patients could fully engage with the ward. After some initial apprehension, the participants reported few challenges with the use of the technology, suggesting that with this level of support, the CVW is broadly accessible for the COPD patient cohort. Further work should be carried on assessing adaptations that may be required for patients with cognitive, visual or hearing impairment or learning disabilities.

Fidelity

The care pathway described by the participants to the research team closely resembled the planned CVW, except for the availability and use of video self-management tools. The close follow-up and contact from the team, appears to have been instrumental in ensuring participants completed their required daily tasks.

Acceptability

The participants were generally satisfied with their experience on the CVW, valuing the reassurance, ease of access to clinical staff and medication and avoiding hospital admissions. The CVW was generally seen as more favourable compared to participants' experiences with hospital visits when they were unwell. However, one participant noted that the quality of information given after discharge from the CVW was not as good as information received after a hospital stay.

Impact on disease

Positive impacts on disease where reported by most participants, including improved symptom awareness, improved comfort and increased willingness to access medical help.

Suggestions for change

Patient's suggestions for change included the provision of more information and feedback after an admission to the CVW, increased flexibility of the questionnaires and remote monitoring and/or questionnaires to take place during the day.

Contextual factors

Important themes which were identified in the process of the analysis, which may influence the patients' experience of and benefit from the CVW, included their understanding of their own diagnosis, their understanding of the purpose of the CVW and their previous experiences of healthcare.

Staff experiences

A total of 15 CARE staff members completed the anonymous questionnaire. The key findings from the survey are summarised below.

Positive Experience

The project closure survey of staff involved in the CVW revealed a generally positive experience, characterised by strong collaboration, enhanced decision-making, and a focus on patient-centred care. 80% of respondents identified as clinical staff, which highlighted the clinical emphasis in patient care delivery. 73.3% of all staff rated their satisfaction with the virtual ward experience highly, appreciating the improved integration of services and outreach for COPD management. Some non-clinical staff reported feeling less engaged in direct patient interactions, as expected.

Impact on Patient Quality of Life

Regarding the impact on patient quality of life, 66.7% of staff rated their potential influence as moderate to high. Staff noted that the CARE model facilitated better management of patients, particularly in preventing hospital admissions during exacerbations. Empowerment in decision-making was also highlighted, with 64.3% of staff indicating they could make better clinical decisions, aided by continuous access to patient data. As expected, non-patient-facing staff expressed limitations in their influence over decision-making.

Strength of Collaboration

Collaboration was a significant strength, with 86.7% of staff emphasising effective teamwork within the CARE model. Structured meetings and improved communication were cited as key factors enhancing team dynamics. Staff also recognised the importance of co-production with patients, with 86.7% believing it is strong, although some staff members indicated a need for further development in this area to fully integrate patient involvement in care.

Enhancements in Patient Education and Self-Management

In terms of patient education and self-management, 60% of respondents felt that co- production had positively impacted these areas. Daily interactions with CARE nurses were deemed essential in empowering patient education and self-management. While many staff members observed improvements in patient outcomes, with 93.3% noting positive changes in patient experiences, some acknowledged challenges such as technical issues and the need for clearer communication regarding digital tools.

Recommendations for Improvement

Overall, the experiences highlighted the model's effectiveness in managing chronic conditions, with 80% of staff recommending the CARE virtual ward to other healthcare teams. Areas for future improvement include enhancing engagement strategies, integrating digital tools, and ensuring clearer pathways for patient-centred care.

Summary of Key achieved Outcomes

Table 6 summarises the key achieved outcomes specific to the CVW performance. This is based on data captured on the Clinical Dashboard over the period November 2023 – May 2025, and including patient follow-up 90 days post discharge from the CVW (until end of August 2025).

Overall, most outcomes were achieved, suggesting the CVW was a successful model of care, offering an alternative patient pathway for managing COPD patients within the community.

Table 6. Outcomes and achievements during the CVW implementation period November 2023 – May 2025

Outcome	Target	Achievement	Status
1. Reduction in ED attendances (COPD)	**≥40% of patients experience a reduction in ED attendances**	92% reported reduction.[3] 181 patients contacted post-discharge: • 16 ED presentations (8.8%) • 13 LUH admissions (7.1%)	✔ Exceeded
2. Reduction in 30-day readmissions (same diagnosis)	**Reduce from 28.7% to 23%**	14.2% readmission rate achieved. • Detail: 66 patients supported discharge; • 18 readmitted within 30 days (27.3%).	✔ Exceeded
3. Reduction in hospital admissions due to COPD exacerbations	**Reduce by 15% hospital admissions with an exacerbation of COPD (based on data from Oct 21-22, 666 over 12 months, 55.5 average)**	18.32% reduction Jan 2024–Jan 2025 544 admissions in 12 months (avg 45.3/month). Supporting outputs: • 1972 unscheduled virtual episodes[1] (55 technical)[2] • 436 unscheduled face-to-face episodes[1,*] • 1289 scheduled virtual contacts[1] • 438 scheduled face-to-face contacts[1,*] • 171 rescue scripts initiated	✔ Achieved
4. Maintain average length of stay	**5.4 days**	7.4 days	✘ Not Met
5. Increase patient empowerment & understanding of COPD	**≥80% report increased understanding of COPD post-intervention**	83.9% completed pre-survey. 57.5% completed post-survey (after excluding	— Partial

