Mixed method evaluation of the initial phase of BSOL-ICS virtual wards programme

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Abstract

Background: The use of virtual wards (VWs) to reduce hospital admissions and/or length of stay is growing, yet there is little consistent evidence informing their effective design and delivery.

Purpose, objective, and contributions: Using the examples of VWs in frailty, respiratory, arthroplasty, and surgical assessment introduced via the National Health Service in England virtual ward programme to describe and evaluate the extent to which VWs have, or might be, successfully implemented in the Birmingham and Solihull Integrated Care System.

Materials and methods: The work comprises four work packages: (1) Understand the factors influencing the design and development of VWs, gathering qualitative data from semi-structured interviews with senior stakeholders; (2) Understanding staff experiences and perspectives of leading and delivering the VW programme, using survey and interview data; (3) Evaluation of patient outcomes on the respiratory VW (specifically the early supported discharge for COPD) vs inpatient care, and (4) Health economic analysis assessing the cost-effectiveness the respiratory VW (specifically the early supported discharge for COPD) vs usual care.

Results: This evaluation provides insight into the early phases of the virtual ward programme in Birmingham and Solihull Integrated Care System with a specific focus on the respiratory virtual ward. The qualitative analysis findings indicate a need for a shared understanding of consistent referral pathways that consider social circumstances. Challenges related to the lack of interoperable databases were identified, as well as the necessity for a patient-facing digital tool accommodating varying levels of digital literacy and connectivity. Staff would benefit from more specific training, and improved messaging is needed to communicate the benefits of the virtual ward to patients and their family/carers. Additionally, robust collaborative agreements between organisations are essential, and broader regional planning should involve patients and staff in designing future iterations. The health economics analysis highlights the need for further work to fully understand the cost-effectiveness of the virtual ward by addressing existing data gaps, such as length of stay and readmissions.

Conclusion: We have identified key areas ranging from individual patient factors to broader influences of policy and commissioning influences, that require careful consideration moving forward with the VW programme and similar large-scale service interventions.

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List of Abbreviations

AF	Atrial Fibrillation
BAME	Black, Asian and Minority Ethnic populations
BCHCFT	Birmingham Community Healthcare NHS Foundation Trust
BHH	Birmingham Heartlands Hospital
BSOL-ICS	Birmingham and Solihull Integrated Care System
COPD	Chronic Obstructive Pulmonary Disorder
DECAF	Dyspnea, Eosinopenia, Consolidation, Acidemia and Atrial Fibrillation score
DSA	Deterministic Sensitivity Analysis
ED	Emergency Department
ESD	Early Supported Discharge
GBP	Great British Pound
GHH	Good Hope Hospital
ICER	Incremental Cost-effectiveness Ratio
LoS	Length of Stay
NASSS	Non-adoption, Abandonment, Scale-up, Spread, and Sustainability framework
NHS	National Health Service
NHSE	National Health Service England
O2	Oxygen
PIS	Participant Information Sheet
PSA	Probabilistic Sensitivity Analysis
PSSRU	Personal Social Services Research Unit
QEHB	Queen Elizabeth Hospital Birmingham
REDCap	Research Electronic Data Capture
UEC	Urgent and Emergency Care
UHBFT	University Hospitals Birmingham Foundation Trust
VW	Virtual Wards
WP	Work Package

1. Introduction and context

Box 1: Summary of Chapter 1

Summary of key points

- Continuing pressure on the capacity of healthcare services has warranted new models of care delivery
- Virtual wards are a technology-enabled or enhanced model of care that enables patients which might otherwise be admitted to, or remain in hospital to be cared for at home
- NHSE have invested £500 million to create between 40 and 50 sustainable virtual ward beds per 100,000 of the population by 2025
- Despite this investment best practice in their design and implementation are still to be fully established
- This report explores the first phase of the VW programme delivered by UHBFT in conjunction with BCHCFT

Background

Healthcare systems in the UK are under growing pressure for a variety of reasons including ageing populations with increasingly complex care demands alongside a corresponding increase in the cost of care [1]. In NHS England (NHSE) in- and out- patient service provisions need to evolve to accommodate this demand. One approach that may ease this pressure is the use of home-based inpatient and outpatient care models to help avoid unnecessary admissions, facilitate early discharge, and reduce unplanned visits [2-4].

Service delivery models that offer inpatient care at home have been in use in various formats for several years [2] This model of care broadly refers to services that offer a limited period of hospital ward-level acute care at a patient's place of residence [5]. Amongst them are NHSE's virtual wards (VWs) that entail variable face-to-face services that combine digital tools with teams of multi-disciplinary care providers to support patients in their place of residence who might otherwise be cared for in hospital [5].

Existing evidence of VWs

Despite limited data on patient and clinical outcomes, early evidence suggest VWs can provide a safe and efficient alternative to bedded care preventing avoidable admissions and supporting early discharge [6]. They meet patient preferences for care in a familiar (home) environment [7], with associated benefits including reduced functional decline and hospital-acquired rates of infection, increased personalisation of care, particularly from a wellbeing standpoint, and improved self-management [2, 8-10]. There are also benefits for health

services due to more precise and efficient contact with clinicians, shorter hospital stays and lowered rates of hospital readmission [2, 8-15]. The premise and potential of VWs appears straightforward and is widely acknowledged with their proliferation across North America [16], Australia [17], the Far East [18] and elsewhere in Europe [19].

NHSE VW programme

The promise of VWs has led to NHSE investing £450 million over two years with the original intention of creating between 40 and 50 virtual ward beds per 100 000 of the population by 2025 [20, 21]. Hospitals were expected to fund their ongoing running costs following the initial setup using NHSE funds [20]. This relatively short timeframe meant that across England a number of local areas have rapidly introduced VWs for patients with a range of conditions. In the West Midlands, Birmingham and Solihull integrated Care System (BSOL-ICS) planned the introduction of five virtual wards for Respiratory, Frailty, Cardiology, Surgery and Diagnostic pathways with the original intention of reaching a combined virtual ward capacity of around 420 beds by the end of 2023. However, the speed of their introduction and the relative novelty of VWs means the models of care which support them are still evolving and best practice in their design and implementation are still to be fully established [14, 20]

This report evaluates the first phase of the VW programme delivered by University Hospitals Birmingham Foundation Trust (UHBFT) and Birmingham Community Health Care NHS Foundation Trust (BCHCFT). In doing so it explores the experiences of senior decision makers, clinical leads and those delivering the service, and examines the impact on a range of patient outcomes and the cost effectiveness in one example of the VW programme.

2. Aims and objectives

Box 2: Summary of Chapter 2

Summary of key points

The work has four key aims

- The broader principles and processes underpinning the design and delivery of the VW programme
- The experiences of clinical and non-clinical staff delivering VWs
- The impact of VWs on service utilisation and patient outcomes
- The 'value for money' of the VW programme vs usual care

Introduction and context

The broad aim of the evaluation was to determine the extent to which the UHBFT and BCHCFT VW programme is acceptable, effective, and affordable. To achieve this there are four discrete aims as described below.

Aims of the evaluation

1. To understand the principles and processes underpinning the design and delivery of the VW programme including the perspectives of senior decision makers and commissioners from BSOL-ICS and the regional NHSE teams supporting the delivery of VWs.
2. To report the experiences and perspectives of clinical and non-clinical staff delivering the VW programme including workload, training, the presence and effectiveness of collaborative networks, and perceptions of patient access and acceptability.
3. The use of aggregated and anonymised routinely collected data to understand the impact of VWs on service utilisation and patient outcomes of the virtual respiratory ward.
4. To assess the cost-effectiveness of the VW programme using the respiratory virtual ward as an exemplar, compared to the traditional inpatient hospital ward.

3. Methodology

Box 3: Summary of Chapter 3

Summary of key points

- The evaluation uses a mixed-methods design
- Qualitative data captured via semi-structured interviews analysed using a pre-determined implementation framework
- Quantitative patient data routinely collected and analysed by "Pioneer" data hub
- Health economic modelling using routinely collected patient data and NHS costs

Introduction and context

To address the aims and objectives outlined in Chapter 2, the work was divided into four work packages each corresponding to one of the aims. The evaluation is mixed method by design incorporating qualitative and quantitative data capture and analysis and health economic modelling. The data from the various elements will be combined using a framework based synthesis informed by the Non-adoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) framework allowing for structured learning that is readily transferable to similar initiatives [22-24].

Theoretical lens

The NASSS Framework

The NASSS framework was developed specifically to help plan the implementation and rollout of technology-enabled care programmes [25]. Its multi-dimensional structure allows the systematic identification of the various elements that contribute to the successful delivery of technology-enabled care interventions. The framework consists of seven domains relating to, 1) the complexity of the *Condition;* 2) the nature of the *Technology;* 3) the *Value proposition* to stakeholders; 4) the attitudes of and impact on *Adopters; 5)* the culture and capacity of the *Organisation; 6)* the influence of the *Wider system;* and 7) the steps needed for the intervention to *Embed over time*. These domains and the underpinning rationale are summarised in Figure 1 and further described in Table 1.

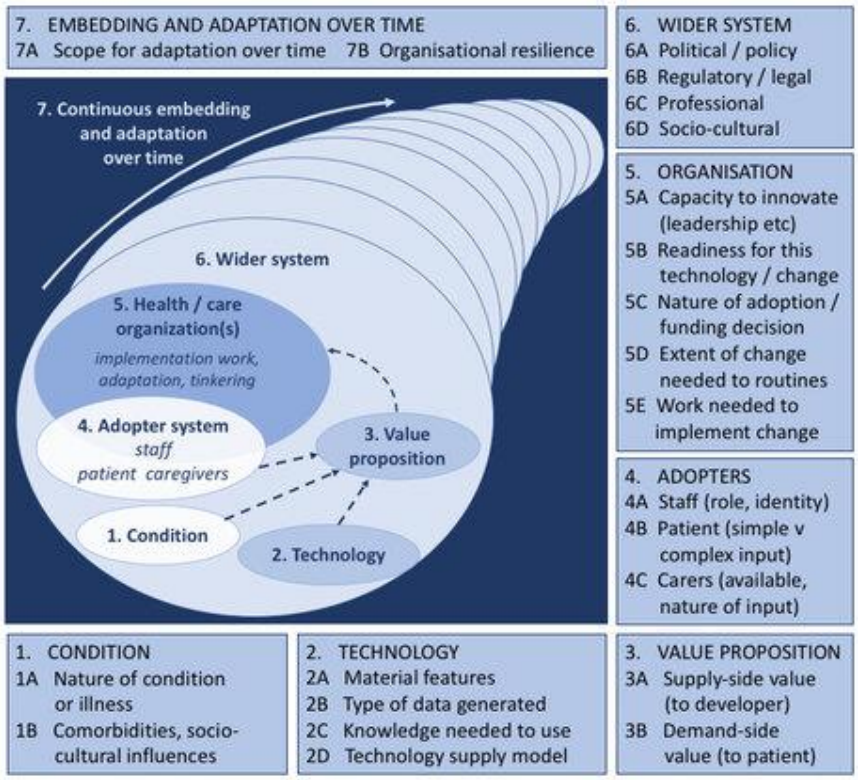

Figure 1: Summary of the NASSS framework

Table 1: NASSS framework – Domains, definitions, and influences on implementation

Domain	Definition	Influences on implementation
Condition	The condition(s) for which the innovation or technology has been designed, these can be physical, mental, or psychosocial in nature.	• The complexity of the condition - its metabolic volatility, association with co-morbidities, impact on cognitive function [26].
Technology	The technology/ies or other innovation that is being introduced. Includes both hardware and software and can include a novel protocol or pathway – or some combination of these.	• Its material properties - functionality, dependability, speed [27]. • The knowledge needed to use them [28]. • The knowledge generated by the technology [29]. • The supply model, and the relationship with the care provider [30]. • The ownership of intellectual property [31].
Value proposition	The value (financial or otherwise) that the new technology and care model generates. This includes, for commercial stakeholders the return on investment; for patients, improvements in comfort, or quality of life; for healthcare organisations, improvements in quality, safety, inclusivity and efficiency of the care delivered.	• Provision of value to a range of stakeholders - suppliers, patients, the healthcare system, and taxpayer or insurer. • Formulating a credible business plan where efficacy or cost-effectiveness studies are unavailable or contested [32, 33].
Adopters	The intended users of the technology or other innovation. This includes patients/lay people, professionals, administrative and support staff.	• Acceptability to service users and their family/carers [34]. - Attitudes towards new and emerging technologies [35]. - Influence of socio-cultural factors such as poverty, social exclusion [36]. • Acceptability to staff - Impact on roles, professional traditions and codes of conduct [23].

Organisations	The cultural and organisational characteristics of the organisations involved. This includes structure, capacity, and capability to adopt new ways of working. As well as resources of staff and infrastructure.	• The organisation's general capacity to innovate [37]. • Readiness for this particular technology [23]. • The decisions around funding the intervention (including the presence of inter-organisational agreements or speculative cross-system savings in the funding decision [38]. • The extent of the change needed including the potential disruption to existing routines [39]. • The work required in implementation - including staff engagement, fidelity of implementation and evaluation [40].
Wider system	The national and local context for the introduction of the technology or programme	• The impact of national and local policies and objectives [41]. • The support of regulatory or professional bodies [42]. • Socio-cultural factors including public perceptions of the technology [43]. • The presence of inter-organisational networking and collaborative initiatives in supporting implementation [44].
Embedding over time	The key changes and uncertainties expected to affect the integration of the technology over the next 3-5 years.	• The ability of the technology to adapt to changing context [45]. • The resilience and cultural stability of the organisations involved [46].

** (adapted from Greenhalgh, Abimbola, Litchfield [23, 24, 47, 48])*

The four work packages (WP) can be summarised as follows:

WP1: Design and development of VWs – Gather the experiences of senior stakeholders and policymakers responsible for the design and development of VWs including regional partners supporting the development of future VWs.

Data: Qualitative

Data Collection: Semi-structured interviews

Data analysis: Directed content analysis using NASSS framework

WP2: Staff experiences and perspectives of VWs - Gather the experiences of clinical and non-clinical staff delivering VWs in terms of workload, training, collaborative working but also their perceptions of patient access and acceptability. We will use a combination of semi-structured interviews and an online survey.

Data: Qualitative, Quantitative

Data Collection: Semi-structured interviews, Survey

Data analysis: Directed content analysis using NASSS framework

WP3: Evaluation of patient outcomes: Use routinely collected data to including information on a variety of patient outcomes on the respiratory virtual ward relating to the care of patients with Chronic Obstructive Pulmonary Disorder (COPD) including a comparison of variables such as length of stay and rates of readmission.

Data: Quantitative

Data Collection: Routinely collected data

Data analysis: Statistical analysis

WP4: Cost-effectiveness of the respiratory virtual ward – evaluate the costs and effectiveness in terms of length of bed days of respiratory VWs in comparison to traditional inpatient hospital wards from the healthcare perspective.

Data: Quantitative

Data Collection: Routinely collected patient data, publicly available NHS reference costs, results of WP3.

Data Analysis: Decision-analytic model in the form of decision tree model

Below we present the detailed methods involved in each work package where relevant describing the population and recruitment, data collection and data analysis.

Detailed Methods

WP1 and WP2: Semi-structured interviews

Evaluation population and recruitment

Senior staff representing a range of roles and specialities designing and developing (WP1) and managing and delivering (WP2) VW services were invited to participate. Staff participants who agreed to be contacted by a researcher were issued with a participant information sheet (PIS) and then offered the opportunity to ask questions before being consented prior to the commencement of the interview. We aimed to carry out interviews with senior decision-makers at national and regional level (WP1) and 5-6 staff members from each VW including lead, staff delivering the service and administrative staff/staff with data knowledge (WP2) for a sample size of between 15-25 staff interviews.

Potential participants were contacted by the researcher and after consideration of the PIS, and the opportunity to have any queries answered, they signed the consent form prior to the commencement of the interview. All interviews were conducted over the phone or via an online platform (Zoom or MS Teams).

Data Collection

Semi-structured interviews were conducted by a team of experienced qualitative researchers including authors IL and RL with backgrounds in applied health research, and medical sociology. All were unknown to participants. The interviews followed topic guides that included questions about their role in VW, the training received, the processes involved, and personal experiences of delivering the service (for detailed summary of the topic guide see Appendix 1). They were conducted via digital platform or telephone according to the participants preference, digitally recorded and transcribed verbatim by an approved transcription service. The data was managed using nVivo10 software.

Data analysis

Data collection and a preliminary analysis was carried out in parallel to provide formative feedback. The final data set from the interviews was used in a directed content analysis to

populate the NASSS framework [49, 50]. This enabled a structured description of the factors influencing the sustainable adoption of VWs.

WP2: Online staff survey

Evaluation population and recruitment

Staff involved in each VW were identified by their managers and sent a link to the online survey (and QR code) via an email issued by the Research Electronic Data Capture (REDCap) system directing them to the online survey. A PIS was provided online to ensure informed and voluntary participation. It contains details on the background to the evaluation, the potential risks associated with participation, and a description of how their data would be used. REDCap maintained a record of the number of surveys started and the number completed. Completed surveys were stored anonymously on REDCap. Where surveys were started but not completed REDCap sent two automated reminders on seven and 14 days.

Electronic (e)-consent was obtained on the REDCap database . On completion of the e-consent form, participants were allocated a unique REDCap pseudo-anonymised code in place of their personal details which was held separately from their personal information. Only authorised personnel will have access to this link.

Data Collection

We carried out a survey capturing staff experiences of delivering any of the extant VWs. Two sets of questions were developed: one for service leads/manager, and one for staff delivering the service. The survey gathered information on the set-up processes and models implemented, staff experiences of implementation, and factors influencing delivery including staff training and experience. The survey included a number of closed questions followed by a final single, open text question to give staff the opportunity to share any wider thoughts (A copy of the survey can be found in Appendix 2).

To reduce burden and maximise response rates, the online survey was designed to take no longer than 15 minutes to complete. The survey was piloted with a small number of individuals to determine whether questions were appropriate and relevant to the role of individual participants and the aims of the evaluation. It was then circulated to the wider staff population.

Data analysis

The quantitative survey data were analysed using statistical software and descriptive statistics produced. Any free text was to be interpreted using a directed content analysis within the seven domains of the established NASSS framework [49, 50].

WP3: Statistical analysis of patient outcomes:

Population

This work uses the early supported discharge respiratory VW as an exemplar referred to as respiratory virtual ward for the purposes of this report. Patients will be identified by the physiological parameters relevant to the VW. For example, Dyspnea, Eosinopenia, Consolidation, Acidemia and Atrial Fibrillation score (DECAF) score ≤1, Bp >110/70 and no episodes below this in preceding 48 hours, Pulse 60-120 and stable, not in atrial fibrillation (AF) unless previously diagnosed, not requiring oxygen (O_2) therapy unless previously known to have home O_2 and access to a telephone.

Data variables

We aimed to identify all patients who meet the eligibility criteria for respiratory VWs vs those receiving inpatient care. Patients will be matched for demographics, disease duration and severity, co-morbidities, and smoking status. At least 10 individuals were to be matched to each patient discharged to a VW. Patients were to be excluded from (respiratory) VW if they have major uncontrolled co-morbidities, including uncontrolled blood glucose, uncontrolled atrial fibrillation, heart failure requiring intravenous diuretics, or confusion. Patients will be matched by demographics, comorbidities, and specific care bundles.

Data collection

This work package was outsourced to "PIONEER" a health data research hub situated within UHBFT. It has access to a comprehensive data set of a patient's journey routinely collected from the electronic health record systems. It includes both presenting symptoms and patient demographics including (but not limited to) age, ethnicity and multimorbidity, serial readings of physiology – such as pulse, blood pressure and oxygen saturation, acuity scores, laboratory results, imaging, and pathology samples. This data is complemented by diagnoses, prescriptions, drug administrations and interventions and previous or subsequent healthcare contacts which led to (or resulted from) an acute healthcare event.

