myCOPD Digital Health Champions

Quantitative Analysis

December 2022

Working in collaboration with

West of England Academic Health Science Network (KSS AHSN) is one of fifteen AHSNs working to transform lives through innovation.

The NHS consists of various organisations working together to provide a variety of health and care services for patients and carers.

Contents

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Executive summary

Context

Unity Insights has been commissioned by West of England Academic Health Science Network to conduct an evaluation of the NHSx Digital Health Partnership project into the potential impact of a new role referred to as Digital Health Champions (DHC). These are band 4 clinicians with dedicated time to support patients and busy front line staff get the best out of digital therapeutics. The Digital Health Champions (DHCs) enrol patients onto the myCOPD self-management application.

This part of the wider evaluation incorporates quantitative and health economic analyses of the delivery model across two Trusts and primary and community services within Bristol, North Somerset and South Gloucestershire Integrated Care Board (BNSSG ICB).

Data collected by the app developer, my myHealth and through primary, secondary and community care deployments were analysed to support a quantitative evaluation of how DHCs have supported engagement and activity on the app, while drawing comparisons to support a cost-benefit analysis of how supported app usage can yield benefits to the healthcare system.

Key results

Positive impact upon patient engagement

In comparison to a recent feasibility study deploying the app in the NHS without specific support, patients enrolled and supported by the DHCs were found to be more likely to access multiple modules on the platform, with 27% accessing four or five modules, compared to 16% in Cooper et al. (2022). The data also suggests that a larger proportion of patients become sustained users of myCOPD, with 38% of activated users providing symptom scores at a 'very high' frequency, compared to 17% in Cooper et al. (2022).

Marginal return on investment results

The cost-benefit analysis suggested a potential benefit-cost ratio of 1.2, representing an estimated return of £1.20 for every £1 invested. Implementation costs meant that a negative benefit-cost ratio of 0.7 is expected in the first twelve months, before rising to 1.4 in subsequent years. This should be considered in the context of multiple limitations that arose during the evaluation, such as:

- Lack of a real-world outcome and comparator data, leading to the reliance upon literature to draw comparisons.
- Due to such issues, a larger optimism bias was applied, dampening benefits further.

The analysis highlighted the heavy influence that DHC utilisation has on the realisation of benefits, with just an additional enrolment per week potentially leading to a significant increase of benefits, and vice versa.

It should be noted that due to a number of limitations, there are reasons to believe that the delivery model could yield further benefits to the healthcare system over the long-term. These factors include:

- Unmodelled benefits, such as reduction in GP appointments, reduction in condition deterioration and more efficient delivery of annual reviews
- Inflation of optimism bias due to a lack of real-world data to base modelling assumptions on
- Inability to identify the impact of the service upon pulmonary rehabilitation enrolment.

Recommendations

Maximise DHC capacity

Due to the heavy influence the utilisation of the DHCs may have on the realisation of benefits, the long-term capacity planning for staff should seek to maximise their utilisation. Whether this is a process of supporting the identification of potential candidates for enrolment, or managing the administrative burden, a small change could have a significant impact on whether or not the programme produces net benefits to the healthcare system.

Support further evaluation

The data collected through this project has great value to measure the impact of the service. Future evaluations can build and develop on the findings of this project and provide greater assurance of the benefits of myCOPD in a real-world setting and provide valuable learnings for successful deployment in other areas. Linking data relating to patient enrolment and ongoing healthcare utilisation for the enrolled patient group, i.e., GP appointments, ambulance calls and hospital readmissions, will provide strong evidence of the scale of benefits observed and reduce uncertainty in the model.

Legacy planning

Due to the nature of the project as a pilot measure, there is a level of remaining uncertainty relating to the long-term costs of operating the service. This will largely depend on the management and administration of DHC staff once the pilot project team is completed. Projected budget plans and costings would support the assessment of the results found in this report.

Further to this, it would be beneficial to observe the service in a wider context, to seek further opportunities to add value to the system. For example, a clearer understanding of pulmonary rehabilitation pathways across the patient group would support an assessment of the proportion of patients who are able to follow a course due to their supported enrolment to myCOPD, while others may be enrolled into alternative courses by other means. To date this comparison has not been possible, meaning that the potential benefits of such courses remain unmodelled.

1. Introduction

1.1. The myCOPD Digital Health Champions

Chronic obstructive pulmonary disease (COPD) prevalence across Bristol, North Somerset, and South Gloucestershire (BNSSG) is rising along with England as a whole, with lung disease in the UK costing £11 billion a year (NHS England, 2022). Nationally, there is a desire to actively deploy innovations to support the growing burden of disease and associated costs, particularly in areas such as Bristol where PHE data indicate emergency COPD admissions are significantly worse than the National average (Public Health England, 2021).

Treatment for COPD includes inhaled medication and exercise programmes, called Pulmonary Rehabilitation, to improve exercise tolerance and resilience to exacerbations. Currently NHS respiratory services are struggling to provide support to patients with COPD, a recent-report highlighted that 75% of people with COPD are not receiving basic care. There is an increasing need therefore to support patients to self-manage their condition effectively, this requires new approaches and pathways of care. myCOPD is a digital self-management and Pulmonary-Rehabilitation app developed by NHS Physicians and people with COPD. It has been rigorously tested in clinical trials and has been shown to deliver similar improvements in symptoms and exercise tolerance to PR exercise-classes and to help patients admitted to hospital, recover more quickly at home. myCOPD is being used by patients in different areas of the UK, but to enable adoption across the NHS, evidence for the health-economic benefits of its use is required.

myCOPD has been rigorously tested and initial pilot phase of testing defined the user interface (UI) and informed content. An initial open study of myCOPD use in 36 patients with moderate to severe disease demonstrated that 66% of patients completed 3 months of sustained use. 95% of these demonstrated a clinically and statistically significant improvement in symptom control. In addition, inhaler technique errors were corrected in over 70% of patients resulting in sustained improvements in technique (North et al European Respiratory Journal 2014 44: 1413). myCOPD has been tested in three separate randomised controlled trials in different clinical settings with different NHS teams. The TROOPER Study explored the performance of myCOPD in delivering pulmonary rehabilitation which confirmed it was non inferior to usual care in delivering these key outcomes and in fact clinical improvements were numerically superior in the myCOPD arm. (Bourne et al BMJ Open 2017).

The RESCUE study investigated the clinical impact of myCOPD on the recovery of patients admitted to hospital with an acute exacerbation. 41 patients were randomised to myCOPD or usual care and followed for 3 months from hospital discharge. Sustained app use rates were seen (81%) with a dramatic increase in rates of clinical improvement in the myCOPD arm compared to SoC- (COPD Assessment Test score 4.49 points lower). 80% of critical inhaler errors were corrected and there was a trend to reductions in exacerbations (34 vs 18) and readmission OR 0.383 with myCOPD (North et al Digital Medicine, 3; 145, 2020). The EARLY study randomised 60 newly diagnosed patients in a primary care setting to myCOPD or usual care and again improvements in inhaler technique were seen (OR for an error 0.30 c myCOPD v SoC) with trends in lower symptom scores in users seen. In all studies, myCOPD has been shown to be safe, patient feedback is excellent with >90% satisfaction rates and with innovations in the clinical pathway activation and sustained use rates are industry leading at over 60%.

RCT evidence for the app is now supported by real world evidence from an array of services and providers. Examples include – the use of myCOPD in supporting pulmonary rehabilitation delivery by Southend University Hospital, this showed that completion rates for home PR were greater with myCOPD use (>100% uplift) with greater improvements in CAT scores seen. In NHS Grampian an assessment of use in a service innovation demonstrated improvements in symptom control, reductions in rescue medication use and 20% reduction in unscheduled care supported by excellent patient feedback. my mHealth is working with NICE to achieve full approval of myCOPD for national adoption. The recent Medical Technologies Guidance recommendation recognised the clinical benefits of the app and suggested further research is required for full approval focusing on use of myCOPD in PR and in supporting self-management.

A recent feasibility study deploying myCOPD in the NHS, which did not use dedicated enrolment and support, was used as a comparator (Cooper, 2022). Successful implementation of myCOPD provides an opportunity to build capacity in primary and secondary care, and community teams where a blended approach with traditional PR and myCOPD is used.

Transformation funding for this project was secured through a successful bid to NHSx to deploy the myCOPD app through a novel implementation strategy using Digital Health Champions (DHCs), with the aim of yielding greater benefits to the patient and healthcare system than would otherwise be seen through unsupported use of the application. It was deployed by healthcare teams across acute hospitals care, community respiratory services, and primary care in BNSSG.

Expansion of the project across primary care was controlled to ensure that primary and community care teams could be informed of the project. Due to this and other factors relating to the establishment of the role within organisations, DHCs have not been working to full capacity to date and are expecting to reach a greater number of patients in the future.

1.2. Purpose of the Report

Unity Insights has been commissioned by West of England Academic Health Science Network to conduct an evaluation into the potential impact of using Digital Health Champions to enrol patients onto the myCOPD self-management application. This report presents the results of quantitative and health economic analyses in support of the wider project. Findings have been combined with the qualitative findings to help produce a final project report.

2. The Evaluation

2.1. Quantitative Analysis

In order to assess the impact of DHCs upon the uptake and usage of myCOPD, a number of measures relating to DHC-enabled myCOPD users were analysed using data provided by my mHealth. Specifically, analysis of the following aspects of the sample was performed:

- Demographics, including age and gender distribution.
- Smoking status.
- Engagement levels with myCOPD, including activation rate, module usage, symptom scoring frequency, and video engagement.
- Various clinically relevant COPD indicators provided in the sample, including COPD assessment test scores, symptom scores, and modified medical research council scores.

The results of this analysis are presented in section 4.1 Quantitative Findings.

2.2. Health Economic Analysis

A health economic cost benefit analysis model was produced, along with sensitivity analysis of the results. Three benefit streams were identified and modelled:

- Reduction in admissions
- Reduction in bed days per admission
- Reduction in inhaler waste

Alongside these benefit streams, one cost stream was modelled:

- DHC staff costs

The methodology of the model, including an outline of each cost and benefit stream calculation and the sources used throughout the model, is outlined in section 3.2 Health Economic Analysis.

3. Methodology

3.1. Quantitative Analysis

In support of the evaluation, detailed reports relating to the use of myCOPD by DHC-enabled patients were provided by my myHealth. These data provide an insight into the proportion of patients that have engaged with the platform following their initial registration, the number of times they have used the platform, the elements and modules users engaged with, and the status of their condition (captured in a short series of questions asked of the user each time they log onto the application). The data also included some basic demographic information, such as gender and age.

Further information was requested from the two trusts participating in the project, as well as the community provider Sirona, and colleagues in primary care services within BNSSG. These data include further demographic and lifestyle information relating to patients enrolled to myCOPD by the DHCs, as well as figures relating to acceptance or decline of the offer.

Comparative analysis has been undertaken to gain an understanding of how the use of DHCs has impacted the uptake of the application, as well as the usage of the platform following activation on the app. Unfortunately, it proved difficult to identify an appropriate comparator from within my myHealth's data within the available timeframe, and therefore many of the comparisons were made against available literature relating to the usage of myCOPD in NHS settings.

Results are presented in this report as a breakdown of the user base of myCOPD, with relevant comparisons informing the assumptions used in the health economic analysis.

3.2. Health Economic Analysis

A health economic model was built using a combination of existing literature and data from the project itself. Benefit streams were calculated based on the number of patients seen by DHCs during the pilot programme, and the increase in myCOPD engagement that some DHC-enabled patients exhibit, as detailed below.

The general methodology followed is the same as for all Unity Insights health economic analysis. More details on the general health economics approach used here can be found in Appendix A. Specific aspects of the modelling process in relation to this programme are laid out below.

