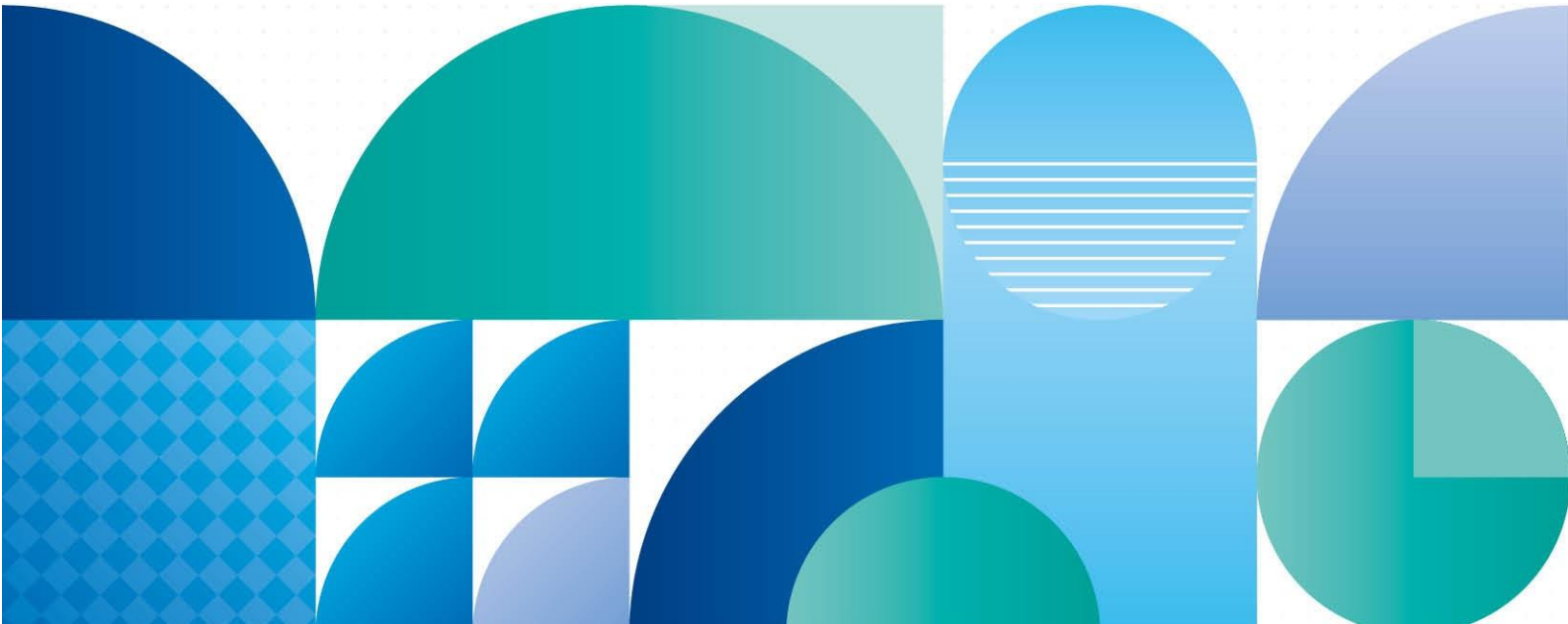
Health Economics Unit

NHS
Midlands and Lancashire
Commissioning Support Unit

Smarter Spending in Population Health

Using economic principles to set priorities for COPD resource allocation in Nottingham and Nottinghamshire ICS



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Introduction

This report summarises the outputs of the Socio-Technical Allocation of Resources (STAR) project undertaken by the Nottingham and Nottinghamshire Integrated Care System's (ICS's) Respiratory Steering Group, facilitated by the Health Economics Unit (HEU). The objective of this project was to support Nottingham and Nottinghamshire ICS to set the priorities for the chronic obstructive pulmonary disease (COPD) pathway, focusing on the wider determinants of health.

The specific aims of this project were to:

1. Develop a common understanding of the COPD population, understand the COPD pathway (i.e., the interventions and programmes offered to prevent and treat COPD) and identify the key challenges for COPD prevention and treatment in Nottingham and Nottinghamshire.
2. Assess the relative value for money of the different interventions in the COPD pathway in Nottingham and Nottinghamshire.
3. Create a priority list of the pathway improvements (i.e., interventions or programmes) that can be implemented in Nottingham and Nottinghamshire.

This report is designed for the respiratory programme to support its planning for the COPD pathway. It can be used to determine which pathway improvements should be taken forward given the available resources.

Recommendations

As a result of this project, it is recommended that the respiratory programme prioritises the following pathway improvements:

- Implementing a three-stage process to identify more undiagnosed COPD cases.
- Mandating GPs to offer 'very brief advice' on smoking cessation during COPD yearly reviews (making every contact count).
- Conducting patients' yearly reviews through group consultations to improve the quality of primary care case management.
- Introducing referral pathways to Breathe Easy.
- Improving uptake of smoking cessation services (doubling the number of people with COPD setting quit dates).

If the targeted COPD screening is successful, it could save up to £1,344,055 through a reduction in hospital admissions and acute exacerbations.

These recommendations are explained in more depth in the **determining the next steps: setting priorities** section.

Socio-technical allocation of resources

STAR builds upon the principles of 'cost-effectiveness analysis' and 'programme budgeting and marginal analysis', combining a technical value-for-money analysis with extensive stakeholder engagement (Airoldi et al., 2014; The Health Foundation, n.d.).

The steps described in this report and the methods document in the appendices can be followed by those interested in applying STAR to other pathways.

By applying STAR, commissioners can:

- Engage all relevant stakeholders in the decision-making process for prioritising resources in a transparent and systematic way.
- Identify the current pathways for preventing, diagnosing, and treating people with COPD in England.
- Identify and prioritise pathway improvements, drawing upon principles of allocative efficiency.

Smarter Spending in Population Health

This project forms a part of the HEU's 'Smarter Spending in Population Health Programme' which aims to support ICSs and Places to allocate resources more efficiently, through scalable and systematic approaches to resource allocation, focusing on the wider determinants of health.

This programme has been supported by the **Midlands Decision Support Network (MDSN)**, which has acted as an 'innovation incubator' and provided a significant proportion of the funding for the programme in 2022/23.

More resources on the Smarter Spending in Population Health Programme and STAR can be found on the HEU's website **here**.

Running STAR in Nottingham and Nottinghamshire

The STAR process revolves around two decision conferences. These are workshops aimed at helping stakeholders arrive at a consensus on how to tackle a particular problem (Phillips, 2007). The first decision conference in Nottingham focused on building a common understanding of the population for those at risk of developing COPD or already living with COPD, and understanding the relative value of all of the COPD pathway components; that is, all the interventions currently offered in Nottingham and Nottinghamshire that are aimed at treating people with COPD. Summaries are found in the **population** and **pathway** sections, respectively.

The second decision conference focused on highlighting the **main challenges** in the pathway and proposing ways in which it can be improved. This process was informed by a visual model of the value-for-money assessment of each suggested improvement in the pathway. The visual model is called an 'efficiency frontier'. The efficiency frontier can be found in the **value of the COPD pathway in Nottingham and Nottinghamshire** section.

Full information on the process that was followed in Nottinghamshire can be found in the **methods document** in the appendices.

Following the decision conferences, the HEU used evidence from published studies and data sources to visualise and summarise the effect that each of the prioritised pathway improvements could have on the COPD pathway. This information is summarised in the **improving the pathway** section.

Recommendations on which pathway improvements are likely to generate the most population health gain for the given cost and should be taken forward are also made in the **setting priorities** section.

Attendees to the decision conferences

The STAR process relies on gathering insights from a broad range of stakeholders to provide their expert opinion on the local population and care provision. Their insight is used to create the efficiency frontier of the COPD pathway and to generate meaningful ways that it can be improved. The people who attended the decision conferences are outlined below:

Breathe Easy / Asthma and Lung UK

- Petra McCauley, Head of Volunteering and Support Groups
- Teresa Burgoyne, Patient representative

East Midlands Ambulance Service

- Michael White, Senior Manager

NHS Nottingham and Nottinghamshire ICS

- Bryony Smith, Health Inequalities Project Manager
- Isobel Scofield, Deputy Director of Finance
- Katie Jordan, Service Transformation Officer
- Natalie Dawes, Place-based Transformation Manager – tobacco control
- Natalie Shouler, Commissioning and Transformation Manager
- Nicola Graham, Senior Commissioner and Respiratory lead
- Sergio Pappalettera, Public Health Management Principal Analyst
- Stephen Brearley, Evaluation Analyst

Nottingham City Care Partnership

- Lissa Henderson, Head of Service – Integrated Respiratory Team
- Victoria Chow, Team Manager – Respiratory Services

Nottingham City Council

- David Johns, Consultant in Public Health

Nottingham University Hospitals (NUH) NHS Foundation Trust

- Stephanie Holliday, Lead COPD nurse specialist

Nottinghamshire County Council

- Andrew Hale, Public Health Intelligence Analyst
- Catherine Pritchard, Consultant in Public Health

Nottinghamshire Healthcare NHS Foundation Trust

- Claire Towne, General Manager
- Matthew Garrod, PCN Lead – Specialist Services
- Rebecca Beale, COPD Specialist Nurse

Primary Integrated Community Services Ltd

- Ian Griffiths, Assistant Clinical Services Lead
- Kerri Sallis, GP and Chair of the ICS Respiratory Steering Group

The COPD population, pathway, and main challenges

Population

The aim of the first part of the decision conferences was to ensure that the attendees all had a common understanding of the population for whom they are making decisions and an understanding of the levels at which they can intervene. For example, smoking cessation interventions would be targeted at those at risk of COPD.

As shown in Figure 1 below, the total population of Nottingham and Nottinghamshire is 1.2 million people. In terms of those at risk of COPD, the percentage of smokers in the ICS is 13.8%, equating to around 169,015 smokers. There are potentially 13,216 people living with undiagnosed COPD in the county and 25,295 people with diagnosed COPD (Nacul et al., 2007).

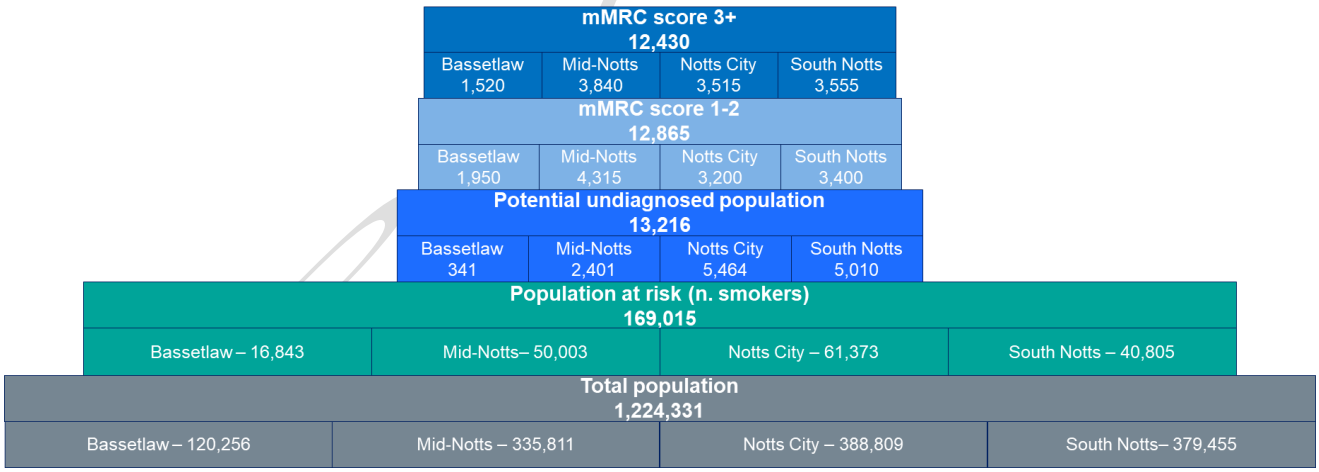

Figure 1 – Population pyramid in Nottingham and Nottinghamshire ICS (sources are described in the appendices)

The COPD pathway

Next, participants were asked to assess the relative value of all the interventions and programmes (pathway improvements) in the COPD pathway. The interventions in the COPD pathway are outlined in Figure 2. This figure was presented to participants to ensure there was a common understanding of all the interventions available.

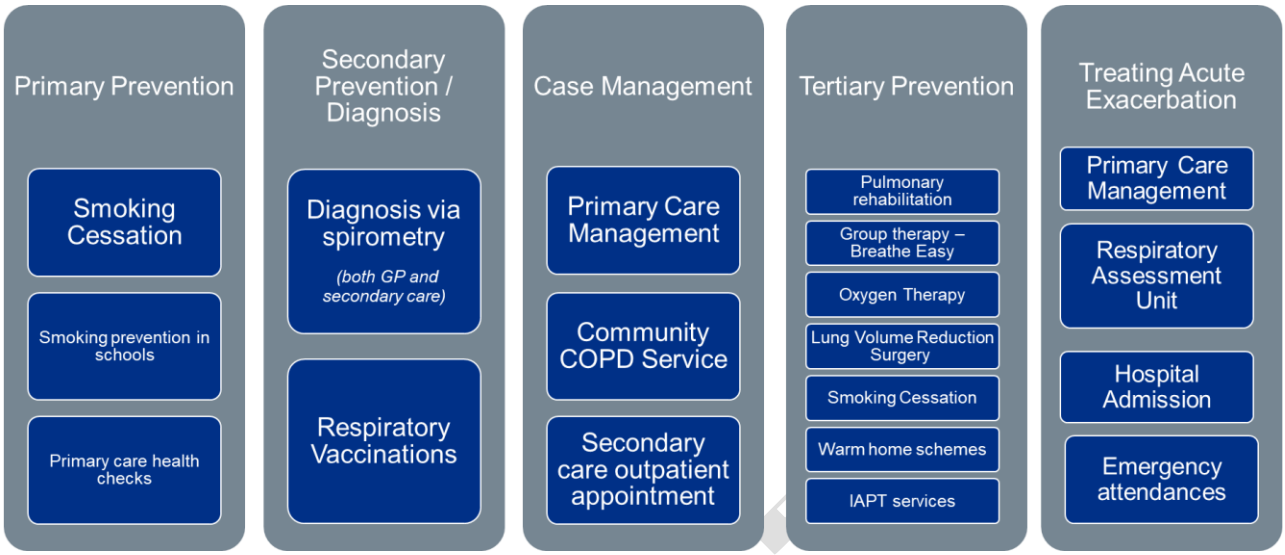

Figure 2 – The current care pathway for those living with and at risk of developing COPD

Valuing the current care pathway

Attendees were then asked to assess the relative benefit (value), in terms of length and quality of life, for all interventions and programmes in the pathway. This process is described in the **methods document** in the appendices. This assessment produced a 'benefit score', which is a key piece of evidence used to populate the efficiency frontier (see the **interpreting the efficiency frontier** section below). This process also helps attendees to think about comparing different interventions with each other and consider the trade-offs between them. For example, some interventions may give people more health in the long term compared with others that have more immediate benefit. The discussions generated by this valuation process can be very beneficial in determining the key challenges and identifying the appropriate interventions to improve the pathway, as well as in helping to build the efficiency frontiers (visual models of the interventions in the COPD pathway).

Participants rated the interventions in the pathway by plotting Post-it notes (representing the interventions and programmes in the current care pathway) on a visual analogue scale (VAS), a tool widely used in health economics (Parkin & Devlin, 2006). The scale and the scores assigned to each intervention are displayed in Figure 3 below. Attendees were

given an information pack (which can be found in the **appendices**) which included information from published academic studies looking at the quality-of-life gain (in terms of quality-adjusted life years[1]) to inform the scoring process.