Data analysis:

Descriptive statistics and a regression analysis was conducted comparing the following variables against usual care.

- Length of stay
- Proportion of patients with Length of Stay (LoS) < 24 and < 48 hours
- Readmission within 30 and 90 days
- Use of Intra Venous antibiotics 48 hours after admission
- Mortality within 90 days

WP4: Economic analysis

Given the limited time and data availability, the analysis specifically assesses the cost-effectiveness of respiratory virtual wards in facilitating early discharge for COPD patients (again hereon referred to as respiratory virtual ward for the purposes of this report), to traditional inpatient care. It provides insights to guide future resource allocation decisions and optimise the virtual ward model for sustainability and value for money in healthcare.

To understand the cost effectiveness of the respiratory VW, we developed a decision-analytic model in the form of decision tree model in Microsoft Excel 2024 (Microsoft Corporation, Redmond, Washington, USA) which was parameterised to reflect the patient pathway within the respiratory virtual ward and the traditional inpatient hospital ward. Decision trees were used to provide a straightforward, step-by-step visual representation of the various pathways that improve clarity and understanding, especially in complex scenarios. The short-term nature of patient turnover within respiratory VWs also makes the decision tree model a suitable application for this analysis. We evaluated the costs and benefits of the respiratory virtual ward for COPD exacerbation patients in comparison to the traditional inpatient hospital ward from the healthcare perspective.

Model Structure

The model structure was developed in consultation with clinical experts from the virtual wards. The agreed model structure, presented in Figure 2, shows the pathways for patients entering either the respiratory virtual ward or the traditional inpatient hospital ward.

In the virtual wards arm, patients with COPD exacerbation initially admitted to a hospital ward can either be early discharged to virtual wards or remain in the hospital ward. Patients admitted to virtual wards can be fully discharged from their care, or some patients might need to be escalated back to the hospital ward if their condition worsens before being fully discharged. Upon discharge, patients can either be readmitted within the first 30 days or not. Additionally, post-discharge, patients can either survive or die. Current data shows that very few patients are escalated to critical care, so it was not deemed worthwhile to model this for the current evaluation.

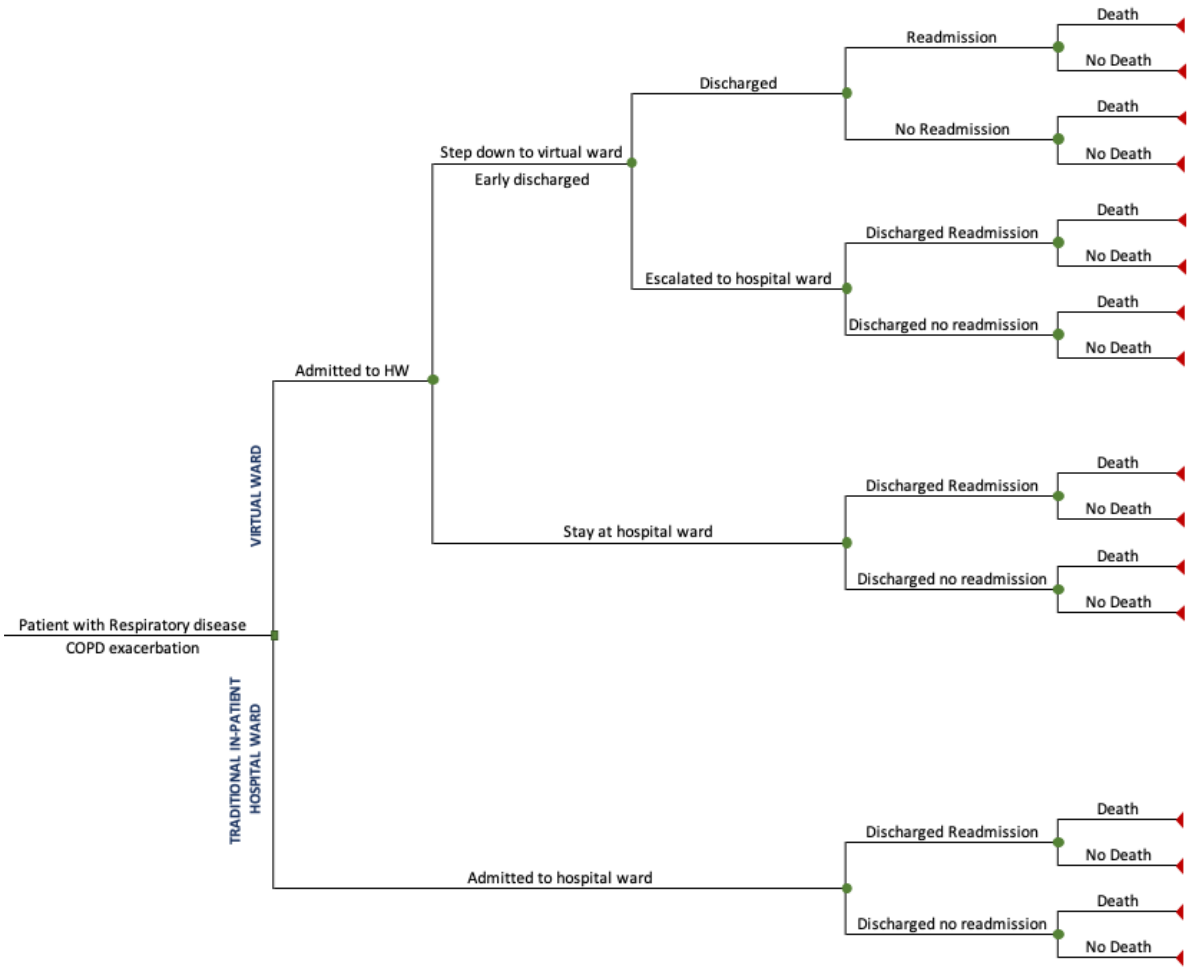

Figure 2: Model Structure

Model parameters

Probabilities

Probabilities indicate the likelihood of patients progressing through different model pathways [51]. To ensure our model reflects the current conditions in the BSOL-ICS, we used probability estimates from the PIONEER Health Data Research Hub report, which provided a quantitative analysis of the BSOL-ICS respiratory virtual ward. When data were unavailable, we sought expert opinions, made informed assumptions, and referred to published literature to derive the necessary probabilities. Model probabilities are presented in Table 2.

Table 2: Model Probabilities

Parameter	Value Used (SE)*	Distribution	Distribution Parameter	Source
Strategy: Virtual Ward				
Proportion of patients stepped down to VW	0.45 (0.18)	Beta	α=2.99 β=3.65	The BSOL-ICS VW database
Proportion of patients escalated back to HW	0.13 (0.052)	Beta	α=5.31 β=35.52	PIONEER report
Proportion of patients readmitted within 30 days (discharged from VW)	0.32 (0.128)	Beta	α=3.93 β=8.35	PIONEER report
Proportion of patients readmitted within 30 days (after escalation to HW)	0.26 (0.104)	Beta	α=4.37 β=12.42	PIONEER report
Proportion of patients died	0.023 (0.0092)	Beta	α=6.08 β=258.41	PIONEER report
Strategy: Traditional Inpatient Hospital Ward				
Proportion of patients readmitted within 30 days	0.19 (0.076)	Beta	α=4.87 β=20.77	PIONEER report
Proportion of patients died	0.023 (0.0092)	Beta	α=6.08 β=258.41	PIONEER report

*SE was calculated using a coefficient of variation of 0.4
VW= virtual ward, HW=hospital ward; SE=Standard Error; BSOL-ICS=Birmingham and Solihull Integrated Care System

Effectiveness measure and Length of Stay

The effectiveness measure focused on the length of stay or saved bed days. The length of stay data for both respiratory virtual wards and traditional inpatient hospital wards was derived from secondary data, based on the result from WP3 to reflect the current situation at the BSOL-ICS. When data was reported as medians with interquartile ranges, we estimated the mean and standard deviation using the method proposed by Wan et al [52]. This data is presented in Table 3.

Table 3: Length of Stay

Parameter	Value use (Mean, SD)	Median (IQR)	Distribution	Distribution Parameter	Source
Strategy: Virtual Ward					
Hospital ward (initial)	4.58 (4.33)	4 (1.96, 7.79)	Gamma	α=1.12 β=0.27	PIONEER report
Hospital ward (escalation)	4.44 (5.07)	4.25 (1.13, 7.96)	Gamma	α=0.77 β=0.13	PIONEER report
Virtual ward	9.79 (8.94)	9 (4.17, 16.21)	Gamma	α=1.20 β=0.15	PIONEER report
Readmission	4.18 (5.26)	3.8 (0.83, 7.91)	Gamma	α=0.63 β=0.09	PIONEER report
Strategy: Traditional Inpatient Hospital Ward					
Hospital ward	4.81 (4.86)	4.29 (1.79, 8.33)	Gamma	α=0.98 β=0.19	PIONEER report
Readmission	3.93 (5.50)	3.2 (0.60, 8.01)	Gamma	α=0.51 β=0.07	PIONEER report

SD=Standard Deviation; IQR=Inter Quartile Range

Cost and Resource Use

The model input costs are presented in Table 4. The unit cost per patient staying in respiratory virtual ward daily was derived from the BSOL-ICS VW business case. This cost incorporates expenses for staff time, technology, setup, and monitoring for 22/23. Other relevant unit costs were identified from established national sources, including the NHS Reference Costs [53, 54] and the Personal Social Services Research Unit (PSSRU) costs [55].

To calculate total costs, relevant unit costs were multiplied by the corresponding resource use data. All costs are reported in 2022-23 Great British pounds (GBP) values. Where necessary, costs were inflated using the Hospital and Community Health Services Pay and Prices Index [55].

Table 4: Model Input Costs

Resource use	Unit Cost (£)	Detail	Distribution	Distribution Parameter*	Source
Virtual ward	74	per patient per day	Gamma	α=6.25 β=0.53	BSOL-ICS VW business case
Hospital ward (COPD)	499.74	per patient per day Service code DZ65A-K; weighted average elective and non-elective long stay	Gamma	α=6.25 β=0.08	NHS Reference cost 2017/2018**
Outpatient appointment (respiratory cases)	198.08	per visit Service code 340***	Gamma	α=6.25 β=0.20	NHS Reference cost 2021/2022

*Using coefficient of variation of 0.4
**The latest NHS reference cost which provided detail information about the average bed days
***Outpatients appointments for respiratory medicine service, with consultant and non-consultant led.

Model-based analysis

The cost-effectiveness analysis took the healthcare perspective. A roll-back method was employed to estimate the anticipated costs and outcomes for both the virtual wards and traditional inpatient hospital ward arms. The results were presented as the difference in costs and bed days. A strategy or intervention is deemed cost-effective if it is cheaper and more effective (fewer bed days), thus dominating the alternative. Conversely, an intervention is considered 'dominated' if it is both more expensive and less effective than another intervention, indicating that the alternative option provides better outcomes at a lower cost.

The model timeframe, which is the duration for which costs and outcomes are measured, was set to 30 days. This timeframe allows us to capture patient readmissions and deaths within 30 days and aligns with the typical monthly budget cycles of the program.

Probabilistic sensitivity analysis

Probabilistic Sensitivity Analysis (PSA) was conducted to assess the uncertainty of the model inputs and base case estimates. PSA presents uncertainty by simultaneously varying multiple input parameters, repeatedly drawing random values to re-estimate differences in costs and outcomes based on parameter distributions [51]. Parameters ranging between 0

and 1, such as model probabilities, were assigned a Beta distribution. Meanwhile, parameters expected to have positively skewed values, like cost and length of stay data, were linked to a Gamma distribution. Given the limited data availability, we intentionally assigned a wide distribution around the estimates by varying the coefficient variant to identify the extent to which changes in these values influenced the cost-effectiveness decision. We arbitrarily used a wide coefficient of variation of 0.4 for parameters where standard error was not available. A higher coefficient of variation indicates greater dispersion or variation around the mean value, implying greater uncertainty [56]. The PSA was run for 5,000 Monte Carlo simulations, and the results were visualised on a cost-effectiveness plane [57, 58].

The cost-effectiveness plane is divided into four quadrants, each representing a different cost-effectiveness scenario [51, 58]. The north-east quadrant represents situations where the intervention is both more effective and more costly than the comparator, indicating that the intervention is cost-effective if the decision-maker is willing to pay more for the additional benefit. The south-east quadrant represents situations where the intervention is both more effective and cheaper than the comparator, indicating that the intervention is dominant and the preferred option. The south-west quadrant represents situations where the intervention is less effective and less costly than the comparator. The north-west quadrant represents situations where the intervention is less effective and more costly than the comparator, suggesting that the intervention is not cost-effective and should only be chosen if there are other compelling factors that justify the additional cost [59, 60].

Deterministic sensitivity analysis

Deterministic Sensitivity Analysis (DSA) was performed to evaluate the sensitivity of the base case results to changes in specific input parameters. This involved altering the value of one parameter at a time while keeping the rest constant. A parameter was deemed sensitive if its value change affected the base case cost-effectiveness results. We adjusted the base value for all model input arbitrarily and also used available values from other studies. Detailed information regarding the values utilised in the DSA is presented in Table 5.

Table 5: Parameter values used in deterministic sensitivity analysis

Variable	Base case value	Value used	Source
MODEL PROBABILITIES			
Strategy: Virtual Ward			
Proportion of patients stepped down to VW after admitted to HW	45%	31.50%, 58.50%	-30%, +30%
Proportion of patients escalated back to HW from VW	13%	10%, 22.20%	NICE study 2023 [61]
Proportion of patients readmitted within 30 days (discharged from VW)	32%	5%, 41.60%	Lower bound using value used in NICE study 2023 [61]; Upper bound +30% base value)
Proportion of patients readmitted within 30 days (after escalated to HW)	26%	18.20%, 33.80%	-30%, +30%
Proportion of patients died	2.30%	2%, 3.80%	Lower bound -30% base value; Upper bound from NICE study 2023 [61]
Strategy: Hospital Ward			
Proportion of patients readmitted within 30 days	19%	8%, 25%	Lower bound using value used in NICE 2023 study [61]; Upper bound +30% base value)
Proportion of patients died	2.30%	2%, 3.80%	Assuming the mortality might not differ from the VW according to NICE 2023 study[61]
LENGTH OF STAY (days)			
Strategy: Virtual Ward			

Hospital ward (initial)	4.58	0.7; 2.2	Lower bound using NICE 2023[61] ; and using value -50%
Hospital ward (escalation)	4.44	2.22; 5.77	-50%, +30%
Virtual ward	9.79	3.9; 12	NICE 2023[61]
Readmission	4.18	2.93; 4.44	Lower bound -30% base value; Upper bound using value assuming the same as hospitalisation after escalation from VW
Strategy: Hospital Ward			
Hospital ward	4.81	3.37; 6.25	-30%, +30%
Readmission	3.93	2.75; 4.81	Lower bound -30%; Upper bound using value assuming the same as initial hospitalisation before readmission
COST			
Virtual ward	£74.00	£96.20	Upper bound +30%
Hospital ward	£499.74	£349.82	Lower bound -30%
Outpatient appointment (respiratory cases)	£198.08	£138.66; £257.50	-30%, +30%
Other scenarios			
VW strategy - LOS Hospital ward (initial)	4.58	2.2	-50%
VW strategy – LOS Hospital ward (escalation)	4.44	2.22	-50%

4. Findings: WP1 Design and development of VWs

Box 4: Summary of Chapter 4

Summary of key findings by NASSS domain

Organisation

- The NHSE regional VW team provided advocacy, support, and monitored progress of local teams
- Teams that had led similar models of care to VWs such as previous iterations of "Early supported discharge" were better able to adopt VWs

Wider System

- The expected numbers of VW beds and capacity were deemed unrealistic, particularly in absence of corroborating evidence of their benefits at scale
- Implementation of the VW programme was supported by pre-existing collaborative partnerships across organisations and shared financial governance

Background/context

The national programme for the development and delivery of virtual wards across the NHS in England emerged as a clear priority for NHS England and the politicians leading the Department of Health and Social Care [6, 62, 63]. Numerous public references to virtual wards were made by the Secretary of State and they achieved a high profile in the public discourse as the national programme unfolded. However, political science literature suggests that national policy objectives may not always be faithfully translated into action on the ground where a range of influences can act on their interpretation. Exploring these influences on the VW programme offers both national and regional organisations the opportunity to learn about the impacts on implementation in terms of future policy development and delivery, and the measurement and understanding of success.

This work package considered the relationship between centralised commissioners and policymakers (NHSE national and regional teams) and the BSOL-ICS to understand the process by which, national objectives were actioned locally. Specifically, we were interested in understanding:

- The process by which national objectives are communicated to local systems for implementation and to what extent and how are national/regional actors involved in local implementation?

- How do local organisations within BSOL-ICS interpret national mandates and how do these policies develop as they cross organisational boundaries?
- What are facilitators and barriers to creating a coherent local approach to system wide policy?

Qualitative results

The data were analysed using the relevant domains of the NASSS framework (see Table 1 section 3). This led to the data being considered in terms of two domains: Organisation, relating to the cultural and organisational characteristics of the organisations involved, and Wider System, describing the national and local context for the introduction of the technology or programme.

Table 6: Description of Participants

Senior Lead Participant ID	Role (In relation to virtual ward programme)	Scope of role (Trust, ICS, Regional, National)
SL01	System Improvement Team	National
SL02	Service Transformation Lead	Trust
SL03	Clinical Lead	Trust
SL04	Clinical Adviser	Regional
SL05	Clinical Specialist	Trust
SL06	Hospital Services	Trust
SL07	Programme Lead	ICS
SL08	Digital Transformation Lead	Trust
SL09	Programme Lead	ICS
SL10	Intermediate Care Lead	Region

Organisation

The work required in implementation

The role of the NHSE regional virtual ward team

The NHSE Midlands regional virtual ward team was nested within the wider Urgent and Emergency Care (UEC) team. The UEC has two primary aims nationally:

- Patients receiving quicker care in emergency departments: with the goal of increasing to 76% of patients being admitted, transferred, or discharged within four hours by March 2024, with continued progress into 2024/25

- Faster ambulance response times: aiming to reduce average ambulance response times for Category 2 incidents to 30 minutes over 2023/24, with further improvements in 2024/25 towards pre-pandemic level.

Situating the NHSE regional VW team here was perceived as better enabling them to link virtual ward development to the wider aims and objectives for UEC. This perhaps became more pertinent in the second year of the programme when national funding for virtual wards was no longer ringfenced but became part of the overall allocation for UEC. The regional teams performed a range of roles including monitoring, support and advocacy. These are summarised in Box 5.

Box 5: Roles undertaken by the regional NHSE virtual ward team

- **Monitoring and performance management**: This involved signing off local plans and challenging local systems where plans did not appear ambitious enough within the context of national targets. If progress with implementation was deemed to be slow, the regional performance team could be notified, and the issue would be incorporated into wider performance meetings with local systems. A regionwide audit of patient eligibility was also used to challenge performance in some cases.

- **Developmental support**: The regional team would adopt a problem-solving approach to ICS delivering the VW programme and support them with access to advice and expertise, guidance on best practice, and link them to other systems with relevant knowledge.

- **Advocacy**: Where systems were unable to meet national targets for reasons that were perceived to reasonable, the regional team would communicate this to the national team and agree a 'below-target' plan.

- **Policy interpretation and permission-giving**: The regional team negotiated with local systems to agree workable models of virtual wards that took into account local contexts and the readiness of local clinical systems.