Benefit Streams

There were three benefit streams identified from the introduction of DHCs for patients enrolled on myCOPD: reduction in hospital admissions, reduction in inhaler waste, and reduction in bed days per admission. These benefit streams rely on dividing patients into sub-groups based on the frequency of recording their symptom scores, using the data provided by my mHealth for DHC-enabled myCOPD users. Due to a lack of suitable data for a comparator group, the rates of symptom scoring frequency found in Cooper et al. (2022) were used as a comparative baseline in both benefit stream calculations.

Reduction in Admissions

The additional benefit conferred by the introduction of DHCs to support patients enrolment and usage of myCOPD is an increase in the proportion of active users who record their symptoms in myCOPD at a very high scoring frequency (VHSF), defined as recording symptoms more than 20 times every 100 days. Cooper et al. (2022) found that just 17% of their active users fall into the VHSF group, whereas the data provided by my myHealth for DHC-enabled users shows that 37.98% of active users recorded their symptoms at a VHSF.

To find the benefit conferred to the population of those with COPD, the rate of activation must also be taken into account. Cooper et al. (2022) report that 78.80% of enrolled users activate myCOPD, whereas the activation rate within the my myHealth data was 70.95%. It is expected that patients using the app will benefit beyond their first year of use. The activation rates for both groups were applied across five years to represent a declining user base. Five-year activation rates were totalled and multiplied by the relevant VHSF user groups (Table 1). Subtracting the baseline (43.99%) from the intervention group (76.08%) provides a rate (32.09%) which may be applied to the overall population, describing the additional patient benefit years brought about by DHCs (among VHSF users across 5-years).

Table 1: Activated users modelled across five years, and subsequent rate of total VHSF benefit years.

User Group	Year 1	Year 2	Year 3	Year 4	Year 5	5-Year total * VHSF group
Baseline (Cooper et al. 2022)	78.80%	62.09%	48.93%	38.56%	30.38%	**43.99%**
Intervention (Study data)	70.95%	50.34%	35.71%	25.34%	17.98%	**76.08%**

Table 2 applies the difference in VHSF and activation rates to the expected throughput of patients (682) per year, which assumes that patient annual referral rate to myCOPD remains flat. This illustrates the additional number of patients benefitting across cohorts each year. Of the 682 patients onboarded by DHCs in the first year, each cohort will experience an additional 210 patient benefit years across five years. Net present value (NPV) was used to model the benefits, which assumes all benefit (210 patient benefit years per cohort) is realised in the first year, with discounting applied to the subsequent years; Appendix A provides greater detail on NPV and discounting.

Table 2: Additional VHSF patients receiving benefits (due to DHCs) up to five years following enrolment.

User Group	2023	2024	2025	2026	2027	2028
Cohort 1	89	56	34	20	11	
Cohort 2		89	56	34	20	…
Cohort 3			89	56	34	…
Cohort 4				89	56	…
Cohort 5					89	…

As shown by Cooper et al. (2022), patients who record their symptoms within myCOPD at a VHSF see a reduction in daily hospital admission incidence of around 0.00065. This is equivalent to roughly 0.237 admissions avoided per patient per year.

The cost of a COPD admission is given by the average cost of a non-elective spell for COPD patients. The figure was calculated using *Hospital Episode Statistics* data (Harvey Walsh Ltd, 2022) from North Bristol NHS Trust (NBT) and University Hospitals Bristol and Weston NHS Foundation Trust (UHBW), over the period January 2022 – August 2022, and was estimated to be £2,449.92 per admission.

The per patient benefit of the reduction in admissions can be calculated by multiplying the change in the proportion of activated patients with VHSF (13.55%) by the number of admissions avoided per patient per year (0.237) and the estimated cost of an admission (£2,449.92):

$$Reduction\ in\ Admissions\ per\ Patient\ Benefit = 0.1355 \times 0.237 \times £2{,}449.92$$

$$Reduction\ in\ Admissions\ per\ Patient\ Benefit = £78.76$$

The total benefit of the reduction in admissions can then be calculated by multiplying the per patient benefit by the target population.

Finally, an optimism bias (OB) correction of 15% is applied to the benefit stream to account for the reliability and age of sources used throughout the calculation. The full benefit stream calculation is shown below in Figure 1: Reduction in admissions benefit stream calculation..

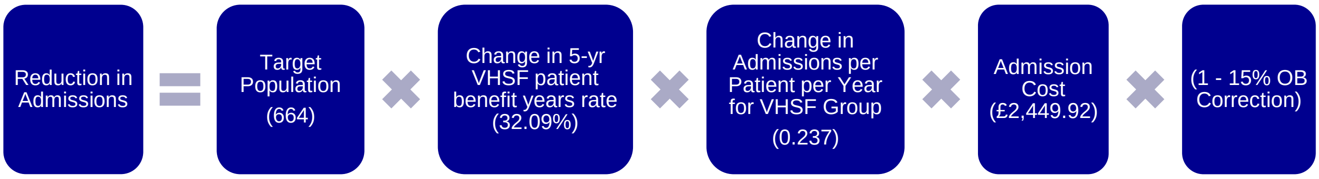

Figure 1: Reduction in admissions benefit stream calculation.

Reduction in Bed Days per Admission

As with the reduction in admissions, the benefit induced by the introduction of DHCs is the increase in patients' engagement levels with the myCOPD app. Namely, the increase in the proportion of patients that activate myCOPD and record their symptom scores at a VHSF. The same five-year rate is used as in Table 1, and when applied to the target population provides a number of years for which the VHSF users will benefit from the intervention. The reduction in bed days per admission is then derived from the patients within the VHSF group who are still admitted to hospital.

As shown by Cooper et al. (2022), patients with a VHSF experience fewer admissions and fewer bed days. Moreover, the number of bed days per admission also drops, i.e., the reduction in bed days is proportionately larger than the reduction in admissions within this group. Cooper et al. (2022) find a daily bed days incidence and daily admissions incidence of 0.009 and 0.00165 respectively for users within the VHSF group before myCOPD enrolment. This implies a bed days per admission of around 5.45. After the intervention, the daily bed days incidence and daily admissions incidence for this group drop to 0.003 and 0.001 respectively, implying a bed days per admission of just 3. The reduction in bed days per admission is then given by:

$$Change\ in\ Bed\ Days\ per\ Admission = 5.45 - 3$$

$$\rightarrow Change\ in\ Bed\ Days\ per\ Admission = 2.45$$

The yearly admissions incidence for the VHSF group after the intervention is given by their daily admissions incidence (0.001) multiplied by the number of days in a year:

$$Admissions\ per\ Patient\ per\ Year\ for\ VHSF\ Group = 0.001 \times 365$$

$$\rightarrow Admissions\ per\ Patient\ per\ Year\ for\ VHSF\ Group = 0.365$$

The average cost of a bed day for a COPD admission was calculated using the average inpatient cost and average inpatient length of stay for COPD patients in the *Hospital Episode Statistics* data (Harvey Walsh Ltd, 2022). Figures were used for NBT and UHBW, over the period January 2022 – August 2022, with the average cost of a bed day estimated to be around £382.78.

The per patient benefit of the reduction in bed days per admission can be calculated by multiplying the change in the proportion of active users (13.55%) by the admissions rate for patients in the

VHSF group (0.365), the change in bed days per admission (2.45), and the average cost of a bed day (£382.78):

$$Reduction\ in\ Bed\ Days\ per\ Admission\ per\ Patient\ Benefit = 0.1355 \times 0.365 \times 2.45 \times £382.78$$

$$Reduction\ in\ Bed\ Days\ per\ Admission\ per\ Patient\ Benefit = £46.38$$

The total benefit is then derived from this per patient benefit multiplied by the number of patients within the target population.

Again, an optimism bias correction of 15% is applied to the benefit stream to account for the reliability and age of sources used throughout the calculation. The full benefit stream calculation is shown below in Figure 2.

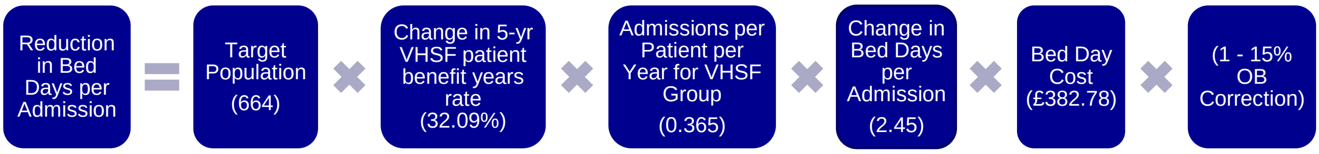

Figure 2: Reduction in bed days per admission benefit stream calculation

Reduction in Inhaler Wastage

The target population reached by the DHCs is calculated in the same way as the previous two benefit streams, by projecting DHC capacity over a full year.

As with the first two benefit streams, it is assumed that the population receiving DHC support will continue to benefit from their increased engagement with the app over the next five years, with those benefits being realised in the first year (i.e., the benefits are given in net present value).

Unlike the previous benefit streams, it is assumed that those patients who watch inhaler technique videos and learn proper inhaler technique do not lose this knowledge over the next five years, i.e., there is no decay rate. The proportion of patients benefiting from the increased rate of inhaler videos watched therefore remains constant in each year.

The patients that benefit from DHC-enabled myCOPD usage are those that watched inhaler videos that otherwise would not have. The proportion of all patients that fall into this category can be calculated by subtracting the proportion of all patients who usually watch inhaler videos from the proportion of patients who did so in our intervention group.

Cooper et al. (2022) report that just 10% of activated patients watched at least one inhaler technique video, whereas 46% of active DHC-enabled myCOPD patients did. Given the activation rates for each of these groups (78.8% and 70.95% respectively), the change in the proportion of all patients who watch inhaler technique videos is given by:

$$Change\ in\ Proportion\ of\ Patients\ Watching\ Inhaler\ Videos = (0.7095 \times 0.46) - (0.788 \times 0.10)$$

$$\rightarrow Change\ in\ Proportion\ of\ Patients\ Watching\ Inhaler\ Videos = 0.2475$$

$$\rightarrow Change\ in\ Proportion\ of\ Patients\ Watching\ Inhaler\ Videos = 24.75\%$$

Given the assumption that these patients do not forget how to use their inhalers, the effective proportion of patients that receive this benefit over 5 years (with all this benefit realised in the first year, i.e., in net present value) is given by:

$$Effective\ Proportion\ of\ Patients\ Receiving\ Benefit = 5 \times 24.75\%$$

$$\rightarrow Effective\ Proportion\ of\ Patients\ Receiving\ Benefit = 123.75\%$$

As reported by van der Palen et al. (2016), critical errors in inhaler technique are very common for patients with COPD, with around 36% of patients performing critical errors upon using their inhalers. However, North et al. (2020) demonstrate that patients with access to inhaler technique videos via myCOPD exhibit an inhaler critical error rate ratio of 0.377, meaning they are significantly less likely to perform critical errors than patients undergoing treatment as usual.

For the purposes of this benefit calculation, it is assumed that patients performing critical errors upon using their inhaler waste *all* of their inhaler. This means that any reduction in error rate is realised in the form of less inhaler wastage. It is important to note that this is an assumption drawn from a worst-case scenario, but has been used in the absence of quantitative data to confirm the proportion of medication wasted and the impact this may have upon prescription rates.

The reduction in inhaler wastage is then monetised using the average cost of an inhaler. This was derived from a weighted average of the six most used inhalers within the DHC-enabled myCOPD users' medication diary, weighted by the number of times an inhaler was used. Figure 3 shows the proportion of uses for each of these inhalers.