In Figure 3, smoking cessation as primary prevention (i.e., to stop people developing COPD in the first place) was given a score of 100 as the intervention deemed to give the most benefit in terms of health gain. A score of 0 indicates an intervention that gives no additional health gain compared with current care.

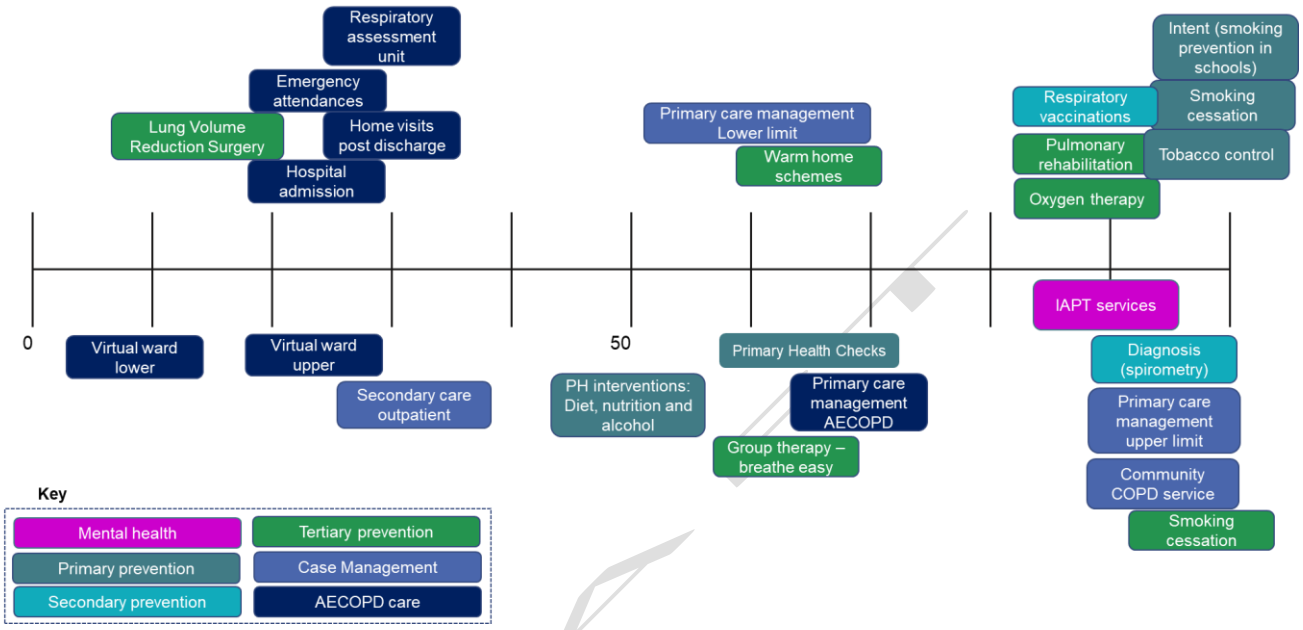

Figure 3 – Benefit scores of each of the interventions in the COPD pathway

The value of the COPD pathway in Nottingham and Nottinghamshire

The expected benefit derived from the VAS score was then combined with information on activity, costs and sources from the literature to build the efficiency frontier. This is a visual representation of the value for money of the COPD pathway in Nottinghamshire.

The methods are presented in the **methodology document** in the appendices.

[1] The quality-adjusted life year (QALY) is a summary outcome measure used to quantify the effectiveness of a particular intervention. QALYs combine the impact of gains in quality of life and in quantity of life (i.e., life expectancy) associated with an intervention (Drummond et al., 2015).

Interpreting the efficiency frontier

The efficiency frontier is produced by triangles representing value for money for each intervention in that pathway. This allows us to visually compare the impact of different interventions and programmes across the whole pathway (e.g., spirometry and pulmonary rehabilitation). The y-axis shows the expected population health benefit for an intervention (the product of the number who benefit and the benefit score) compared with current care. The x-axis displays the estimated annual cost for an intervention.

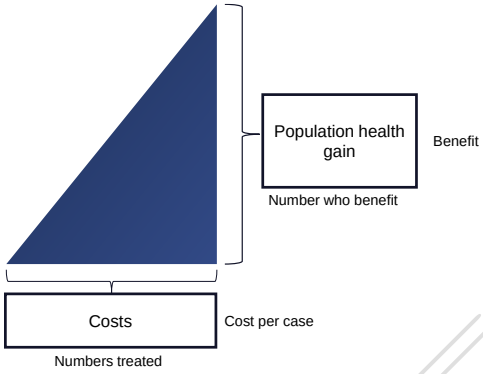

Figure 4 – Populating the efficiency frontier

STAR's visual models are what makes it applied common sense. In the triangles below, we can see at a glance that the triangle on the right represents an intervention that is much more cost-effective than the intervention represented by the triangle on the left: as we increase spending, the benefits increase quickly for the triangle on the right but only slowly for the triangle on the left.

Figure 5 – Triangles showing low value for money (left) and high value for money (right)

The triangles are then ordered according to their value for money to display the 'efficiency frontier'. This shows either where there are opportunities to spend the existing money in a different way to provide more value for money, or where additional investment will be best targeted. The purpose of the efficiency frontier is to help stakeholders think about how the care pathway for COPD ought to be developed. The aim is to move the curve to the left

and upwards (represented in Figure 6a), thus reducing costs and improving the population health benefit of the pathway (compared with the curve in Figure 6b).

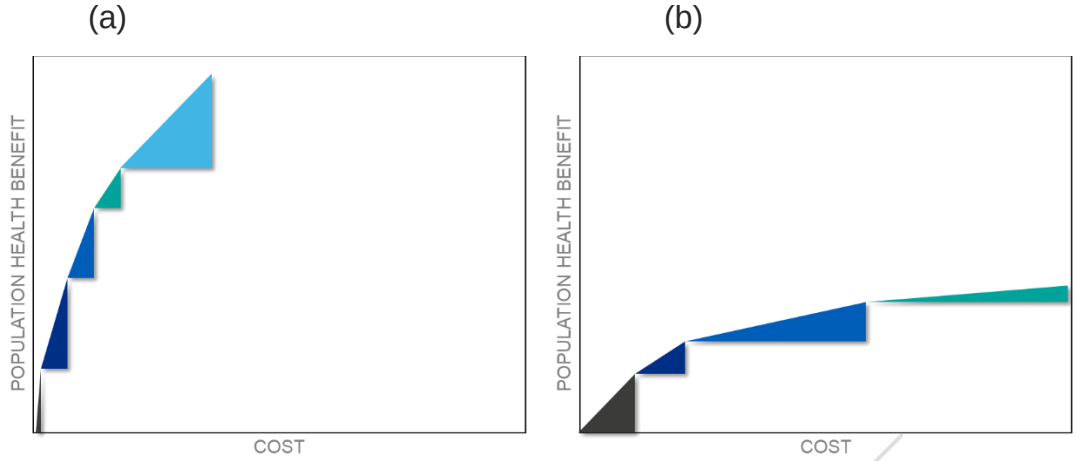

Figure 6 – Different efficiency frontiers with good (a) and bad (b) value for money

The efficiency frontier in Nottinghamshire

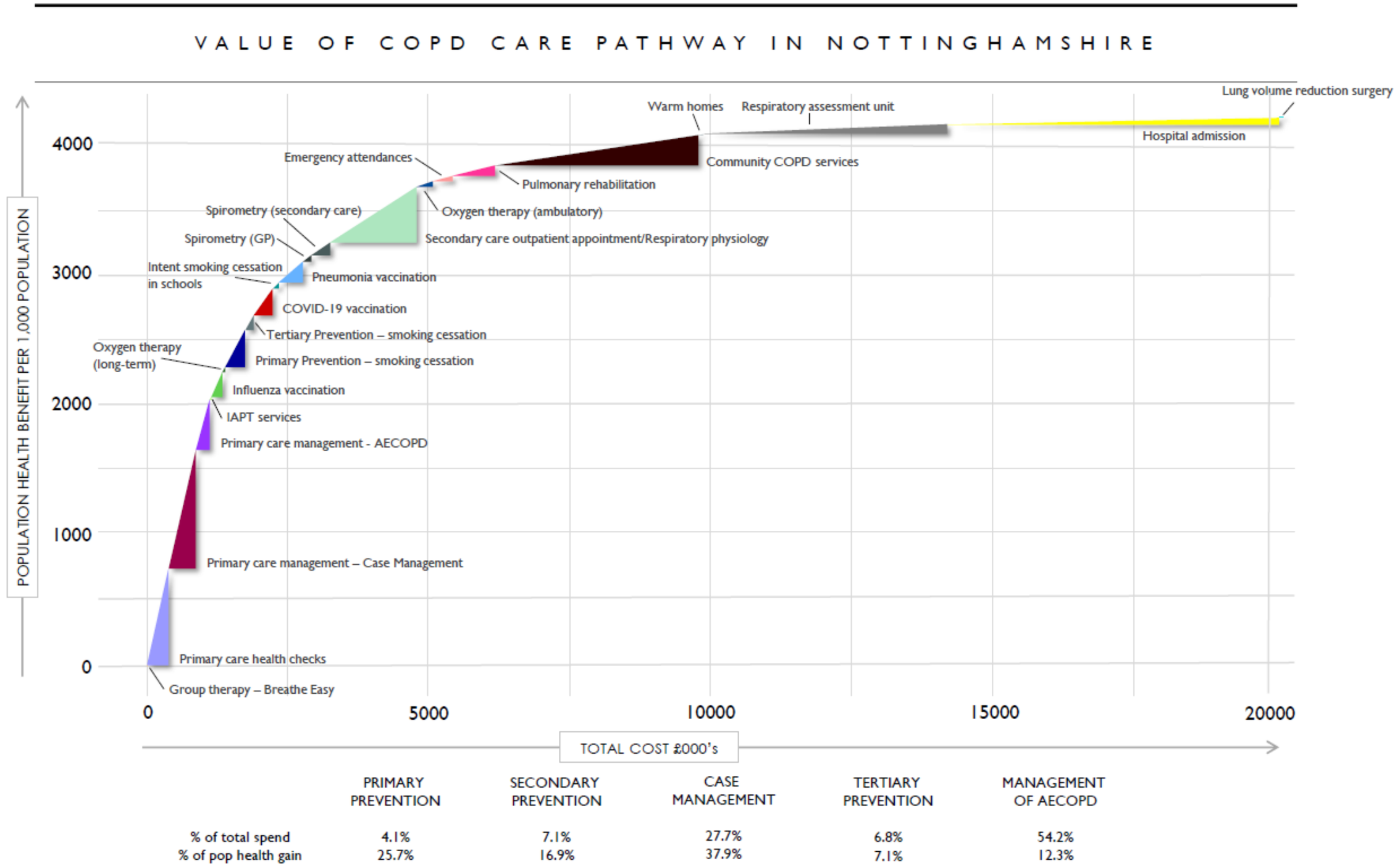

Figure 7 – The efficiency frontier for the COPD pathway in Nottingham and Nottinghamshire

Main challenges

By reflecting on the output from Figure 7 (efficiency frontier and value-for-money triangles along the COPD pathway) and through considering the challenges identified by the stakeholders involved in the decision conference, we were able to select three main challenges as areas of focus:

- Preventing people from smoking and supporting those who do smoke to quit
- Improving case management in primary care and the community
- Improving uptake of tertiary prevention services.

Stopping more people from smoking and supporting more smokers to quit

Smoking cessation was given the highest relative value due to the long-term effects of quitting smoking – whether before or after someone develops COPD. However, the low numbers of people who quit make smoking cessation interventions relatively expensive per quitter.

Approximately 174,000 adults in the ICS smoke (64,000 in Nottingham and 110,000 in Nottinghamshire) (Office for Health Improvement & Disparities, 2022). However, fewer than 5,000 people across the county set a quit date in 2021/22, and only around 3,000 quit.[2] This means that 4.5% of the smoking population was covered by a smoking cessation programme; the National Institute of Health and Care Excellence (NICE) recommends a target of 5% of the smoking population.

Improving case management in primary care and the community

There is variability in the care offered in primary care. Some clinicians working in primary care may have experience or training in respiratory conditions and therefore are able to provide better advice and guidance on things like inhaler technique. Where they do not, their input may be limited to filling out prescriptions and signposting on to other services.

Similarly, the percentage of people living with COPD who have their yearly review varies by primary care network (PCN). In Mansfield North PCN, 46.9% had a yearly review in 2021/22, compared with 73.7% in Rushcliffe PCN. As general practice is the gateway to many other services, this means a significant amount of people with COPD will not be interacting with the health service. Reducing this variability in uptake and quality of primary care management could have great benefits for people living with COPD.

[2] Data provided by the public health teams in Nottingham City and Nottinghamshire County Councils.

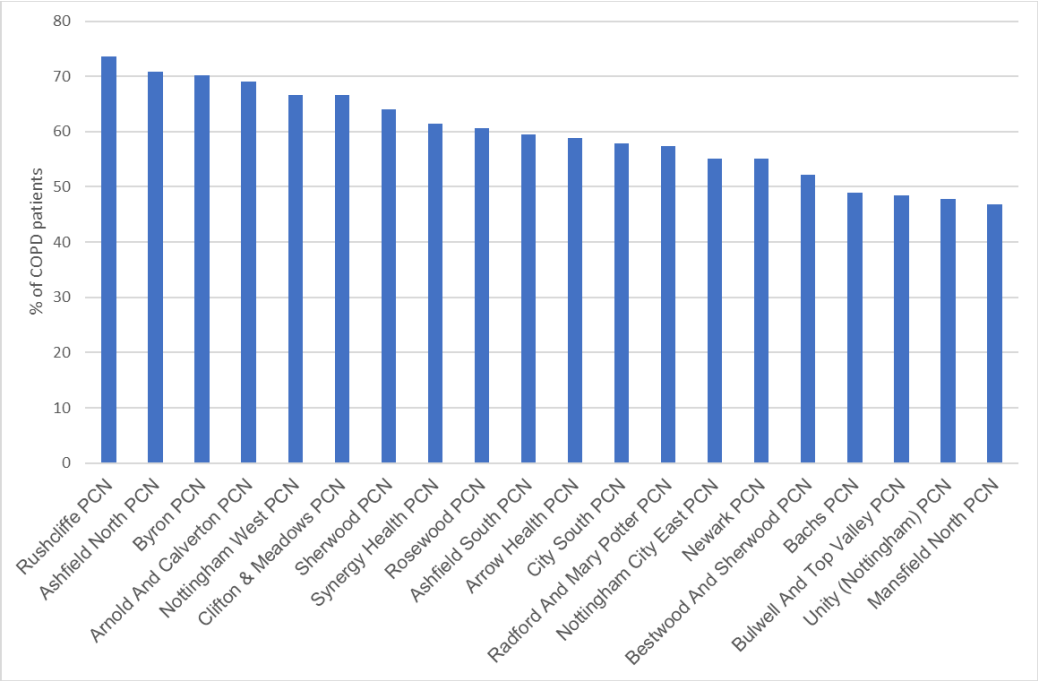

Figure 8 – Percentage of people living with COPD who had a yearly review by PCN in 2021/22 (Office for Health Improvement & Disparities, 2022)

Improving uptake of tertiary prevention services

There are many services on offer in the county which have a sound evidence base for their effectiveness in COPD; however, uptake of these services remains low.