Organisation (domain of the NASSS)

The strength of inter-organisational agreements

The members of the regional team did not view themselves solely as agents for the dissemination of national policy. In some respects, they positioned themselves as a buffer zone between national requirements and local contexts – recognising that the national objectives may need some amendment when being implemented in different health and care systems. This could involve 'saying the unsayable' (SL04) to the national team. Generally, local system actors found their interactions with the regional team helpful and responsive to local issues. One participant described how they would fulfil a supportive role for example attempting to link VW programme leads with areas of best practice:

> *"…is there anything that [the regional team] can support you with? What model are you using, can we link you up with anybody that's doing that more successfully so you can get some ideas and help you progress your model?" SL01, System Improvement Lead, National*

The regional team would also act as advocate on behalf of the BSOL-ICS service in their interaction with national service leads, explaining and supporting the sometimes-different approach that was taken:

> *"…on a number of occasions [the regional link person] would actually on our behalf go back [to the national team] and say I don't think this is the right approach, or actually the way they're approaching it and the numbers they're putting against this is right…" SL02, Service Transformation Lead, Trust*

A supportive financial governance system across the system was also reported, with a shared control total (ie managing resources at a system level as well as at the level of individual providers) and a system-wide investment committee which considered how much local resource should be allocated to virtual wards. This served to address financial barriers to collaborative working, such as misaligned payment incentives, that have been frequently observed in the NHS.

However, some challenges to local system working were also identified. Recent structural change to the NHS (for example, the shift from Primary Care Trusts to Primary Care Groups to Integrated Care Boards) was seen as an inhibitor to joint working as it disrupted joint plans that were being developed over time. Problems aligning information technology and information governance across acute and community trusts were also identified. In addition,

working relationships with general practice were less productive due to their fragmentation, although the creation of stronger locality working was potentially seen as a way of mitigating this.

The extent of change needed

A form of respiratory virtual ward (early supported discharge) had already been developed in BSOL-ICS prior to and during Covid, which provided a foundation for work under the national programme. However, while the concept of virtual wards was embraced there was a degree of pushback against the level of national ambition and the timelines required. This resulted in the presentation of a plan that was (and remained) significantly below the number of virtual ward beds expected in the national plan. While it was recognised that this lack of compliance theoretically put at risk the national funding that was available, this was not considered to be significant. The initial requirement that Year 2 funding be matched by local systems (later abandoned) also provided a counterweight to any benefit of an overambitious target:

> *"And for the so-called stepdown models we took a view that we would encourage people [in systems] to do what they thought was right, and what was possible, partly because there was a huge gulf between what NHSE thought...and what clinician confidence would genuinely allow" SL05, Clinical Adviser, Trust*

Regional service leads were comfortable in pushing back against the centralised targets based on what was achievable within the local system:

> *"…even if we're not reaching the targets, as long as we can justify it locally and explain and evidence it then I have no objection going back to the regional or national team and saying we haven't done that…" SL09, Programme Lead, ICS*

Having agreed a plan for bed numbers, local leaders resisted any temptation to manipulate their returns which might have been achieved, for example, by inflating numbers of patients allocated to virtual wards, by counting patients cared for in the community that didn't meet the definition of the virtual ward service, or by changing the definitions used to determine eligible patients. This presented some element of risk; either of a loss of the national resource or of being seen as poor performers. However, a principled stance of transparency

was adopted though not with suspicion that elsewhere attempts at gaming the system were ongoing:

> *"…some people managed that NHS England target by doing those things [ie gaming], by not discharging people, by putting people on the virtual ward that actually shouldn't have been on a virtual ward. We had many conversations in [the trust] about that we didn't want to do that." SL09, Programme Lead, ICS*

> *"…you can get yourself off the naughty step quite quickly sometimes [by gaming]. But what's the point…and if we don't think we can do it then we shouldn't say we can" SL10, Intermediate Care Lead, Region*

The wider system

The impact of national and local policies and objectives

The lack of evidence-based policy

The issue was raised of the lack of consistent evidence of the efficacy of VWs by multiple participants across the region with the perception that any which did exist was partial and inconsistent, notwithstanding the fact that a national roll-out had already been mandated. Pre-existing evidence for home care for specific conditions such as COPD, for example from 'hospital-at-home' or earlier supported discharge schemes, enabled implementation to take place with little questioning. However, for other respiratory conditions such as pneumonia and asthma a lack of formal evidence relating to safety and effectiveness acted as an inhibitor to local implementation:

> *"…there's a flaw with the national programmes. They don't have any evidence, which is fine, but then they say "We're going to give you time to do the evidence" but they want the delivery straight away" SL02, Service Transformation Lead, Trust*

This requirement for clinical confidence appears to have led to an evolutionary approach to VW development on a condition-by-condition and specialty-by-specialty basis. This may have led to trade-offs between clinical acceptance and speed and scale of implementation. A further consequence of the perceived risk among hospital consultants was the allocation of considerable senior clinical time to the assessment of patients being considered for early supported discharge. While this may well have delivered quality benefits, the opportunity cost of this input was questioned:

> *"There's never really been a robust evidence base that says that it's worked. So it felt like a hell of a punt" SL06, Hospital Services Lead, Trust*

A perceived lack of evidence on the cost-effectiveness of virtual wards also inhibited implementation with scepticism about the validity of target numbers of virtual beds and the extent to which they actually released inpatient beds. Indeed, some respondents saw national targets as largely guesswork. However, in Year 2 the requirement to dedicate local resources to virtual wards stimulated a far greater focus on a local business case with a more robust understanding of impacts:

> *"…when systems then had to start putting their own money into it that…starts sharpening the mind somewhat doesn't it?"* SL10, Intermediate Care Lead, Region

The NHSE choice of metric

The national programme for VWs was expected to support the NHS's ambition to provide cost-effective and personalised care and, reduction of service pressures on secondary care. However, the priorities amongst these aims shifted over time. Originally the aspiration was originally to create 10,000 virtual ward beds nationally by 2023. But the emphasis shifted to the achievement of high utilisation (80%) of the virtual ward beds that existed, alongside a focus on the 'step up' (admission avoidance) model for virtual wards. Despite this shift the high political resonance of the programme and strong national push for delivery was clear. However, there was some doubt amongst senior decision makers as to exactly how realistic the purported aims were. As one participant explained:

> *"Nationally they were pumping out propaganda effectively saying, 'We're going to have 10,000 virtual ward beds!' and 'They're going to free up 10.000 bed days every day!' and you're just like '…well, they're not.". SL06, Hospital Services Lead, Trust*

There were also concerns about the pressure placed on delivering a properly designed and tested service whilst remaining within the centrally imposed timelines:

> *"But the dictats about 'You must put so many people on', and 'This is the timelines that you need to do it', and 'This is how many beds you need' aren't quite so helpful…it was forced through, pushed through at speed". SL03, Clinical Lead, Trust*

There was an acknowledgement by some at regional and local system level that the metrics chosen at a national level were not sophisticated enough to drive the intended behaviours and achieve the expected outcomes. The proposed number of 40-50 beds per 100,000 population raised questions about the most appropriate patient population. For example, whether the relevant population was all adults or only older adults (given that virtual wards were most likely to be used by older adults and that BSOL-ICS had a relatively young population).

Using (and comparing across sites) the metric of bed utilisation was also considered problematic in that it did not account for how many unique patients were using the beds and what the overall length of stay was *per* patient. For example, it was questioned whether a high utilisation of VW beds by a small number of patients (a long length of stay which might represent poor value) was as good a use of as a high utilisation of those beds by a large number of patients (which might indicate an efficient flow of patients).

Understanding whether or not patients in VW beds would otherwise be in a hospital bed was presented as a binary option but for local teams delivering VWs was seen as a complex and nuanced question which did not lend itself to crude indicators. In particular the possibility was raised that some patients may receive a 'safety net' service that put additional care and security around a hospital discharge or avoided admission rather than truly avoiding an inpatient stay or reducing the length of hospital stay which was the true goal:

> *"My biggest gripe with the communications from those [NHSE] teams was around the metrics that were being used to evaluate virtual wards. So, all of the focus was on maximising the number of patients…how can we get as many virtual ward beds as possible and make sure that their utilisation is as high as possible…My issue with it was it wasn't looking at the number of unique patients…it was the wrong KPI" SL08, Digital Transformation Lead, Trust*

It was also generally recognised that there was a requirement for the national team to use a tangible, quantitative metric with which to monitor overall progress with implementation. Despite this the questioning of the national metric led to successful attempts to negotiate a local target which was significantly below that expected by the national programme (discussed further below):

> *"The numbers were bonkers…the numbers that were stated [by NHSE] it was they were suggesting within 18 months you'd be opening up the size of a district general hospital!" SL06, Hospital Services Lead, Trust*

Interviewees acknowledged that however unrealistic some of the numbers are, the national programme together with regional support provided a significant source of motivation to develop and prioritise implementation of virtual wards. In particular, the combination of hypothecated funding and NHSE attention provided fresh impetus to local effort, resulting

in progress that was likely more ambitious than would have been achieved without. The importance of specific national funding was also brought into relief by the reduction in target numbers of virtual ward beds when the funding ringfence was removed.

5. Findings: WP2: Experiences of clinical and non-clinical staff delivering VWs

Box 6: Summary of Chapter 5

Summary of key findings by NASSS domain

- *Condition:* Clinical criteria were a crude measure of inclusion on the VW differing across specialities and failing to account for social circumstance.
- *Technology:* Stand-alone purposely designed patient tablets were preferred over portals accessed via smart phone.
- *Value proposition:* Benefits of VWs such as increased independence and improved efficiency were tempered by concerns over safety.
- *Adopters' staff:* Were required to adjust to changes in traditional responsibilities and roles imposed by being moved to delivering VW.
- *Adopters' patients*: Some were unsure of their safety and many unaware they were on a VW but overall preferred care at home (VWs) to inpatient care particularly for those admitted through the ED.
- *Organisation:* There were challenges presented by ad hoc staffing models, communication and shared responsibility between community and hospital trusts exacerbated by a lack of data interoperability
- *Wider system:* there were issues adjusting to changeable centrally imposed policies though this was mitigated by best practice being shared across regional networks
- *Embedding over time*: There was need for greater flexibility in staffing models and changes in delivery and the need for earlier engagement with end-users in technology procurement

Background/context

This work package was conducted in two parts, WP2a: an online survey and WP2b a series of qualitative interviews. The findings are presented below including summary statistics (WP2a) and a directed content analysis using the NASSS framework including exemplar quotations (WP2b).

WP2a: Staff survey

Characteristics of participants

A total of 27 participants responded; 16 clinical and 11 non-clinical with the majority employed on VWs between 1 and 12 months though the majority of these were sharing their time between VWs and another post. Only 12 respondents were prepared to answer which ward they worked on and ten of these worked on Arthroplasty. Respondents believed that VWs had a positive effect on readmission or attendance at the Emergency Department (ED) and length of stay.

Summary of additional questions

Participants confirmed that the VW was delivered using various combinations of telephone, in-person, and digital (remote monitoring) modes. Remote monitoring equipment was distributed and managed by clinical staff by contacting patients once a day. Thirteen of the 27 participants that responded indicated a low to moderate impact on staff workload and stress levels. Two of 25 respondents felt that additional training was required to deliver the VW service with one participant specifying that these additional training needs should relate to better understanding the clinical pathways, and processes linked to triage.

Perspectives on patient experience

Overall, 10 participants felt that service users felt reassured whilst on the virtual ward. In terms of barriers to accessing the service, 10 participants confirmed that this was an issue across Black, Asian and Minority Ethnic (BAME) populations, patients with learning disabilities, elderly, non-English speakers, and those with cognitive impairments. However, participants also confirmed that the service was capable of accommodating specific requirements.

Table 7: Summary of Participant job characteristics and role in virtual ward (response rate)

Participant job characteristics						
Clinical/non-clinical (n=27)						
Clinical			Non-clinical			
16			11			
Band (n=14)						
1	3	5	6	8a		
1	2	2	3	6		
Role in virtual wards						
Time in VW post (n=12)						
1-6 months	7-12 months	13-18 months	19-24 months			
5	5	2	0			
Are you sharing the role in VW with another post (n=13)						
Yes	No					
11	2					
How did you find out about the nature of the VWs? (n=24)						
Personal experience	NHS Futures	NHSE Guidelines	Colleagues	Other		
4	2	5	12	1		
Virtual ward speciality (n=12)						
Arthroplasty	Cardiology	Frailty	Respiratory	SAU		
10	2	0	0	0		
Role delivering VW						
Clinical Lead/Manager	Staff delivering	Other				
3	11	13				
Tasks performed in VW service						
Clinical (ticked all that apply)						
Referral	Triage	Patient monitoring	Escalation	Discharge		
7	14	11	10	10		
Non-clinical (ticked all that apply)						
Service design	Set-up	Management	Other			
3	*7*	5	13			
Who is involved in identifying and referring patients on your VW?						
Nurse	Ward manager	Consultant	GP	Other		
2	1	2	1	1		
Do you think the service is having an impact on the following (ticked all that apply) [n=13]						
Reduce patient mortality	Reduce Patient morbidity	Reduce Health inequalities	Early identification	Reduce (re)attendance at ED	Reduce hospital admissions	Reduce length of

			of deterioration			stay in hospitals
8	8	6	12	13	10	9

WP2b: Qualitative exploration of the experience of staff delivering VWs

Participant characteristics

Interviews were conducted at 2 trusts UHBFT and BCHCFT with thirteen staff; nine were service leads (7 UHBFT, 2 BCHCFT) and three delivered the service (1UHBFT, 2 BCHCFT). Each interview lasted between 30-60 minutes.

Qualitative data

Staff experiences of delivering the VWs are described below within the seven domains of the NASSS framework alongside illustrative quotes where staff are identified by their job category and their role in delivering the service.

Detailed qualitative analysis

Condition

Multiple conditions of varying complexity

There were a number of different specialities each with their own associated complexities and criteria for referral onto VWs. There were different interpretations and staffing models in VW between specialities across UHB. The respiratory VW was more tightly focussed on COPD whereas the frailty ward had a broader remit and were able to recruit more rapidly:

> *"The models are slightly different, so respiratory was quite specific in terms of criteria to get onto the virtual ward, so completely focused on COPD early supported discharge to start off with, whereas frailty was much more about a wider remit of if somebody is deemed clinically suitable and the surgical virtual ward was again quite specific in terms of conditions that would be eligible for admission onto the virtual ward. I suppose for me what I've been able to witness is the increase in occupancy on the virtual wards for frailty have been much better and quicker. They've got admission avoidance and early supported discharge, but by having a wider remit but with quite tight clinical oversight in terms of who gets on, we've been able to see a bigger increase in those occupancy numbers, whereas respiratory have found it much harder to get going now." P06, UHBFT, Service lead*

What was shared across specialties were the limitations of using clinical criteria alone to determine suitability for VWs. Staff went on to describe other contextual considerations

including the patients support network and ability to monitor various physiological parameters:

> *"…because we thought as we do in the NHS yeah we'll move that patient to there and everything will be grand, but it's so much more complicated than that…that cohort that we thought was massive, is quite small, because we're [not] just looking at the clinical criteria, but actually we've got to look at every patient individually as suitable for that virtual ward." P02, BCHCFT, Service lead*

Staff described how the numbers recording as being admitted on to virtual wards were constrained by the very specific definition as to what a VW consisted of. As a senior lead on VW respiratory ward explained:

> *"I think we're getting hugely confused here in the definition of "virtual ward" they should be in a hospital bed, and you're putting them in their home, whereas actually there's a big impact here we can have on readmissions, and admission avoidance [by broadening the inclusion criteria]. We know that 30% of COPD patients will readmit within a couple of months, or 30 days or 90 days, but actually can we prevent that next readmission by putting them onto a virtual ward platform? But that isn't a true definition of a virtual ward. So that's where I think we're stuck, is our numbers look really small, but we're being really specific about who we're putting on..." P01, UHBFT, Service lead*

Technology

Material properties of the technology

Functionality

In the initial stages of the BSOL-ICS VW programme the intention was to use a bespoke digital platform known as Big Picture this could be used via PC or laptop and allowed patients to independently enter data which could then be viewed on the staff facing element of the portal. However, only a small number of patients possessed a smart phone, internet connectivity and a degree of digital literacy – as well as meeting the clinical criteria for onboarding on to the VW.

> *"So what's really important is that the patient either can consent to going home early under early discharge, whether clinicians will ring them every day, or visit them day one and then phone them, or they'll consent to being*

> *on the Big Picture platform - when they put their own sats and readings, and answer the questions, and then can consent to that - if they've got the ability to use a smartphone or a tablet. That's a huge issue, we just aren't finding the numbers, we don't have equipment to give them… we haven't got time to sit and teach them how to use that level of platform, and also, we aren't finding that many patients that are able to use that level of platform. So, it has a two- factor authentication password, and they need their own smartphone, and I think those things are issues and barriers to getting them onto the home monitoring side." P01, UHBFT, Service lead*

Accessibility

The Big Picture dashboard also had issues with accessibility, some of these were due to language. A member of the community workforce pointed out that the portal needed to be made available in a variety of languages, without this it was suggested that patients would need to relay on a family member of carer to provide the translation.

> *"…as long as there's someone there with the patient that can translate, that's okay I think … it might be a barrier to use the Big Picture software…because I think at the moment I don't think it's available in lots of languages." P03, BCHCFT, Service delivery*

As another member of staff confirmed, the lack of suitable patients meant that the VW was under populated:

> *"… were using four out of 20 beds, virtual beds that we could be using, because people aren't able to use the technology properly. From my clinics a lot of people don't necessarily have smartphones or internet access." P03, UHBFT, Service delivery*

A standalone, handheld digital device purposely developed for patients to enter a range of health and well-being variables known as Docobo was introduced (https://www.graphnethealth.com/solutions/remote-monitoring). The introduction of Docobo was seen as a major improvement in terms of accessibility to the VW. Not only was it supplied by the service so did not rely on the patient having access to a smartphone but it could be used offline and so precluded the need for internet connectivity.

> *"The good thing about Docobo is that we provide all of the kit, including the tablet, and the tablet is enabled with a SIM card, so there's no reliance on*

the patient needing to own any kind of technology, or having broadband or access to the internet." P05, UHBFT, Service lead

Value proposition

Better quality care for patients

Staff understood the benefits for the physical and mental well-being of patients of being cared for outside of the hospital environment, these included maintaining higher rates of physical activity, confidence and independence:

> *"I say this a lot, that as a physio background inpatient stays are just the worst for anybody. You're not around, there's hospital acquired infections, there's rehabilitation issues for every three days you're… every one day you're in hospital it's three days' worth of rehabilitation. All our patient's chests go off, everyone gets pyjama paralysis. They're losing confidence, and obviously thinking about our frailty patients they've been in for seven days, they're not being as active as they were. It's just it's really, really a lot of people I suppose, well they do, they struggle when they come out of hospital. So I think there are risks, but I think the benefits for the wider population do outweigh those risks." P02, BCHCFT, Service lead*

Another key benefit as described by one of the service leads was that patients preferred to be in their home rather than hospitals. At home they are happier and comfortable enjoying their own food, the comfort of their family and pets, and the typically quieter environment:

> *"I'm going to start with probably the most important bit, which is patient experience. In my mind anyway I think it's the right thing to do for patients. We know that a lot of older patients are really scared about going into hospital, and if they're in they want to come out as quickly as possible, and part of that is a fear of losing function etc, while they're in, and that fear of not coming out again. We know that from patient experience that has been shared to date nationally there's that ability to be in the comfort of your own home with your comforts around you with the noise of a ward keeping you awake etc, etc, having pets, home food, I think are key for patients." P06, UHBFT, Service lead*

Impact on safety

Clinical confidence in the care provided by virtual wards was seen as an important factor that determined the speed and direction of implementation. For hospital clinicians, the early supported discharge element of the VW represented a potential and personal clinical governance risk. Patients transferred to the VW remained under the formal care of the

referring consultant but would be managed by a different team and in a domiciliary setting. This required that a referrer have confidence in the capability of receiving team. It was remarked that there was a gulf in operational environments between hospital and community environments, with the latter presenting more risks to care and fewer available care resources.