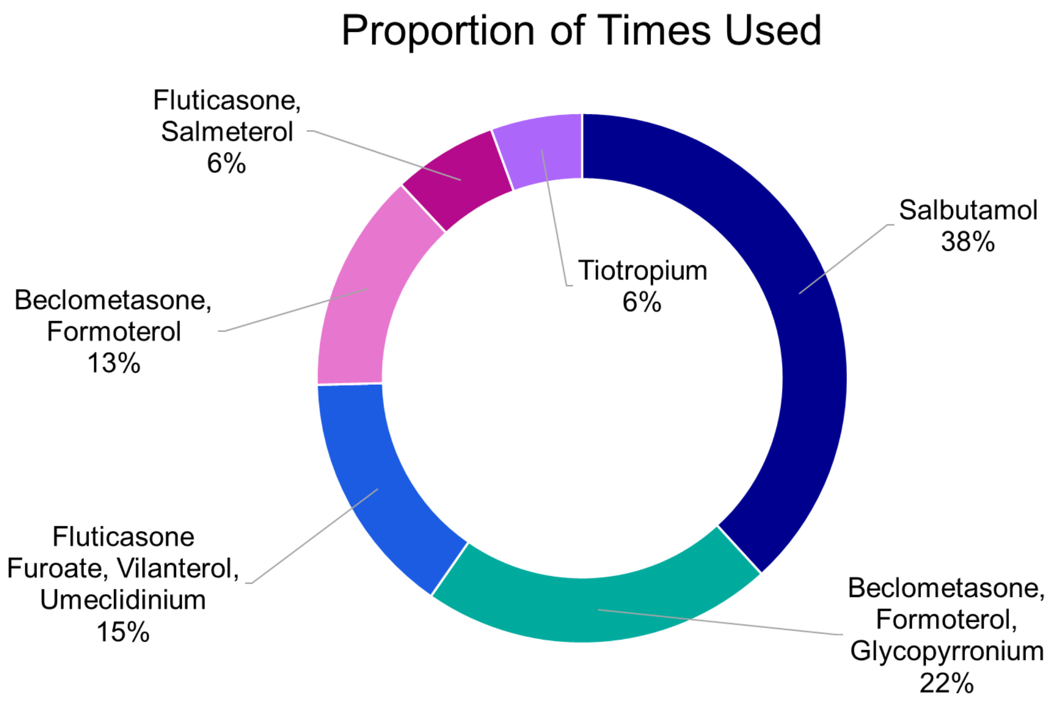

Figure 3: Proportion of inhaler usage within medication diary for six most used inhalers

The per-inhaler costs for salbutamol; beclomethasone and formoterol; fluticasone and salmeterol; and tiotropium were sourced from the *Drug Tariff December 2022* (NHS Business Services Authority, 2022). The costs for beclomethasone, formoterol, and glycopyrronium; and fluticasone furoate, vilanterol, and umeclidinium; were taken from the 'NHS indicative price' in the respective medication's National Institute for Clinical Excellence (NICE) BNF *Medicinal forms* entry (NICE, 2022a, 2022b). The use-weighted average cost of this selection of inhalers turns out to be £25.48 per inhaler.

The per patient benefit of the reduction in inhaler wastage is therefore calculated by multiplying the effective proportion of patients receiving the benefit of increased inhaler video engagement over 5 years (123.75%) by the percentage of patients that perform critical errors (36%), the inhaler critical error rate ratio for patients using myCOPD (0.377), and the average cost of an inhaler (£25.48):

$$Reduction\ in\ Inhaler\ Wastage\ Benefit\ per\ Patient = 123.75\% \times 36\% \times 0.377 \times £25.48$$

$$Reduction\ in\ Inhaler\ Wastage\ Benefit\ per\ Patient = £4.28$$

The total benefit is then calculated by multiplying this figure by the number of patients seen by DHCs in one year.

Finally, as with the other benefit streams, an optimism bias correction is applied to the benefit stream to account for the reliability and age of the sources used throughout the calculation. This time, a larger value of 30% is applied due to the presence of a somewhat older source (van der

Palen et al., 2016). The full benefit calculation is shown below in Figure 4: Reduction in inhaler wastage benefit stream calculation..

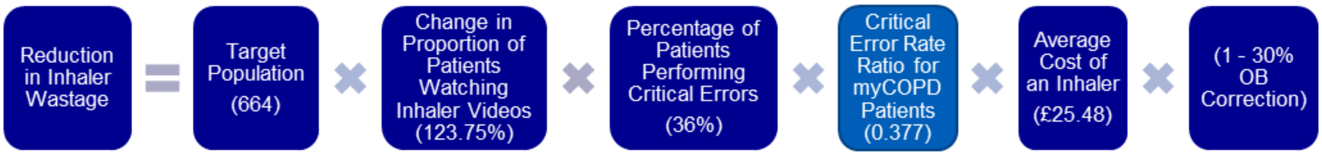

Figure 4: Reduction in inhaler wastage benefit stream calculation.

Cost Streams

The direct costs of providing myCOPD app licences to patients has not been included within the model used here which is designed to evaluate the impact of the DHC on app deployment and uptake. myCOPD apps were available as part of BNSSG licence agreement in 2017. Future commissioning of the myCOPD app across BNSSG remains outstanding.

Project Staff costs

Staff costs have been provided by the project team, accounting for both the initial setup costs that were incurred over the course of the initial twelve-month pilot, and the projected costs for future years.

Implementation Costs

Costs for the initial project implementation and management throughout the pilot phase of the project were divided into two phases, reflecting the staggered launch of the project across participating teams.

The costs for the first phase include the combined staff costs for 1.2 whole time equivalent (WTE) DHCs for a full year (£49,820.00, including on-costs), Project management and support, Clinical Leadership and on-site Clinical Champion roles to support engagement with primary and community care. The total staff costs for phase 1 of the implementation stage was £97,231.14.

The second phase costs included 1.8 WTE DHCs for six months (£37,365.00, including on-costs), as well as additional project management and support costs and further Clinical champion and leadership time. The total staff costs for phase 2 of the implementation phase was £78,248.89.

The total implementation costs for the first year of the project was £175,479.03.

Ongoing Costs

The project costs for future years were designed on the basis that, project evaluation and development would not be required by the participating organisations, the external project team is no longer needed. Instead, a Team Lead role was introduced at 0.2 WTE (£14,754.28 including on-costs) in addition to the DHCs themselves (1.8 WTE; 74,729.86).

The annual ongoing costs are £89,484.14 in total.

Finally, an optimism bias correction has been applied to the cost stream. As project costs are taken directly from the project itself, the figure applied is 0% in this instance. The full cost stream calculation is shown in Figure 5.

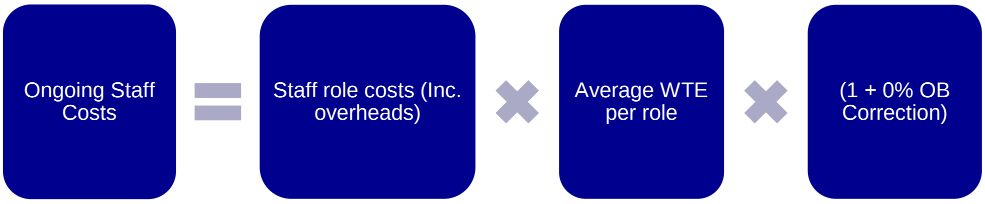

Figure 5: DHC staff cost stream calculation.

Scenario Analysis

Three different scenarios were considered within the preliminary scope of the evaluation, seeking to estimate:

1. The impact of the programme as a whole
2. The impact of the programme in primary care only
3. The impact of the programme in secondary care only

The benefit and cost stream calculations outlined above are indicative of the first scenario. Due to the nature of assumptions used to define the benefit and cost streams it was decided that the first scenario would provide the sole focus. Further dividing the benefits across settings would only be performed on a proportionate basis as it has not been possible to derive the expected benefits in terms of reduced GP appointments.

Therefore, the results section of this report pertain to Scenario 1.

4. Results

4.1. Quantitative Findings

DHC Utilisation

Over the course of 2022, 682 patients were onboarded to myCOPD by the Digital Health Champions across both acute and community settings, at a mean rate of 56.8 enrolments per month. North Bristol Trust was the largest source of enrolments, with 322. A breakdown by organisation can be seen in Table 3, below, average rates of enrolment have been adjusted for the number of months DHCs were active within each organisation.

Table 3: DHC enrolments by site

Organisation	COPD Acute Spells (Jan-Dec 2022)	Total enrolled	Average enrolment per Month
North Bristol Trust	1025	322	**26.8**
University Hospitals Bristol and Weston Trust	910	125	**12.5**
Sirona (Community Provider)	N/A	235	**29.4**
Total	1935	682	**56.8**

Table 4, below, provides further insight into the original service that referred patients to DHCs for application support.

Table 4: DHC enrolments by Referral Source

Organisation	North Bristol Trust	University Hospitals Bristol and Weston Trust	Sirona (Community Provider)
Community	8	1	81
Inpatient Services	55	64	0
Outpatient Services	36	31	0

Organisation	North Bristol Trust	University Hospitals Bristol and Weston Trust	Sirona (Community Provider)
Previous User	0	0	17
Primary Care	223	29	134
Unknown	0	0	3
Total	**322**	**125**	**235**

The majority of patients were enrolled onto MyCOPD over the phone, with face-to-face enrolment accounting for only 14% of total enrolments (n = 95). Data provided by the community provider, Sirona, suggests that an average of 3.27 calls were required to complete enrolment. It is unclear from the available data whether this was replicated across the two acute trusts. The two trusts captured additional data regarding the length of each call, suggesting that the average length of a contact call was 13.06 minutes.

Details of follow-up calls were provided for a total of 1004 contacts, the most common reasons given for these calls were 'Coaching / behaviour change' (61.35%), 'On-boarding to app / website' (4.98%) and 'Digital support' (2.29%). It should be noted that a significant number were recorded with non-standard reasons, under the 'Other' category (27.89%). Specific reasons were provided in a free-text format, but qualitative analysis of these calls was not possible within reporting timeframes.

Demographics

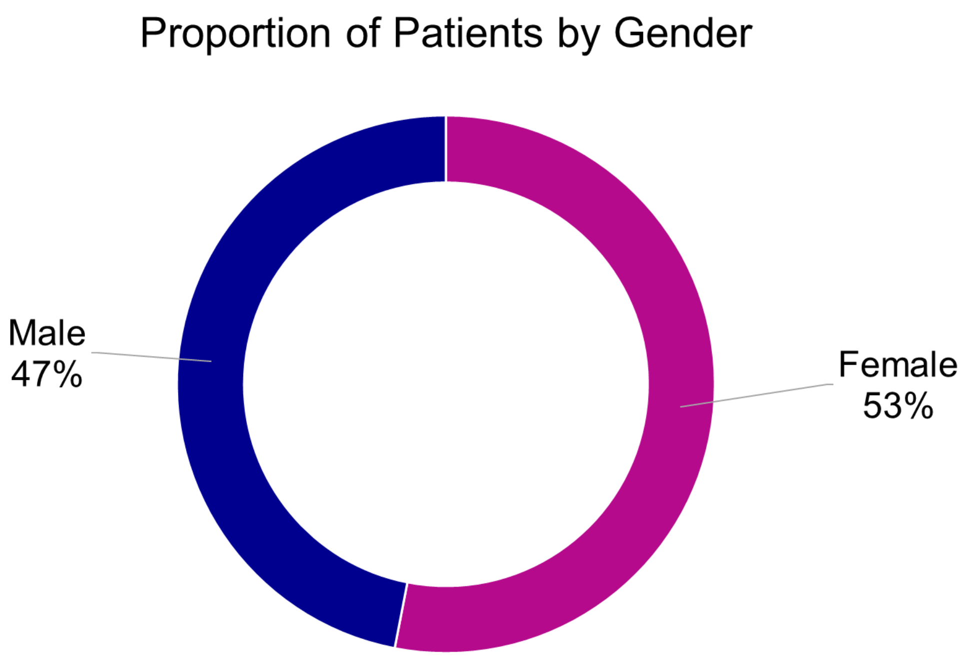

Figure 6: Proportion of male and female patients within target population.