		pathway exits). 82 patients exited pathway before post-survey.	
6. Digital upskilling of respiratory staff	**Train 27/30 staff (90%); 17 licenses issued**	27/30 trained (90%). 20 staff issued licenses (exceeding target).	✔ Achieved

*The process for collecting of this information was revised in April 2024 and included onboarding process for nurse to complete with patients as otherwise patients were missing this within the app.

[1]These figures are under-reported due to process for inputting data within the app by staff during initial on-going app development

[2]During a period of change from Model 1 to Model 2 and to the Corsano continuous monitoring device, additional technical support visits to patients were required. Moving forward, these additional visits will not be required.

[3]The reported outcomes are based on patients admitted and followed-up 90 days post discharge since May 2025.

Discussion

Overview of the CARE Virtual Ward

The evaluation of the CARE Virtual Ward (CVW) in Co. Donegal highlights its substantial benefits for high-risk COPD patients and illustrates its broader applicability within Ireland's healthcare system. This model not only serves as an innovative approach to managing COPD but also aligns closely with national healthcare reform priorities.

Key Benefits of the CVW

The CARE Virtual Ward (CVW) represents a significant advancement in community-based care, providing a virtual alternative to hospital admission for eligible COPD patients. Effective coordination of COPD discharge care is central to helping patients remain well at home and avoid the “revolving door” of hospital admissions. By integrating hospital, primary care, community services, and virtual ward support, patients receive a seamless, personalised approach that bridges the gaps between episodic care encounters. Through wearable monitoring technology and a bespoke digital platform, patients are assessed daily using a Green, Orange, Red (GOR) system, guiding timely clinical interventions.

The model empowers Respiratory Advanced Nurse Practitioners (ANPs) to prescribe COPD rescue packs, facilitating prompt treatment and improving patient outcomes. Early identification of high-risk individuals allows for timely optimisation of pharmacotherapy, comorbidity management, and education on self-management. Structured follow-up, including virtual monitoring and regular check-ins, allows for early detection of deterioration. Collaborative multidisciplinary huddles and shared care plans ensure that all teams are aligned, reducing duplication and providing a clear point of contact for patients. Addressing social and behavioural determinants, such as smoking cessation, nutrition, housing, and carer support, further strengthens the patient’s ability to manage their condition at home.

By effectively reducing hospital admissions, evidenced by average healthcare savings of €192,257 per patient under Model 1 and €177,742 under Model 2, resulting in total cost savings of €4,218,727.50 to the HSE, the CVW alleviates pressure on acute care services. This is critical given the increasing demand for healthcare services due to an aging population and rising chronic disease prevalence in Ireland.

The adoption of a standardised COPD exacerbation management protocol with integrated sputum surveillance has delivered exceptional outcomes since its implementation on the CVW platform. This structured approach has enabled early identification of Pseudomonas and similar resistant infections, allowing for prompt activation of targeted therapy that has significantly improved clinical outcomes while maintaining patient safety and antibiotic stewardship. Real-time symptom tracking through digital monitoring tools has proven invaluable in identifying early signs of deterioration, ensuring appropriate escalation of care and individualised management. The protocol’s emphasis on patient education and clear follow-up timelines has successfully empowered patients to manage their condition at home, with participants reporting increased confidence in recognising and responding to symptom changes.

Alignment with National Reform Priorities

The CVW model aligns seamlessly with several national reform initiatives, in particular the Enhanced Community Care (ECC) Programme (22) and the Sláintecare Implementation Strategy (15, 16). The CARE model is integrated within Donegal's Chronic Disease Management (CDM) service (23), part of the ECC structures. It enables the delivery of care at or near home, supported by community hubs, specialist teams, and GP referral pathways. This integration addresses the ECC's aims of hospital avoidance, early supported discharge, and care coordination for complex chronic disease patients, making it scalable across both urban and rural areas. Furthermore, the CARE model embodies Sláintecare's principle of "right care, right place, right time" by shifting care out of hospitals and into communities. It advances health equity, ensuring that patients in remote areas, including the islands of Donegal, receive the same standard of care as those living closer to Letterkenny University Hospital (LUH). By proactively targeting high-risk COPD patients, the CVW supports integrated, person-centered care through collaboration between acute and community clinicians. Additionally, the CARE model leverages existing infrastructure while embedding digital platforms and wearable monitoring devices to enhance care pathways, strengthening patient engagement and empowerment by prioritising education and co-management of their illnesses.