The extent to which a VW bed could, in practice, substitute fully for hospital care was also challenged, in particular due to the absence of near-patient testing. This resulted in caution as to the conditions that were deemed safe to refer into the virtual ward which inhibited the scale of ambition for virtual wards. At the time of the interviews, a move towards a generic rather than specialty-organised virtual ward had recently been announced. This was seen by some as introducing yet more risk due to diminished confidence in the access to appropriate clinical specialist advice within the VW team:

> *"For a hospital-based doctor nowadays they have no conception what exists outside the hospital environment. So moving people into something that was unknown felt like a risk." SL04, Clinical Adviser, Regional*

> *"So we were going to start evolving, but now it's not the community [specific specialty] specialists I have zero confidence that I would send anyone out that isn't straightforward" SL05, Clinical Specialist, Trust*

Impact on efficiency

There was concern amongst some that the design and implementation of the VW programme was a result of overcrowding in hospitals and so policymakers were overly motivated by moving patients out of hospitals without properly understanding the potential repercussions for the quality of patient care:

> *"Virtual ward is a kneejerk reaction. It is again because we need to create capacity. It wasn't necessarily designed and put together with the first thought of let's provide better patient care, it's more about we need some capacity, and then pitch your care after that. So I think just in virtual ward and everything else it's just that we are always behind the curve unfortunately and that's what causes a lot of pain and stress for our patients and our staff." P07, UHBFT, Service lead*

For others, the ability of VWs to ease pressure on bedded care by providing a cost-effective alternative was recognised and explicitly embraced:

> *"…for us as a system we have the ability to provide capacity… we know we don't have enough acute beds, and we know that's only going to get worse, because we have an ageing population. So, if we can provide an alternative cheaper way of providing that capacity then we should do… alongside the fact that it's actually preferred by patients…then I suppose the last point is that actually it's more cost effective, it's cheaper to run a virtual ward bed than it is a normal acute bed…" P06, UHBFT, Service lead*

Adopters

Staff-adopters

Impact on professional traditions

The delivery of virtual wards relied on a new way of working for many and this change in roles and responsibility was apparently difficult for some clinicians to come to terms with. For example, the need to pass patients on to other teams who would then be relied upon to complete the passage of care they had started ran counter to usual care where clinicians would assume direct responsibility for a patient until discharge:

> *"… clinicians have found that really, really difficult since we've said, 'We cannot just work completely independently in these pseudo teams anymore, we have got to work as a team'. So once you've done your bit it goes to somebody else, and I think the old school nurses and clinicians among us it doesn't sit well with us because they've been referred to us, and you want to ensure that everything has been done, and it has been flagged up by somebody that actually if I'm seeing this patient I'm not going to just take them on do my assessment, make sure they're safe for a few days and discharge them, I want to keep them on. But the whole point is that we're only replicating those last final days of hospital, and then we're standing them down to services that they need. So, I think it is going to be a challenge for some of the clinicians, to take a step back…" P02, BCHCFT, Service lead*

Impact on current roles

Related to this change in role was the increased reliance on remote monitoring and teleconsultation as opposed to the predominantly in-person care clinicians were trained and experienced in:

> *"Clinicians are concerned about that, because they're so used to doing a face to face, even to be able to do a few obs. on a patient, just to get a bit of*

information and talk to them, it's different doing that by telephone, or virtually, or just looking at what they're filling in on their iPad on Docobo. It's a different mindset that people have got to have towards it, and different decision-making skills as to how you decide 'Do I need to see that patient or not?" P03, BCHCFT, Service delivery

Engagement of co-opted staff

The point was made that at least in the early phases of the implementation staff were not necessarily given a choice but to work on the VWs. Ultimately as the workforce grew specific appointments were made where individuals applied to work on VWs:

"I think because we're using a team who have not applied for a job to do virtual wards and have just been said, 'This is what you're going to do' then I think that's quite different … it's not like they went, "Oh yes I want to work on virtual ward," it wasn't…I don't think they particularly want to be employed on a seven-day working virtual ward, you know what I mean? Only because of working hours, and terms and conditions and all that kind of stuff, from what they were doing in their usual day job." P03, BCHCFT, Service delivery

Patient-adopters

Patient suitability

Some staff questioned the ability of elderly patients to satisfactorily fulfil some of the self-monitoring required as part of the VW. Although the increased usability of the "Docobo" system was seen as an improvement on the previous smart phone application. However, it did not negate the need for patients to provide a range of physiological measurements using various instruments:

"…you just think of patients that you know, or your own family members of the public that are more elderly, and you're thinking "Actually really would they be able to manage that?" I'm not sure. It's not just being able to tick a box and questions on Docobo, it's being able to actually do a blood pressure, or your SPO2 or do a temperature. I think the jury is still out for me on that one. I'm being told this is what we're going to do, this is how we do it, but I think that remains to be seen." P03, BCHCFT, Service delivery

The hesitancy of family members and carers was also described, with some reportedly questioning the motivation behind the hospital's adoption of VWs, with concern expressed that their relative was being discharged inappropriately with the expectation that the family member would become the de facto care provider:

> *"… the older population that are more nervous of going home, and their carers of having them home, "You just want to get mum and dad out, and we're going to be doing all the personal care, and all you're going to do is phone them every day!" The families need to be reassured as well. You've got the really young ones that are at work, have got childcare, don't want to be doing this, they want to just get back straight to work… So, we're seeing a very small [suitable patient] population of middle aged people that first language is English and they're really IT savvy." P02, BCHCFT, Service lead*

Staff described the need to reassure patients that expected to be discharged from hospital before they were fully well. They noted that even though patients might fulfil the clinical criteria it was important that they were psychologically prepared for the VW model of care.

> *"Half the patients we've got to do this reassurance, they're so used to being in hospital, right to the point where they feel 100% better there are going to be patients sitting there going, "You just want me out of hospital" and they're going to be really nervous…and we have had a few instances where patients have come out, and even though clinically they've met the criteria for virtual ward psychologically they are not ready for that." P02, BCHCFT, Service delivery*

Patient preferences for care at home

Despite the misgivings of some patients and confusion as to exactly what constituted a VW there was anecdotal evidence of patient's appreciation of the VW:

> *"…we've got really great patient stories…so, there are lots of patients that don't want to be in hospital, if you're a COPD patient and you get admitted to hospital two or three times a year you tend to really hate that, and you want to get home as quickly as you can back to the comfort of your own home. So, the insights through that patient feedback is that the virtual ward is it's allowed me to go home early or not to go into hospital at all, and so that… we're seeing that as really positive." P05, UHBFT, Service lead*

Patients that had experienced firsthand the issues of overcrowding were particularly pleased to be leaving the hospital environment.

> *"…in general the patients are very favourable about it, because most of the patients come through the emergency pathway, most of the patients have ended up being overnight on a trolley, or a chair, or… and actually when you give them the option to say go home from a trolley they're overjoyed!" P08, UHBFT, Service lead*

Although VWs are reasonably well understood by care providers and commissioners' patients were reportedly less aware or indeed concerned about the precise concept or nomenclature, particularly in the early stages of their introduction when technology played a minimal part. At this point their understanding was only that they are being discharged earlier than they might have been with additional clinical support at home:

> *"…at the moment they're not understanding that they're on a virtual ward, they're just being seen by a clinician at home. I think that's what it is at the moment, because there's no technology involved, and I think that will be the difference when technology is involved." P03, BCHCFT, Service delivery*

Organisation

Strength of Inter-organisational agreements

Participants generally believed that virtual ward implementation had benefited from strong, pre-existing relationships between local partners. In particular, the experience of running early supported discharge during Covid gave a head start to the creation of the relationships across providers that were fundamental to the introduction of the respiratory VWs. The existence of formal system-wide structures were also felt to be helpful in mustering a local response to the national mandate. For example, the overall responsibility for VW implementation could be incorporated into existing governance mechanisms for intermediate care and, in addition, a dedicated steering group for VWs with multi-stakeholder membership was established:

> *"That's what worked really well, developing the relationships with [specific community staff]. I'm also going to say having dedicated and enthusiastic driven clinicians…" SL03, Clinical Lead, Trust*

> *"So when I was working with both [acute and community] respiratory teams they had been working together for years. So in terms of getting onto a call with all of them, workshopping ideas, working out what to do, then actually going live, that was all pretty good" SL08, Digital Transformation Lead, Trust*

A member of staff from the community team questioned where the balance of responsibility lay for the clinical decisions made for a patients on the VW between the consultant operating remotely and the clinician visiting the patient at their home. This led to community staff noting the timing and content of discussions with consultants:

> *"One of the negative points we found about that was… and we tried to overcome this in documentation, but you have a consultant telling you or advising you to half the medication, double the medication. Now that's great as the consultant, and I don't question the validity in her decision-making, but you were the clinician going out and doing that, and we're always taught as nurses you don't just do as you're told, it's you've got to question, you've got to… and if you're going to withdraw somebody's meds… So, I was very clear to the staff to say that 'Information shared with consultant so and so, put the name there.', the date will always reflect because you're doing it chronologically in the RiO diary anyway, 'this is the conversation, the advice given was this, therefore I shared this information with the patient, and they agreed' … not for blame, but to share that responsibility equally, because that's how the decision has come about." P01, BCHCFT, Service lead*

Staff working on the respiratory ward described the challenges of working across trusts and reaching consensus on processes with staff possessing different experience and expertise.

> *We've tried to add new pathways in, that's been quite tricky, and we are working with a number of teams for respiratory, so trying to get UHB acute, of which there are three teams essentially, one for [hospitals], as well as the [region] community team and then the [region] community team, which is split into the, the community nursing and the therapists. Trying to get all of those to agree and take things forward has probably added to the challenge in respiratory. But we are getting there, it's just a much slower process. So*

there's willing, it's just I think it's slowing the process down slightly. P06, UHBFT, Service lead

Readiness for technology

There were issues raised about the difficulties in storing and sharing the data generated by the VW model with much of the data currently added manually to spreadsheets of individual design:

"They [IT systems] need to be better, because we're still tending to rely on maybe a spreadsheet or something to collate things on, whereas if the IT system was better, we wouldn't have to do that. So, there's still a lot of improvements that could be made with IT to support it." P03, BCHCFT, Service delivery

Staff capacity and capability

It was noted that in the early stages that the work of delivering the VW was taken on in addition to existing responsibilities, with delays in the recruitment of additional staff specific to the VW role:

" …I think it's one of those things where you absorb it until there's a bit more evidence…I think it's always hard to absorb something extra, but in most circumstances it's very rare that someone just says, "Here's some funding to start something." You normally start it way, way before you actually get the funding to do it, that's just… and everybody knows that, and then we work in the NHS, we're used to high workloads for sure, and yeah stretching to fit. It's always stretching to fit, and people just manage it as best they can." P02, UHBFT, Service lead

Another member of staff described how some of the impact of the delays in recruitment for VW specific staff were mitigated by the flexibility of experienced staff who would move to the project at short notice:

"Things haven't happened very quick on virtual wards within recruiting…there's actually nobody employed at the moment, or hardly anybody to do virtual wards because it being a new project. So, they're just

beg and borrowing people from other parts to do it." P03, BCHCFT, Service delivery

Wider system

Impact of local and national policies

Local policies and priorities

The pressures on capacity across bedded care and VWs were widely recognised. However, it was noted that conversations as to how capacity might be increased between VWs and inpatient care were not happening in a joined-up fashion, instead taking place independently of the other. The lack of ringfenced funding for VWs led to fears investment would be diverted to existing care offers in acute or community settings leaving VWs unsustainable:

"I know that on the acute side they will have done a calculation that says we need another 100 acute beds in West Midland… You just know intuitively that virtual wards is part of that solution, but the plans for how many acute beds we need and how many virtual ward beds need they are very separate, we're not doing this as a joint enterprise…money for virtual wards is no longer ringfenced, the money is given to systems to spend on developing capacity for the whole system, general and acute bed capacity for the whole system… I think we've got to get to the point where we're saying what do we really need across the whole system, and across acute and community provision, because virtual wards isn't the only thing is it? And unless we crack that I don't think we can… we'll be able to sustain virtual wards, because it will become unaffordable." P05, UHBFT, Service lead

National policies - chronic lack of funding

For those staff leading the respiratory pathway it was observed that VWs were another drain on an already very busy service and though funds might become available in due course that did not guarantee that appropriate staff could be recruited quickly enough:

"From a funding point of view the [region] community respiratory team is significantly underfunded… so we have got virtual ward funding, and we've got ongoing recruitment with regards to that as we develop the bronchiectasis pathway, we've got recruitment to partner that. So, I'm sure that the next phase will bring recruitment for the admission avoidance

element of that. So, I'm optimistic that's coming round the corner, but then obviously the issue there is recruiting to the money once you get it, which isn't always as easy. With the right skill mix, the right experience, the right profession, that sometimes proves difficult. But we will remain optimistic." P04, UHBFT, Service lead

The presence of inter-organisational working to support VW implementation

The initial issues with the acceptability of the proposed Big Picture platform were addressed by the purchase of the Docobo system a decision informed by the experience of other sites across the region:

"…there was an expectation by NHS England that all virtual wards would be enabled by technology, and so what I meant by remote monitoring is the ability for patients to be able to take their own vital signs recordings and submit that to an application that then gives the clinicians an oversight of all of the patients that they're responsible for. … Now we didn't have any of that technology in place when we started, and we set out to work out which would be the best system for us, and in the end against our initial judgement, there was a system called Docobo, that out of all of the [region] systems we were the only one not using, and I think that was a little bit like well if everyone else is using it we're not going to, we're going to do something different." P05, UHBFT, Service lead

There was also learning when senior leads attended multidisciplinary meetings at other sites and brought ideas back to the BSOL VW programme:

"I think we have learnt that there's definitely been the good points that have been drawn in from the other services that are running virtual wards, for example we've implemented the MDT after [name] from [Trust] has gone and spent some time with a different service, and how they were running their virtual ward. So there's been a lot of shared learning." P04, UHBFT, Service lead

This shared learning also applied to the teams operating in Birmingham as over time understanding grew as to which VW systems and processes could be aligned between different specialities:

> *"So the two community teams work in slightly different ways, but we try and align as much as possible as we can, and I think that's been a challenge, but I think is essential, and this is giving a nice way in to hopefully demonstrate how we can align and work in a similar way respecting the need for when it does need to be different. The different sites at [Trust] from an acute referring out all works slightly differently. Again trying to align as much as we can where we can. I suppose it's knowing where it's worth trying to align and where it's worth actually accepting that it might be done a little bit differently." P06, UHBFT, Service lead*

Embedding over time

Ability to be incorporated into routine care

Standardizing across specialities

Moving forwards the plans for a VW programme that shared a generic community offering across specialities utilising specialist support only when needed:

> *"The respiratory and frailty virtual wards I think quite a lot of their patients probably could sit on either ward, and for the ones that come through UCR or the rapid response, probably is a conversation about where they best sit. From a [region] point of view, and I think moving forwards for [region] the generic community nursing resource that we've got will be providing the generic support of both respiratory and frailty, so that essentially we only utilise the specialist respiratory nursing input for those patients that really need it. That way we can best utilise the limited resource that we've got." P06, UHBFT, Service lead*

For those charged with leading the service through its next phase there was regret that there wasn't a more consistent approach in how the VWs were delivered, tempered by an understanding that practically this would have been difficult as specialties were building on existing service offers.

> *"I've found it incredibly difficult to step into I suppose this post, to try and standardise the virtual wards. If I could give one bit of advice over a year ago to everybody starting virtual wards is don't start it in one specialty. So no, not start in one specialty, but because we were so well setup in respiratory, and then we started one in a completely different I suppose looking at it completely differently in a different specialty… I suppose you could argue*

> *that it's good to share learning across what's good and what's both different models and bringing it together. But I found it quite hard to standardise I think the operational side. Because… and I suppose it was timing, we had to setup different ways of delivering stuff in different specialties at different times. So, we were always going to come up with a different pathway weren't we?" P02, BCHCFT, service delivery*

Flexible and experienced staff

In terms of lessons learnt over time it was felt important to the early stages of a the new service that experienced staff were employed, more confident and capable of adapting to changes as they happened:

> *"I think have staff who are flexible with it, or people running it who are flexible, who are prepared to say, "Right, this is what we're going to do, however we need to be looking at this as we go along and change it if we need to do," and things come up and you think 'oh how are we going to handle that now? And I think you've got to have that approach to it really… the other pathways have got to be in place properly, and I think at the moment they haven't been in place, because of us having to do virtual ward and staffing. But in the ideal world virtual ward now if we can get that up and running properly we should be able to start the other services." P03, BCHCFT, Service delivery*

The earlier involvement of patients

It was observed that patients had not been involved in the preliminary discussions around the design of the VWs nor was there consultation on the content and design of patient facing explanatory materials:

> *"From processes that I have been involved in…you would do your fact finding, you would get some project idea together, you'd also you'd have some group conversations of which you'd have representatives of different specialties, different elements of the service and pathway, so you'd have a service user present, an expert patient present to feedback in. To my knowledge that hasn't been done. …monthly we have to attend the patient carers, commissioners council group where we have governors, clinicians, lay members of the [region] board all present, and we discuss updates and*

concerns, and it's a two way conversation. I had given them an overview of what's happening in terms of virtual ward activity, 'they'd asked how is this being publicised within the community?'. I took that back to one of the virtual ward meetings, and they have now asked for the PCCC group to provide feedback, patient information leaflets, and just generally the service. So I don't know whether that was in the pipeline, or whether that's something I brought to the table…" P04, UHBFT, Service lead

6. Findings: WP3 Patient outcome evaluation

Box 7: Summary of Chapter 6

Summary of key findings

- The (COPD early supported discharge) Virtual ward did not reduce length of stay.
- Patients on average spent 9 days on the COPD Virtual Ward post discharge from the acute ward, requiring a total of 13 days of specialist-led care vs 5 days for usual care.
- The COPD Virtual ward does not increase mortality at any site.
- QEHB saw an increase in the number of 30-day readmissions which was not seen at BHH or GHH.

Background/context

At the time of the evaluation the virtual respiratory ward in BSOL-ICS provided Early Supported Discharge and latterly Admission Avoidance, It is supported by community teams from BCHCT in collaboration with the acute respiratory team at UHBFT. The “37 bedded” respiratory VW began in Sept 2022.

Outline of the evaluation

The premise of the Early Supported Discharge element is that it enables reduced length of stay for patients, and decreased rates of readmission without increasing mortality. The work presented in this chapter provides an evaluation of the ESD element against clinical key performance indicators comparing the performance of the VW against usual care using a series of matched ‘respiratory’ controls. The eligibility criteria for inclusion on the respiratory ward are summarised in Box 8.

Box 8: BSOL-ICS Eligibility for Respiratory Virtual Ward

Patients are eligible for early supported discharge or admission avoidance if:

- Assessed to have COPD (Chronic Obstructive Pulmonary Disease) exacerbations
- A DECAF (dyspnoea, eosinopenia, consolidation, academia, and atrial fibrillation) score of 1 or less (UHB started with these DECAF criteria, but extended subsequently to consider higher scores)
- biochemically and physiologically stable
- older than 18 years
- have access to a telephone and a safe environment.
- Additional criteria for eligibility were subsequently introduced at QEHB which are:
    - Acute NIV
    - New to long-term home NIV/Oxygen/Nebulisers
    - 3+acute admission in the last 6 months

Objectives

The primary outcomes consisted of an evaluation of the effectiveness and outcomes of respiratory virtual wards at UHBFT, compared to inpatient admissions, focusing on length of stay, Readmissions in 30 days (all cause), mortality (7 days and 30 days post discharge from hospital). A secondary outcome was considered of readmissions in 90 days (all causes).

Study population

Included patients were all those admitted with a COPD exacerbation were divided into 2 cohorts – those placed on the virtual ward for an exacerbation and those not on the virtual ward between January 2019 and December 2023. Data was included from patients presenting to Queen Elizabeth Hospital Birmingham (QEHB), Birmingham Heartlands Hospital (BHH) and Good Hope Hospital (GHH). Excluded patients were all those patients with weekend short stays (2pm Friday onwards to 8am Monday (virtual ward not operational for new admissions at these times; existing admissions continued to be managed over weekends), prior admission within 62 days (one index admission per exacerbation).