As seen in Figure 6, just over half of users in the programme were female (252 of 475; 53%), with a slightly lower number of males (223; 47%) also present. Notably, this is a very similar gender distribution to the sample of COPD patients found in Cooper et al. (2022), who report around 51% and 49% of their sample as females and males respectively.

As shown in Figure 7, most users within the target population were between the ages of 65 – 79 years, with the entire sample of DHC-enabled myCOPD users having a mean age of 68.04 years. There were a small number of users (5 of the total 475) below the age of 45 years, but as would be expected for COPD patients, the vast majority of the target population of (around 99%) were 45 years old or more.

There were no significant differences in age between groups based on frequency of symptom scoring. This suggests that older were patients were no less likely to be highly engaged myCOPD users when given access to DHCs.

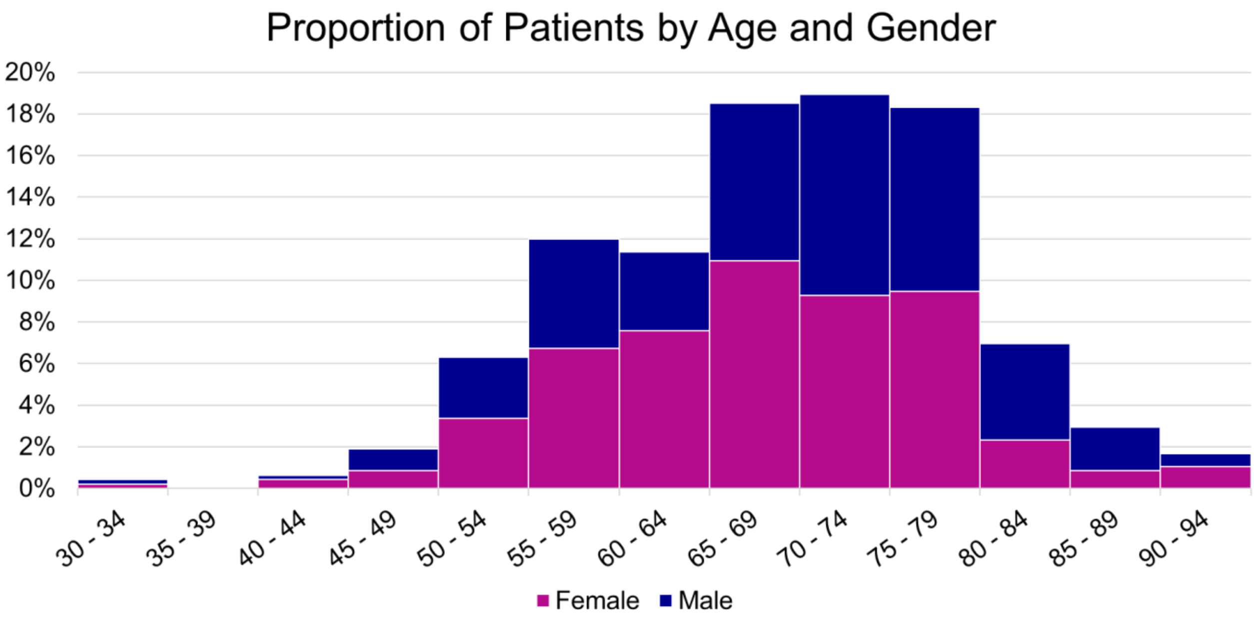

Figure 7: Distribution of DHC-enabled myCOPD patients by five-year age bands and gender.

Declined Patients

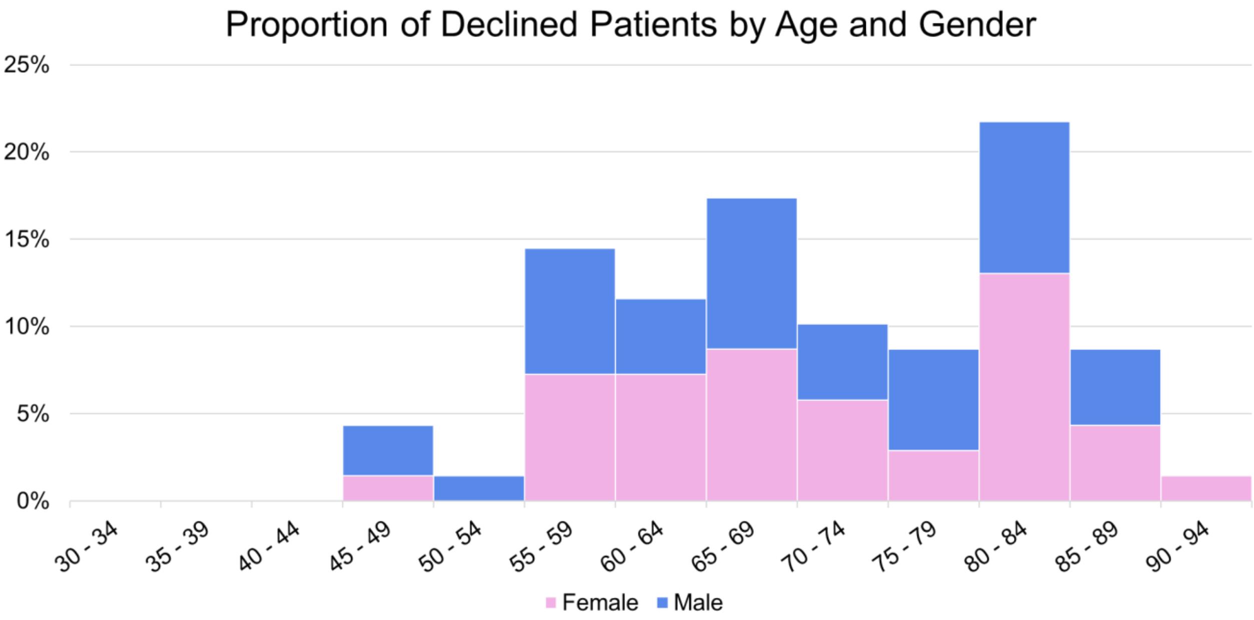

Figure 8: Distribution of patients who declined myCOPD enrolment by five-year age bands and gender

Data provided by two of the three operating sites suggested that 69 patients declined the offer of supported enrolment to myCOPD following referral to the DHC team. This reflects an overall declining rate of 11% of the 626 patients referred into the service.

Figure 8 shows the demographic breakdown of patients who declined to enrol with myCOPD. In general, patients who declined tended to be older than those who enrolled, although the difference is not necessarily significant: patients who declined had a mean age of 70.83, almost 3 years higher than those who did enrol. Conversely, the gender breakdown for declined patients is quite similar to those who enrolled, with around 48% of declined patients being male and the remaining 52% being female.

Smoking Status

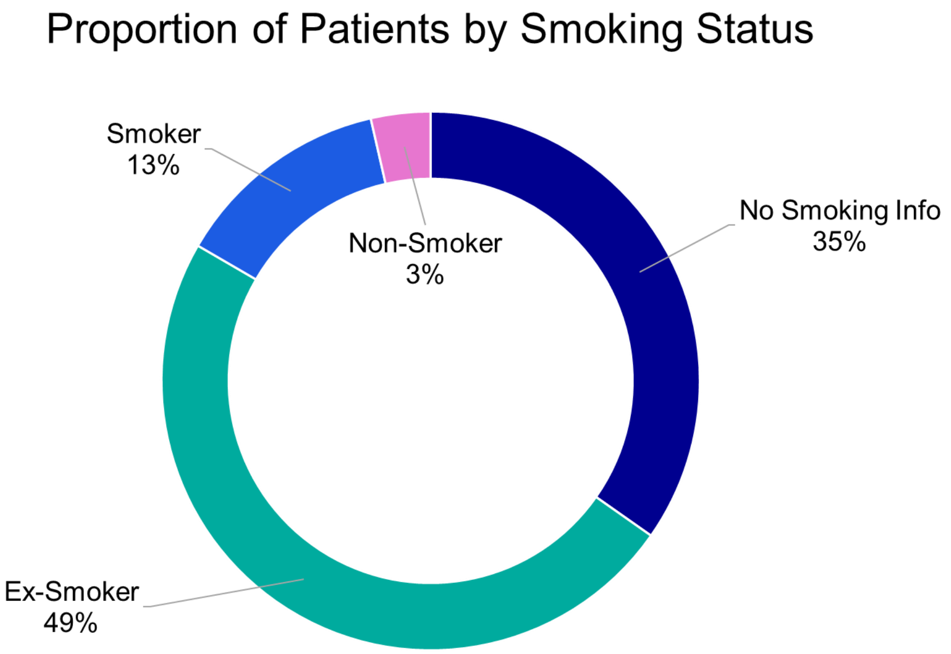

Figure 9: Proportion of all DHC-enabled myCOPD patients grouped by smoking status

Data on patient's smoking habits, as entered into the myCOPD app, were provided. The majority of patients (293 of 475; 62%) in the sample were either smokers or ex-smokers (Figure 9). Excluding patients for which no smoking data was entered (165 patients; 35%), this number rises to 95%.

Just 17 patients, or around 3% of all patients in the sample, were non-smokers (5% if you exclude those without smoking information). On the other hand, when excluding those without smoking information, 20% of all DHC-enabled myCOPD patients were still smoking.

In comparison to the available data for patients that declined enrolment to the app, it appears that smoking status had little influence on whether a patient would accept the offer of enrolment, as 77% of all declining patients were listed as ex-smokers (compared to 75% of the adjusted population for accepting patients). The proportion of declining patients who were current smokers also did not significantly differ from the accepting group (21% vs 20%, respectively), with just 2% of the declining group having never smoked.

myCOPD Engagement

Activation Rate

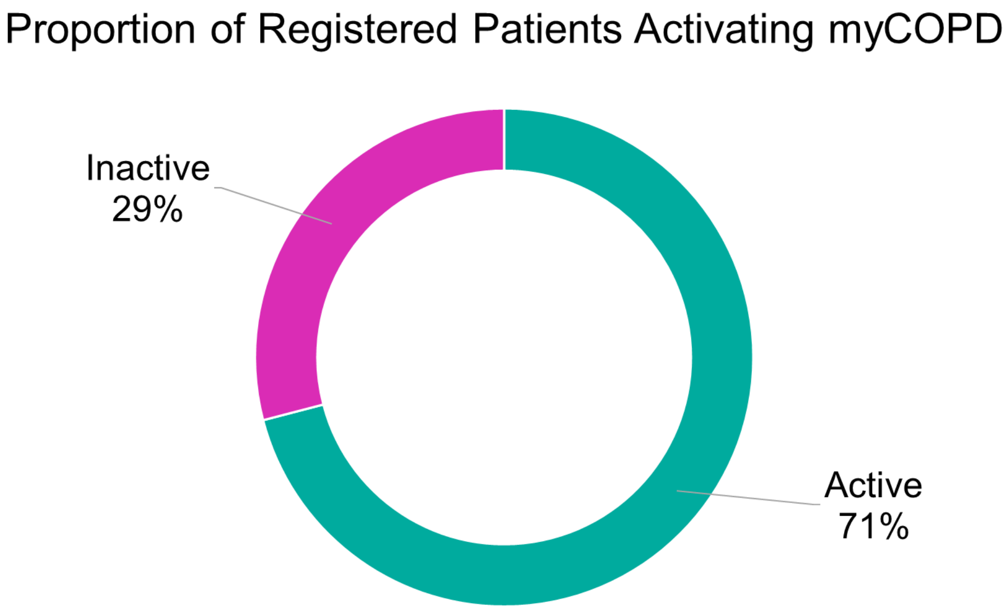

Figure 10: Proportion of registered DHC-enabled users that activated myCOPD

As discussed in the benefit stream calculations, not all patients who registered with the programme ended up activating myCOPD. 138 of the total 475 registered patients (29%) failed to activate the myCOPD app (Figure 10). The remaining 337 patients (71%) did activate the app.