For example, pulmonary rehabilitation (PR) is widely regarded as one of the most effective nonpharmacological interventions for people with COPD. It is available to all people with COPD with an MRC score of 3 and above. There are 12,430 people with an MRC score of 3 and above in the county according to eHealthScope, but only 2,249 accepted referrals in 2021/22; thus only 18.1% of eligible people had accepted referrals to PR services.

Improving the pathway

Addressing the main challenges

After discussing the main challenges, attendees were asked to identify pathway improvements that could address these challenges.

The pathway improvements that the attendees decided should be taken forward for consideration are summarised in the graphic below and then explained in more detail.

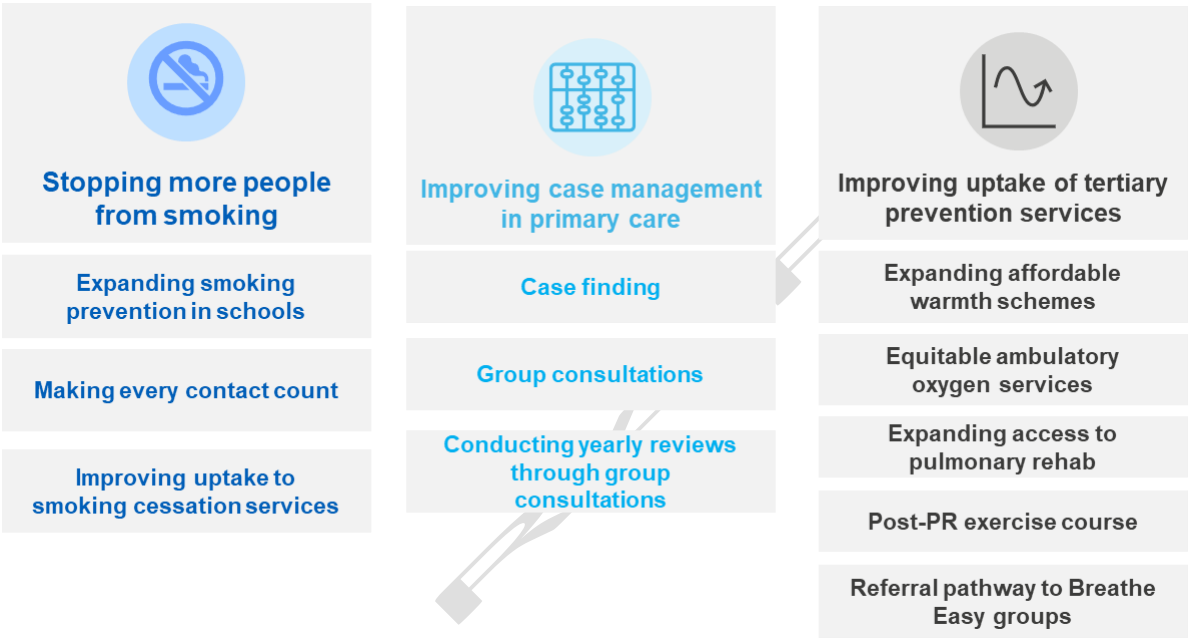

Figure 9 – Pathway improvements set out to meet the main challenges

Pathway improvement: a definition

Here we have used the phrase ‘pathway improvement’ to mean the programmes and initiatives that were proposed in the decision conferences by the attendees as ways of improving the COPD pathway.

This could be a single intervention; for example, a pathway improvement looking to expand pulmonary rehabilitation would consist of only pulmonary rehabilitation. However, other pathway improvements may consist of multiple interventions; for example, the pathway improvement ‘improving signposting to services’ would consist of the signposting intervention itself as well as the expected increase in uptake of the services being signposted.

Stopping more people from smoking and helping more people to quit

Expanding the INTENT smoking prevention programme in schools

More could be done to prevent young people from smoking and vaping. NICE recommends school-based interventions as one way of achieving this (NICE, 2021). One such programme is the INTENT smoking prevention programme. This programme targets teenagers who have never smoked and helps them to create ‘personal plans’ about how to refuse an offer of cigarettes.

Nottingham City and Nottingham County councils have signed a licence with INTENT for four years from 2021/22. According to Nottinghamshire County Council, 12 out of 48 secondary schools were signed up to the programme in the first year; the aim is to cover all 48 schools in four years.

Making every contact count

Every point of contact with a clinician is an opportunity to encourage a smoker to quit.

One way of making every contact count would be for staff in general practice to be mandated to offer ‘very brief advice’ (VBA) to people with COPD as part of their yearly reviews. This can increase the likelihood that a smoker will go on to engage with a smoking cessation service and successfully quit smoking (Stead et al., 2008).

The National Centre for Smoking Cessation and Training (NCSCT) online module is one recognised training module available for staff. It teaches them how to give VBA on smoking cessation.

Improving uptake to smoking cessation services

The current smoking cessation services in the county have a high conversion rate (i.e., proportion of set quit dates that convert to a successful four-week quit) of 58–59%. However, of the estimated 169,015 smokers in Nottingham and Nottinghamshire, only 6,689 (3.96%) were referred to smoking cessation services in 2021/22. Increasing the number of people engaging with smoking cessation services should lead to more people quitting smoking.

Improving case management in primary care and the community

Improving case-finding through targeted COPD screening

Undiagnosed COPD cases can be found by screening people at higher risk of developing COPD during routine primary care visits. Given that high-risk smokers – defined as current smokers and those who have quit within five years (Tindle et al., 2018) – are one of the most prominent at-risk groups for developing COPD (Office for Health Improvement & Disparities, 2022), undiagnosed COPD cases are likely to be more prevalent among them.

Based on available data sources and the literature review, we suggest that a **three-stage process** could be a cost-effective way to find undiagnosed COPD cases:

1. Identify high-risk smokers.
2. Screen them with a clinically validated questionnaire (COPD diagnostic questionnaire, CDQ).
3. Administer diagnostic spirometry testing for those with a CDQ score of 16.5 and above.

High-risk smokers can be identified via eHealthScope, an integrated dataset pulled from general practices in Nottinghamshire that registers people's smoking status. A few selection criteria based on age, smoking history and other demographics might also be applied to identify those at higher risk of having undiagnosed COPD.

To further refine the target population for diagnostic spirometry testing, we can use the CDQ as a cost-effective case-finding strategy, as suggested by the literature review (Johnson et al., 2021; Wright et al., 2015). According to Johnson et al. (2021), administering the CDQ during routine primary care visits (to community pharmacies, GPs, or community centres) at 5-year intervals is the most cost-effective case-finding strategy. The study by Wright et al. (2015) also implies that the diagnosis rate can be improved up to twofold if GPs can refer people with a CDQ score of 16.5 and above for spirometry testing.

Conducting patients' yearly reviews through group consultations

Group consultations (often referred to as shared medical appointments) involve seeing multiple patients in one session. Some studies suggest that group sessions tend to last around 90 minutes for up to 12 patients (Edelman et al., 2012; Hayhoe et al., 2017). This contrasts with the current individual reviews, which normally take around 15 minutes per patient. Group consultations could improve the quality of primary care case management by allowing clinicians more time to interact with patients and give them more tailored advice, and also by facilitating peer learning among patients. If the appointments were scheduled at full capacity (12 patients per session), group consultations could also free up clinicians' time by up to 15 minutes per patient.

Offering group consultations as an option for patients' yearly reviews may be a way to see more patients as well as improving the quality of those yearly reviews.

Doing more secondary care outreach clinics in the community

We have identified two examples of outreach clinics in the community:

- A community clinic in Nottingham West, run by Dr Jonathan Corne and the respiratory nurses at Primary Integrated Community Services Ltd (PICS). This is normally done through home visits but occasionally involves video consultations.
- A virtual community clinic run by Dr Amy Binnion in South Nottinghamshire. There are discussions about scaling this up elsewhere.

Expanding these clinics could be beneficial for patients as they can be seen closer to home.

Due to a lack of available data on the number of people currently seen in the outreach clinics and how much they cost to run, this scenario has not been taken forward to the ***assessing the impact of the proposed pathway improvements*** *section.*

Improving uptake of effective services

Expanding affordable warmth schemes

Living in a cold home has been shown to lead to increased respiratory symptoms, poor self-reported health and an increase in the risk of an acute exacerbation (Osman et al., 2008). District councils in the country offer affordable warmth schemes for people with COPD, defined here as grants for installing insulation, boiler replacements and fuel vouchers.

The current affordable warmth schemes offered are small in scale, covering fewer than 200 people with COPD. These schemes are not currently offered in Nottingham City.

Therefore, there is scope to expand the budget for people for affordable warmth schemes to cover a larger proportion of the eligible population.[3]

Equal access to ambulatory oxygen services

Due to historical contracts, there is variation in how oxygen services are delivered across the county. In Nottingham City, CityCare Partnership provides both long-term and ambulatory oxygen therapy, through the integrated respiratory and oxygen service (IROS). In Mid-Nottinghamshire and Bassetlaw, Nottinghamshire Healthcare NHS Trust runs a home oxygen service. In Nottingham West, PICS runs an oxygen service which covers part of South Nottinghamshire. People living in the rest of South Nottinghamshire must attend Nottingham University Hospitals NHS Trust to have an oxygen assessment.

Commissioning an ambulatory oxygen service in South Nottinghamshire or expanding one of the existing contracts to cover that area would improve access for people living in South Nottinghamshire.

It is not possible to model the impact of commissioning an ambulatory oxygen therapy service in South Nottinghamshire as data on oxygen service provision was not available at this aggregate level. This means it is not possible to assess the difference in rates of ambulatory oxygen therapy in the different Place-Based Partnerships in the ICS. Therefore, this scenario has not been taken forward to the ***assessing the impact of the proposed pathway improvements*** *section.*

Expanding access to pulmonary rehabilitation

PR is widely regarded as one of the most effective nonpharmacological interventions for people with COPD. Currently, everyone in the county with an MRC score of 3+ is eligible. PR is not recommended for people who are housebound, although there is a virtual offering available (Bolton et al., 2013). According to the QOF register, only 39.5% of those eligible were referred to a PR clinic in 2021/22 (Office for Health Improvement & Disparities, 2022).

Expanding access to PR services and encouraging more people to access them could be very beneficial for those patients and for the COPD pathway more widely.

[3] Defined as everyone aged 65 and over who lives in areas (LSOAs) of high income deprivation (most deprived quintile) and where the proportion of households in fuel poverty (as identified by the Department for Business, Energy and Industrial Strategy) is highest (highest quintile = top 20% of LSOAs).

Offering a post-PR exercise course

One of the issues with PR is that people do not tend to keep up with the exercises after the course has ended.

The Breathe Easy groups in Nottinghamshire run an exercise group which has one online and one face-to-face session a week in West Bridgford. Offering this service to people who complete the PR course may be one way of helping to sustain the benefit and develop an offer for post-PR rehab.

Introducing a referral pathway to Breathe Easy groups

Breathe Easy (part of Asthma and Lung UK) offers a wide variety of support groups in the county. These include singing groups, peer support groups and other groups aimed at supporting patients with COPD.

However, these groups are not well known by clinicians, nor are they always integrated into healthcare pathways. Similarly, the groups rely on volunteers and therefore cannot be offered to everyone.

Enabling clinicians to refer into Breathe Easy groups would help to expand this service. This may be particularly beneficial to people who are unable or unwilling to undergo PR.

Assessing the impact of the proposed pathway improvements

During this phase of the programme, the HEU outlined the expected change that could occur over a period of one year because of each pathway improvement. Where possible, a visualisation of the impact each one could have on the efficiency frontier was also produced, alongside summary statistics. Different scenarios have been included where there are multiple possibilities for implementing the pathway improvement, or where there is uncertainty around how the improvement could be implemented.

This piece of work can be used to demonstrate the potential impact of each improvement and help the respiratory programme team to determine which improvements it should focus on. The equations in this section have been developed using the guidance published by The Health Foundation and through consultation with subject matter experts (The Health Foundation, n.d.).

To support this phase, information was taken from the literature review that was conducted as part of the programme (see the box below).

Understanding the impact of pathway improvements: literature review

While there is a strong body of evidence in relation to clinical intervention options for COPD, via the **NG115 guidance**, evidence on interventions impacting wider determinants of health, such as behavioural, environmental and socio-economic interventions, is more limited

Therefore, as part of the Smarter Spending in Population Health programme, an umbrella review (exploring previously published systematic literature reviews and network meta-analyses) was conducted to understand the impacts of both the clinical interventions and those impacting the wider determinants of health on quality of life and healthcare resource use. A total of 64 publications were selected for the review. We examined the interventions found and identified the benefit in terms of the outcome reported.

In this phase of the programme, the information from this review has been used to estimate the numbers needed to treat (NNT); that is, the number of people who need to receive an intervention in order for one good outcome to occur. For example, an NNT of 5 for hospital admissions means five people would need to be treated to avoid one hospital admission. This is explained further in the **developing the visualisations** section below.

The results of the umbrella review will be published separately.

Developing the visualisations

The methods used in developing the visualisations of the impact each pathway improvement could have on the COPD pathway are explained in further detail in the table below. The exact numbers, calculations and assumptions used for each pathway improvement can be found in the **data sources and calculations** section in the appendices. These formulae were adapted from those in the work of Airoldi et al. in discussion with external experts.

Metric	Methods
Additional population health benefit due to pathway improvement **(PHB)**	This can be represented as: $$PHB_{j+k+i} = N_j \times B_j + N_i \times B_i + N_k \times B_k \ ...$$ Where j, I and k represent each intervention in the pathway improvement.

	Where N_j is the number of individuals who would benefit from the intervention j each year and B_j is the potential benefit in quality (and length) of life, assuming successful implementation, to the typical beneficiary (i.e., QALY gains), compared with current care. The benefit from improvement j consists of direct health benefit in terms of length and quality of life from the intervention itself as defined by participants in the decision conferences.
Additional costs of pathway improvement **(N_tC)**	Where j, I and k represent each intervention in the pathway improvement. This can be represented as: $$N_tC = N_{t_j} \times C_j + N_{t_i} \times C_i + N_{t_k} \times C_k \ldots.$$ Where N_{tj} is the number of individuals expected to be treated by intervention j within a given year, and C_j is the expected average cost of the intervention per individual. It is assumed that costs apply to each person treated and that there is a linear relationship between costs and numbers treated.
Expected impact on healthcare resource use **(R)**	The expected impacts on healthcare resource use elsewhere in the COPD pathway (defined as 'pathway components' and including hospital admissions, GP appointments or acute exacerbations) for each pathway improvement have been calculated using numbers needed to treat (NNTs) sourced from the literature review. When information was not available in the literature, it was assumed that the improvement would not have an impact on other pathway components. NNT is an epidemiological measure representing the number of patients it is necessary to treat to avoid one additional bad outcome. For example, an NNT of 5 for a hospital admission would mean that five people need to be treated to avoid one hospital admission. NNTs can be estimated from odds ratios, rate ratios and mean differences (Centre for Evidence-Based Medicine, n.d.; da Costa et al., 2012). Expected changes to the pathway have only been included if the literature review

	identified a paper outlining a statistically significant effect ($p < 0.05$) that can be used to estimate an NNT. We have modelled the latest timeframe in which the improvements are expected to have statistically significant effects on the rest of the pathway. Number who benefit ($N_{j,l,k...}$) from each intervention in the pathway improvement has then been divided by the relevant NNT: $$R_y = \frac{N_j}{NNT_y}$$ Where y is equal to the pathway component affected by the improvement (usually hospital admissions). Due to the different timescales for the effects that primary prevention will have on the COPD pathway (through reducing the number of people developing COPD) compared with other pathway improvements, its effects on the rest of the pathway have not been included in the visualisations below but have been included in the **summary statistics**.
Cost savings **(RC_v)**	The cost savings expected for each pathway improvement have been calculated by multiplying the expected impact on healthcare resource use by the estimated costs of each improvement, as defined in the **data sources for the efficiency frontier** section in the appendices. $$RC_{y+x+z} = R_y \times C_{vy} + R_x \times C_{vx} + R_z \times C_{vz....}$$ Where y, x and z represent the components impacted by the improvement, and C_v represents the cost of the pathway component in question. For example, the expected cost of a hospital admission is £2,855.05. If a pathway improvement was expected to lead to 10 fewer hospital admissions, the cost saving would be £28,550.50.