Cases consisted of all patients on the Virtual respiratory ward having had a UHBFT COPD discharge within 5 days of their admission to the virtual ward. Controls consisted of admissions with a COPD exacerbation not placed on the virtual ward care

pathway but matched to VW patients on a case-by-case basis. Population data is described in Table 8.

Table 8: Population data

Characteristic	Potential Controls N = 2676	Cases N = 902	p-value	Overall N = 3,578
Age	72 (63, 78)	72 (64, 78)	**0.6**	72 (63, 78)
Sex			**0.6**	
Female	1,508 (56%)	500 (55%)		2,008 (56%)
Male	1,168 (44%)	402 (45%)		1,570 (44%)
Ethnicity			**0.3**	
White	2,457 (92%)	820 (91%)		3,277 (92%)
South Asian	72 (2.7%)	18 (2.0%)		90 (2.5%)
Black	21 (0.8%)	8 (0.9%)		29 (0.8%)
Other	29 (1.1%)	12 (1.3%)		41 (1.1%)
Unknown	97 (3.6%)	44 (4.9%)		141 (3.9%)
IMD quintile			**0.9**	
1 (Most deprived)	1,691 (63%)	558 (62%)		2,249 (63%)
2	496 (19%)	167 (19%)		663 (19%)
3	281 (11%)	104 (12%)		385 (11%)
4	97 (3.6%)	35 (3.9%)		132 (3.7%)
5 (Least deprived)	79 (3.0%)	26 (2.9%)		105 (2.9%)
Not recorded	27 (1.0%)	6 (0.7%)		33 (0.9%)
Smoking status			**<0.001**	
Current	927 (35%)	402 (45%)		1,329 (37%)
Ex	587 (22%)	308 (34%)		895 (25%)
Exsmoker and current vaper	15 (0.6%)	11 (1.2%)		26 (0.7%)
Never smoked	531 (20%)	149 (17%)		680 (19%)
Not recorded	616 (23%)	32 (3.5%)		648 (18%)
Hospital Site			**0.025**	
Birmingham Heartlands Hospital	509 (19%)	208 (23%)		717 (20%)
Good Hope Hospital	151 (5.6%)	43 (4.8%)		194 (5.4%)
Queen Elizabeth Hospital Birmingham	2,016 (75%)	651 (72%)		2,667 (75%)
NIV	23 (0.9%)	8 (0.9%)	**>0.9**	31 (0.9%)
Invasive ventilation	9 (0.3%)	2 (0.2%)	**0.7**	11 (0.3%)
DECAF score			**<0.001**	
0-1	486 (20%)	277 (38%)		763 (25%)
2	302 (13%)	133 (18%)		435 (14%)

3-6	182 (7.7%)	94 (13%)	276 (8.9%)
Not recorded	1,407 (59%)	229 (31%)	1,636 (53%)

Statistical significance is set at 0.01.

*Ventilation is not well-recorded in PICS, NIV numbers are likely to be an underestimation.

Matching criteria

Cases and controls were matched using the three steps described below. The flow diagram for patient selection is shown in Figure 3.

First step

- Patient as own control. Patient with had another COPD admission at the same site/within the relevant 2-6 months (391 cases matched)

Second step

- Coarsened matching.
- Coarsened matching on age (within 5 years) and time-period cohort (within 6 months)
- Exact matching smoking status, sex, DECAF score on admission, hospital site (507 cases matched)

Third step

- Relaxed matching
- Coarsened matching on age (within 5 years) and time period cohort (within 6 months)
- Exact matching smoking status, sex, hospital site but not DECAF score (4 cases matched)
- All admissions were matched

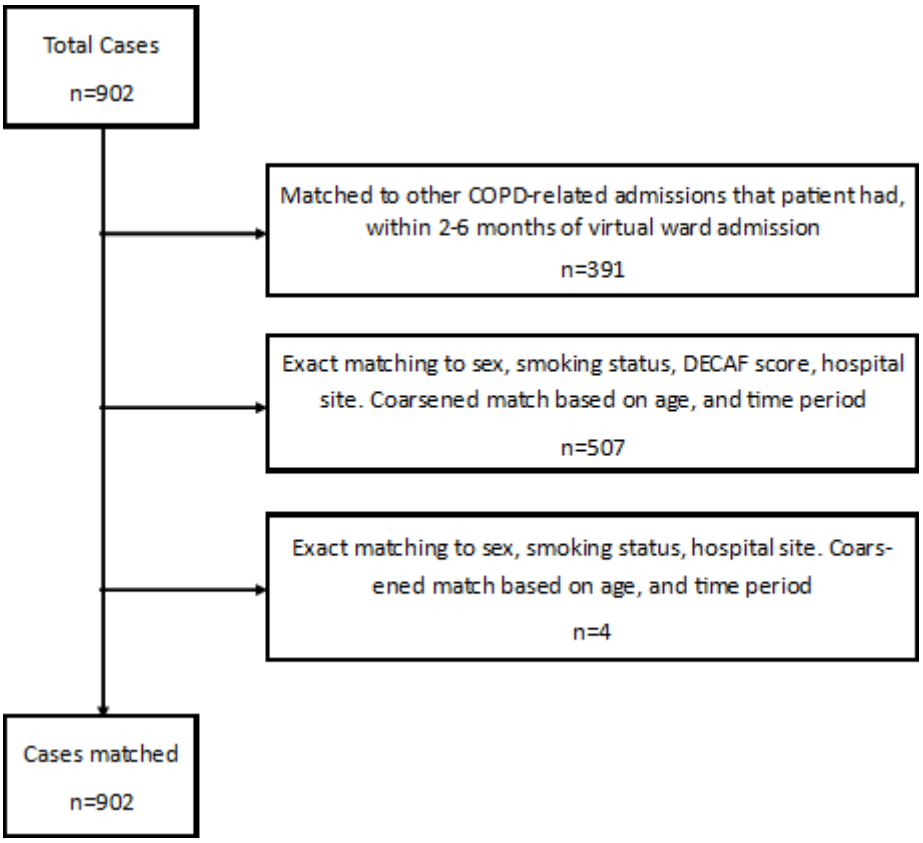

Figure 3: Flow Chart of Patient Selection

The characteristics of cases and controls across matched criteria across is shown in Table 9

Table 9: Matched criteria

Characteristic	Controls N = 902	Cases N = 902	p-value
Age	72 (64, 78)	72 (64, 78)	0.3
Sex			>0.9
Female	500 (55%)	500 (55%)	
Male	402 (45%)	402 (45%)	
Ethnicity			0.3
White	830 (92%)	820 (91%)	
South Asian	27 (3.0%)	18 (2.0%)	
Black	5 (0.6%)	8 (0.9%)	
Other	10 (1.1%)	12 (1.3%)	
Unknown	30 (3.3%)	44 (4.9%)	
IMD quintile			0.9
1 (Most deprived)	574 (64%)	558 (62%)	
2	154 (17%)	167 (19%)	
3	98 (11%)	104 (12%)	
4	32 (3.6%)	35 (3.9%)	
5 (Least deprived)	31 (3.5%)	26 (2.9%)	
Not recorded	8 (0.9%)	6 (0.7%)	
Smoking status			**<0.001**
Current	348 (39%)	402 (45%)	
Ex	237 (26%)	308 (34%)	
Exsmoker and current vaper	7 (0.8%)	11 (1.2%)	
Never smoked	203 (23%)	149 (17%)	
Not recorded	107 (12%)	32 (3.5%)	
Hospital Site			>0.9
Birmingham Heartlands Hospital	208 (23%)	208 (23%)	
Good Hope Hospital	43 (4.8%)	43 (4.8%)	
Queen Elizabeth Hospital Birmingham	651 (72%)	651 (72%)	
NIV	6 (0.7%)	8 (0.9%)	0.6
Invasive ventilation	2 (0.2%)	2 (0.2%)	>0.9
DECAF score			**<0.001**
0-1	202 (22%)	277 (31%)	
2	108 (12%)	133 (15%)	
3-6	66 (7.3%)	94 (10%)	
Not recorded	526 (58%)	398 (44%)	

Virtual Ward cases had fewer patients with missing DECAF compared to matched controls. There is no difference in the distribution of DECAF scores

Overall Matched Data-Outcomes

The median LoS on VW was 9 days, but some patients stay on VW longer with upper quartiles staying on VW>16 days. The Median LoS for readmission for VW patients is 91.6 hours (IQR: 19.8-189.9) or 3.8 days and 20% of these go back on VW. The Median LoS for readmission for controls is 76.2 hours (IQR: 14.3-192.2) or 3.2 days but only 10% of these enter VW. The Median LoS on VW has consistently dropped over time from 414 hours (17.3days) in 2020, to 335 hours in 2021, 266 hours in 2022 and finally to 124 hours (5.2days) in 2023. Table 10 Summarises the overall matched data outcomes for cases and controls. Below this we show Table 11 outcomes over time, Table 12 presenting Matched subgroups by DECAF score, and Table 13 showing outcomes matched by DECAF score (0-1, 2,3-6). These data pertaining to LoS and readmissions are summarised in Figures 4- 8.

Table 10: Summarises the overall matched data outcomes for cases and controls.

	Controls N = 902	**Cases** N = 902	**p-value**
Primary outcomes			
LOS (in hospital - including ED hours)	103 (43, 212)	96 (47, 187)	>0.9
LOS (on Virtual Ward)	NA	216 (100, 389)	NA
Total LOS (In hospital (incl. ED) + VW)	103 (43, 212)	351 (222, 591)	**<0.001**
Readmission within 30 days	171 (19%)	236 (26%)	**<0.001**
Direct readmissions from VW	NA	120 (13%)	NA
Readmission within 30 days of discharge from VW	NA	288 (32%)	NA
Died within 7 days post discharge	10 (1.1%)	3 (0.3%)	0.05
Died within 30 days post discharge	21 (2.3%)	21 (2.3%)	>0.9
Secondary outcome			
Readmission within 90 days	366 (41%)	405 (45%)	0.07
Readmission within 90 days of discharged from VW	NA	429 (47%)	NA

Table 11: Outcomes over time

2020	Controls	Cases	
	N = 145	N = 185	p-value
LoS in hospital	77 (23, 172)	96 (44, 175)	0.039
LoS on VW	NA	414 (193, 770)	NA
Total LoS	77 (23, 172)	575 (335, 894)	**<0.001**
Readmission within 30 days	33 (23%)	54 (29%)	0.2
Direct readmissions from VW	NA	25 (14%)	NA
Readmission within 30 days of discharged from VW	NA	75 (41%)*	NA
Readmission within 90 days	60 (41%)	82 (44%)	0.6
Readmission within 90 days of discharged from VW	NA	93 (50%)	NA
2021	Controls	Cases	
	N = 193	N = 202	p-value
LoS in hospital	107 (47, 198)	121 (66, 196)	0.13
LoS on VW	NA	335 (170, 577)	NA
Total LoS	107 (47, 198)	494 (312, 755)	**<0.001**
Readmission within 30 days	31 (16%)	54 (27%)	**0.01**
Direct readmissions from VW	NA	41 (20%)	NA
Readmission within 30 days of discharged from VW	NA	75 (37%)*	NA
Readmission within 90 days	87 (45%)	98 (49%)	0.5
Readmission within 90 days of discharged from VW	NA	107 (53%)	NA
2022	Controls	Cases	
	N = 262	N = 186	p-value
LoS in hospital	109 (50, 210)	75 (46, 142)	**0.008**
LoS on VW	NA	266 (145, 317)	NA
Total LoS	109 (50, 210)	338 (247, 451)	**<0.001**
Readmission within 30 days	41 (16%)	41 (22%)	0.085
Direct readmissions from VW	NA	24 (13%)	NA
Readmission within 30 days of discharged from VW	NA	44 (24%)	NA
Readmission within 90 days	93 (35%)	70 (38%)	0.6
Readmission within 90 days of discharged from VW	NA	72 (39%)	NA
2023	Controls	Cases	
	N = 273	N = 331	p-value
LoS in hospital	122 (45, 230)	98 (39, 219)	0.5
LoS on VW	NA	124 (69, 173)	NA
Total LoS	122 (45, 230)	261 (175,370)	**<0.001**
Readmission within 30 days	56 (21%)	89 (27%)	0.068
Direct readmissions from VW	NA	30 (9%)	NA
Readmission within 30 days of discharged from VW	NA	94 (28%)	NA
Readmission within 90 days	110 (40%)	155 (47%)	0.11
Readmission within 90 days of discharged from VW	NA	157 (47%)	NA

There were delays in the recording of patients being discharged from the VW in the early period of time

Table 12: Matched subgroups by DECAF score

DECAF score =0			
Outcomes	**Controls**, N = 83	**Cases**, N = 93	**p-value**
LOS (in hospital - including ED hours)	89 (51, 148)	66 (39, 106)	**0.002**
LOS (on Virtual Ward)	NA	264 (144, 416)	NA
Total LOS (In hospital (incl. ED) + VW)	89 (51, 148)	337 (193, 487)	**<0.001**
Readmission within 30 days	7 (8.4%)	21 (23%)	**0.010**
Readmission within 90 days	20 (24%)	36 (39%)	0.038
Died within 7 days post discharge	0 (0%)	0 (0%)	NA
Died within 30 days post discharge	2 (2.4%)	0 (0%)	0.2

DECAF score =1			
Outcomes	**Controls**, N = 119	**Cases**, N = 184	**p-value**
LOS (in hospital - including ED hours)	125 (73, 245)	82 (44, 155)	**<0.001**
LOS (on Virtual Ward)	NA	246 (144, 343)	NA
Total LOS (In hospital (incl. ED) + VW)	125 (73, 245)	332 (245, 510)	**<0.001**
Readmission within 30 days	14 (12%)	46 (25%)	**0.005**
Readmission within 90 days	29 (24%)	85 (46%)	**<0.001**
Died within 7 days post discharge	0 (0%)	2 (1.1%)	0.5
Died within 30 days post discharge	1 (0.8%)	4 (2.2%)	0.7

DECAF score 2			
Outcomes	**Controls**, N = 108	**Cases**, N = 133	**p-value**
LOS (in hospital - including ED hours)	150 (83, 264)	117 (54, 212)	0.025
LOS (on Virtual Ward)	NA	264 (116, 458)	NA
Total LOS (In hospital (incl. ED) + VW)	150 (83, 264)	411 (244, 695)	**<0.001**
Readmission within 30 days	14 (13%)	52 (39%)	**<0.001**
Readmission within 90 days	40 (37%)	77 (57%)	**0.002**
Died within 7 days post discharge	2 (1.9%)	0 (0%)	0.2
Died within 30 days post discharge	3 (2.8%)	4 (3.0%)	>0.9

DECAF score 3-6			
Outcomes	**Controls**, N = 66	**Cases**, N = 94	**p-value**
LOS (in hospital - including ED hours)	173 (113, 324)	161 (111, 256)	0.4
LOS (on Virtual Ward)	NA	198 (78, 485)	NA
Total LOS (In hospital (incl. ED) + VW)	173 (113, 324)	425 (266, 752)	**<0.001**
Readmission within 30 days	9 (14%)	24 (26%)	0.067
Readmission within 90 days	17 (26%)	41 (44%)	0.021

Table 13: Outcomes matched by DECAF score (0-1, 2,3-6)

DECAF score: 0-1			
Outcomes	**Controls**, N = 202	**Cases**, N = 277	**p-value**
LOS (in hospital - including ED hours)	114 (65, 194)	74 (43, 128)	**<0.001**
LOS (on Virtual Ward)	NA	246 (144, 381)	NA
Total LOS (In hospital (incl. ED) + VW)	114 (65, 194)	332 (223, 510)	**<0.001**
Readmission within 30 days	21 (10%)	67 (24%)	**<0.001**
Readmission within 90 days	49 (24%)	121 (44%)	**<0.001**
Died within 7 days post discharge	0 (0%)	2 (0.7%)	0.5
Died within 30 days post discharge	3 (1.5%)	4 (1.4%)	>0.9

DECAF score 2			
Outcomes	**Controls**, N = 108	**Cases**, N = 133	**p-value**
LOS (in hospital - including ED hours)	150 (83, 264)	117 (54, 212)	0.025
LOS (on Virtual Ward)	NA	264 (116, 458)	NA
Total LOS (In hospital (incl. ED) + VW)	150 (83, 264)	411 (244, 695)	**<0.001**
Readmission within 30 days	14 (13%)	52 (39%)	**<0.001**
Readmission within 90 days	40 (37%)	77 (57%)	**0.002**
Died within 7 days post discharge	2 (1.9%)	0 (0%)	0.2
Died within 30 days post discharge	3 (2.8%)	4 (3.0%)	>0.9

DECAF score 3-6			
Outcomes	**Controls**, N = 66	**Cases**, N = 94	**p-value**
LOS (in hospital - including ED hours)	173 (113, 324)	161 (111, 256)	0.4
LOS (on Virtual Ward)	NA	198 (78, 485)	NA
Total LOS (In hospital (incl. ED) + VW)	173 (113, 324)	425 (266, 752)	**<0.001**
Readmission within 30 days	9 (14%)	24 (26%)	0.067
Readmission within 90 days	17 (26%)	41 (44%)	0.021
Died within 7 days post discharge	4 (6.1%)	1 (1.1%)	0.2
Died within 30 days post discharge	7 (11%)	5 (5.3%)	0.2