The activation rate here is lower than the activation rate of 78.8% reported by Cooper et al. (2022).

Figure 11: Distribution of active and inactive patients by five-year age bands and gender

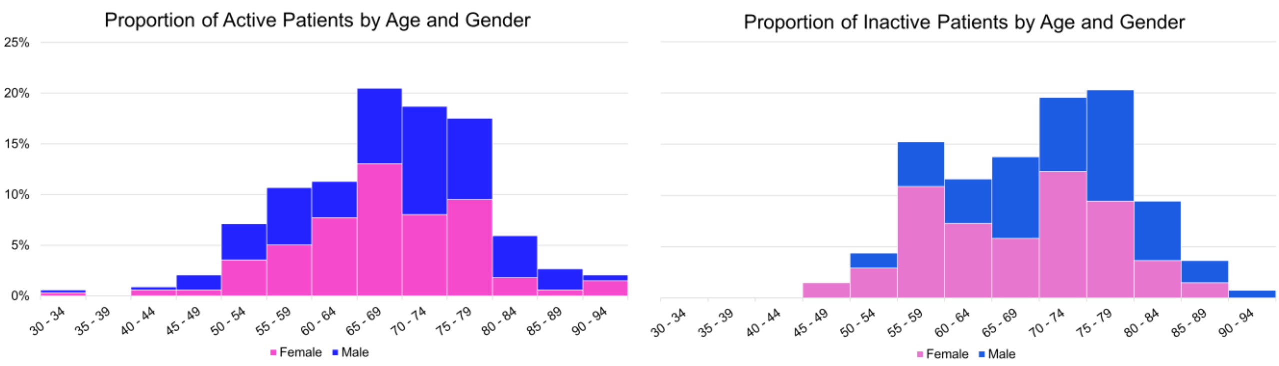

Figure 11 shows how the age and gender distribution differs for active (left panel) and inactive (right panel) patients. Overall, there was a slight trend towards inactive patients being older and more likely to be female than active patients: inactive patients had an average age of 69.4, around 1.4 years higher than the average age of active patients, 68.0; around 55% of inactive patients were female, with the remaining 45% being male, in comparison to 52% and 48% of active patients being female and male respectively.

Module Usage

Cooper et al. (2022) provide two main measures of myCOPD engagement: symptom scoring frequency, and the number of myCOPD modules used. To remain consistent with the existing literature, both measures were estimated for DHC-enabled myCOPD users.

For the purposes of this analysis, a patient was counted as using a module if they: watched any education, inhaler technique, or mindfulness videos; used the medication diary at least once; clicked on the self-management plan at least once; clicked on the lung function section at least once; or clicked on the COPD checklist at least once.

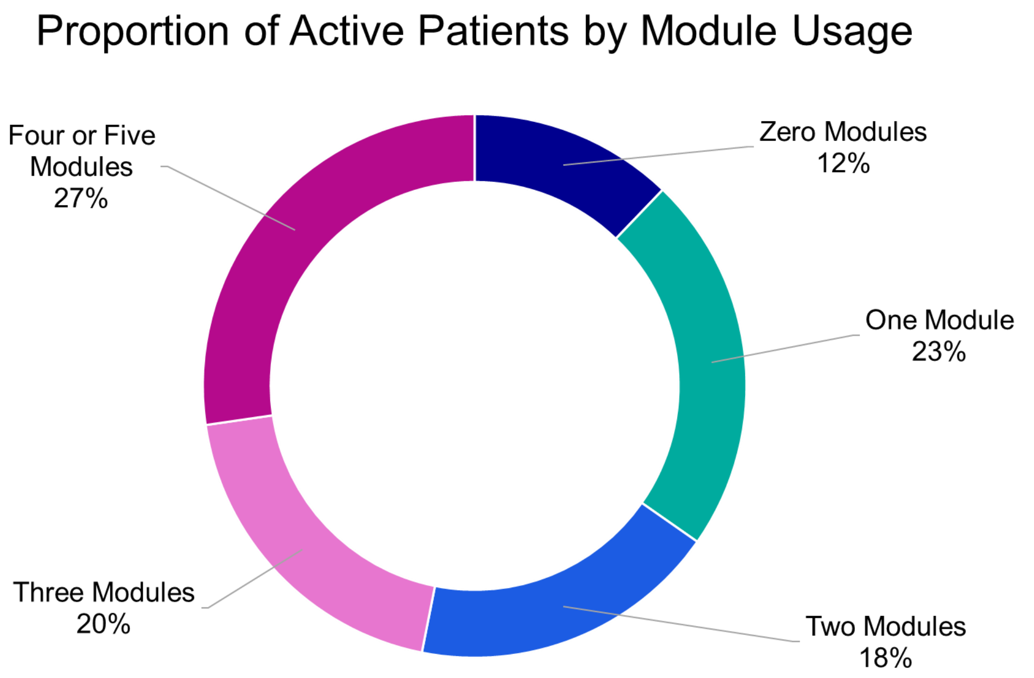

Figure 12: Users grouped by number of myCOPD modules used

On this definition, as a proportion of active patients, 12% of DHC-enabled myCOPD users used zero modules, with the remaining 88% of patients using at least one module (Figure 12). This is a very similar level of engagement with at least one module to the one reported by Cooper et al. (2022). On the other hand, 27% of active DHC-enabled myCOPD patients in the sample used four or five modules, a significant improvement on the 16% reported by Cooper et al. (2022).

It is unclear if these figures are actually directly comparable as the definition of a myCOPD module used here may differ to that found in Cooper et al. (2022), but this does suggest an increase in the level of engagement with myCOPD within the target population.

Symptom Scoring Frequency

The second measure of myCOPD engagement provided by Cooper et al. (2022) was the frequency of symptom score recording. Active patients were grouped into five groups based on the number of times they entered their symptom scores every 100 days. To be precise, patients were defined as having a scoring frequency of ‘never’ (0 times per 100 days); ‘low’ (<1 time per 100 days); ‘moderate’ (1-5 times per 100 days); ‘high’ (6-20 times per 100 days); or ‘very high’ (>20 times per 100 days). The proportion of active patients within each symptom scoring frequency group is shown in Figure 13.

In comparison to Cooper et al. (2022), a significantly lower proportion of active patients never recorded their symptom scores – just 2% in the current sample vs. 12% in Cooper et al. (2022). This suggests an increase in minimum engagement levels with myCOPD among active patients.

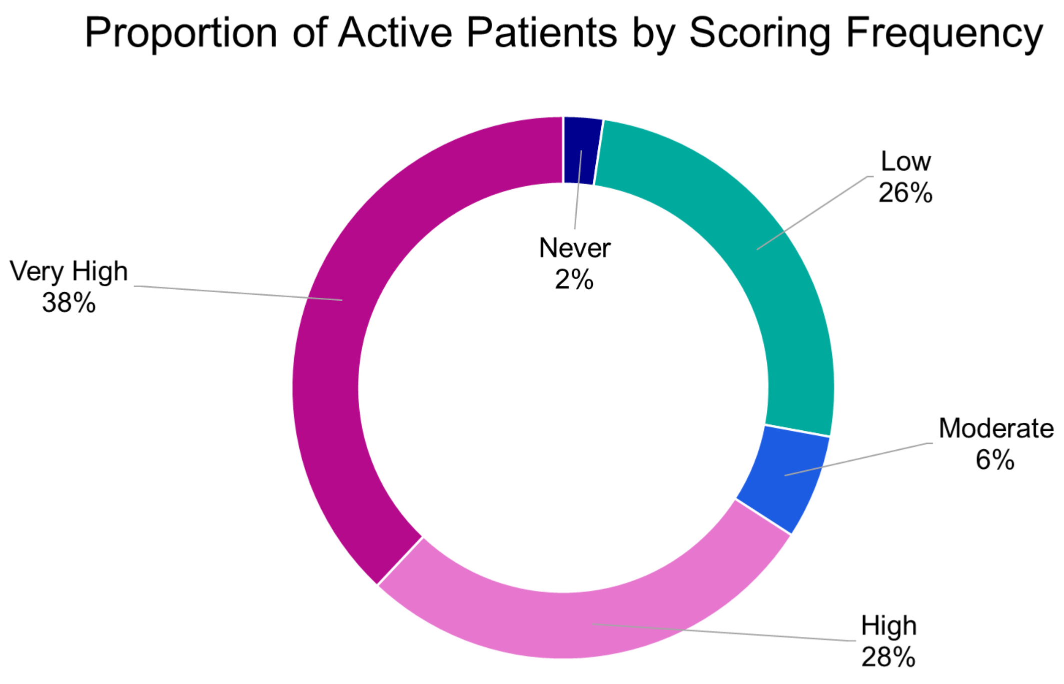

Figure 13: Active users grouped by symptom scoring frequency

Similarly, considerably more active patients were categorized as recording their symptom scores at a very high frequency; 38% of active DHC-enabled myCOPD users vs. the 17% of active users reported by Cooper et al. (2022). This suggests a significant increase in the proportion of users with high levels of engagement with myCOPD. This increase is the basis for the benefit streams of reduction in admissions and reduction in bed days per admission.

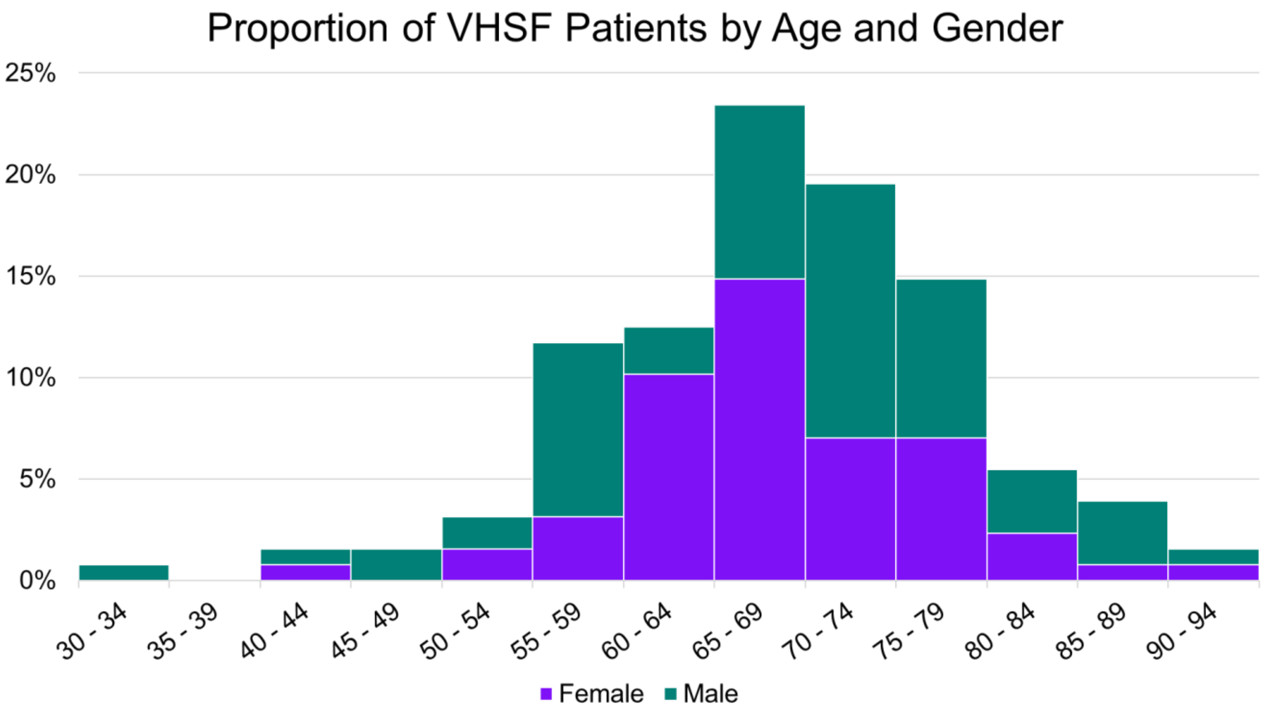

Figure 14: Distribution of patients with a very high scoring frequency by five-year age bands and gender

In general, the demographics of the VHSF group were similar to those of the whole sample, as shown in Figure 14. In terms of age, the VHSF group had an average age of 68.13, extremely close to the average age of 68.04 for the entire sample. On the other hand, those in the VHSF group were somewhat more likely to be male than in the whole sample, with 52% and 48% of patients with a VHSF being male and female respectively, in contrast with 47% male and 53% female across the entire sample.