Summarising the results

In each section below, summary statistics have been provided as additional pieces of evidence to support Nottinghamshire's respiratory programme in prioritising the pathway improvements and in influencing stakeholders and decision-makers to implement them.

The methods for calculating these summary statistics are provided in the table below.

Statistic	Definition
Total additional pathway cost	This is equal to the additional cost of the pathway improvement minus the cost savings. It can be written as: $$N_t C - RC_v$$ This method can determine whether the improvement is likely to save money overall or incur additional costs. Negative numbers represent cost savings. *Primary prevention* For pathway improvements that will reduce the number of people expected to get COPD in the future, the cost saved has been estimated by multiplying the expected number of cases of COPD avoided by the expected cost of treating one person with COPD for a year. NNTs have been used to calculate the expected reduction in the number of people developing COPD in the future, using the same methodology outlined above. This has then been multiplied by the expected cost per person per year. This has been calculated as the probability that a person with COPD would receive each intervention in the current COPD pathway multiplied by the estimated cost per person of each intervention. This is equal to £523.27. This figure has been subject to a sensitivity (scenario) analysis, which is explained in the **discussion** section below.
Additional cost / additional population health ratio	This can be written as: $$\frac{N_t C - RC_v}{PHB}$$

	This metric will help us understand the costs for each additional unit of population health gain. The lower the ratio, the better, with a negative ratio representing interventions that are both cost-saving and health-generating. A ratio of 1 would mean it costs £1 to generate one additional unit of population health gain.
Cost ratio	This metric is calculated by dividing the cost saving by the additional cost of the improvement. It can be written as: $$\frac{RC_v}{N_t C}$$ A ratio of 1 means the improvement is cost-neutral (i.e., £1 saved for every £1 spent elsewhere in the pathway). A ratio of 1.1 means £1.10 is saved elsewhere in the pathway for every £1 spent on the improvement. Numbers below 1 represent interventions that are cost-incurring. This metric will help us understand the potential returns each improvement will likely give back to the system.
Timeframe	The timeframe in which the expected changes are due to be realised will differ depending on the particular pathway improvement under consideration. It is important to understand when these benefits are realised for financial and operational planning. Estimates of when the benefits are likely to be realised come from the literature. For example, a study reports a reduction in hospital admissions after three years; we would expect the benefits to be realised 'after three years'.

Impact of the pathway improvements

Stopping more people from smoking and helping more people to quit

Here the focus is on the effect of stopping people smoking on the COPD pathway. It should be noted that smoking cessation or prevention has wider societal benefits, such as financial savings for the person who quits and health benefits to those who surround them. However, as this project focuses on the COPD pathway, these are out of scope.

For each pathway improvement, scenarios have been developed to model the expected benefit of its introduction. Efficiency frontier figures have been visualised for each of the pathway improvements, and the total additional pathway cost, costs for each additional unit of population health gain and cost ratios are presented in a table for each pathway improvement.

Expanding the INTENT smoking prevention programme in schools

Expected change

Smoking is one of the largest risk factors for developing COPD (NICE, n.d.).

The INTENT programme is expected to lead to fewer pupils taking up smoking and, as a result, fewer people developing COPD. It has been tested in three studies, including a cluster randomised controlled trial, and has shown positive effects on preventing pupils from smoking in schools (Conner et al., 2019).

The incidence rate for COPD among smokers is higher than in never and former smokers (Terzikhan et al., 2016). This means that fewer people will develop COPD and therefore fewer people will require services aimed at managing COPD and acute exacerbations.

Scenario

As the only impact of this pathway improvement would be on primary prevention, we have not created a visualisation for this scenario.

Here we have modelled what it would look like assuming all 48 secondary schools in the county are covered. Overall, the improvement is not expected to be cost-saving, and any savings due to the cases of COPD avoided would only be realised in the long term as people do not tend to develop COPD until they are older (Safiri et al., 2022).

Metric	Total	Interpretation
Total additional pathway costs	£203,758.40	The number of COPD cases avoided per year (at a cost of £523.27) is not expected to offset the costs of the pathway improvement.
Additional cost / additional population health ratio	1.45	This improvement costs £1.45 for every additional unit of population health gain it generates.
Cost ratio	0.29	This improvement is not cost-saving. It would save £0.29 due to cases of COPD avoided for every £1 spent.

Making every contact count

Expected change

If staff were to provide VBA to smokers with COPD, this would likely expand the number of people setting quit dates and make those who do more likely to quit.

A meta-analysis pooling the results of 17 trials suggested that the provision of brief advice was associated with a statistically significant increase in the rate of quitting, by 66%, compared with no advice (risk ratio 1.66, 95% CI 1.42–1.94) (Stead et al., 2008).

As above, stopping people with COPD from smoking can impact the rate of exacerbations and hospital admissions for the individuals involved (Au et al., 2009; Godtfredsen, 2002).

Scenario

Here we model what making every contact count would look like, through general practice staff offering VBA on smoking cessation to people with COPD as part of their yearly review. It is expected that this intervention would lead to an additional 243 people with COPD quitting smoking per year. This would lead to cost savings due to the reduction in the number of hospital admissions and acute exacerbations that stopping people smoking is expected to avoid.

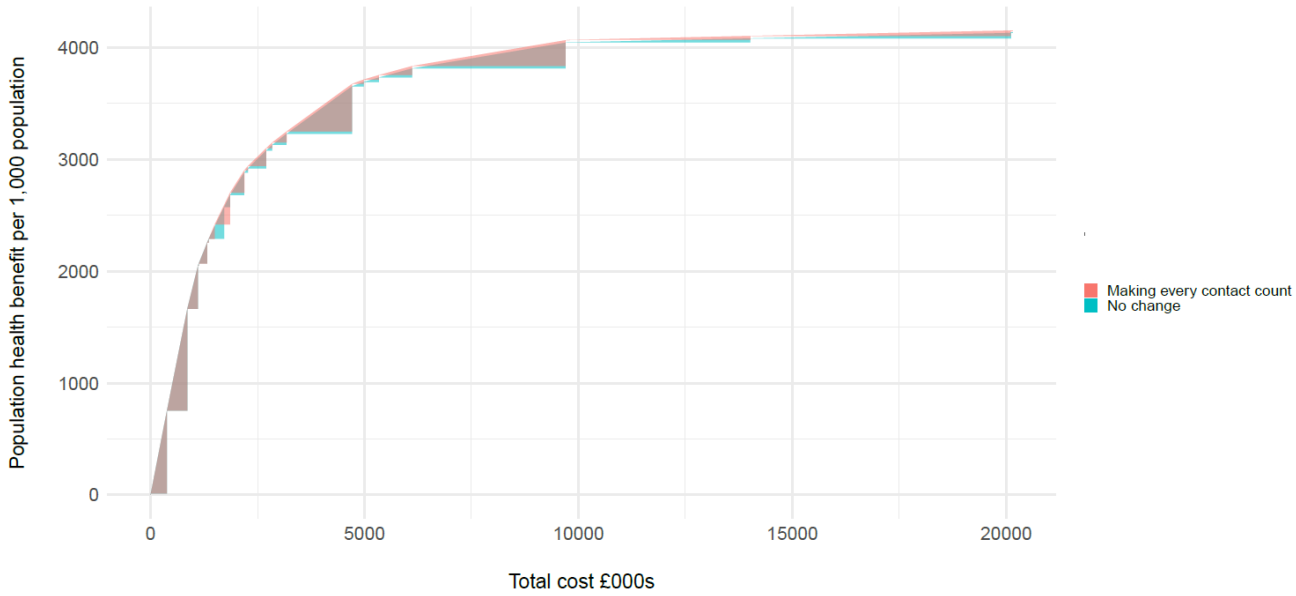

Figure 10 – Expected change to the pathway following implementation of making every contact count for smoking cessation

Metric	Total	Interpretation
Total additional pathway costs	-£2,488.77	This pathway improvement is cost-saving due to the expected reduction in the number of hospital admissions and acute exacerbations.
Additional cost / additional population health ratio	-0.10	This pathway improvement will save £0.10 for every additional unit of population health gain it generates.
Cost ratio	1.20	This intervention is cost-saving. It will save £1.20 elsewhere in the COPD pathway for every £1 spent.

Improving uptake of smoking cessation services

Expected change

If more people were to engage with smoking cessation services in the county, it is likely that more people would quit smoking. In order for this to happen, the following steps would be required:

- More people would need to be referred to smoking cessation services.
- The capacity of the smoking cessation services would need to be expanded in order to deal with this increase in referrals.

Stopping people with COPD from smoking through smoking cessation programmes can impact the rate of exacerbations and hospital admissions for the individuals involved (Au et al., 2009; Godtfredsen, 2002). Au et al. found a reduction in exacerbation rates in veterans in the US who were ex-smokers compared with current smokers (hazard ratio (HR) 0.78, 95% CI 0.75–0.87), but the results were only statistically significant when individuals had quit for 10 years or more (HR 0.65, 95% CI 0.58–0.74). Godtfredsen et al. found a statistically significant reduction in hospitalisations among ex-smokers compared with quitters in a Danish population, with an average follow-up time of 14 years (HR 0.57, 95% CI 0.33–0.99).

In terms of primary prevention (i.e., stopping people from smoking before they develop COPD), it is expected that stopping more people smoking will lead to a reduction in the number of people developing COPD. According to Terzikhan et al., among a cohort of 14,619 participants in the Netherlands, the incidence of COPD was 19.7/1000 person years (95% CI 18.1–21.4) among current smokers, and 8.3/1000 person years (95% CI 7.6–9.1) among former smokers, with a maximum follow-up time of 25 years (Terzikhan et al., 2016).

Scenario

Here we model two different scenarios, one looking at improving uptake of smoking cessation generally and the other focusing on people with COPD alone:

- **Increasing uptake to meet the 5% target set by NICE.** This would require an extra 1,762 people with and without COPD across the county to set a quit date each year.
- **Doubling the number of people with COPD who set quit dates.** This approach would mean an additional 1,865 people with COPD setting quit dates each year. This would have a more direct impact on the COPD pathway than expanding capacity more widely.

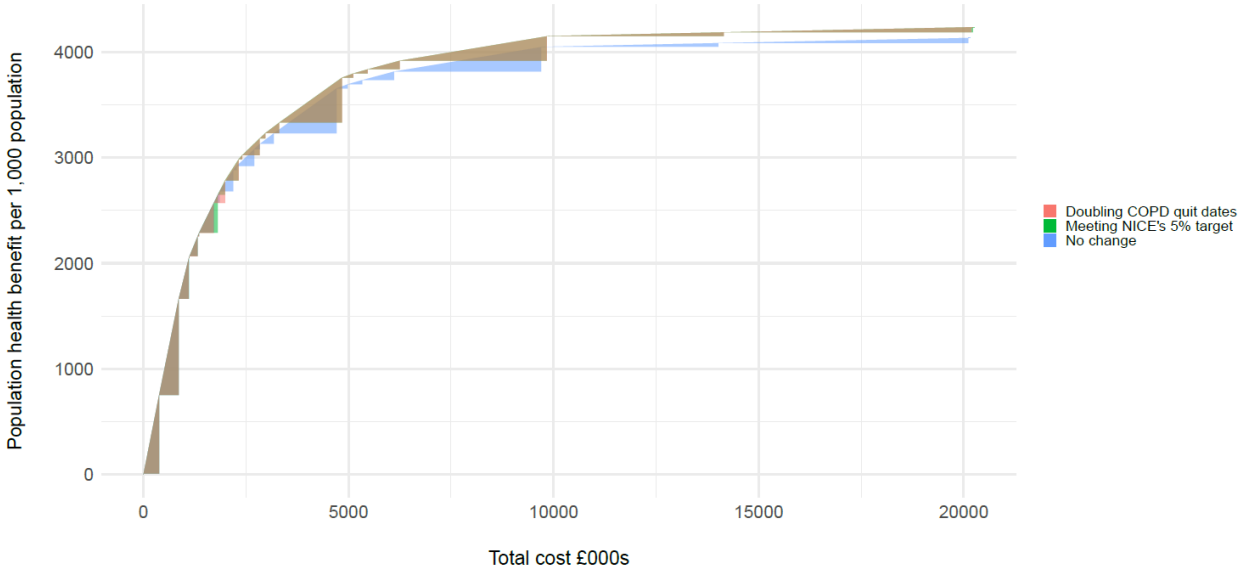

Figure 11 – Expected change to the pathway following improved uptake of smoking cessation services

Neither scenario is estimated to be cost-saving for the COPD pathway. However, both cost less than £1 for every additional unit of population health they generate (see tables below). If the focus is on the COPD pathway in the shorter term, then doubling the number of people with COPD would have the more immediate impact on the COPD pathway of the two scenarios. It is expected to lead to 21 fewer hospital admissions and 58 fewer acute exacerbations managed in primary care per year.

Increasing uptake to meet the 5% target set by NICE

Metric	Total	Interpretation
Total additional pathway costs	£69,018.14	This scenario is not expected to be cost-saving. The number of cases of COPD avoided and the reduction in hospital admissions and acute exacerbations it avoids would not offset the cost of the additional smoking cessation services.
Additional cost / additional population health ratio	0.67	This scenario would cost £0.67 for every additional unit of population health gain it generates.

Cost ratio	0.47	This scenario is not cost-saving. It saves £0.47 elsewhere in the pathway for every £1 spent.

Doubling the number of people with COPD who set quit dates

Metric	Total	Interpretation
Total additional pathway costs	£76,402.73	This scenario is not expected to be cost-saving. The reduction in hospital admissions and acute exacerbations it avoids would not offset the cost of the additional smoking cessation.
Additional cost / additional population health ratio	0.72	This scenario would cost £0.72 for every additional unit of population health gain it generates.
Cost ratio	0.45	This scenario is not cost-saving. It saves £0.45 elsewhere in the pathway for every £1 spent.

Improving case management in primary care and the community

Improving case-finding through targeted COPD screening

Expected change

We assume that the three-stage COPD case-finding will lead to two positive changes along the care pathway:

- An earlier diagnosis of COPD compared with no case detection.
- A higher diagnosis rate compared with conventional case detection screening without using the CDQ.

Earlier diagnosis of COPD allows opportunities for early interventions, such as programmes for smoking cessation and pharmacotherapy to reduce symptoms, both of which can reduce the risk of exacerbations and hospitalisations and improve quality of life and other long-term health outcomes (Decramer et al., 2011; Kostikas et al., 2020). However, early diagnosis would require regular screening, and Johnson and colleagues

(2020) recommended that the best-practice frequency of screening was **once every five years**.