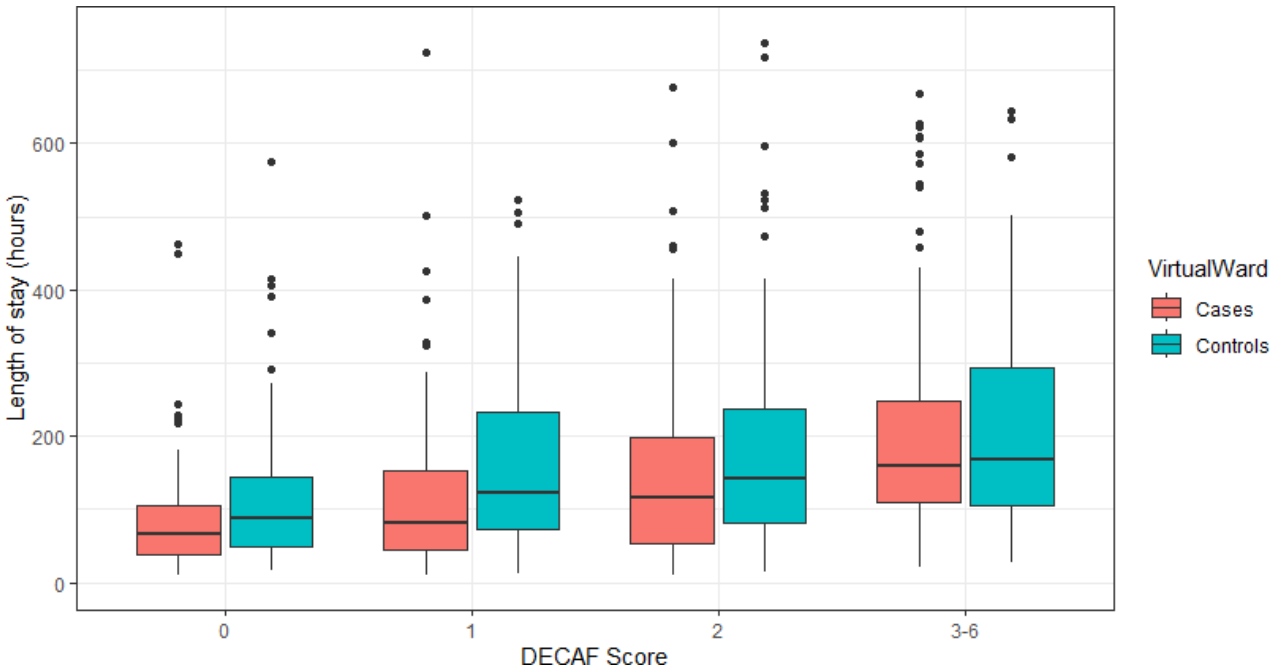

*Figure 4: In-hospital Length of Stay by DECAF score – cases vs. controls**

**(excluding patients without a DECAF score)*

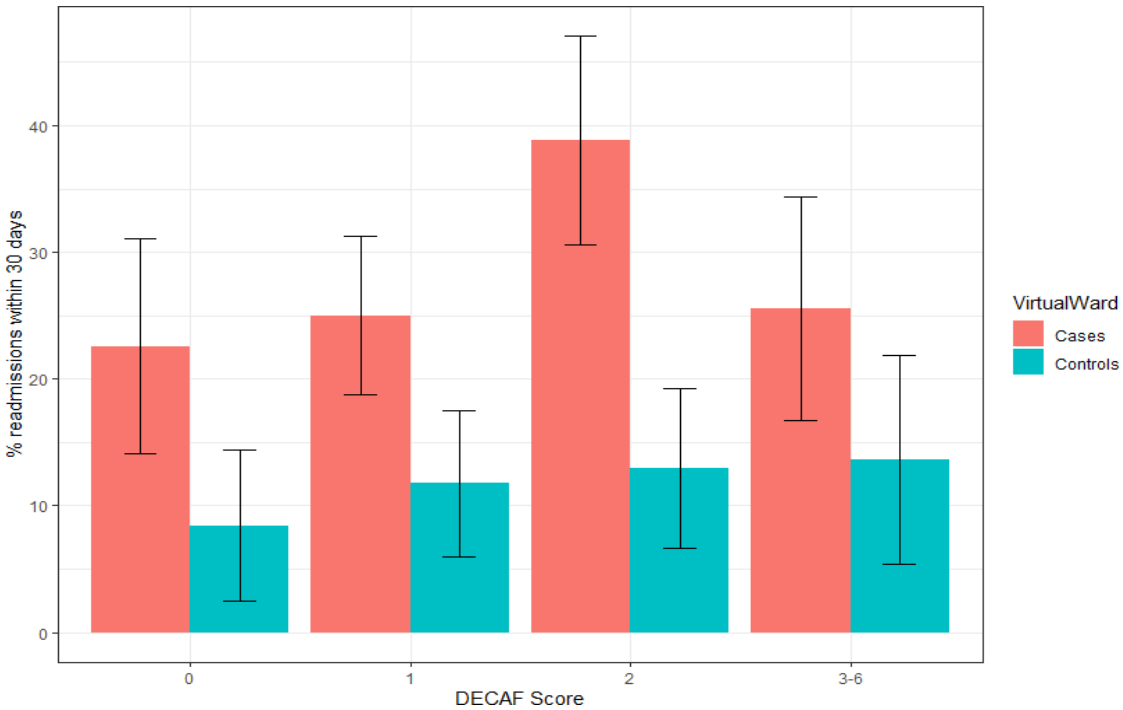

*Figure 5: In-hospital Length of Stay by DECAF score – cases vs. controls**

**(exclude patients without a DECAF score)*

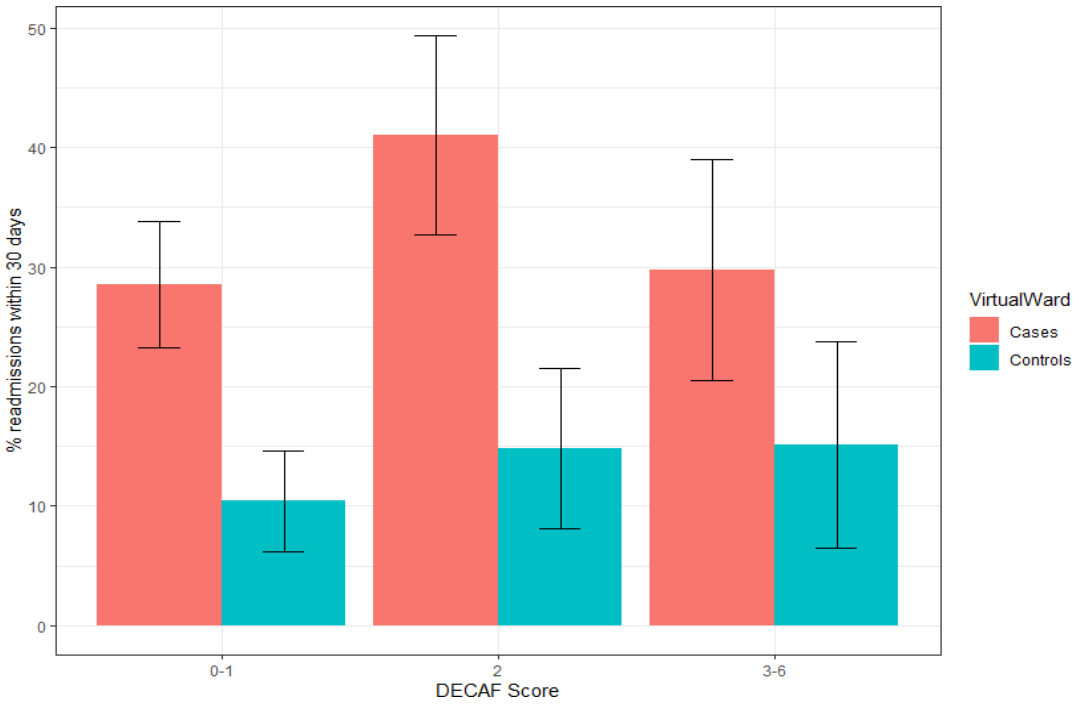

*Figure 6: Readmissions (%) within 30 days by DECAF score – cases vs. controls. All sites**

**(exclude patients without a DECAF score)*

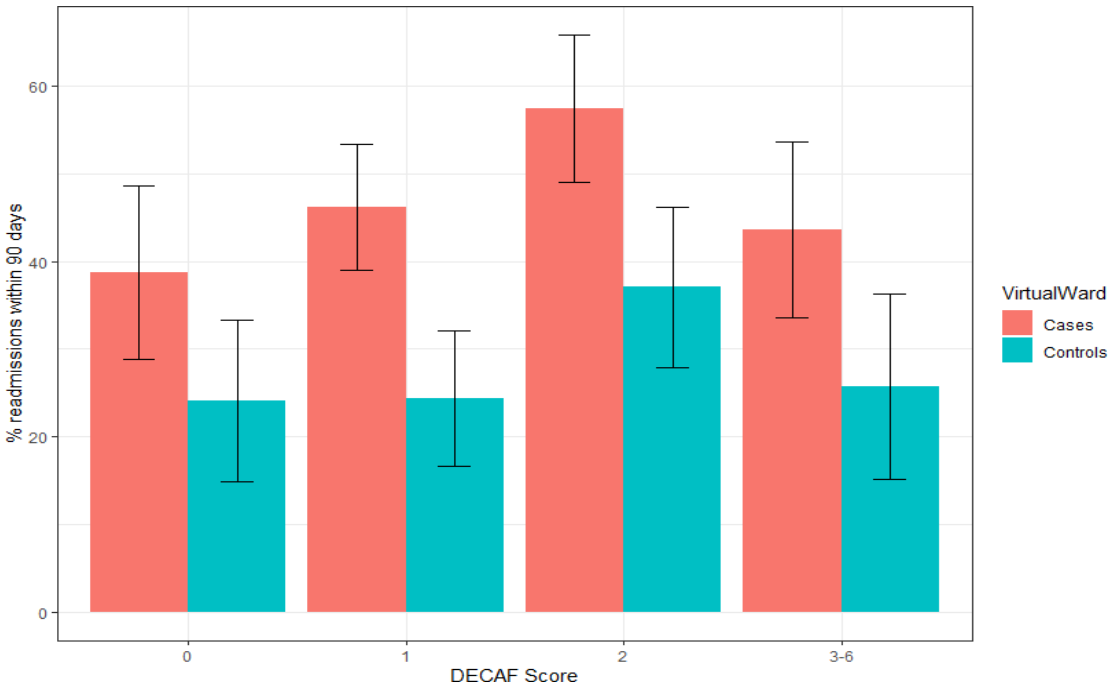

*Figure 7: Readmissions (%) within 90 days by DECAF score – cases vs. controls. All sites**

(exclude patients without a DECAF score)

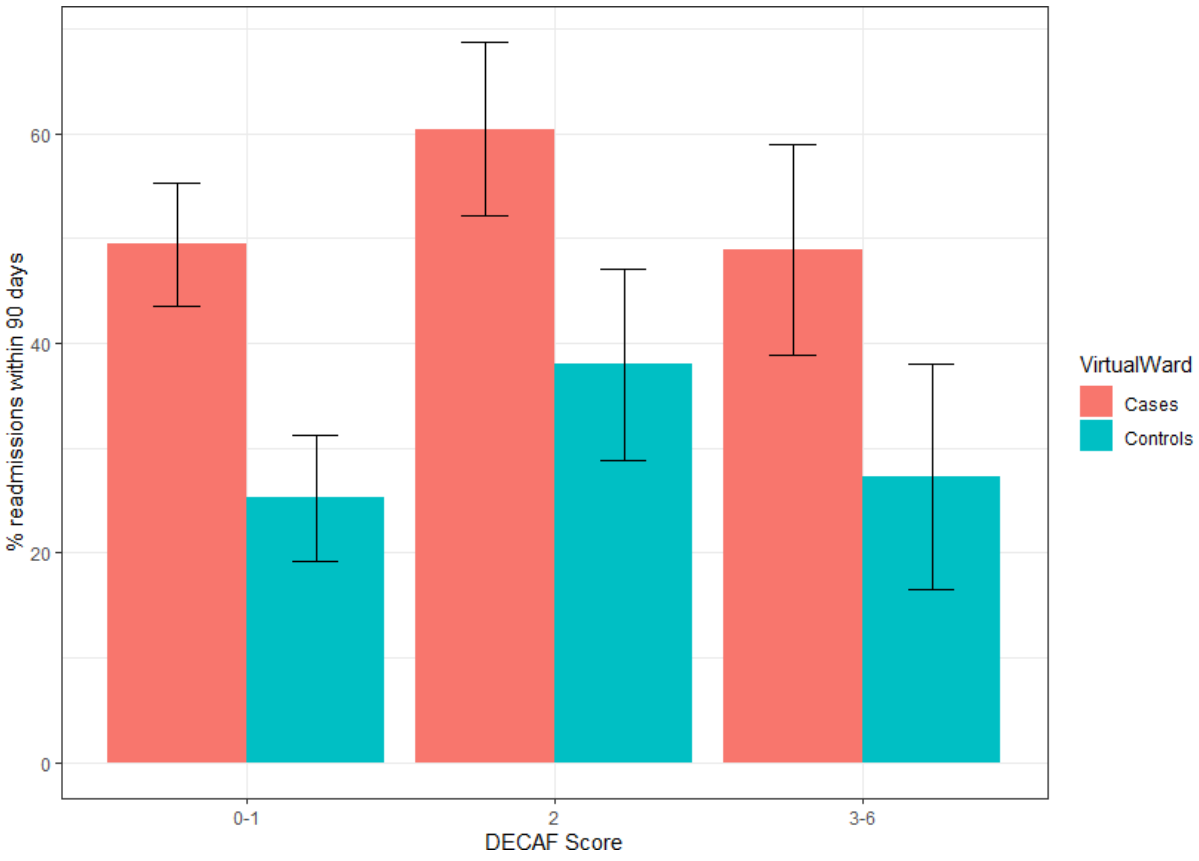

*Figure 8: Readmissions (%) within 90 days by DECAF score – cases vs. controls. **

**(exclude patients without a DECAF score)*

Overall Summary

The COPD Virtual ward does not increase mortality, nor does it reduce length of stay (Controls 4.2 days vs. VW 4.0 days). However, subgroup analysis of patients with lower DECAF scores (0-1) found LoS to be significantly reduced in VW vs. control (74 vs. 114 hours, $p<0.001$). Patients on average spent 9 days on the COPD Virtual Ward post discharge requiring 13 days of specialist-led care vs 5 days for usual care. The data also indicates that the COPD Virtual ward is associated with an increase 30-day readmissions both overall and across all DECAF scores compared with controls.

In considering readmissions, for every 14 admissions to the virtual ward there is an extra readmission within 30 days The average LOS for the readmission is 90 hours (3.75 days). There was no significant difference in 90-day readmission rate overall, but an increase for

patients with a DECAF score of 0-1 and 2. However there is a large proportion of patients who do not have a DECAF score recorded, conclusions regarding DECAF scores are limited to those with a recorded score.

The LoS on VW shows a cohort effect over the 4 years, reducing from 414, 335, 266 to 124 hours in latest period. There may be a learning effect as the VW system matures over time. More data would be required to understand if this performance is maintained over time and if any further reduction observed. The service reported they have been evolving over time, in terms of patient selection and teams providing the service.

Summary across sites

In exploring mortality across sites COPD Virtual ward does not increase mortality at any site. The QEHB saw an increase in the number of 30-day readmissions which was not seen at BHH or GHH. Although the proportion of 30-day readmissions of controls at QEHB is lower than that at BHH and GHH, the demographics between sites appear different, therefore care must be taken when comparing across sites. The LoS was unchanged at all sites however at GHH an admission to the COPD Virtual ward was associated with an increased LoS, and a shortened Virtual ward stay than based on other sites. The summary of the data by site is found in Table 14.

Table 14: Site summary

Queen Elizabeth Hospital Birmingham			
Outcomes	**Controls**, N = 651	**Cases**, N = 651	**p-value**
LOS (in hospital - including ED hours)	103 (44, 207)	95 (47, 170)	0.5
LOS (on Virtual Ward)	NA	258 (124, 461)	NA
Total LOS (In hospital (incl. ED) + VW)	103 (44, 207)	368 (236, 645)	**<0.001**
Readmission from VW	NA	96 (15%)	NA
Readmission within 30 days	116 (18%)	179 (27%)	**<0.001**
Readmission within 30 days post discharge from VW	NA	224 (34%)	NA
Readmission within 90 days	253 (39%)	305 (47%)	0.004
Readmission within 90 days post discharge from VW	NA	328 (50%)	NA
Died within 7 days post discharge	10 (1.5%)	3 (0.5%)	0.051
Died within 30 days post discharge	20 (3.1%)	16 (2.5%)	0.5

Birmingham Heartlands Hospital			
Outcomes	**Controls**, N = 208	**Cases**, N = 208	**p-value**
LOS (in hospital - including ED hours)	103 (37, 200)	85 (39, 228)	>0.9
LOS (on Virtual Ward)	NA	168 (96, 278)	NA
Total LOS (In hospital (incl. ED) + VW)	103 (37, 200)	316 (201, 505)	**<0.001**
Readmission from VW	NA	18 (8.7%)	NA
Readmission within 30 days	45 (22%)	46 (22%)	>0.9
Readmission within 30 days post discharge from VW	NA	51 (25%)	NA
Readmission within 90 days	95 (46%)	80 (38%)	0.14
Readmission within 90 days post discharge from VW	NA	82 (39%)	NA
Died within 7 days post discharge	0 (0.0%)	0 (0.0%)	NA
Died within 30 days post discharge	1 (0.5%)	4 (1.9%)	0.4

Good Hope Hospital			
Outcomes	**Controls**, N = 43	**Cases**, N = 43	**p-value**
LOS (in hospital - including ED hours)	137 (41, 257)	173 (113, 292)	0.054
LOS (on Virtual Ward)	NA	29 (22, 95)	NA
Total LOS (In hospital (incl. ED) + VW)	137 (41, 257)	248 (147, 451)	**<0.001**
Readmission from VW	NA	6 (14%)	NA
Readmission within 30 days	10 (23%)	13 (30%)	0.5
Readmission within 30 days post discharge from VW	NA	13 (30%)	NA
Readmission within 90 days	20 (47%)	20 (47%)	>0.9
Readmission within 90 days post discharge from VW	NA	20 (47%)	NA
Died within 7 days post discharge	0 (0%)	0 (0%)	NA
Died within 30 days post discharge	0 (0%)	1 (2.3%)	>0.9

7. Findings: WP4 Cost-effectiveness of the early supported discharge respiratory virtual ward

Box 8: Summary of Chapter 7

Summary of key points

- This model-based analysis, using the best available limited evidence, suggests that the respiratory virtual ward (VW) costs £531.42 more and results in 5.5 additional bed days compared to traditional inpatient wards.
- The probabilistic sensitivity analysis indicates a low probability—under 19%—that the respiratory VW is cost-effective, contradicting most existing studies.
- If initial hospitalisations and post-escalation hospital stays in VW strategy were reduced by about 50% of current value, it potentially could become cheaper option than traditional care.
- Further research is essential to fully understand and quantify the true value and impact of these VWs due to the limited scope and data availability for the current analysis.

Background and context

A decision-analytic model taking healthcare perspective was developed using best available, albeit limited, evidence from WP3 results, published literature, expert opinions and assumptions to explore the cost-effectiveness of respiratory virtual ward in comparison with traditional inpatient ward. Deterministic and probabilistic sensitivity analyses were performed to assess the impact of parameter uncertainties.

Results

Base case results

The base case results are presented in Table 15 The average cost per patient in the respiratory virtual ward was £3,504.36, which was higher than the £2,972.93 observed for the traditional inpatient hospital ward. Additionally, the respiratory virtual ward had a longer average length of stay—10.37 days compared to 5.5 days for the comparator. This resulted in an additional cost of £531.42 and 4.82 more bed days than the traditional inpatient ward. Consequently, in this analysis, the incremental cost-effectiveness ratio (ICER) was dominated by the traditional inpatient ward.

Table 15: Base case results

	Mean Costs	Mean Effect (Bed days)	Mean Incremental Costs	Mean Incremental Effect	ICER
Respiratory Virtual Ward	£3,504.36	10.37	531.42	-4.82	Dominated
Traditional Inpatient Hospital Ward	£2,972.93	5.55			

ICER=Incremental Cost-Effectiveness Ratio

Probabilistic sensitivity analysis (PSA)

The PSA results are visualised in the cost-effectiveness plane (see Figure 9), where the difference in costs is plotted against the difference in the length of bed days. The results indicate that most data points fall within the north-west quadrant of the cost-effectiveness plane. This positioning suggests that the respiratory virtual wards are both more expensive and less effective in terms of bed days saved. As a result, only 18.78% of the simulations indicate that the virtual wards are cost-effective compared to traditional inpatient care.

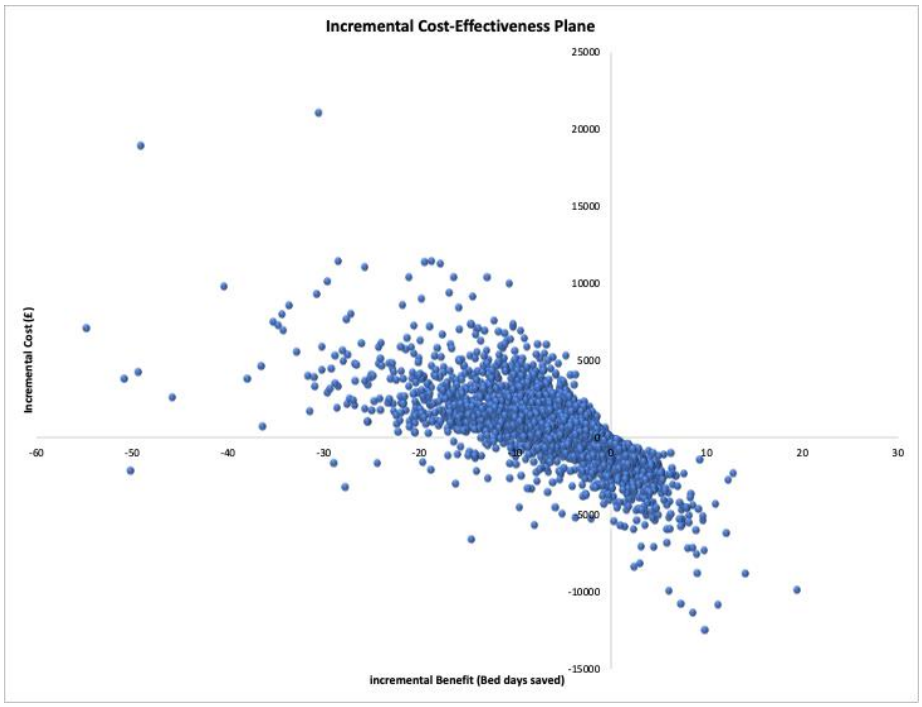

Figure 9: The Cost-Effectiveness Plane

Deterministic sensitivity analysis (DSA)

The results of the deterministic sensitivity analysis (DSA), presented in Table 16, indicate that the respiratory virtual ward is generally dominated by traditional inpatient wards, signifying that it is more expensive and less effective in most scenarios.