Video Engagement

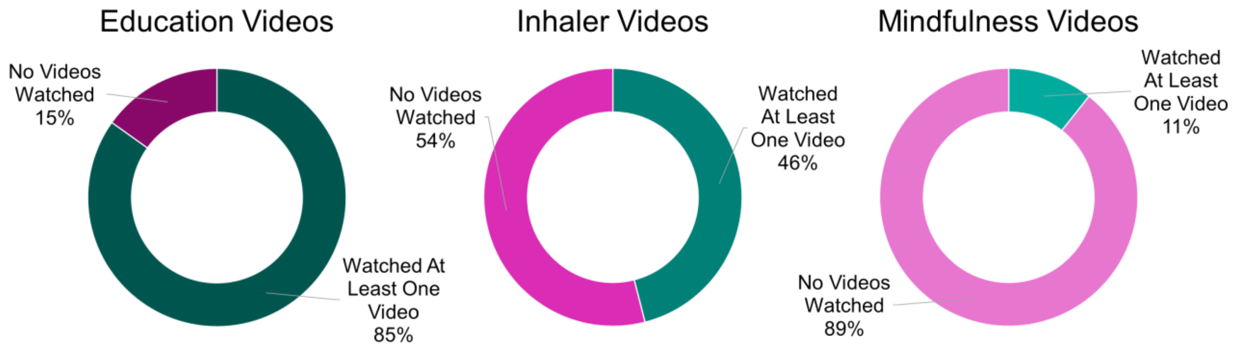

Figure 15: User video engagement rates for educational, inhaler technique, and mindfulness videos

As shown in Figure 15, there were varying levels of engagement across the three categories of educational videos found in myCOPD: education, inhaler, and mindfulness. The highest level of engagement was with education videos, for which 85% of patients watched at least one education video. This is significantly higher than the 24% of patients who viewed educational course material reported by Cooper et al. (2022).

The second highest level of video engagement was with inhaler videos, where 46% of DHC-enabled myCOPD users watched at least one inhaler video. This is another considerable improvement on the 10% of users found in Cooper et al. (2022). Moreover, this improvement in engagement with inhaler videos found in the patients within our sample provides the basis for the reduction in inhaler wastage benefit stream.

The least video engagement was shown toward mindfulness videos, with just 11% of DHC-enabled myCOPD users watching one or more videos. Nevertheless, there does appear to be a pattern of improved video engagement overall with patients within the sample when compared with those found in Cooper et al. (2022).

COPD Indicators

Patients are able to record various clinically relevant indicators within myCOPD, such as their symptom scores, modified Medical Research Council (MMRC) scores, and their COPD assessment test (CAT) scores. For MMRC scores, patients enter their score once, meaning no changes over time can be seen within the data. On the other hand, the data for symptom and CAT scores often contain multiple entries for each patient, meaning changes over the period that they have been using the app can be measured.

Table 5: Averages of COPD indicators for active patients, and grouped by smyptom scoring frequency.

Indicator	All Patients	Symptom Scoring Frequency			
		Low	Moderate	High	Very High
First Symptom Score	**1.23**	1.24	1.14	1.24	1.23
Last Symptom Score	**1.33**	1.24	1.62	1.43	1.27
Change in Symptom Score	**0.10**	0.00	0.48	0.18	0.04
First CAT Score	**15.78**	16.01	14.95	14.98	16.38
Last CAT Score	**16.13**	16.01	14.14	15.71	16.83
Change in CAT Score	**0.35**	0.00	- 0.81	0.73	0.45
MMRC Score	**1.62**	1.45	1.43	1.57	1.78

The averages for each indicator for all active patients, and for each symptom scoring frequency group are presented in Table 5. In general, no significant changes were found for any of the indicators.

The average first symptom score for all active patients in the sample was 1.23, rising slightly to 1.33 on average for patients' last symptom score, amounting to an insignificant change of just 0.10 overall. Similarly, when grouping patients by symptom scoring frequency, no large changes in symptom scores were found within any of the groups. Moreover, when testing for significant differences between each symptom scoring frequency group and the average for all active patients, all p-values from t-tests were above 0.1. This indicates that there were no statistically significant differences in the average change in symptom scores between each group and the average for all patients. This does not contradict clinical expectations, as improvement would be expected to take place over multiple years, if at all. In many cases the objective of condition management may rather be to slow or prevent deterioration.

The results are similar for CAT scores, with a modest average increase of just 0.35 for all active patients. Although the estimates for the average change in CAT score does vary somewhat by symptom scoring frequency group, once again these average changes within each sub-group are not statistically significantly different from the average change in CAT score for all patients.

Finally, the average MMRC score for all active patients was 1.62. It is worth noting that there seems to be a trend of higher MMRC scores as the frequency of symptom scoring increases – patient with a low scoring frequency averaged an MMRC score of 1.45, whereas high and very high scoring frequency patients averaged 1.57 and 1.78 respectively. This may indicate that patients with more severe cases of COPD are more likely to record their symptom scores frequently, and otherwise engage with the app. However, again the differences in MMRC score between each sub-group and the average for all active patients are statistically insignificant, so no strong conclusions can be drawn in this regard.

4.2. Health Economic Results

The results of the health economic model are presented in this section. The model produced estimates of the costs and benefits of the programme as a whole. The results are estimated over a period of 5 years, in net present value terms, in line with the general health economic methodology detailed in Appendix A.

Importantly, an additional, universal optimism bias correction is applied to *all* benefits and costs to ensure maximum prudence in the estimation of the impact of DHCs for enrolment and engagement with myCOPD. The total benefit, cost, net present value (NPV), and benefit-cost ratio (BCR) are the main outputs of interest and will be provided. The BCR represents the return on investment made for every £1 spent. A BCR of 1.2, for example, indicates that the intervention would return £1.20 for every £1 spent.

Scenario 1 – Whole Programme

Table 6: Scenario 1 results table.

Whole Programme (£ represented as net present value in 2022 figures)	2022/23	2023/24	2024/25	2025/26	2026/27	5-year Total
Benefits	-	-	-	-	-	-
1.1 Reduction in Admissions	£85k	£83k	£80k	£78k	£75k	£402k
	£50k	£49k	£47k	£46k	£44k	£237k

1.2 Reduction in Bed Days per Admission						
1.3 Reduction in Inhaler Waste	£2k	£2k	£1k	£1k	£1k	£7k
Total Benefits	£137k	£133k	£129k	£125k	£121k	£646k
Costs						
Total Costs	**£193k**	**£96k**	**£93k**	**£91k**	**£88k**	**£560k**
NPV						
Total NPV	**-£55k**	**£38k**	**£36k**	**£34k**	**£33k**	**£86k**
Total BCR	**0.7**	**1.4**	**1.4**	**1.4**	**1.4**	**1.2**
***The figures above have been rounded to the nearest whole pound for presentation and as such totals may not sum**						

Table 6 presents the estimates of the costs and benefits of the entire programme over the next five years, assuming continuation at current operation levels. The total benefit comes to £646,000 with total costs of around £560,000 after 5 years. In NPV terms, the model therefore estimates a return (relative to the size of the benefits and costs) of £86,000 after five years. Higher implementation costs in first year means an initial loss of -£55,000 is expected, which then rises to around £90,000 per year in subsequent years.

The implied BCR for the whole programme is therefore around 1.2. With a BCR of 0.7 in the first year and 1.4 in subsequent years.

The largest benefit is provided by the NHS non-cash-releasing benefit of the reduction in admissions, which generates £402,000 over five years and accounts for around 62% of the total benefit generated by the programme. Then comes the NHS non-cash-releasing benefit of the reduction in bed days per admission, which totals £237,000 after five years and is responsible for roughly 37% of the total benefit. Finally, a comparatively small benefit of £7,000 after five years is provided by the reduction in inhaler wastage, which accounts for just 1% of the total.

Sensitivity Analysis

Due to incorrect costing structure being used in an earlier stage of analysis, the sensitivity analysis performed does not reflect the final position of the health economic analysis. For this reason, these results have been included in Appendix B.

5. Discussion

The evidence collected over the course of the myCOPD DHCs pilot project in 2022 has been found to suggest that the use of DHCs to enrol patients to the myCOPD platform can result in higher engagement. Quantitative analysis suggests that more patients engage with multiple modules, and also that more patients are likely to turn into consistent users of the platform. These results do have some limitations, however, which are highlighted below, in that comparisons have had to be drawn against clinical efficacy effect sizes from previous studies, rather than real world evidence relating to unsupported enrolment. Therefore, the full impact is not fully understood, even if the results available are encouraging.

As comparisons have had to be made against standard myCOPD app enrolment not supported by DHC and published in the literature, rather than real-world evidence, an inflated optimism bias has been applied to the health economic analysis, which will have dampened the potential value of benefits observed. With real-world comparison data informing the assumptions made in the model there is a chance that the benefits would be significantly larger. With the evidence available, the health economic analysis has resulted in a positive return over the course of the projected five-year time horizon, with an expected loss in the first year of implementation. As shown in Figure 187, the capacity and utilisation rate of the DHCs has a significant bearing on the scale of benefits realised.

Further data collection and linked evaluation of how patients utilise healthcare services, could provide a clearer understanding of the full impact of future deployments. Such development should incorporate benefits that have not been included to date due to the lack of reliable comparator data, such as the reduction in GP appointments. Some further benefits have also not been included due to the absence of data, such as the long-term avoidance of condition deterioration and how a patient’s use of the platform can support efficient and effective annual reviews. These data will only emerge over a much longer timeframe and therefore were not included within the scope of this evaluation.

5.1. Limitations

Comparator data

- No comparator possible from intervention-level data, so literature was used
    - Can only define increase in activity as compared to those activity markers identified in the literature (VHSF)
    - Completely unable to show difference in use of specific modules, completion, demographic analysis/engagement

- Only able to use change in 'highly-engaged' users to confer benefit. Limits scope of patients to whom we may apply benefit (only proportion of highly engaged users)
- Literature assessed included mostly my myHealth. Unlikely that app users enrolled into these studies are truly 'unsupported users'. Hence the baseline and intervention populations considered may be more closely related than we are assuming in the modelling, reducing the overall impact.

Sourcing and assumptions

- Heavy reliance on the results of Cooper et al. (2022)
    - Change in daily bed days incidence provided by Cooper et al. (2022) not statistically significant
- Assumptions regarding inhaler wastage
    - In the absence of quantitative data reflecting the impact of reduction in critical errors upon prescription rates, an assumption has been used that an individual not using their inhaler effectively will waste an entire inhaler.
- Assumptions surrounding population
    - Total population based off linear extrapolation of observed DHC enrolment data
    - At the time of the initial analysis only 1 DHC had submitted enrolment data, therefore annual capacity estimates may not be representative of all DHCs
- Assumptions related to sustainability of app usage over 5 years

Excluded benefits

- No benefits conferred to primary care due to lack of suitable comparator for those benefits. Cannot be modelled.
- No myCOPD pulmonary rehabilitation (PR) data were provided. Improving PR uptake is expected to confer significant benefit to patients. Cannot be modelled.