A higher diagnosis rate will save NHS resources used for spirometry testing as well as reducing the logistic burden of healthy and low-risk patients who might otherwise be tested unnecessarily. According to Wright and colleagues (2015), targeted case detection using clinically validated questionnaires (e.g., CDQ) can identify one patient with moderate severity COPD (GOLD-2) for every two screened (equivalent to 50%), which is substantially higher than the current diagnostic rate of 27.7% in ICSs in Nottingham.[4]

Scenarios

In this pathway improvement, we model the potential impact of applying the **three-stage process** for improving case-finding:

1. Identify high-risk smokers via eHealthScope.
2. Ask them to fill in the CDQ via routine primary care visits once every five years.
3. Have GPs refer those with a CDQ score of 16.5 and above for diagnostic spirometry testing.

The modelling assumes that the tests take place in primary care and are additional to the tests currently being carried out.

[4] According to data provided by the System Analytics and Intelligence Unit, part of Nottingham and Nottinghamshire ICS. Rate is assumed the same in both secondary care and GP-led spirometry tests.

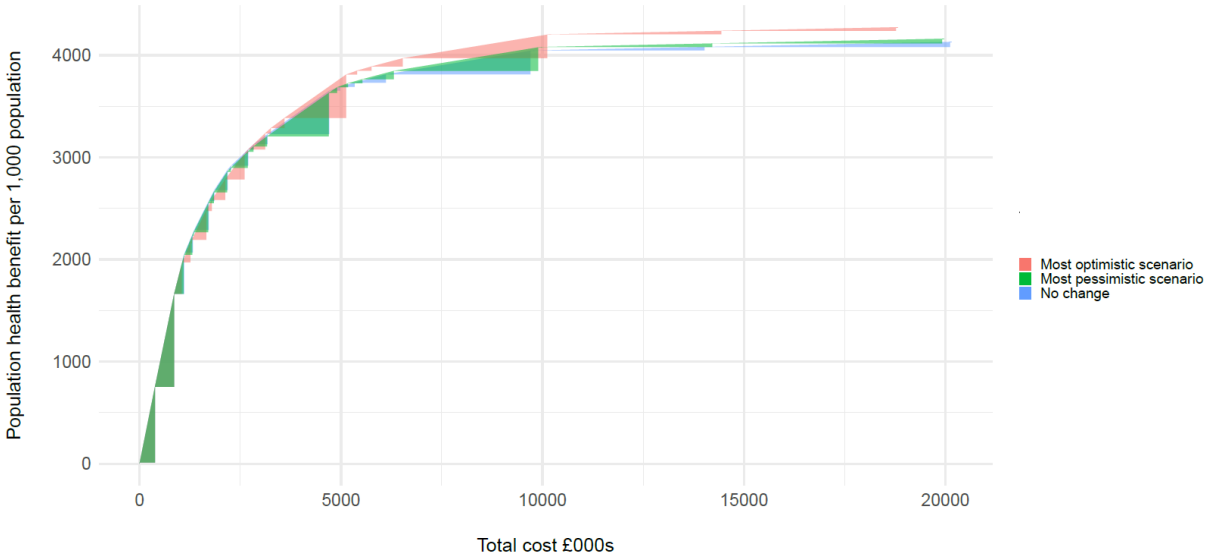

Figure 12 – Expected change to the pathway following implementation of targeted COPD screening for case-finding

We understand that the diagnosis rate may vary depending on the demographic characteristics of the screened population and the underlying COPD prevalence, and there is uncertainty in the number of people who would come forward for testing. Therefore, we have modelled two scenarios:

- **The most optimistic scenario:** 20% of the potential at-risk population are contacted for the CDQ survey, 80% of them are reached and 50% of them complete it; 56.6% of those meet the CDQ score of 16.5 come forward for testing, 70% of those come forward for testing; and the diagnosis rate is improved from the current level (27.7%) to 50%.
- **The most pessimistic scenario: :** 20% of the potential at-risk population are contacted for the CDQ survey, 80% of the potential-at-risk population are reached for the CDQ survey, and 20% of them complete it; 56.6% of those meet the CDQ score of 16.5 come forward for testing, 70% of those come forward for testing, and the diagnosis rate stays at the current level of 27.7%.

The main benefit of earlier diagnosis lies in successful early interventions (e.g., programmes for smoking cessation and pharmacotherapy to reduce symptoms), which also incur costs. However, we only model the direct costs of targeted screening; this is to avoid double-counting, as the costs and benefits of smoking cessation programmes are modelled separately in this report. We also assume that the unit cost of administering the test remains the same regardless of changes in capacity.

Even the most pessimistic scenario is still expected to be cost-saving. This is due to the large number of hospital admissions that early diagnoses are expected to avoid (one hospital admission for every 4.34 early diagnoses compared with late diagnoses).

Most optimistic scenario

Metric	Total	Interpretation
Total additional pathway costs	-£1,344,055	This scenario is cost-saving due to the number of hospital admissions (617) expected to be avoided by earlier diagnoses.
Additional cost / additional population health ratio	-5.28	This scenario is cost-saving and health-generating. It would save £5.28 for every additional unit of population health gain it generates.
Cost ratio	3.80	This scenario is cost-saving. It would save £3.80 for every £1 spent elsewhere on the COPD pathway.

Most pessimistic scenario

Metric	Total	Interpretation
Total additional pathway costs	-£196,521.37	This scenario is cost-saving. It is expected to save £196,521.37.
Additional cost / additional population health ratio	-3.48	This scenario is cost-saving and health-generating. It would save £3.48 for every additional unit of population health gain it generates.

Cost ratio	1.94	This scenario is cost-saving. It would save £1.94 for every £1 spent elsewhere on the COPD pathway.

Conducting patients' yearly reviews through group consultations

Expected change

Group consultations could improve the quality of yearly reviews due to opportunities for shared learning and could potentially increase the number of people who can be seen in the same amount of time.

No studies were identified in the literature review which suggested that improving the quality or quantity of yearly reviews, or primary care case management more generally, would impact on other pathway components such as hospital admissions.

Scenarios

The correct number of yearly reviews that should be conducted as group consultations is not known. Therefore, we model three different scenarios here:

- 10% of the time spent on yearly reviews devoted to group consultation.
- 25% of the time spent on yearly reviews devoted to group consultation.
- 50% of the time spent on yearly reviews devoted to group consultation.

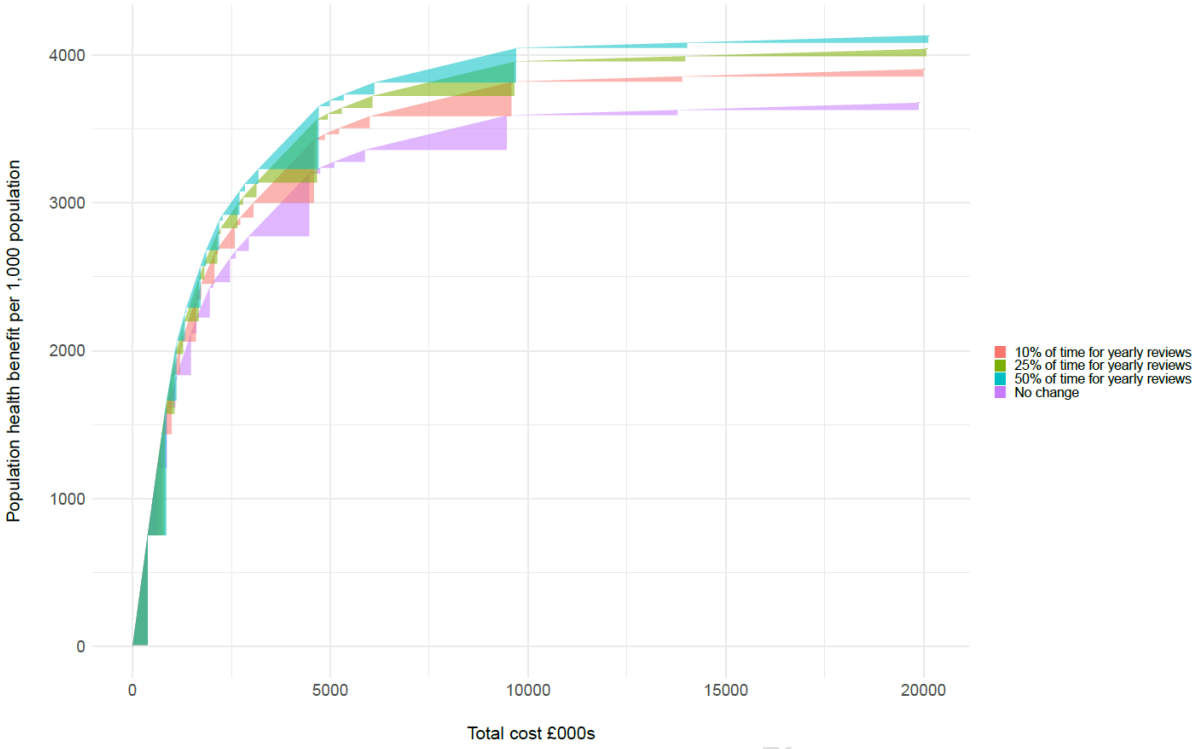

Figure 13 – Expected change to the pathway following implementation of group consultations for patients' yearly reviews

If 50% of the time spent on yearly reviews was devoted to group consultations, it would improve the population health gain of the pathway more than any other pathway improvement, mainly by increasing the number of people reviewed. Introducing group consultations is estimated to be almost cost-neutral and health-generating, no matter what percentage of the time spent on yearly reviews is devoted to them.

Metric	Total	Interpretation
Total additional pathway costs • 10% of yearly reviews • 25% of yearly reviews • 50% of yearly reviews	 £32.15 £30.37 £60.74	This pathway improvement is essentially cost-neutral.
Additional cost / additional population health ratio	0.00	The pathway improvement is essentially cost-neutral and health-generating.

Cost ratio	1.00	This pathway improvement is essentially cost-neutral.

Improving uptake of effective services

Expanding affordable warmth schemes

Expected change

Expanding the budget available for affordable warmth schemes could help to meet the increased demand for affordable warmth schemes brought about by the cost-of-living crisis.

No statistically significant pathway effects for warm home schemes were found in the literature. One randomised controlled trial of warm home schemes conducted in Aberdeen suggested a small, non-statistically significant, decrease in the number of hospital admissions for people living with COPD who were given home energy efficiency improvements. However, the study also noted that patients may be unlikely to take up the schemes (Osman et al., 2010).

Scenario

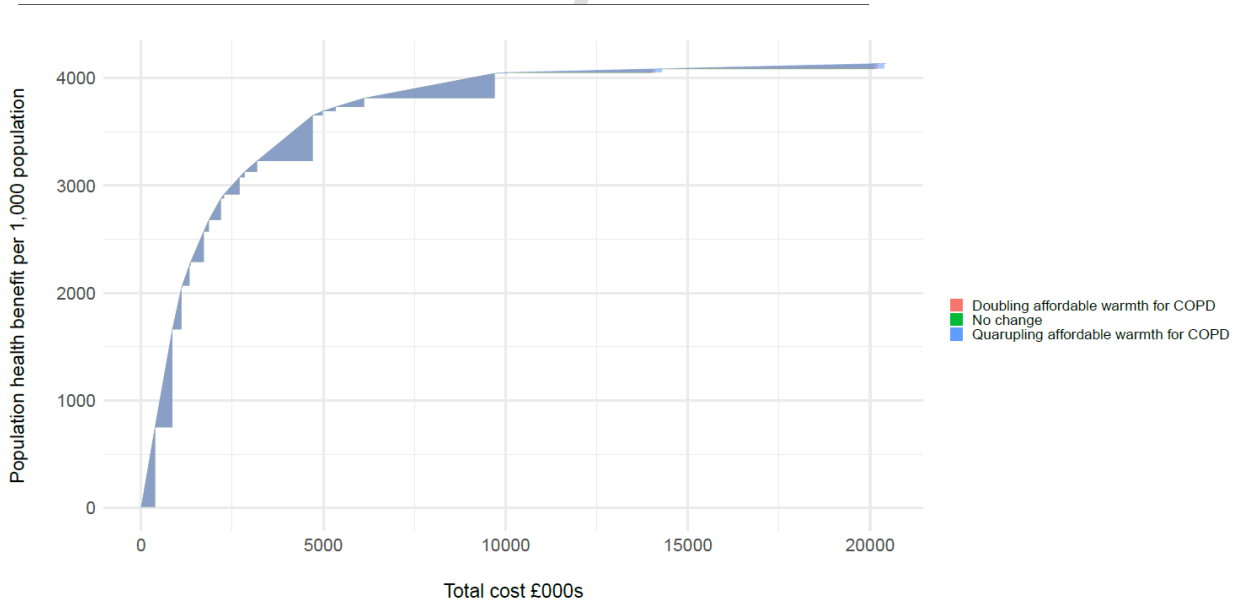

Figure 14 – Expected change to the pathway following an expansion of affordable warmth schemes in people with COPD

As evidence is only available on energy efficiency improvements, only that aspect has been included in the modelling below. The number of people who would be eligible for such a scheme (normally defined as those diagnosed with COPD and living in a home with an energy performance rating of D or lower) is not known (Bowers et al., 2022). Therefore, we look at the potential implication of two scenarios:

- Doubling the number of people with COPD given energy efficiency improvements
- Quadrupling the number of people with COPD given energy efficiency improvements.

As there were no statistically significant impacts on the rest of the COPD pathway, we cannot say that there are expected cost savings due to an expansion in affordable warmth schemes. Similarly, as affordable warmth schemes were given a relatively low benefit score (65) in the decision conferences compared with other interventions, the expected increase in population health gain due to this pathway improvement is modest. Therefore, the overall effect on the pathway is minimal.

Although the body of evidence is growing on the impact of affordable warmth and similar conditions on respiratory health, more research is required (Milner & Wilkinson, 2017). For affordable warmth schemes to be cost-neutral, they would have to avoid one hospital admission for every 1.2 people given support (at a cost of £2,855.05 per hospital admission and £2,370.97 for every person given support through an affordable warmth scheme).

Doubling the number of people with COPD given energy efficiency improvements

Metric	Total	Interpretation
Total additional pathway costs • Doubling the number of people with COPD given support • Quadrupling the number of people with COPD given support	£92,467.83 £277,403.49	There are significant cost implications associated with expanding affordable warmth schemes. This is because there are no expected pathway savings from affordable warmth schemes.
Additional cost / additional population health ratio	36.48	It is expected that this pathway improvement would cost £36.48 for every additional unit of population health gain.

Cost ratio	N/A	There are no expected cost savings due to this improvement.

Expanding access to pulmonary rehabilitation

Expected change

To increase the number of people undertaking PR in the county, two things would need to happen:

- The capacity of PR services would need to be expanded.
- More people would need to be encouraged to access PR services, perhaps through standardised referral pathways from primary care.

A Cochrane review suggested that PR had a positive effect on hospital readmission rates compared with usual post-exacerbation care after nine months in people with an MRC score of 3+ (odds ratio 0.44, 95% CI 0.21–0.91) (Puhan et al., 2016).