However, if the length of stay associated with initial hospitalisations before patients transition to the virtual ward, as well as the length of hospital stays following escalations back from the virtual ward, were to decrease by approximately 50% of their current values, the respiratory virtual ward could become a cheaper option compared to traditional inpatient care. This finding underscores the high sensitivity of the model to this parameter, suggesting that any significant reduction in hospitalisation duration could substantially impact the cost-effectiveness of the virtual ward strategy.

Table 16: Deterministic sensitivity analysis result

Variable	Base case value	DSA Value	Difference in cost	Difference in benefit	ICER
MODEL PROBABILITIES					
Strategy: Virtual Ward					

Proportion of patients stepped down to VW after admitted to HW	45%	31.50%	372	-3.37	Dominated
		58.50%	690.00	-6.26	Dominated
Proportion of patients escalated back to HW from VW	13%	10%	503.14	-4.76	Dominated
		22.20%	618.19	-4.99	Dominated
Proportion of patients readmitted within 30 days (discharged from VW)	32%	5.00%	310.67	-4.38	Dominated
		41.60%	609.92	-4.97	Dominated
Proportion of patients died	2.30%	2%	531.43	-4.82	Dominated
		3.80%	531.43	-4.82	Dominated
Proportion of patients readmitted within 30 days (after escalation to HW)	26.00%	18.20%	521.9	-4.8	Dominated
		33.80%	540.96	-4.84	Dominated
Strategy: Hospital Ward					
Proportion of patients readmitted within 30 days	19.00%	8%	628.76	-5.01	Dominated
		25%	478.34	-4.71	Dominated
Proportion of patients died	2.30%	2%	531.43	-4.82	Dominated
		3.80%	531.43	-4.82	Dominated
LENGTH OF STAY (LOS) (days)					
Strategy: Virtual Ward					
Hospital ward (initial)	4.58	0.7	-339.92	-3.07	£110.72/bed day (Cheaper, less benefit)*
		2.2	-3.35	-3.75	£0.89/bed day saved (Cheaper, less benefit)*
Hospital ward (escalation)	4.44	2.22	467.9	-4.69	Dominated
		5.772	569.35	-4.89	Dominated
Virtual ward	9.79	3.9	335.67	-2.17	Dominated
		12	604.8	-5.81	Dominated
Readmission	4.18	2.926	443.45	-4.64	Dominated
		4.44	550.02	-4.85	Dominated
Strategy: Hospital Ward					
Hospital ward	4.81	3.367	854.81	-5.46	Dominated
		6.253	209.78	-4.17	Dominated

Readmission	3.93	2.751	582.01	-4.92	Dominated
		4.81	494.03	-4.74	Dominated
COST					
Virtual ward	£74.00	£96.20	629.25	-4.82	Dominated
Hospital ward	£499.74	£349.82	469.82	-4.82	Dominated
Outpatient appointment (respiratory cases)	£198.08	£138.66	531.43	-4.82	Dominated
		£257.50	531.43	-4.82	Dominated
Other scenarios					
LOS Hospital ward initial LOS Hospital ward escalation	2.2 2.22	less 50% less 50%	-66.88	-3.62	£18.47/bed day (Cheaper, less benefit)*
*Traditional inpatient hospital ward versus virtual ward setting					

There were several limitations to the model based economic analysis that should be acknowledged in interpreting the results. It was constrained by the level of data we had access to, which did not include individual patient data, which might affect the robustness of our results and conclusions. At the time of the evaluation only a step-down model was in operation, so did not include data exploring admission avoidance This could result in missing significant aspects of future virtual ward implementation, their associated costs and benefits, and underestimating potential cost savings. The analysis also focused solely on early supported discharge respiratory virtual ward, limiting the generalisability to other types of virtual wards. For example, those developed to avoid admission or frailty. Additionally, we did not have long-term outcomes and quality of life data, which are crucial for a comprehensive evaluation. Finally, it must be acknowledged that the analysis was conducted solely from an NHS perspective, which might not capture broader economic or societal impacts.

8. Discussion and Conclusion

Box 9: Summary of Chapter 8

Summary of key points from across work packages 1-4 by NASSS domain

- *Condition:* Lack of shared understanding of (consistent) referral pathways including the impact of social circumstance
- *Technology*: issues with lack of interoperable databases and patient facing tool suitable for a range of digital literacy and connectivity.
- *Value proposition*: Further work to confirm the impact on length of stay, readmissions, and cost-effectiveness.
- *Adopters*: Staff – Specific training and delineation of responsibility needed.
  Patients – improved messaging needed to support engagement
- *Organisations*: Importance of collaborative agreements and impact on workforce and IT systems
- *Wider system*: Need for the devlopement of coherent long-term (regional) planning
- *Embedding over time*: Us of co-design to ensure sustained patient and staff engagement

Background and context

This chapter consolidates our findings using the domains of the NASSS framework and sets them in the context of existing literature, exploring the implementation of VWs and similar models of technology-enabled care. In doing so we explore the broader barriers to and facilitators of the implementation of VWs and suggest areas of consideration for improving and sustaining future iterations of the VW programme. These are primarily for the benefits of senior service leads within BSOL ICS but will also contribute to NHSE's wider evaluation of the VW programme. Finally, we conclude with reflections on the strengths and limitations of this evaluation and on implications for future work in light of these findings and those from other sites in England delivering the VW programme.

Existing literature and implications for practice

The findings of work packages 1-4 are synthesised and summarised in Table 17 and discussed below in context of the existing literature and their implications for future practice.

*Table 17: Influences on implementation of BSOL-ICS VW presented within the NASSS framework**

Domain	***Definition***	***Influences on implementation***	***Examples from VW programme***
Condition	The condition(s) or specialities for which the intervention has been designed.	*The complexity of the condition (including (cognitive function)*	*Complexity* • Clinical criteria were only one measure of who was appropriate for VWs alongside digital literacy and connectivity and their network of support • Multiple conditions deemed appropriate for VWs though each with different models of care. Confusion emerged amongst BCHCFT staff working with different specialities due to differences in referral criteria and pathways, levels of patient dependency, and the differing roles of senior clinicians
Technology	The technologies or other innovation that is being introduced. Including hardware and software, a novel protocol or pathway – or some combination of these.	*The material properties of the technology, including functionality and accessibility.*	*Functionality* • Relatively few patients were able to use Big Picture platform which became a limiting factor to the numbers of patients suitable for tech-enabled VWs *Accessibility* • Docobo preferred option as all-in-one solution (no need for patient to own smartphone etc)
Value proposition	The proposed value (financial or otherwise) that	*The potential improvements in quality, safety, inclusivity,*	*Quality*

	the new technology/care model generates.	*and efficiency of the care delivered.*	• Multiple accounts of the value of patients being cared for at home as early as possible – re independence, confidence, and satisfaction *Efficiency and safety* • Staff saw the benefit of increasing ward capacity by discharging patients from inpatient care as early and as safely as possible • Staff had reservations that it was driven by efficiency only with concerns expressed over their safety • On the respiratory VW, length of stay, readmissions, and time under specialist care all increased vs usual care *Cost-effectiveness* • Savings reported on virtual respiratory ward vs usual care of
Adopters	The intended users of the technology or other innovation. This includes patients/lay people, professionals, administrative and support staff.	*Acceptability to,* *Staff: including the impact on current roles and professional traditions.* *Patients and family/carers: Including preferences,*	Staff: *Impact on current roles* • For some staff their role on VW was imposed due to delays in recruitment (in the early stages none had applied to work on VW specifically) • Tech-enabled monitoring provided reassurance that patients were safe.

		reassurance, suitability, clinical contact	• Staff missed face-to-face and noted the difficult skill-sets associated with teleconsultations *Impact on professional traditions* • The handover of patients to unknown colleagues in community settings was difficult for some senior clinicians Patients: *Reassurance* • Some patients needed reassurance that they would be safe on the VW with some not psychologically ready for the move. • Communication over the nature and benefits of VWs for patients and their carers/families appeared poorly understood. For example, patients were unaware they were on a "virtual ward" and just happy to be out of hospital and have contact from clinical staff *Preferences* • VW was the preferred option for those admitted through ED and experiencing long waits on trolleys *Suitability*

			• Every patient had to be judged individually because of their social circumstances including support for activities such as eating and washing • Staff adopted a two-tier system where the alternative option to technology-enabled VWs involved telephoning and/or in person visits (due to a patient's lack of infrastructure/digital literacy/capacity)
Organisations	The cultural and organisational characteristics of the organisations involved. This includes structure, capacity, and capability to adopt new ways of working. As well as resources of staff and infrastructure.	*Readiness for the innovative pathway including the strength of inter-organisational agreements or funding arrangements; the extent of the change needed; readiness for technology; the work required in implementation.*	*Strength of inter-organisational agreements* • Establishing reliable lines of communication across teams and trusts was complicated • Issues in shared decision-making/responsibility for decisions on patients on VW (community team with sight of patient vs consultant) *Extent of change needed* • There were differences between specialities in degree of clinical oversight and complexity of the VW model eg respiratory ward more experienced • There was push-back against unrealistic central targets *Readiness for technology*

			• IT systems were ill-prepared for cross-Trust working. Lack of interoperability. *The work required in implementation* • The regional NHSE VW team performed a number of key roles in supporting roll-out
		Staff capacity and capability and the culture and work practices that supported the learning of individuals and/or the organization	*Staff capacity and capability* • There were delays in recruitment and ad hoc staffing models • Staff borrowed from elsewhere were used to staff the early stages of the VW, often sharing their VW role with usual care
Wider system	The regional and national and local context for the introduction of the technology or programme	*The impact of national and local policies and objectives and localised socio-cultural factors*	*Impact of local and national policies* • Lack of joined up thinking on how the number of new beds created for VWs and inpatient care might complement each other • Staff expressed concerns over a lack of evidence for the policy including its cost-effectiveness • Concerns that the target parameters were unrealistic or poorly defined • Fear that needs of acute system outweigh others eg community • Chronic lack of funding of community systems meant they were ill-equipped to incorporate additional workstreams

			• Staff moved from previous key pilot projects onto VW – lack of coherence in planning
		The presence of inter-organisational networking and collaborative initiatives in supporting implementation.	*Inter-organisational networking* • Docobo adopted after learning of its success in other settings • Senior staff spent time working with other groups and gained valuable insight into other teams
Embedding over time	The key changes and uncertainties expected to affect the integration of the technology/innovative pathway over the next 3-5 years.	*The ability of the technology and supporting processes to be incorporated into routine care.*	*The ability of VWs to be incorporated into usual care* • The need for flexibility in staffing models was observed • The value of standardising the offer across specialities was described • Patient representatives need to be involved in designing the next phase of the VW programme

**(adapted from Greenhalgh, Abimbola, Litchfield [23, 24, 47, 48])*

Condition

In this, the first phase of the programme VWs were developed independently across a number of specialities, with differences in referral pathways and the dependency of patients deemed suitable for inclusion. The clinical criteria of those onboarded to the ward were only a part of the conversation in terms of who staff considered suitable for the VW. Staff also described the importance of understanding individual domestic circumstance, in terms of digital connectivity, and access to support of carers and family. These broader considerations have arisen previously in other examples of VWs particularly in the service of elderly patients [5]. It has also been reported previously how those being cared for on the VW are reliant on the support of families and carers not only in relation to physiological measurements and the upload of data to remote management systems but also the provision of broader assistance with meal preparation and hygiene [2, 18, 64].

Technology

Functionality of technology

For much of the early part of the period evaluated the service was provided almost entirely through the use of telephone and in-person visits to patients due to issues of functionality and access of the proposed "Big Picture" platform. Staff describing how it was unsuitable for many patients that were otherwise deemed clinically appropriate for referral on to the VWs. The automated and streamlined VW service was expected by many to be predicated on the use of digital healthcare technologies [65-67]. However, policymakers, commissioners and those delivering the service understood VWs were a hybrid service as reliant on telephone and in-person contact, with patients seldom being monitored solely via digital technologies [2, 13, 15, 18, 68-70].

Accessibility of technology

Although implicit within the expected digital transformation of healthcare that the relevant technologies are available across all levels of society, persistent discrepancies exist [71, 72]. These include differences between communities in how they access and utilise digital technologies and are compounded by the growing sophistication in the functionality of devices and connectivity [73]. The Big Picture system required access to a smart phone and reliable internet connectivity and staff described a two-tier, digital vs analogue VW system as a result, with many patients supported by analogue systems: a divide reflective of many technology-enabled care interventions [74].

The result as witnessed in the small numbers of patients eligible to use the Big Picture platform is that comparative advantages continue to be afforded to groups that can maximise the capabilities of digital technologies [74-79]. These broader societal differences

in access and adoption are influenced by infrastructure, socio-economic environment and individual characteristics such as educational background and physical disability [80-85]. Latterly in BSOL-ICS the Docobo system was employed. This proved a more inclusive system and possessed significant advantages in line with recommendations for the design of patient facing digital health tools; it required a single login [86], could be used off-line, and had simple-to-use interfaces [87, 88]. However, there was no immediate evidence of exactly how inclusive the model of VW using Docobo was in BSOL-ICS, both in terms of patient demographics onboarded or its acceptability amongst patients. This needs to be better understood in future iterations as failure to address the "digital divide" will mean the demographic patterns of patients treated on BSOL-ICS's VW will continue to be reflective of longstanding disparities in access to care amongst patients from minority ethnic groups and other underserved populations [89, 90].

Interoperability

Staff participants described the lack of interoperability of the systems used to manage patient data across UHBFT and BCHCFT meaning they were expected to enter patient data manually with the associated increased risk of error [91]. The importance of using healthcare technologies acceptable to staff end-users managing virtual wards is recognised [92] and the NHS has produced recommendations for the procurement of digital platforms specifically for the purpose of managing VWs, intended to improve coordination of care, and enhance patient safety [93].

Value Proposition

Quality of care

The benefits for patients of being cared for at home as opposed to hospital were widely recognised by staff and have been evidenced previously, particularly regards improvements in independence, confidence and secondary infection rates [94-96]. Participants also described the potential benefits to capacity of early discharge but shared concerns expressed previously of a rush to implementation in advance of sufficient evidence of their efficacy and safety [97-99].

Efficiency and safety

Using the exemplar of the early supported discharge respiratory VW we determined that there was no reduction in length of stay vs usual care, with patients requiring a total of 13 days of specialist-led care vs 5 days for usual care, alongside an increase in readmissions associated with the VW though with no increase in mortality. Although evidence from previous studies exploring the impact of virtual wards (and similar hospital-at-home type models of care) on patient outcomes is inconsistent there are growing indications they reduce length of stay and readmissions [13, 15, 100-103].

Some of this inconsistency might be attributed to differences in the definition, design and implementation of "virtual wards" across and within different models of healthcare [2]. Though even where the design of VWs is centrally mandated and supported, regional variations in their implementation remain [104]. Our data highlighted differences in readmission rates across the different sites in the BSOL-ICS VW programme reflecting the experience of NHSEs recent nationally mandated covid VW programme. This produced evidence that localised influences of culture, resource and workforce experience can all have a significant impact on referral criteria, uptake of digital technologies, and staffing models of VWs [103, 105-110].

Health economic analysis

The NHSE funding for the current VW programme is intended to support only the initial implementation with it capable of becoming self-funded after three years [21, 63]. More detailed and holistic accounting should be built into any future VW service to better understand the set-up and running costs of VWs [5, 15, 103, 111], particularly considering how these vary by region, speciality, and the capabilities of the organisations involved [111, 112].

The results of the model-based analysis suggest that the total cost of the early supported discharge respiratory virtual ward was £531.42 higher per patient, as a result of 5.5 additional bed days compared to traditional inpatient hospital wards. The probabilistic sensitivity analysis supports these findings, indicating a very low probability (under 19%) that the respiratory virtual ward is cost-effective, i.e., cheaper and consisting of fewer bed days. However, these findings rely heavily on secondary data, primarily derived from the PIONEER study for the majority of model inputs. Since we received the data results without conducting the analysis ourselves, there are uncertainties regarding the reliability of these inputs, which could influence the conclusions about the cost-effectiveness of virtual wards.

It is also important to clarify that the 5.5 additional bed days encompass the total duration of stay, including time spent in both the virtual and hospital wards (initial or escalation). Therefore, these additional days may not necessarily indicate increased hospital time but could potentially represent a shift in care from the hospital to the virtual ward setting.

Furthermore, the deterministic sensitivity analysis indicates that if the length of stay associated with initial hospitalisations before transitioning to virtual wards, as well as the length of hospital stays following escalations back from the virtual ward, were to decrease by approximately 50% of their current values, the respiratory virtual ward could become a cheaper option compared to traditional inpatient care. This finding highlights the model's

sensitivity to changes in hospitalisation duration, suggesting that even modest reductions could significantly impact the cost-effectiveness of the virtual ward strategy.

This finding, that respiratory virtual wards are potentially not cost effective, contradict the majority of existing studies in this area [61, 113]. Typically, virtual wards reduce hospital stays by enabling earlier discharge and facilitating remote care, thereby lowering overall costs. Although this discrepancy could be due to differences in patient populations, healthcare practices, or specific implementations of virtual wards, reliance on aggregate result data from another study—without access to granular per-patient data—could be a critical factor in understanding the true impact of the virtual ward strategy.

Adopters

Staff adopters

Impact on current roles

Although staff participants appeared satisfied that used appropriately technology can offer additional reassurance of patient safety there were also concerns that some patients may be at increased risk due to the pace of the implementation and expansion of the programme. Such clinician concerns over the safety have been reported previously in VWs for a range of conditions [5, 97-99, 114] particularly for complex patients or where there were high-levels of clinical uncertainty such as with COVID [115-119]. One way in which staff concerns around VWs can be addressed is if there are clearly defined routes by which patients can be rapidly admitted to hospital if their condition deteriorates [120].

Impact on professional traditions

The data was collected at a time prior to purposeful staff recruitment and the imposed move to remote working and teleconsultation appeared to introduce uncertainties in workflows, and professional responsibilities, particularly amongst community staff recently moved to the VW. These concerns around where responsibility for clinical decision making ultimately lies have been witnessed previously in similar examples of remote care services [70, 110], where the confidence of staff depended upon their level of experience and expertise [121]. Meanwhile, the NHS's guidance for the clinical leadership of VWs specifically recommends that responsibilities are openly negotiated and clearly defined between teams working in different settings [122, 123].

More broadly its understood that healthcare staff can be resistant to changes in working practices, particularly where they feel they lack the necessary skill-set [124]. The successful delivery of VWs requires staff possess skills in IT and teleconsultation and in some cases a shift towards more frequent episodes of remote working [5, 110]. Meanwhile (in Spain) the

unique combination of skills needed to deliver VWs has been recognised and led to the development of a specialised training programme [125].