5.2. Recommendations

Maximise DHC capacity

Due to the heavy influence the utilisation of the DHCs may have on the realisation of benefits, the long-term capacity planning for staff should seek to maximise their utilisation. Whether this is a process of supporting the identification of potential candidates, or managing the administrative burden, a small change could have a significant impact on whether or not the programme producing net benefits to the healthcare system.

Any required adjustments may vary between primary and secondary care settings, with DHCs taking part in the discharge process in secondary care, while effective signposting and referrals processes may need to be communicated to primary and community organisations in the local area to increase throughput.

Support further evaluation

The data collected through this project has great value to measure the impact of the service. Future evaluations can build and develop on the findings of this project and provide greater assurance of the benefits of myCOPD in a real-world setting and provide valuable learnings for successful deployment in other areas. Linking data relating to patient enrolment and ongoing healthcare utilisation for the enrolled patient group, i.e., GP appointments, ambulance calls and hospital readmissions, will provide strong evidence of the scale of benefits observed and reduce uncertainty in the model.

Legacy planning

Due to the nature of the project as a pilot measure, there is a level of remaining uncertainty relating to the long-term costs of operating the service. This will largely depend on the management and administration of DHC staff once the project team is dissolved. Projected budget plans and costings would support the assessment of the results found in this report in full context.

Further to this, it would be beneficial to observe the service in a wider context, to seek further opportunities to add value to the system. For example, a clearer understanding of pulmonary rehabilitation pathways across the patient group would support an assessment of the proportion of patients who are able to follow a course due to their supported enrolment to myCOPD, while others may be enrolled into alternative courses by other means. To date this comparison has not been possible, meaning that the potential benefits of such courses remain unmodelled.

6. Concluding Remarks

This evaluation has found evidence that the utilisation of Digital Health Champions to support the enrolment of patients to the myCOPD platform has had a positive impact in terms of engagement with and sustained use of the application. While the proportion of patients accessing at least one module (88%) is similar to published, non-DHC supported app enrolment findings, the proportion of patients accessing four or five modules on the platform is 27%, compared to 16% in Cooper et al. (2022). The data also suggests that a larger proportion of patients become sustained users of myCOPD, with 38% of activated users providing symptom scores at a ‘very high’ frequency, compared to 17% in Cooper et al. (2022). This result suggests that a larger proportion of patients find myCOPD a beneficial system for tracking their condition if they are properly introduced into the potential of the platform. Further analysis has highlighted no significant differences between age cohorts in how patients engage with the platform, which should ease concerns of digital exclusion.

The health economic benefits of Digital Health Champions service, however, are less precise but are likely to be at least cost neutral. The modelling has returned a positive benefit-cost ratio (BCR) of 1.2 over a five-year time horizon, meaning that for every £1 invested, an estimated £1.20 benefits are experienced by the healthcare system. This result comes at the cost of an implementation phase, which is estimated to return a BCR of 0.7 for the first year of deployment. The evidence available suggests that this may be a worthwhile investment in the long-term, however, if the potential benefits of digital self-management platforms are to be more reliably realised.

Due to the absence of some requested datasets, as well as the lack of real-world comparator data, assumptions have had to be drawn in comparison to literature. This has meant that higher optimism biases have had to be applied against the findings, dampening benefits that may be observed in a real-world setting. Furthermore, there are known benefits of proper usage of myCOPD, which have been found in previous research that could not be included in the health economic analysis, such as a reduction in GP appointments, due to the lack of comparable data.

Other benefits may exist, such as increased access to pulmonary rehabilitation courses, reduced condition deterioration, and supporting efficient annual reviews, but have not been included as further, longer-term data collection would be required to fully understand the impacts of myCOPD, and whether the use of DHCs has supported them.

The results provide a good foundation for further evaluation of DHCs, with the impact found in contrast to RCT evidence and the scale of potential benefits. Future evaluation work will build upon these findings, providing the opportunity to observe the real-world impact of using DHCs to support patients in managing their condition with myCOPD over the long-term.

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8. Appendices

Appendix A

Health economic details

Net present value

There is a mismatch between the investment decision to implement the programme and the timeframe over which any returns are realised. It is important to note that, in general, returns received earlier are more valuable than returns received later, even accounting for inflation.

The principle is that, in a world without inflation, an investor would rather invest £100 and receive £120 the next day, than invest £100 and receive £120 a year later. This is a social preference and a concept known as the time value of money.

For the investor to accept receiving the returns a year later, they would have to receive an additional amount that is subjective and depends on the individual. One investor may require £130 to be happy to wait one year, whereas another may require £150.

The time value of money, essentially, means that future returns are less valuable than present returns. As a result, an investment decision in the present would be better informed by adjusting for this effect.

The outputs of the health economic analysis in this evaluation, therefore, use discounting on benefits and costs realised in future years to equate them to their present values, in this case, using 2022 as the base year.

While the discounting rate is subjective, it is standard practice in healthcare in England to use a discount rate of 3.5% per year, in line with the rate used (HM Treasury, 2022).

Benefit-cost ratio

The benefit-cost ratio (BCR) measures the present value of benefits against the present value of costs. The BCR is a ratio that summarises the overall relationship between relative costs and benefits of the project (e.g., £X return for every £1 invested).

$$Benefit\ Cost\ Ratio = Present\ Value\ Benefits\ X\ Present\ Value\ Costs$$

If the BCR is greater than 1, it is estimated that the project would deliver a positive NPV (e.g., a BCR of 2 indicates that for every £1 spent, there is an expected £2 return). If the BCR is equal to 1, it is estimated that the benefits equal the costs. Where the BCR is less than 1, the value of the costs is suspected to outweigh the benefits.

It is important to note that summary measures are not without limitations (i.e., measures may not fully capture all potential impacts of the intervention and counterfactual pathways).

Benefit streams

To calculate the return on invest of the project, discussions around monetisable impacts of the project took place.

Within the model, these two factors were formed into a benefit stream. A calculation of the difference the intervention has caused on each from the baseline is used to produce a per patient change. This per patient impact is then scaled according to the population seen after implementation of the intervention, this also allows for other populations to be modelled through different scenarios.

This report takes a prudent approach to identify benefits and separates the fiscal savings into the following benefit streams:

- **NHS related cash releasing benefits:** These benefits produce immediate cashable savings to the provider
- **NHS related non-cash releasing benefits:** These benefits are important to reducing demand and strain on services, but a fiscal value cannot be realised without decommissioning of services. Benefits which can be described as non-cash releasing include improvement of time savings.
- **Social benefits:** Social benefits relate to the overall benefit to the public, including, but not limited to, improved health and wellbeing e.g., environmental or transportation costs.
- **Other benefits:** It is important to acknowledge other benefits that might not have an accurate value and may be attributed through qualitative review e.g., staff experience or patient experience.

Adjustments for inflation

Adjusting for inflation removes the general effects of inflation and presents costs and benefits included within the appraisal in ‘real’ base year prices rather than in nominal prices (i.e., the first year of the project). Within this appraisal a Gross Domestic Product (GDP) deflator of 2% has been used to convert nominal to real values. Various rates were applied depending on data type, namely:

- Inflation rate (using March 2014 Office for Budget Responsibility forecast; HM Treasury, 2022)
- Healthcare inflation

Discounting

Discounting is a technique that enables the comparison of costs and benefits on a consistent basis and accounts for the concept of ‘social time preference’ (i.e., it allows costs and benefits that occur at different time periods to be compared on a “present value” basis). Discounting is applied to all future costs and benefits and is not applied retrospectively.

A discount rate of 3.5% is applied to benefits to deflate outcomes to real terms and reflect the changing value of healthcare within GDP (HM Treasury, 2022). For social outcome streams linked to welfare or utility values (e.g., QALYs), a discount rate of 1.5% is applied as this excludes the change in expected growth per capita over time and only considers health and life effects.

Optimism bias

Optimism bias is defined as “*the tendency for a project’s costs and duration to be underestimated and/or benefits to be overestimated*” (Mott MacDonald, 2002). To account for these ‘optimistic’ estimates, it is recommended that public sector economic analysis applies an optimism bias adjustment to reduce the benefits and increase the costs compared to the calculations using the raw data.

The Unity Insights approach is a development of the model created by the Greater Manchester Combined Authority (GMCA) Research Team (formerly New Economy; HM Treasury, 2014). The GMCA model follows the guidance and principles from HM Treasury’s (2022) Green Book and offers a robust and prudent approach to economic analysis.

It is reasonable to assume that the risk of over-optimistic estimates is greater where the data is of low quality (HM Treasury, 2022); such as due to the applicability of the estimate to the modelled pathway, the underlying methodology used for the estimate, or the age of the data source. For optimism bias, each data input is graded according to its quality, and the calculation of a benefit (cost) stream is then decreased (increased) by an optimism bias factor, decided by the ‘worst’ grade amongst the stream’s data inputs. The Unity Insights optimism bias grades, and the relevant factor that the calculations will be increased or decreased by, are displayed in Table 7.

Table 7: Unity Insights' optimism bias confidence grades.

		Data Source									
Confidence grade		Formal service delivery contract costs / Figures derived from local stats / RCT trials		Practitioner monitored costs / Figures based on national analysis in similar areas		Costs developed from ready reckoners / Figures based on generic national analysis		Costs from similar interventions elsewhere / Figures based on international analysis		Cost from uncorroborated expert judgement	
		1		2		3		4		5	
Age of Data: < 2 Years	1	1.1	0%	2.1	10%	3.1	15%	4.1	25%	5.1	40%
Age of Data: 2 - 3 Years	2	1.2	5%	2.2	10%	3.2	15%	4.2	25%	5.2	45%
Age of Data: 3 - 5 Years	3	1.3	10%	2.3	15%	3.3	20%	4.3	30%	5.3	50%
Age of Data: 5 - 10 Years	4	1.4	15%	2.4	25%	3.4	30%	4.4	40%	5.4	55%
Age of Data: > 10 Years	5	1.5	25%	2.5	30%	3.5	40%	4.5	50%	5.5	60%

In addition to the optimism bias factors applied at the benefit and cost stream level, a further factor of 15% is applied to reduce the benefits and increase the costs. This additional factor is included to protect against bias that may occur in the economic modelling approach and ensures Unity Insight's role as an impartial, third-party assessor.

The Unity Insights approach to optimism bias is developed from the GMCA model. The GMCA model uses optimism bias to account for all types of uncertainty within the estimations due to sensitivity analysis not being used. The model used in this report takes a more refined approach; accounting for certain types of uncertainty, namely those that are not biased such as random errors, through sensitivity analysis. This reduces the necessity for optimism bias adjustments. In this way, Unity Insights seek to provide more accurate estimates of the true costs and benefits while also providing information on the certainty and variability of the results.

Sensitivity analysis

A degree of uncertainty in the estimates of the model are accounted for by using sensitivity analysis. It is important to note that the sensitivity differs from optimism bias in that it is applied on each individual assumption or input in the model, rather than by benefit or cost stream as in the case of optimism bias. The method used by Unity Insights is Monte Carlo simulation, which is used to provide a range of estimates of the overall return on investment/net benefit.

Monte Carlo analysis is a modelling technique that simulates the impact of the expected variance in key variables on the output of interest, in this case the net present value return on investment. The approach is best described using an example:

Step One: Allocation of ranges

Variables of interest are given base-case values (or mean estimates), and an expected range. The range given to each assumption is dependent on the confidence grading applied seen in Table 8.

Table 8: Unity Insights' sensitivity confidence grades.