Scenarios

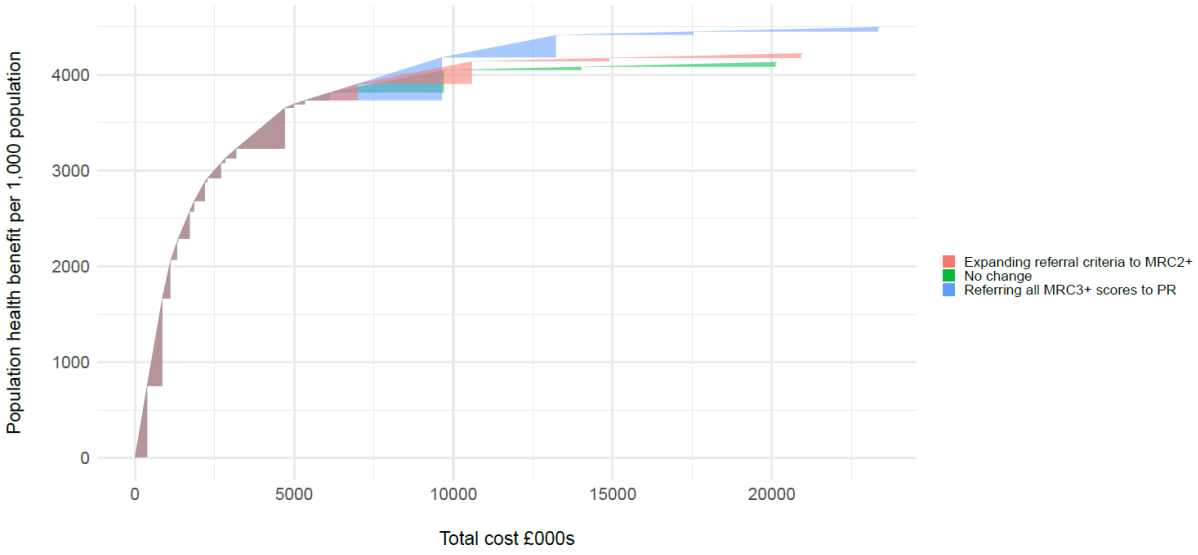

Figure 15 – Expected change to the pathway following an expansion of PR services for people with COPD

Here we model two different scenarios for how the number of people undertaking PR could be increased:

- Referring all people with an MRC score of 3+ to PR services.

A total of 2,249 people were referred to a PR course in 2021/22. Assuming everyone with an MRC score of 3+ is eligible, that would mean 18.1% of eligible patients undertook the course. Here we look at what expanding that to 50% of people with an MRC score of 3+ would look like.

- Expanding referral criteria so that people with an MRC score of 2+ are eligible.

  According to the British Thoracic Society guidelines, people with an MRC score of 2+ who are limited by breathlessness could also benefit from PR (Bolton et al., 2013). It is assumed the benefit would be comparable to that in the Puhan et al. study (Puhan et al., 2016) and that 18% of people with an MRC score of 1 or 2 are referred.

Both scenarios are expected to have a large cost implication associated with them and relatively meagre increases in population health gain. This is because only 40% of the people who have accepted referrals to PR services are expected to complete the course and therefore benefit from it. Increasing the number of people who complete PR courses is the key to making the intervention more cost-effective. However, even if the number of people with an MRC score of 3 and above who complete the course was doubled to 80%, the number of hospital admissions expected to be avoided would only save £299,780.25 per year, so the first scenario would still incur costs of over £3,000,000 a year.

It should be noted that there is uncertainty around whether PR would have the same effect on people with an MRC score of 2+ as it does on people with a score of 3+. More research would be required to study the effect of PR on people with a score of 2+.

Metric	Total	Interpretation
Total additional pathway costs • Referring all people with an MRC score of 3+ • Expanding referral criteria to MRC score of 2+	£3,222,845.75 £806,954.70	There are substantial cost implications for this scenario.
Additional cost / additional population health ratio	8.79	This scenario would cost £8.79 for every additional unit of population health it generates.

Cost ratio	0.09	This scenario is not cost-saving. It would save £0.09 due to a reduction in hospital admissions for every £1 spent.

Offering a post-PR exercise course

Expected change

Sustained exercise will improve the relative health gain generated by PR.

There were no papers identified in the literature review which suggested that exercise programmes following PR would impact other areas of the pathway. An economic evaluation conducted by Burns et al. alongside a randomised controlled trial comparing people who undertook a maintenance programme following PR versus just PR gave mixed results and concluded that further research was needed (Burns et al., 2016). It did suggest that there was a 72.9% probability that the intervention was cost-effective using the NICE threshold of £20,000 per QALY gained, but also noted that there was no statistically significant difference in outcomes after 12 months (based on the COPD respiratory questionnaire and QALY gains). This was due to the fact that any improvement following the programme was not sustained.

Scenario

It is not known how many people would take up the offer of Breathe Easy exercise groups following PR. Therefore, we have modelled three scenarios:

- 10% of people who complete PR attend the post-PR exercise groups
- 25% of people who complete PR attend the post-PR exercise groups
- 50% of people who complete PR attend the post-PR exercise groups.

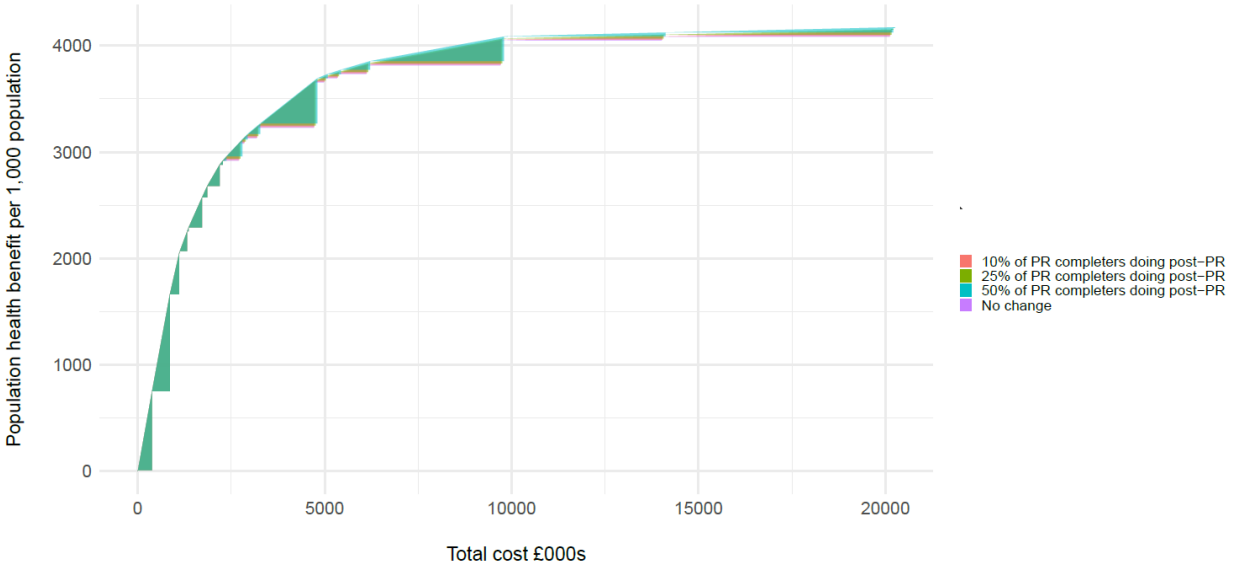

Figure 16 – Expected change to the pathway following the implementation of a post-PR exercise course

As there are no cost savings expected elsewhere in the pathway, this pathway improvement is likely to be cost-incurring. The population health gain that this improvement would generate is also uncertain; it depends on how likely people are to engage with the exercise classes, and this number is likely to be modest. Even if 50% of people completing PR attend the courses, it would only benefit 451 people. It is likely that participation in this course would drop off over time (Burns et al., 2016).

Metric	Total	Interpretation
Total additional pathway costs • 10% of people who complete PR • 25% of people who complete PR • 50% of people who complete PR	£19,800 £49,500 £99,220	This intervention is relatively cheap, but there are no estimated cost savings elsewhere in the pathway.
Additional cost / additional population health ratio	2.44	This pathway improvement would cost £2.44 for every additional unit of population health gain it generates.

Cost ratio	N/A	There are no expected cost savings due to this improvement.

Introducing a referral pathway to Breathe Easy groups

Expected change

Breathe Easy groups become part of the referral pathway being offered to patients, where appropriate. This would expand the number of people accessing this service.

Lack of peer and social support is related to decreased physical activity, a lower likelihood of quitting smoking and lower pneumococcal vaccination rates alongside social isolation. Peer support programmes can help people manage their symptoms and reduce exacerbations (Fan & Coultas, 2022).

A randomised controlled trial looking at healthcare professional support and peer support compared with healthcare professional support alone found fewer COPD-related acute care events after three months (incidence rate ratio 0.68, 95% CI 0.50–0.93) and six months (incidence rate ratio 0.84, 95% CI 0.71–0.99) (Aboumatar et al., 2022). However, this improvement is not maintained after nine months (incidence rate ratio 1.08, 95% CI 0.84–1.39), and therefore the results of this study have not been used in this modelling exercise.

Scenario

The additional uptake in activity that this would generate for Breathe Easy is not known. Therefore, we look at what increasing capacity by 10, 25 and 50% would look like.

- 10% increase in uptake
- 25% increase in uptake
- 50% increase in uptake

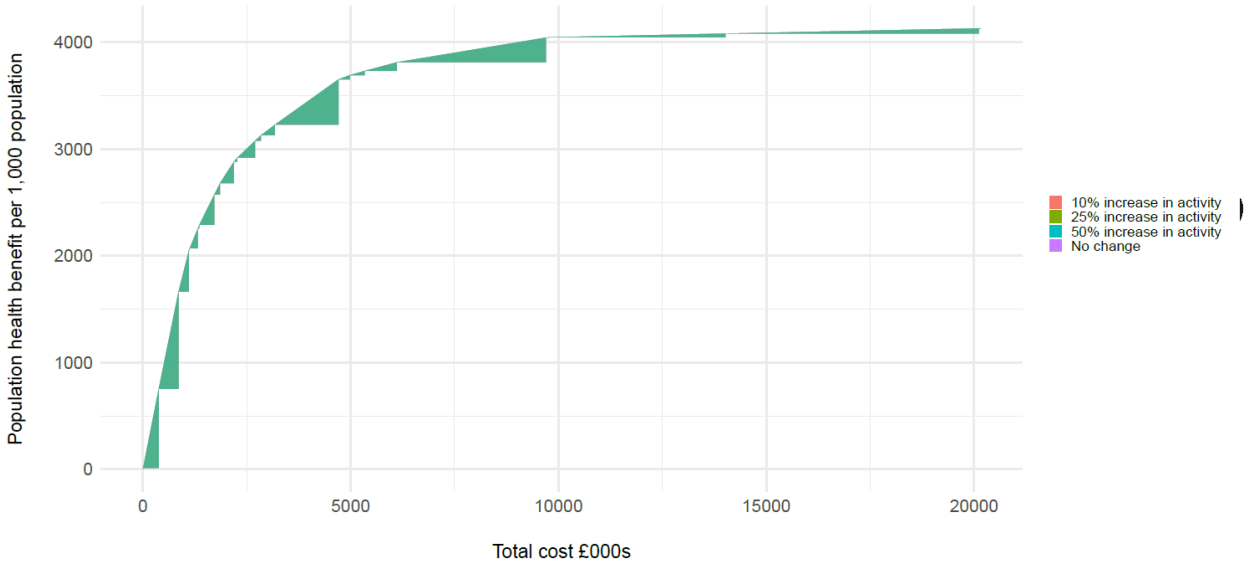

Figure 17 – Expected change to the pathway following the implementation of a referral pathway to Breathe Easy

Breathe Easy groups are relatively cheap to run compared with the other improvements suggested here for the additional population health gain they are expected to generate. However, as the total number of people they could reach is modest (even a 50% increase in uptake would only lead to 88 extra people attending the groups), the overall effect on the pathway is likely to be minimal. This means that all three scenarios are virtually indistinguishable from each other in the efficiency frontier in figure 17. The challenge will be in scaling up the groups, as they currently rely on volunteers to run. Support should be given to Asthma and Lung UK if this pathway improvement is prioritised.

Metric	Total	Interpretation
Total additional pathway costs	10%: £558.54 25%: £1,365.32 50%: £2,730.64	Although there are no expected cost savings elsewhere in the pathway due to this improvement, it is relatively cheap.
Additional cost / additional population health ratio	0.50	This pathway improvement would cost £0.50 for every additional unit of population health gain it generates.

Cost ratio	N/A	There are no expected cost savings due to this improvement.

Determining the next steps: setting priorities

Using the results of the modelling for decision-making

The modelling approach outlined in the previous sections produces three outputs which can be used for priority-setting:

- **Ranking interventions by cost/population health ratio.** Prioritising in this way will help to ensure that the pathway improvements taken forward will produce the most health within the given available budget. The lower the ratio, the better, with a negative ratio representing interventions that are both cost-saving and health-generating. The ratio for each pathway improvement is, in and of itself, meaningless; it only has meaning in comparison to the cost/population health ratios of other pathway improvements.
- **Ranking interventions by cost ratio.** Prioritising in this way can determine the pathway improvement that will offset the most costs elsewhere in the system. The bigger the ratio, the better.
- **Ranking interventions by total additional pathway cost.** Like looking at the cost ratio, this method can determine whether the pathway improvement is likely to save money overall or incur additional costs. Negative numbers represent a cost saving.

We recommend that priority-setting of the pathway improvements is done based on the cost/population health ratio. Using this method will ensure the most efficient allocation of resources based on cost per unit of population health gain, thereby improving the value for money of the pathway.

A ranking of the pathway improvements by their cost/population health ratios is displayed in the table below. Where the modelled improvements include multiple scenarios with different outcomes, the scenarios have been displayed separately.

Ranking	Pathway improvement (scenario)	Cost/population health ratio
1	Improving case-finding by targeted COPD screening (most optimistic scenario)	-5.28
2	Improving case-finding by targeted COPD screening (most pessimistic scenario)	-3.48
3	Making every contact count	-0.10
4	Conducting patients' yearly reviews through group consultations	0.00
5	Introducing a referral pathway to Breathe Easy groups	0.50
6	Improving uptake of smoking cessation services (increasing uptake to meet the 5% target set by NICE)	0.67
7	Improving uptake of smoking cessation services (doubling the number of people with COPD who set quit dates)	0.72
8	Expanding the INTENT smoking prevention programme in schools	1.45
9	Offering a post-PR exercise course	2.44
10	Expanding access to PR	8.79
11	Expanding affordable warmth schemes	36.48

Recommendations

Based on the results presented in the above table, it is recommended that Nottingham and Nottinghamshire ICS invest in the pathway improvements that have the best cost/population health ratio, as this will ensure the investment leads to the most health

generated per pound spent. It is recommended that the ICS focus on the following interventions:

- **Implement a three-stage process to identify more undiagnosed COPD cases.** This pathway improvement is expected to be the most cost-saving of any of those suggested here. In the most optimistic scenario, it is estimated to save £1,344,055, and in the most pessimistic scenario it is estimated to save £196,521.37.
- **Mandate GPs to offer VBA on smoking cessation during COPD yearly reviews (making every contact count).** Even though this improvement is only expected to lead to a small number of additional people quitting (243) per year, the fact that it is inexpensive for clinicians to offer this advice makes it cost-effective.
- **Conducting patients' yearly reviews through group consultations to improve the quality of primary care case management.** Offering group consultations for yearly reviews is effectively cost-neutral in all three scenarios modelled (whether 10, 25 or 50% of time spent on yearly reviews is devoted to group consultations). At the same time, a large amount of net population health gain is generated by this improvement due to the extra people who will receive a yearly review.
- **Introducing referral pathways to Breathe Easy.** As the Breathe Easy groups are relatively inexpensive to run, these scenarios are expected to be cost-effective. However, as the groups currently rely on volunteers, they may not be easy to scale up. Therefore, Asthma and Lung UK should be supported if this improvement is taken forward.
- **Improving uptake of smoking cessation services.** Both scenarios modelled for this pathway improvement are expected to be cost-effective. Doubling the number of people with COPD who set quit dates will have a more immediate impact on the COPD pathway due to the expected number of hospital admissions (21) and acute exacerbations (58) it is expected to avoid. However, smoking cessation as primary prevention would have wider benefits outside of the COPD pathway that it is important to consider.