Patient adopters

Preferences for care at home/Reassurance

Staff participants described patients favourable response to being discharged early and being cared for at home echoing previous patient sentiment in VWs across a range of chronic conditions and health systems [94, 126-128] including COVID [129-132]. However, patients were said to be unaware that they were on a "Virtual Ward" and just grateful to be home earlier than anticipated. This lack of awareness is linked to a lack of engagement in the remote monitoring aspect of the VW with potential consequences for their clinical outcomes [133, 134]. The use of properly designed digital tools such as those associated with VWs can help support this engagement but it is contingent upon patients understanding their role and the associated benefits of technology-enabled care [133, 135]. It should also be noted that some patients required reassurance that they would be safe on the VW having previously been discharged when more fully recovered, a hesitancy amongst VW patients that has been observed previously [94]. It appears that more consistent messaging around VWs might address both issues.

Organisations

Strength of inter-organisational agreements

Interprofessional collaboration is key to sustaining VWs [136] though as with any element of integrated care there is a need for transparent systems and shared goals [69]. The importance of VWs was understood by senior service leads appreciative of the expectations for the programme amongst central policymakers and commissioners. This contributed to the key goals being widely understood across the teams that collaborated to deliver the early phases of the VW programme, an alignment of motivation and resource that its known can mitigate micro-political barriers that might otherwise constrain implementation [137].

Readiness for technology/extent of change needed

As described above, IT systems were ill-prepared for cross-Trust working citing the lack of interoperability. Beyond the current VW programme, progress on resolving issues of interoperability in NHS software systems has been slow [138-140] and it remains a recognised and significant barrier to VWs and other models of integrated care [141]. There were also differences in preparedness between specialties, with the respiratory VW team already having established links with community teams due to their previous collaborations on similar remote service offers.

Staff capacity and capability

The BSOL-ICS VW programme was impacted by delays in recruitment and in the UK as elsewhere it is understood that the broader capacity of organisations to rapidly adopt innovative ways of (technology-enabled) working is vulnerable to variable levels of investment and resource, including the number and experience of the existing workforce [142-144]. Even when funds were made available, identifying and recruiting staff was slower than anticipated and these staff shortages are reflective of wider gaps in the NHS workforce and threaten the viability of the next generation of VWs [145-147].

Wider system/ Embedding over time

Impact of local and national policies

Issues of chronic underfunding and staff shortages were expressed by participants from both BCHCFT and UHBFT and the need for significant investment in bedded capacity and staff to cope with the expected growth in demand is acknowledged [1]. The lack of resource is supported by the latest evidence which suggests that spending on the NHS has continued to be eroded to the extent that the estimated shortfall since 2010 is some £362 billion [148].

In understanding the need for increased capacity (including through the use of VWs), staff described issues with the coherence of long-term planning with what were thought of as key initiatives cut short and resources reallocated (in this instance toward the VW programme). This is a reflection of short-term (often 12 monthly) funding cycles and policy making which has been widely recognised and criticised by leading health care research bodies and think tanks [149].

Local interpretation of national policy

The NHSE regional VW team played an important role in maintaining focus on the intended outcomes, while listening to and accepting legitimate challenges to the national mandate. The implementation of the national programme was adapted by BSOL to reflect local workflows, existing service offers, and precise definitions of what constituted a VW. Such local interpretations of national policy initiatives are beneficial as they enable care delivery sensitive to local needs and capacity, with the caveat it is balanced with advancing central policy aims [150-152].

There was also scepticism that NHSE targets for VW bed numbers and capacity were achievable, amidst suspicions some sites may have gamed the system to meet them [64, 153, 154]. Senior decision-makers at BSOL-ICS chose to be transparent over what could be achieved, and the regional team fed this back to NHSE with the result that targets were subsequently readjusted. This suggests that more honest transparent conversations with central commissioners might reduce the negative impacts of target driven health care such as unhelpful sanctions and reduced staff morale [155].

The presence of inter-organisational networking

Senior staff participants reported benefits of sharing best practice through regional networks, and the importance of these networks in supporting innovative care is understood particularly where there is uncertainty due to rapid and fundamental shifts in modes of delivery [106, 137].

The ability of the VW model to be incorporated into usual care

The different care pathways developed by the various specialities presented difficulties for those staff delivering the service unsure of the correct criteria to follow. The next iteration of BSOL-ICS's VW programme is providing a more consistent cross-speciality approach following previous recommendations for common standards and processes in the delivery of VWs [94].

Patient sensitive service design

The lack of patient engagement with Big Picture further exemplified the need for patient engagement in the design and implementation of future iterations of the VW and its recognised that a shift is needed from co-designing with technology users to co-designing with patients and care providers [156, 157]. Enacting a more comprehensive approach to consultation over the design and implementation of VWs, involving patients from the outset will better ensure their needs and preferences are prioritized, and improve acceptability and engagement [156]. Care providers also play a critical role in shaping practical, user-friendly solutions that align with clinical workflows [157]. Strategies such as participatory design, where patients actively contribute to each stage of development, can bridge the gap between technology and patient-centred care, leading to more successful outcomes.

Evidence from other NHSE VWs

Patient experience and outcomes

Findings at sites across England implementing their versions of the VW programme reflected our own evidence of patient attitudes towards virtual wards i.e. that they were happier at home, presented improved ability to self-manage, though some had difficulty using the remote equipment (especially those living alone) Specifically these were reported at sites in South London [158], Hampshire [159], Dudley Group [160], Leeds [161], Hertfordshire [162] and Essex [163].

There were reports in BSOL-ICS's VW programme that patients were neither aware (nor particularly cared) that they were on a virtual ward. This evidence was also reflected in a quantitative survey conducted in South Central and West Commissioning Support Unit

which also found a lack of awareness and misconceptions about VWs [134]. Despite this, they reported that over half of those surveyed would prefer to be treated on a VW [134].

The concerns of staff that some cohorts of patients would be excluded from VWs because of their lack of connectivity or digital literacy appeared to be supported by the work conducted in South East region where black and minority ethnic people were consistently underrepresented in VW patient cohorts [164].

Positive patient outcomes, including reduced length of stay and readmission rates were reported in a collated report published by NHSE in 2023 [162]. More specifically, work in Essex described reduced likelihood of acquiring infections [163], and improved independent social care outcomes [163]. The Essex programme also reported positive results in relation to healthcare utilisation, including reduction in length of stay and readmission rates, and the opportunity to save bed days [162, 163]. Meanwhile in Cheshire and Merseyside their specialist virtual ward created to manage acute heart failure demonstrated lower mortality rates and odds of readmission compared to usual care [165].

Service utilisation and financial impact

The majority of evidence on the impact of service utilisation was from an evaluation conducted in south east region which indicated a positive impact of reduced hospital activity at each stage of the UEC pathway, from initial attendance at A&E, non-elective admissions, to length of stay in hospital, and readmission [164]. This evidence was particularly compelling regards the significant impact on non-elective admissions, both in terms of patient flow and avoided hospital activity [164]. This is in contrast to the preliminary data from UHBFT described above which indicated an increase in readmission.

There were relatively few health economic analyses conducted across other sites. Work in the south east region collating and analysing data from 22 VWs reportedly led to an estimated 3117 avoided A&E attendances per year which equates to £1,305,995 per year [164]. Further to this, the analysis concluded that half of the VWs analysed were found to be associated with a positive net financial benefit with a mean net benefit per VW patient of £244 with a median value of £204 [164]. The cost per patient appeared to fall the longer the VW had been operating [164]. An overall analysis of 22 virtual wards in South East London also identified a positive net financial impact, with an estimated net benefit per annum of £3.53 million [166]. An economic evaluation of the Liverpool heart failure virtual ward model described a net cost benefit of £1135 per patient per episode (including VW set-up costs) [167].

Strengths and limitations of the evaluation

This study is the first in the West Midlands area to contribute to the ongoing evaluation of all virtual wards in the UK. It successfully employed qualitative, quantitative and a model-based economic evaluation. It assessed staff experience across the programme and provided a comparison of key outcomes and cost effectiveness between the respiratory VW and usual care. The NASSS framework proved a capable means of analysing and presenting the data from all work packages.

However, there are a number of limitations to the work which can be considered in two key areas. Firstly, the evaluation encompassed the early phases of the programme and included only the step-down approach. Subsequently the VW evolved to include an admissions avoidance element which did not form part of this evaluation. It is also important to note that subsequent to these early phases of the BSOL-ICS VW offer NHSE developed an operational framework that has included a number of recommendations for the design and delivery of VWs that in places differed to those reported here [168]. Secondly, we were unable to engage patients in the evaluation as intended, their recruitment proved challenging, and we were reliant on busy VW staff to make the initial approach as per the ethical approvals. However, the perspectives of staff proved a valuable analogue.

Considerations for future iteration of BSOL-ICS VW programme

Building on insights from the evaluation we have compiled a series of considerations for senior decision makers and service leads responsible for the next iteration of the BSOL-ICS VW programme, which is expected to focus on admission avoidance, frailty and at one site (Good Hope Hospital) acute medicine. These have been framed within the domains of the NASSS network and are presented in [25] and complement and reiterate much of NHSE's operational framework for virtual wards [168].

Table 18: Considerations for future VW implementation

NASSS domain	Theme from the evaluation	Possible questions to ask before proceeding
Condition	An understanding of social context of individual informs the decision to refer to VW.	• How is social context formally captured at the time of referral? • How are decisions made on adequacy of the available support from informal care providers (e.g., family caregivers)?
Technology	Issues with suitability of smart phone-based technology	• Is there an understanding of the digital literacy, internet connectivity of individuals? • Have patients been consulted on the appropriateness of the chosen technology?
Value proposition	Concerns amongst staff that expansion of VWs driven by concerns over capacity (with a lack of evidence of safe, efficient and cost-effective care)	• Has the latest (NHSE) evidence been used in designing/refining the VW service? • What does the staff messaging look like around the rationale for introducing VWs?
Adopters	Staff: Concerned over change in roles and shared responsibility across settings	• Have staff been engaged in the development and delivery of VWs? • Are staff appropriately trained to deliver VWs including teleconsultations? • Are responsibilities of various roles defined and understood by all, particularly between Trusts?

NASSS domain	Theme from the evaluation	Possible questions to ask before proceeding
	Patients: Lack of understanding of being on the VW including its safety and rationale; issues over inclusivity	• What does the messaging for patients and families/carers look like? ○ Are the benefits and safety procedures routinely explained (and understood)? • To what extent are patients from underserved populations being catered for and how is this being determined?
Organisations	There were differences in the experience and training of the staff delivering VWs	• Has specific training for VWs been considered? ○ How capable are the staff of managing IT systems and conducting teleconsultations?
Wider system	A lack of coherence in long-term planning and the impact of longstanding challenges to resource	• How far reaching is the planning cycle and to what extent are all Trusts and settings involved?
Embedding over time	Lack of standardisation of the service and a lack of co-production impacted the ability to incorporate the service into usual care.	• Are there plans for co-production of the next iteration of the VW? ○ Are patients involved?

Conclusions

In VWs are to be sustained, then its important to prioritize early and ongoing patient engagement in the design process to help ensure their needs and preferences are effectively integrated into the system, enhancing user satisfaction and overall outcomes [156]. Their should be iterative feedback from healthcare providers to create systems that support existing clinical practices [169], maintain efficient data flow and minimize disruptions in care [157]. Finally, its important that training and support is provided for both patients and healthcare staff including messaging on the structure and benefits of VWs. This will enhance user experience and engagement and patient outcomes [169].

Whether for VWs or any other care intervention, rapid ongoing assessments are acknowledged as an integral component of policymaking, commissioning and implementation [170]. The delivery and evaluation of future iterations of the VW programme can be supported by expanding the scope of data collection to include the admission avoidance and universal support models that will be adopted across specialities. To address the limitations identified in our study, future research and evaluations can better enhance the understanding and evaluation of virtual wards. There is an obvious need for a concerted attempt to engage patients and their families and carers to understand their lived experience. It's also important to expand the scope of clinical data to include diverse health conditions beyond respiratory and gathering long-term outcomes data and detailed per-patient data to enhance the accuracy and depth of the analysis.

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Appendix 1: Topic Guide

Summary topic guide- Service leads

1. Can we start with a description of your current role?
   (Prompts included)
   Length of time in post,
   Key responsibilities)

2. How did the model of VW for [condition] originate and how did it develop over time?
   Who led the development of the model?
   Has any learning from VWs elsewhere been incorporated?
   What was the nature/extent of partnership working to design/deliver the model?

3. What are the aims of the VW and its main features?
   What is your understanding of the patient groups being served

4. What are the main goals/outcomes of the service/model?

5. What are the key processes involved in the VW model?

6. Can you share your thoughts about patient safety concerns and/or near misses that have occurred since the service began?

7. Have there been any occasions of patients refusing treatment and/or dropping out?

8. What impact, if any, has the introduction of the service/model had on the following:
   Patients and their management of [condition]
   Tackling health inequalities and/or reaching high risk populations
   Delivery of the service within your own organisation
   The wider health and care system

9. What are the factors that act as barriers and facilitators in the design and implementation of VW?

10. What is the current staffing arrangement used to deliver your model?
    Number of staff/ pay band/grades
    Any new additional staff been recruited
    Redeployment of staff working elsewhere within the organisation

11. How is patient data linked across systems?
    Who is able to access these data?
    What is your opinion on the quality of the data?

What data or information, if any, would you have liked to have collected

12. What are the lessons learnt from implementing the VW?

Interview topic guide_ Staff delivery

1. Can we start with a description of your current role?
   Length of time in post,
   Key responsibilities

2. What are the aims of the VW and its main features?
   What is your understanding of the patient groups being served

3. May you describe your experience of delivering VW specific to your role?
   Referral processes (variation by age, ethnicity, deprivation)
   Patient triage
   Patient information and training
   Patient monitoring (what was monitored and how)
   Mechanisms used for patient data reporting (i.e. app, paper-based)

4. Can you share your thoughts about patient safety concerns and/or near misses that have occurred since the service began?

5. Describe how you felt when you learned about the use of the technology to support patients in the home?
   Confidence about their own technological/digital literacy
   Previous experience of using a new technology to treat patients
   Have their attitudes changed towards the use of digital platforms since working on the VW?

6. Can you describe the training you have received to explain and deliver the VW to patients? What further training would you like?

7. What skills, from your previous/existing role, have been useful when delivering VWs to patients?

8. Describe the experience of working with new staff or across Trusts
   Challenges and tensions (e.g., communication with new colleagues)

9. Can you describe the nature of support and guidance you received (if any) during the set up and delivery of the service from within your organisation?

10. Can you describe the nature of your engagement with patients referred to the VW?
    Did you have trouble accessing any patient groups? Has there been any tailoring of the service to meet specific needs/requirements?
    Do you feel patients and carers received all of the necessary information? Do you feel they understood the information?
    Do you feel that you gathered enough information from your patient and carers in relation to their wider social circumstances to understand how best to use remote monitoring for them?
    Did any patients appear anxious/need reassuring at any stage?
    How would you describe your experience engaging with family members and/or carers of patients?

11. What are the lessons learnt from implementing the VW?

Appendix 2: WP2 Online Staff Survey

Group of questions	Questions to cover
Is participant clinical lead/managers or staff delivering VW	- Clinical lead/manager or staff delivering VW (please select) *(this will affect which questions are provided)*
Demographic characteristics- **ALL**	- Professional role and band / clinical, non-clinical, administrative (*for delivering staff only)* - What role have they played in VW *(i.e. set-up/management, referral, triage, patient monitoring, escalation and discharge).* - How long have they been involved in VW - When starting your role in VW did you have any relevant experience or were you in need of training from the beginning? *(select from these options in a drop-down. Plus 'had relevant experience but still required training.'* - Did they have any relevant experience? or needed training from the beginning - Whether they are sharing the role delivering VW with other roles?
Questions on the processes for VW – **CLINICAL LEADS/MANAGERS ONLY**	- Where/who/how is the service managed? - Type of model - Is the service being delivered 24 hours per day, 7 days per week? (Y/N) - When was your VW launched? - Type of monitoring used *(Paper based/app/both)* - How are patients identified and referred? - What processes are involved in the model? *(select all that apply)* o Patient triage o Patient information and training o Patient monitoring o Tools for flagging deterioration o Escalation processes and referring to other services o Patient discharge from the ward Questions about the model of care: - Who is distributing remote monitoring equipment? *(clinical staff, non-clinical staff, volunteers, students, other)*

	- Who is carrying out remote monitoring? *(Select all that apply: clinical staff, non-clinical staff, volunteers, students, shielding individual, other)* - How often do staff contact with patients *(Select from: several times per day, once per day, weekly)* - Which services are patients signposted to during or after being discharged from the VW? *(Select from: GP, community care, other)* o
Staff experiences of delivering VWs – **DELIVERING STAFF ONLY**	- How have you found delivering VW? In particular: *(Likert scale – very easy to very difficult, N/A)* o The triage processes o Monitoring patients (e.g. using the app/paper-based system) o Processes to escalate patients o The IT systems you are using o Working with other trusts/services
Training/support received – **DELIVERING STAFF ONLY**	- Do you feel adequately supported in your role? *(Yes/No)* - Have you received training in your area of responsibility? *(Yes/No)* - Are you confident in your ability to carry out your responsibilities *(Yes/No)* - Questions about training needs: o Do you feel clear about your role, responsibility and accountability? *(Yes/No)* o Do you feel that you have any further training or support needs? *(Yes, No)* If yes, what do these relate to? *(select all that apply – clinical pathways, processes to triage, processes to monitor patients (e.g. documenting patient interactions), escalation, conflict resolution, use of IT systems, other)*
Training/support received – **CLINICAL LEADS/MANAGERS ONLY**	Questions about support: - To what extent do you agree with the following statement: There is enough staff/capacity to deliver the service as intended? *(Likert scale from strongly disagree to strongly agree)* - Are there any additional training resources/training required to deliver the service *(Yes/No)*

	○ If yes, what do these relate to? Clinical pathways ○ Processes to triage ○ Processes to monitor patients ○ Processes to escalate patients ○ The IT systems you are using
Impact of VW on workload, and job satisfaction – **ALL**	- Questions on the impact of VW on their work, including: ○ Impact on staff workload – in addition or instead of their usual work? ○ Impact on staff job satisfaction levels? ○ Impact on stress
Staff perspectives on engagement and experiences of service users – **DELIVERING STAFF ONLY**	- How have service users engaged with/responded to the service? *(Likert scale – very poorly to very well)* - How well do you think service users have engaged with/ used/ carried out the following *(very poorly to very well, N/A):* ○ Monitoring their condition ○ Providing readings over the phone ○ Providing responses via app - Do you think that service users have felt reassured whilst on the VW? *(yes/no)* - Are there any types or groups of service users facing barriers to accessing the service? *(yes/no)* ○ If yes, which groups? *(select all that apply: BAME, patients with learning disabilities, elderly, non-English first language, cognitively impaired)* ○ Has there been any tailoring of the service to accommodate specific needs/requirements? *(yes/no)*
Impact - **ALL**	Do you think the service is having an impact on the following? *(select all that apply)* o Reduce patient mortality o Reduce patient morbidity o Reduce health inequalities o Increase health inequalities o Early identification of cases of deterioration o Reduce attendance/reattendance to ED o Reduce hospital admissions o Reduced length of stay in hospital

	o Other
Data – **CLINICAL LEADS/ MANAGERS**	- What data are you collecting from patients at present to monitor service delivery? *(select all that apply)* - Have these data helped you to monitor progress against your expected outcomes? *(Likert scale)*
Use in different settings – **CLINICAL LEADS/ MANAGERS**	- Have you been a part of VW for service users with other specialities? *(yes/ no)* o If yes, which specialities? *(select all that apply)*
Open text question - **ALL**	- Is there anything else you'd like to tell us about your experience of delivering/ managing VW? *(Please write in the box below)*