Comprehensive Model of Care

The CVW functions as a holistic care model, connecting patients with the right specialists at the right time and in the right place. Many patients within this pathway present with multiple comorbidities, such as heart failure and diabetes, demonstrating the model's potential to integrate respiratory, cardiology, and diabetes pathways under the ECC framework. This not only improves care for COPD patients but also enhances holistic management for complex patients across various chronic conditions. By leveraging a multidisciplinary team and robust digital platforms, the CVW ensures that patients receive coordinated management tailored to their complex needs. Daily engagement through questionnaires and direct access to clinical support fosters early intervention and empowers patients to take an active role in their health management.

Scalability and Future Potential

The CVW model is highly adaptable and has significant potential for a scaled rollout to support complex patients with various chronic conditions across Ireland. It integrates seamlessly with ECC Chronic Disease Hubs and Community Healthcare Networks, making it suitable for both rural areas, like Kerry, where it can use virtual monitoring and outreach, and urban settings, such as inner-city Dublin, where it can manage larger caseloads with closer ties to acute hospitals and specialist teams. This flexibility allows the CVW model to be transferable to other chronic conditions, including heart failure and diabetes, aligning with Sláintecare's goals for equitable, integrated, and digitally enabled care. The mainstreaming of the CVW model, can significantly impact high healthcare users, empowering GPs and primary care teams to identify suitable patients for structured self-management education and proactive community-based

care. This integrated approach will improve continuity of care, strengthen connections between patients and specialist teams, and ultimately enhance patient outcomes.

Conclusion

The CARE Virtual Ward is not merely a pilot project but a proven service that has redefined respiratory care in Donegal. Its successful implementation demonstrates measurable improvements in patient outcomes, hospital avoidance, and healthcare efficiency. Continued investment in this model is essential, as it addresses the pressing challenges of rural healthcare delivery and aligns with international best practices. By embracing and expanding the CVW model, Ireland can enhance its chronic disease management efforts, reduce reliance on acute services, and ultimately improve health outcomes for its population. The choice is clear: sustain and scale the CARE Virtual Ward to build on its success and solidify a future where integrated, patient-centred care is the standard.

Recommendations

- Continue the roll-out and full integrated implementation of CVW in co Donegal for patients with COPD
- Align staff training with new technology to further promote continued and accurate data capture in co Donegal
- Continue support of COPD patient training in using devices and engagement with educational resources via the app to further empower patients to self-manage their COPD condition
- Promote by the clinical team closer monitoring of patient vital signs during the day and ensure questionnaire completion during the day with providing more feedback to patients after discharge from CVW
- Develop engagement initiatives to increase involvement of both clinical and non-clinical staff in patient interactions and decision-making processes to foster a more inclusive care environment
- Implement clearer communication and training to staff members around digital tools to enhance their effectiveness in patient management and self-care education
- Patients with COPD are generally from an age group who may not have high confidence in using technology. The close support that has been offered to the patients enrolled on the ward so far should be continued to ensure maximum ability to participate in the ward.
- The CARE team should explore reasons why videos and other self-management content were not accessed by the majority of the participants in this evaluation, in spite of expressing interest in accessing this type of material. CVW team should consider encouraging continued use of self- management content post-discharge to support patients in becoming partners in their care
- Participants suggested a review after completing their admission on the ward, to understand the findings of the remote monitoring
- Participants indicated that early morning is not suitable for completing symptom questionnaires. If clinically appropriate, the CVW team could suggest patients submit questionnaires after a brief morning activity
- Participants expressed a desire for daytime monitoring, possibly due to a lack of understanding of overnight monitoring's rationale. The team should explain this during onboarding or evaluate the benefits of daytime monitoring for patients
- Some participants were not clear on their diagnosis, which may have impacted their understanding of the CVW. At the time of onboarding, the clinical team could assess the patient’s understanding of their own disease, and offer clarity where possible
- Participants in this evaluation had no cognitive, visual, or hearing impairments, thus accessibility for these groups was not assessed. Further work is needed to identify feasible adaptations for their access to the ward.

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Disclosure

The evaluation outlined in this report was conducted independently, guaranteeing that all findings reported were unaffected by influence from the team directly associated with the CVW.

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