Investing in all these pathway improvements would have a yearly budget impact (sum of the additional costs of the improvements) of at most £872,714.20 and at the least £407,901.94, dependent on how many people come forward for spirometry testing through targeted screening, what percentage of time for yearly reviews is spent on group consultations, and how many people come forward for the Breathe Easy groups.

If the targeted COPD screening is successful, it could save up to £1,344,055, which would save more money – due to a reduction in hospital admissions and acute exacerbations – than the cost of all the suggested pathway improvements combined. The challenge is being able to release the savings from the screening into other parts of the system.

Discussion

This report outlines the use of the STAR methodology for prioritising interventions in the COPD pathway for Nottingham and Nottinghamshire ICS.

The aim of the project was to design an engagement process and choose a prioritisation technique that would lead to recommendations on how best to invest resources in the COPD pathway in a robust and evidence-based way.

The STAR approach included facilitated workshops, called decision conferences, during which numerous stakeholders from across the Nottinghamshire ICS were asked to discuss and identify the main challenges faced in the COPD pathway. This led to a list of interventions that were seen as likely to improve the quality of life of people with COPD and reduce health inequalities – ultimately improving the COPD pathway, as well as allocating resources most effectively. By applying STAR, the five most impactful or cost-effective interventions were identified. With budget limitations, local commissioners can use this information to make decisions around how best to invest resources, with a clear understanding of the possible benefits and opportunity cost elsewhere in the pathway.

For some of the interventions, it was more challenging to estimate the potential impact because there was very little information upon which to base a judgement in terms of outcomes and cost implications. This meant that several assumptions were made, such as only including impacts to the COPD pathway where they could be evidenced through the literature review. Similarly, it was not possible to evidence the potential capital or programme costs that may be involved in the development of the pathway improvements within the timeframe of this project. These may affect the cost/population health ratios if they were included.

Different examples of the STAR approach use different methods for valuing the individual health gain generated by the interventions. Here we used the method employed by Airoldi et al. (assessing each intervention on the VAS, as described in the **methods document**) (Airoldi et al., 2014). Elsewhere, The Health Foundation have taken a different approach to modelling; for example, they weighted the quality of life of patients with different severities of eating disorders and calculated the proportion of patients who would deteriorate, stay the same or, to varying degrees, recover, and the resulting average quality of life (The Health Foundation, 2012).

The Airoldi et al. method was chosen here, in part because it encourages participants to think about the principle of ‘relativity’ of the interventions and improvements; that is, to directly compare the health gains of each intervention together. Also, the large number of interventions that needed to be valued meant that the Health Foundation method would not have been practical in the time available. It is possible that using different methods to

generate the individual health gains generated by each intervention and improvement would give a different bearing on the results.

The results for Nottingham indicate that case-finding for COPD would be the most cost-effective intervention. However, it is important to note that we have not factored in the cost of treating the additional cases of COPD identified. If we use the expected cost per person of £523.27 as described in the **summarising the results** section, in the most optimistic scenario, where an extra 2,679 people are diagnosed, this would have an associated cost of £1,401,840.33 (plus the additional drug costs, which are out of scope of this piece of work, as described in the **methods document**). Including the estimated costs of the case-finding itself, it would cost a total of £1,882,352.33 and incur a cost of £57,785.33 after considering the cost savings. That said, even taking this into account, the cost/population health ratio would still be 0.23, so this would still be the third-ranked improvement.

Limitations

There are some limitations that should be kept in mind when interpreting this work.

There is a lack of available data in the literature regarding the impact on healthcare resource use of the pathway improvements. In most cases, the literature review only identified impacts on urgent care (hospitalisations and exacerbations). The impacts of improvements on other elements of the pathway are not known.

Pharmacological treatments were out of scope of this project, and therefore the costs used do not include the cost of pharmacotherapies for standard COPD (e.g., the cost of inhalers).

The pathway improvements modelled below have been developed to support decisions on where best to allocate resources by looking at how each pathway improvement could affect the allocation of resources across the entire COPD pathway. They are not meant to represent an accurate reflection of the costs and benefits of the COPD pathway pre- and post-improvement, nor do they represent a full economic evaluation. Further work would be required to build these scenarios into business cases or to conduct a full economic evaluation.

Appendix

1. Methodology document

STAR method document Notts ICS v

2. Information pack for attendees

SSPH Decision Conference Participan

3. Sources for the population pyramid

The below provides details on the sources that were used to create the tables in section 3.

1. **Total number of people with COPD registered with a GP in Nottinghamshire:** eHealthScope.
2. **COPD population by severity level:** eHealthScope.
3. **Estimated undiagnosed population:** Nacul et al. (2007) estimated that in 2007, the true prevalence of COPD in the country was 3.1%. This estimate is the difference between QOF register prevalence and this expected true prevalence. https://pophealthmetrics.biomedcentral.com/articles/10.1186/1478-7954-5-8
4. **Estimated number of smokers:** Lower estimate: QOF register – estimated smoking prevalence among people over the age of 18 in Nottingham and Nottinghamshire CCG in 2020/21. https://fingertips.phe.org.uk/search/QOF#page/1/gid/1/pat/15/ati/167/are/E38000243/iid/114/age/1/sex/4/cat/-1/ctp/-1/yrr/1/cid/4/tbm/1
5. **Total population registered with a GP in Nottingham and Nottinghamshire:** QOF register – numbers of people on GP practice lists in 2020/21 https://qof.digital.nhs.uk/.

4. Data sources for the efficiency frontier

Primary prevention

Smoking cessation

Metric	TOTAL	Source
Relative benefit score	100	Agreed upon by stakeholders in the first decision conference.
Number of people treated:	4,824	Data for period 2021/22 provided by Notts CC. (Notts City data from NHSD).
Number who benefit: **Number who quit after four weeks**	2,833	
Cost per person setting a quit date	£74.52	2021/22 According to Notts CC, the cost of NRT per referral is £30.55. It is not possible to disaggregate the cost of the rest of the service as it is provided as part of an integrated well-being service. Therefore we have estimated the cost of advisor support based on the PSSRU estimate of 90 minutes minimum per person with an advisor at a cost of £29.31 per hour (£43.97 for 90 minutes).

Primary care health checks

Metric	TOTAL	Source
Relative benefit score	65	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of people reviewed**	11,410	Data on Primary Health Checks 2017/18 Assumed everyone benefits.
Number who benefit: **Number of people reviewed**	11,410	
Cost per person	£33	Average cost of GP surgery consultation according to PSSRU.

INTENT smoking cessation in schools

Metric	TOTAL	Source
Relative benefit score	90	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of secondary school children in the ICS**	13,637	Assumed remaining number of schoolchildren (aged 12–16) who (according to ONS) are in the three-quarters of schools not already involved in the INTENT programme.
Number who benefit: **Number of smokers and vapers expected to not smoke or vape due to the programme**	419	According to NHS Digital, 9% of school-aged children smoke and 3% vape – a total of 12%. Here we assume the benefit is to people who stop smoking and vaping. According to INTENT, people are 25.6% less likely to smoke since going through their programme.
Cost per person setting a quit date	£6.30	Average cost per school pupil (based on £205 per quitter).

Secondary prevention and diagnosis

Diagnosis with spirometry

Spirometry in GP practices

Metric	TOTAL	Source
Relative benefit score	95	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of people given a spirometry test**	1,955	eHealthScope – Spirometry (GP) 2021/22 – all ages.
Number who benefit: **Number of patients with a diagnosis of COPD confirmed using spirometry**	541	eHealthScope.
Cost per person	£72	This figure based upon tariff cost provided by Northamptonshire.

Spirometry in secondary care

Metric	TOTAL	Source
Relative benefit score:	95	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of people given a spirometry test**	3,770	Pulled from the 2021/22 outpatient dataset in the secondary user services (SUS) database using a procedure code of E93.2 for spirometry.
Number who benefit: **Number of people diagnosed with COPD following a spirometry test**	1,044	Assumed the same diagnosis rate as in primary care.
Cost per case: **Cost per spirometry test**	£89.40	Pulled from the 2021/22 outpatient dataset in SUS using a procedure code of E93.2 for spirometry.

Respiratory vaccinations

COVID-19 vaccinations

Metric	TOTAL	Source
Relative benefit score:	90	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of vaccinated COPD patients**	22,105	GPRCC, 2021/22 activity data.
Number who benefit: **Number of avoided acute exacerbations**	2,234	Assumed same as influenza.
Cost per person	£15	Item of Service cost (excluding housebound) from NHSE. Based on Northamptonshire return.

Pneumonia vaccinations

Metric	TOTAL	Source
Relative benefit score	90	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of vaccinated COPD patients**	14,165	PPV coverage monitoring for England 2021; assumes 56.14% of COPD patients have some coverage from PPV.
Number who benefit: **Number of avoided acute exacerbations**	1,771	According to a Cochrane review, the number of patients needed to treat to prevent a patient from experiencing an exacerbation is eight (Walters et al., 2017).
Cost per person	£30	£30 for PPV (Pharmacy prices). Annualised value used for the analysis. Based on Northampton.

Influenza vaccinations

Metric	TOTAL	Source
Relative benefit score:	90	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of COPD patients given an influenza vaccination**	20,515	GPRCC, 2021/22 activity data.
Number who benefit: **Number of avoided acute exacerbations**	2,072	According to a pooled estimated in a recent Cochrane review, on average, people receiving a flu vaccine had 0.37 fewer exacerbations than people receiving a placebo (Kopsaftis et al., 2018). The means that 9.90 people would need to be treated to avoid one additional exacerbation. This number assumes there is only one avoided exacerbation per person (20,515 / 9.90).
Cost per person	£9.58	2021/22 Item of service cost. Based on Northampton.

Case management

Primary care management

Metric	TOTAL	Notes
Relative benefit score:	75	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of people reviewed by their GP**	12,148	2020/21 QOF Register.
Number who benefit: **Number of people reviewed by their GP**	12,148	2020/21 QOF Register.
Cost per person	£39.23	Costs are the same as outlined in the PSSRU for a GP consultation including consultation costs.

.Community COPD service case management

Metric	TOTAL	Source
Relative benefit score	95	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of patients with COPD on case load**	2,427	This number assumes the % of total patients with COPD accessing the community service in Bassetlaw is the same as elsewhere in the county.
Number who benefit: **Number of patients with COPD on case load**	2,427	
Cost per person setting a quit date	£1,477.04	Assumes cost is equivalent across all services.

Secondary care outpatient appointments

Metric	TOTAL	Source
Relative benefit score:	33	Score given in the decision conferences.
Number treated: **Number of outpatients attendances**	12,865	2021/22 linked data GPRCC/SUS, number of OP attendances in TFC 340 or 341 for COPD patients with associated costs.
Number who benefit: **Number of outpatient attendences**	12,865	2021/22 linked data GPRCC/SUS, number of OP attendances in TFC 340 or 341 for COPD patients with associated costs.
Cost per person	£119	Linked Data GPRCC/Community.

Tertiary prevention

Pulmonary rehabilitation

Metric	TOTAL	Source
Relative benefit score:	90	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of accepted referrals to PR (all patients)**	2,249	2021/22 provider data for all ICPs except Bassetlaw. Bassetlaw based on rates in other areas. Data for all patients, not just COPD.
Number who benefit: **Number who complete the course**	901	
Cost per person	£346	2021/22 NHSE National Tariff. Local cost estimates not available.

Group therapy: Breathe Easy

Metric	TOTAL	Source
Relative benefit score:	62	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of patients with COPD seen by Breathe Easy in a 12-month period**	175	According to Breathe Easy Nottingham there are between 25 and 45 people per group. Have used lower estimate as more reflective of care now.
Number who benefit	175	Assumed everyone benefits.
Cost per person	£31.03	Cost of running support group is around £1,086.15 according to ALUK. Estimated group attendance of 35 people.

Oxygen therapy (ambulatory)

Metric	TOTAL	Source
Relative benefit score:	90	Agreed upon by stakeholders in the first decision conference.
Number of people treated (ambulatory and long-term)	436	Average number of patients on ambulatory oxygen therapy between May 2021 and April 2022 (April 2021 data not provided, so used May–April to represent financial year). Have used average to avoid double-counting patients (i.e., patients being prescribed ambulatory oxygen therapy over multiple months).
Number who benefit:	436	Assumed everyone receiving oxygen benefits.
Cost per person	£623	Cost per patient for providing oxygen therapy for a year. Total cost £271,893.97 divided by 436 (average number of people on oxygen therapy each month).

Oxygen therapy (long-term)

Metric	TOTAL	Source
Relative benefit score:	90	Agreed upon by stakeholders in the first decision conference.
Number of people treated (long-term)	378	Average number of patients on LTOT between May 2021 and April 2022. No data provided for April 2021 so have used this 12-month period. Average has been used to avoid double-counting patients who receive therapy over multiple months.
Number who benefit:	378	Assumed everyone benefits.
Cost per person	£96	Average cost per patient provided by Regional Lead for Home Oxygen (East Midlands)

Lung volume reduction

Metric	TOTAL	Source
Relative benefit score:	13	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of people undergoing LVRS**	5	Extracted from the 20/21 secondary user services (SUS) database. The number of people registered with a GP in Nottingham or Nottinghamshire who had an admitted patient episode with the OPCS code for LVR surgery (E54.6) (rounded to nearest five for low number suppression).
Number who benefit:	4	Based on assumption that 20% of people say they receive no benefit.
Cost per person	£7,700	Extracted from SUS as above.

Smoking cessation

Metric	TOTAL	Source
Relative benefit score:	98	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of people referred**	1,865	Data provided by Nottingham City Council Proportion of people undertaking programme with COPD from City data has been applied to Notts County data.
Number who benefit: **Number who quit**	1,088	
Cost per person setting a quit date:	£74.52	2021/22 According to Notts CC, the cost of NRT per referral is £30.55. It is not possible to disaggregate the cost of the rest of the service as it is provided as part of an integrated well-being service. Therefore we have estimated the cost of advisor support based on the PSSRU estimate of 90 minutes minimum per person with an advisor at a cost of £29.31 per hour (£43.97 for 90 minutes).

Warm homes

Metric	TOTAL	Source
Relative benefit score:	65	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of people with a respiratory condition given support**	39	NOTE: only Rushcliffe council was able to provide the total number of people given support and the people with COPD given support. Have assumed that the proportion of people with COPD receiving support is the same in other district councils.
Number who benefit: **Number of people with a respiratory condition given support**	39	
Cost per person	£2,370.97	Average cost of schemes provided by district councils.

IAPT services

Metric	TOTAL	Source
Relative benefit score	90	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of people with COPD referred to IAPT services (excl. Bassetlaw)**	215	SUS
Number who benefit: **Number of people with COPD referred to IAPT services (excl. Bassetlaw)**	215	
Cost per person	£86	Used the PLICS national data to derive the average cost of an IAPT appointment.

Management of acute exacerbations

Primary care management

Metric	Total	Source
Relative benefit score:	70	Agreed upon by stakeholders in the first decision conference.
Number treated: **Number of patients receiving 12 or 13+ 5mg prednisolone prescription**	5,511	There is no readily available data on acute exacerbations managed in primary care. Therefore, prednisolone prescriptions of 12 or more 5-mg tablets have been sourced from e-pact as a proxy. This will capture prescriptions for people with other respiratory conditions as well as COPD. The use of a nebuliser may also be required.
Number who benefit: **Number of patients receiving 12 or 13+ 5mg prednisolone prescription**	5,511	

		The assumption has been confirmed by a GP specialising in respiratory medicine.
Cost per person	£45.19	According to Maisun Elftise, GP in Coventry, a patient whose AECOPD is managed in primary care will be seen by the GP and given a rescue pack (prednisolone 5mg tablets, nebuliser vial and a nebuliser). According to BNF, the NHS tariff for prednisolone per pack of 28 tablets is £0.79. Assuming that the AECOPD would take the same amount of time as a GP appointment, that would make the estimated cost of managing a AECOPD in primary care £45.19.