			Data Source									
	Confidence grade		Formal service delivery contract costs		Practitioner monitored costs		Costs developed from ready reckoners		Costs from similar interventions elsewhere		Cost from uncorroborated expert judgement	
			Figures derived from local stats / RCT trials		Figures based on national analysis in similar areas		Figures based on generic national analysis		Figures based on international analysis			
			1		2		3		4		5	
Age of Data	< 2 Years	1	1.1	10%	2.1	10%	3.1	15%	4.1	20%	5.1	25%
	2 - 3 Years	2	1.2	10%	2.2	15%	3.2	20%	4.2	25%	5.2	25%
	3 - 5 Years	3	1.3	15%	2.3	20%	3.3	25%	4.3	25%	5.3	30%
	5 - 10 Years	4	1.4	20%	2.4	25%	3.4	25%	4.4	30%	5.4	35%
	> 10 Years	5	1.5	25%	2.5	25%	3.5	30%	4.5	35%	5.5	40%

The example in Table 9 demonstrates the quality-of-life adjustment factor and life expectancy.

Table 9: Example of sensitivity range allocation.

Variable	Sensitivity Grading	Range Applied	Lower range estimate	Base-case / mean estimate	Upper range estimate
Quality of life adjustment factor	2.4	+/- 25%	0.420	0.565	0.70
Life expectancy (years)	4.4	+/- 30%	4.41	6.30	8.19

Step Two: Allocation of a distribution shape

All data has a shape to its distribution. If there is equal likelihood of any value within a range being drawn, then a rectangular distribution can be used (so called because a graph of the probability of any specific value being drawn would appear to be a rectangle). If there is a lower likelihood of a value at the extreme ends of the range being drawn, then a triangular distribution could be used.

If there is reason to believe the distribution meets the statistical qualities required to be defined as normal, Poisson, etc, then these can be applied. In this study, we have generally applied triangular distributions as this best reflects the ranges used and diminishing probabilities of more extreme ends. Where a different distribution has been used, it is expressly noted in the text.

Step Three: Random selection of values within the range

The model selects at random a value for each variable from within the range between the upper and lower estimate and calculates the outcome from each draw, considering the distribution shape selected and therefore the probability of any value being drawn.

Step Four: Repetition

Five draws are given in Table10, using a rectangular distribution. These deliver estimates lying between £40,500 and £105,000. The draw is repeated thousands of times. In this evaluation we use 10,000 runs as standard.

Table 10: Example of random variation within Monte Carlo simulation.

Variable	Draw 1	Draw 2	Draw 3	Draw 4	Draw 5
Quality of life adjustment factor	0.45	0.50	0.55	0.60	0.70
Life expectancy (years)	4.5	5.0	5.5	6.0	7.5
Quality of Life Year monetary value	£20,000	£20,000	£20,000	£20,000	£20,000
Benefit (lives saved X value of lives saved)	£40,500	£50,000	£60,500	£72,000	£105,000

Creating 10,000 estimates allows the creation of a distribution of possible outcomes from the draws made. From this distribution we can then compute the range within which we expect 90% of the observations from the draws to fall. This is called the 90% confidence interval, illustrated in Figure 16.

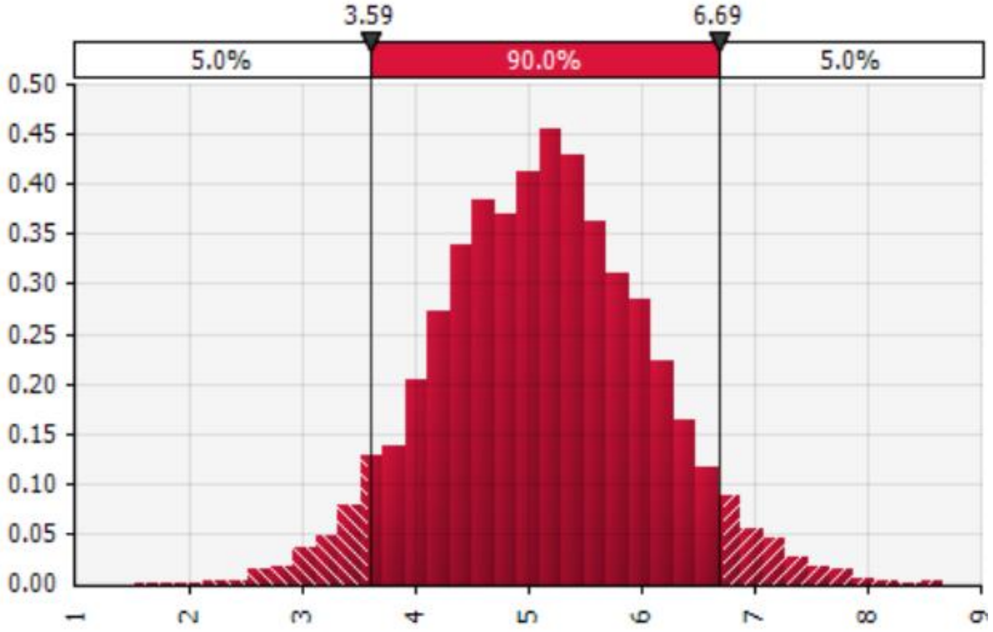

Figure 16: Illustration of sensitivity analysis.

The source for many of the data inputs in the model may also include a confidence interval, such as if the source is an academic study. In these cases, the confidence interval from the data source is used to provide the maximum and minimum ranges for the data input in the sensitivity analysis. Where no confidence interval is provided, the quality of the data is graded in a similar way to optimism bias to express the degree of certainty that Unity Insights has in the estimates.

Appendix B

Sensitivity Analysis

Note: Due to incorrect costing structure being used in an earlier stage of analysis, this sensitivity analysis does not reflect the final position of the health economic analysis. The values listed do not reflect the final benefit-cost ratio of 1.2. The range of outcomes are still of use, in particular, in determining the influence of inputs upon the final outcome, but the values noted have since been updated.

The sensitivity analysis provides a quantitative estimate of how various sources of uncertainty within the model contribute to the overall uncertainty in the results. Figure 17 presents the results of the analysis performed using @RISK.

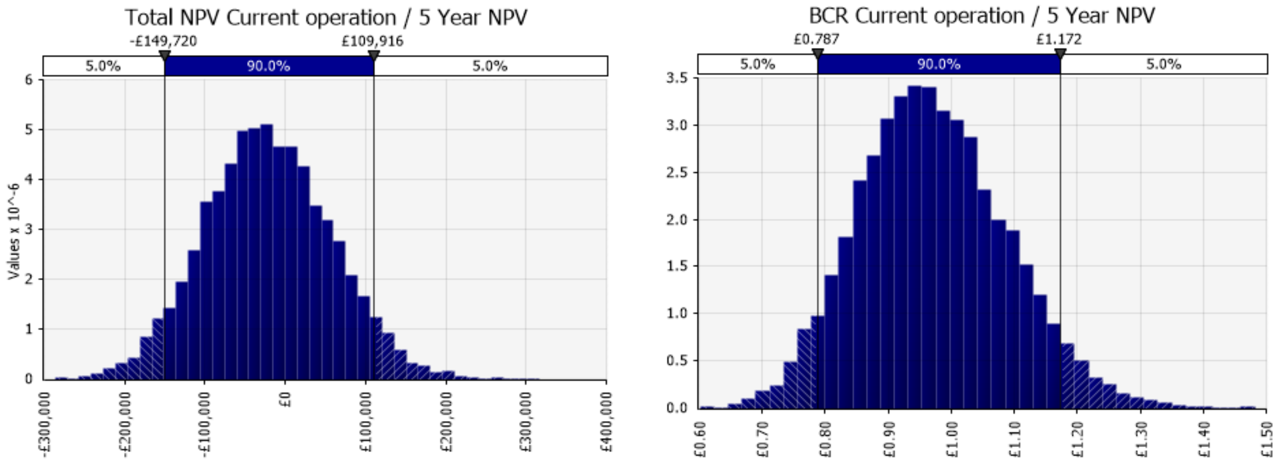

Figure 17: Scenario 1 sensitivity analysis results.

As seen in the left panel of Figure 17, over a five-year period the 90% confidence interval for the NPV for scenario 1 falls between -£150,000 and £110,000, with an expected value (mean) of around -£21,000.

In the right panel of Figure 17, the results of the sensitivity analysis for the BCR are displayed. After five years, the 90% confidence interval for the BCR falls between 0.79 and 1.17, with an expected value of 0.97.

Figure 18 shows the tornado chart for scenario 1, which indicates the variables in the model that have the largest proportional impact on the results when changed. As would be expected, the variables with the largest impact on the overall NPV are the DHC capacity in primary and secondary care. This is because DHC capacity directly feeds into calculations for the number of patients seen by the programme, and therefore the benefits generated by the programme. Moreover, as it is assumed that the costs for one DHC would remain constant in the case of higher or lower capacity, the NPV and BCR will differ significantly under different capacities.

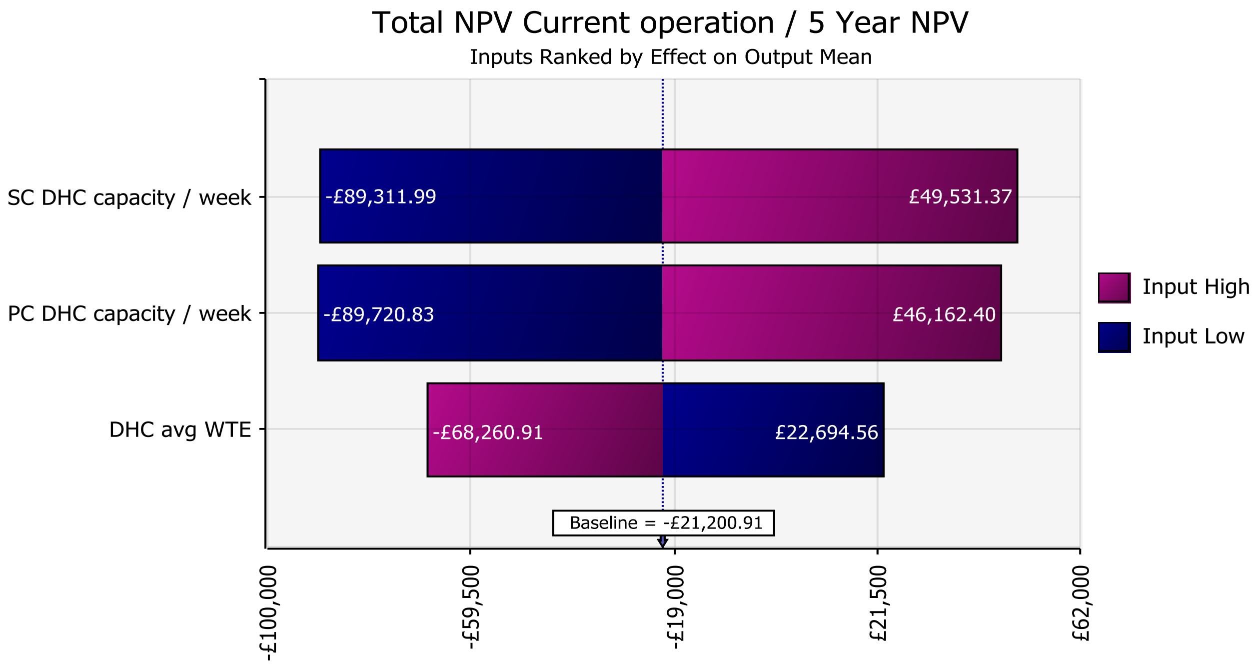

Figure 18: Tornado chart for scenario 1.

To be precise, if one more patient was seen per week by each DHC within secondary care, the NPV from the programme would rise to around £50,000. Similarly, if the capacity of DHCs within primary care were to increase by one patient per week, the five-year NPV for the project would rise to roughly £46,000. Conversely, a one patient drop in weekly capacity for DHCs in primary or secondary care would result in a decrease in the five-year NPV for the project to around -£90,000 and -£89,000 respectively.

Another important determinant of the NPV is the average WTE worked by each DHC. As this would affect the costs but not the benefits (assuming capacity were to remain constant) the effect is the opposite of capacity: if the average DHC worked 10% more or less WTE, the five-year NPV of the programme would change to -£68,000 or £23,000 respectively.

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