Hospital admission

Emergency attendances

Metric	TOTAL	Notes
Relative benefit score:	23	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of people admitted for acute exacerbation of COPD**	1,735	Data for 2021/22. Extracted from SUS emergency care database using COPD SNOMED codes. This is likely to be an underestimate as people will attend for breathlessness without realising they have COPD, or the SNOMED codes are not recorded.
Number who benefit: **Number of people admitted for acute exacerbation of COPD**	1,735	
Cost per person	£205.20	

Hospital admissions

Metric	TOTAL	Notes
Relative benefit score:	23	Agreed upon by stakeholders in the first decision conference.
Number of people treated	2,135	Pulled from the 2021/22 admitted patient care dataset in SUS using the same strategy as PHE Fingertips (activity). Activity data rounded. Upper estimate using the COPD code (J44) in any position: 18,982 admissions at a total cost of £49,426,939 (£2,604 per admission). Lower estimate – using the AECOPD code (J449) in the primary position: 2,042 admissions at a total cost of £5,845,734 (an average of £2,863 per admission).
Number who benefit: **Number of people admitted for acute exacerbation of COPD**	2,135	
Cost per person	£2,856	

Respiratory assessment unit

Metric	TOTAL	Source
Relative benefit score	30	Agreed upon by stakeholders in the first decision conference.
Number of people treated: **Number of people admitted with COPD**	1,152	Data for 2021/22 only available for Morton Ward NOT ARCU (advanced respiratory care unit). Total cost of spells is £4,226,525.66. Assumed everyone benefits.
Number who benefit: **Number of people admitted with COPD**	1,152	
Cost per person	£3,668.86	

5. Assessing the impact of the proposed improvements: data sources and calculations

Expanding the INTENT smoking prevention programme in schools

Metric	Value	Description
Cost per person of programme (C)	£6.30	The estimated cost per person of including one pupil in Nottinghamshire on the INTENT programme. This figure is the same as the one that was used in the **efficiency frontier.**
Benefit (B)	100	Score given to primary prevention smoking cessation and tobacco control in the decision conference.
Number treated: Number of additional pupils included on the INTENT Programme (Nt)	45,632	According to ONS estimates, there are 60,843 pupils aged between 12 and 16 in the eight local authority districts that make up Nottingham and Nottinghamshire ICS (Nottingham, Ashfield, Bassetlaw, Broxtowe, Gedling, Mansfield, Newark and Sherwood, and Rushcliffe). 12 out of 48 (25%) schools are already covered. Assuming this equates to 25% of pupils aged between 12 and 16 who have already received the programme, there are 45,632.25 pupils who are yet to be covered by an INTENT programme.
Number who benefit: Number of smokers and vapers avoided (N)	1,402	According to INTENT, children are 25.6% less likely to smoke due to their programme (University of Leeds, 2020). According to NHS Digital, 3% of school-aged children in the country smoke and 9% vape (NHS Digital, 2022). Assumed someone either smokes or vapes. Here we assume the risk of developing COPD from vaping is the same as that from smoking. So an

		estimated 12% of school-aged children currently smoke in Nottinghamshire. Therefore, it can be expected that, due to the INTENT programme, 3.07% (0.12 × 0.256) of children would avoid smoking. 45,632 × 0.03072 = 1,401.82
Additional costs of pathway improvement	£287,481.60	Number of additional pupils on the INTENT programme × cost per person. 45,632 × 6.3
Additional population health gain	140,200	Number of avoided smokers and vapers × benefit score 1402 × 100
Pathway effects		
Number of avoided cases of COPD	160	NNT = 1/absolute risk reduction (ARR) ARR = control event rate – experiment event rate Terzikhan et al. reported the incidence of COPD in current smokers was 19.7/1000 person years (PY) and 8.3/1000 PY in former smokers. ARR = 0.197 – 0.083 = 0.114 NNT = 1/0.114 = 8.77 Number of expected avoided cases of COPD per year: 1402/8.77 = 159.86. This is expected to save £523.27 per case avoided per year.
Cost savings	£83,723.20	Number of avoided cases of COPD × expected cost of treating one person with COPD for one year 160 × 523.27

Making every contact count

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£1	The cost of the NCST training module is free. Providing VBA is free, and it could be given as part of a yearly review.
Benefit score (B)	98	The benefit score given to tertiary smoking prevention in the decision conferences as part of the original **efficiency frontier**.
Number treated: Number who have yearly reviews (Nt)	12,148	The number of people who had a yearly review in 2021/22, according to the QOF register and used in the original **efficiency frontier**.
Number who benefit: Number additional who quit (N)	243	Stead et al. (2008) suggested that a further 1–3% additional people would quit due to a VBA intervention. Taking the mid-point of an extra 2% of people quitting, that would mean 243 of the 12,148 people who receive yearly reviews would quit smoking as a result of the VBA intervention.
Additional population health gain	23,814	Benefit score × additional number who quit. 98 × 243
Additional costs of pathway improvement	£12,148	Cost per person × number who have yearly reviews. 1 × 12148
Pathway effects		
Reduction in hospitalisations	5	NNT = (1 – (PEER × (1 – HR))) / ((1 – PEER) × (PEER) × (1 – HR)) Godtfredsen et al. (2002) reported a HR of 0.57.

		In 2021/22 there were 725 hospital admissions for COPD among 15,328 people. Therefore, the patient expected event rate is 4.7 per 100 people (725/15,328). NNT = (1 – (0.047 × (1 – 0.57))) / ((1 – 0.047) × (0.047) × (1 – 0.57)) = 50.87. Reduction in hospitalisations = 243/50.87 = 4.78 The unit cost for a hospital admission is £2,855.05 as used in the original **efficiency frontier**.
Reduction in primary care-managed AECOPD	8	In 2021/22 there were an estimated 5,234 primary care-managed AECOPD among 15,328 people with COPD. Therefore, the expected event rate is 34.15 per 100 people (5,234/15,328 × 100). Au et al. (2009) reported a HR of 0.78. NNT = (1 – (0.3415 × (1 – 0.78))) / ((1 – 0.3415) × (0.3415) × (1 – 0.78)) = 18.69. Reduction in primary care-managed AECOPD = 143/18.69 = 7.65. The unit cost for a primary care-managed AECOPD is £45.19.
Cost savings	£14,636.77	Cost of hospital admission × expected reduction in hospital admissions + number of primary care-managed AECOPDs avoided × cost of primary care-managed AECOPD. (2,855.05 × 5) + (8 × 45.19)

Improving uptake of smoking cessation services

Increasing uptake to meet the 5% target set by NICE

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£74.52	Cost of smoking cessation programmes used in the original **efficiency frontier**.
Primary prevention		
Benefit score (B)	100	Benefit score attributed to primary prevention smoking cessation in the decision conference.
Number treated: Number of additional people setting a quit date (Nt)	1,271	An extra 1,762 people would need to set a quit date to meet the NICE target of 5% of the smoking population setting a quit date. Assuming that 27.88% of people setting a quit date have COPD (the same rate as used in the original **efficiency frontier**), the remainder would be for primary prevention. 1,762 – (1,762 × 0.2788) = 1,270.75
Number who benefit: Number who quit (N)	746	Assuming the same quit rate for primary prevention as the original efficiency frontier of 58.73%.
Tertiary prevention		
Benefit score (B)	98	Benefit score attributed to tertiary prevention smoking cessation in the decision conference.
Number treated: Additional number of	491	27.88% of the total number of people setting quit dates are expected to have COPD.

people setting a quit date **(Nt)**		
Number who benefit: **Number who quit** **(N)**	286	Assuming the same quit rate for primary prevention as the original **efficiency frontier** of 58.33%.
Additional population health gain	102,628	Benefit score (tertiary prevention) × number who quit (tertiary prevention) + benefit score (primary prevention) × number who quit (primary prevention). (98 × 286) + (100 × 746)
Additional costs of pathway improvement	£131,304.24	Cost of smoking cessation programme × number of people setting a quit date (primary and tertiary prevention). 74.52 × (491 + 1,271)
Pathway effects		
Reduction in number of people developing COPD	85	NNT = 1/absolute risk reduction (ARR) ARR = control event rate – experiment event rate Terzikhan et al. (2016) reported incidences of COPD of 19.7/1000 PY in current smokers and 8.3/1000 PY in former smokers. ARR = 0.197 – 0.083 = 0.114 NNT = 1/0.114 = 8.77 Reduction in number of people developing COPD = 746/8.77 = 85.06. This is expected to save £523.27 per case avoided per year.
Reduction in hospitalisations	6	NNT = (1 – (PEER × (1 – HR))) / ((1 –PEER) × (PEER) × (1 – HR))

		Godtfredsen et al. (2002) reported a HR of 0.57. In 2021/22 there were 725 hospital admissions for COPD among 15,328 people. Therefore, the patient expected event rate is 4.7 per 100 people (725/15,328). NNT = (1 – (0.047 × (1 – 0.57))) / ((1 – 0.047) × (0.047) × (1 – 0.57)) = 50.87. Reduction in hospitalisations = 289/50.87 = 5.68. The unit cost for a hospital admission is £2,855.05.
Reduction in primary care-managed AECOPD	15	In 2021/22 there were an estimated 5,234 primary care-managed AECOPDs among 15,328 people with COPD. Therefore, the expected event rate is 34.15 per 100 people (5,234/15,328 × 100). Au et al. (2009) reported a HR of 0.78. NNT = (1 – (0.3415 × (1 – 0.78))) / ((1 – 0.3415) × (0.3415) × (1 – 0.78)) = 18.69. Reduction in primary care-managed AECOPDs = 286/18.69 = 15.30. Unit cost of primary care-managed AECOPDs = £45.19.
Cost savings	£62,286.10	Number of cases of COPD avoided × expected cost of treating someone with COPD for a year + number of hospital admissions avoided × cost of a hospital admission + cost of a primary care-managed AECOPD × number of AECOPDs avoided. (85 × 523.27) + (6 × 2855.05) + (45.19 × 15)

Doubling the number of people with COPD who set quit dates

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£74.52	Cost of smoking cessation programmes used in the original efficiency frontier.
Tertiary prevention		
Benefit score (B)	98	Benefit score attributed to tertiary prevention smoking cessation in the decision conference.
Number treated: Number of additional people setting a quit date (Nt)	1,865	The number of people with COPD who set a quit date used in the original **efficiency frontier**.
Number who benefit: Number who quit (N)	1,088	Assuming the same quit rate for primary prevention as the original **efficiency frontier** of 58.33%.
Additional population health gain	106,624	Number of people who quit × benefit score. 1,088 × 98
Additional costs of pathway improvement	£138,979.80	Number of people setting a quit date × cost per person of smoking cessation programme. 1,865 × 74.52
Pathway effects		
Reduction in hospitalisations	21	NNT = (1 – (PEER × (1 – HR))) / ((1 – PEER) × (PEER) × (1 – HR))

		Godtfredsen et al. (2002) reported a HR of 0.57. In 2021/22 there were 725 hospital admissions for COPD among 15,328 people. Therefore, the patient expected event rate is 4.7 per 100 people (725/15,328). NNT = (1 – (0.047 × (1 – 0.57))) / ((1 – 0.047) × (0.047) × (1 – 0.57)) = 50.87. Reduction in hospitalisations = 1088/50.87 = 21.38. The unit cost for a hospital admission is £2,855.05.
Reduction in primary care-managed AECOPD	58	In 2021/22 there were an estimated 5,234 primary care-managed AECOPDs among 15,328 people with COPD. Therefore, the expected event rate is 34.15 per 100 people (5,234/15,328 × 100). Au et al. (2009) reported a HR of 0.78. NNT = (1 – (0.3415 × (1 – 0.78))) / ((1 – 0.3415) × (0.3415) × (1 – 0.78)) = 18.69. Reduction in primary care-managed AECOPDs = 1088/18.69 = 58.21. The unit cost of a primary care-managed AECOPD is £45.19.
Cost savings	£62,577.07	Number of hospital admissions avoided × cost of a hospital admission + cost of primary care-managed AECOPD × number of AECOPDs avoided. (21 × 2855.05) + (58 × 45.19)

Improving case-finding by targeted COPD screening

Most optimistic scenario

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£89.70	Costs are defined as the following: - **Identifying smokers:** 24 days a year for a band 6 analyst to identify and send update to high-risk people at £55 an hour: £9,900 (55 × 7.5 × 24) (Burns & Jones, 2021). - **Responding to queries**: 0.2 FTE × NHS band 6 annual salary: 41.9 weeks (1,573 hours) per year, 37.5 hours per week: £17,303. - **Survey administration costs:** £5 per survey (13,521 × 5) = 67,605 - **Number of tests completed:** unit cost of spirometry test is assumed to be £72 (5,357 × 72) = £385,704 Total cost: £480,512. Per-person cost: £480,512 / 5,357 = £89.70.
Benefit score (B)	95	Benefit score attributed to spirometry testing in the decision conferences.
Number treated: Number of people tested (Nt)	5,357	Assumes that, of the 169,015 potentially at-risk people, 20% of them are contacted with the

		survey, 80% are reached, and 50% of them complete it. (169,015 × 0.2 x 0.8) x 0.5 = 13,521. Then 70% of those people come forward for testing, the same response rate as a recent breast screening programme and that 56.6% of participants score about 16.5 on the CDQ. (Johnson et al., 2021; NHS Digital, 2019). 13,521 × 0.7 × 0.566 = 5,357.10
Number who benefit: **Number of people diagnosed with COPD** **(N)**	2,679	Assume 50% diagnosis rate. 5,357 × 0.5 = 2,678.5
Additional population health benefit	254,505	Number of people diagnosed with COPD × benefit score. 2,679 × 95
Additional costs of pathway improvement	£480,512	Cost of test × number of people tested. 89.70 × 5,357
Pathway effects		
Predicted reduction in COPD hospital admissions	617	NNT = 1/absolute risk reduction (ARR) ARR = control event rate – experiment event rate After three years, Kostikas et al. (2020) report a hospitalisation rate of 73.52 per 100 PY in late-diagnosed COPD patients and

		50.46 per 100 PY in early-diagnosed COPD patients. ARR = 0.7352 – 0.5046 = 0.2306 NNT = 1/0.2306= 4.34 Predicted reduction in COPD hospital admissions: 2679/4.34 = 617.28 per year. A hospital admission has a unit cost of £2,855.05.
Predicted reduction in AECOPDs managed in primary care	1,388	After three years, Kostikas et al. report an exacerbation rate of 57.23 per 100 PY in early-diagnosed COPD patients and 108.94 per 100 PY in late-diagnosed COPD patients. ARR = 1.0894 – 0.5723 = 0.5171 NNT = 1/0.5171= 1.93 Predicted reduction in AECOPDs managed in primary care = 2679/1.93 = 1,388.08. The unit cost for a primary care-managed AECOPD is £45.19.
Cost savings	£1,824,567	Number of avoided hospital admissions × cost of a hospital admission + number of avoided primary care-managed AECOPDs × cost of primary care-managed AECOPD. (617 × 2,855.05) + (1,388 × 45.19)

Most pessimistic scenario

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£97.31	Costs are defined as the following: - **Identifying smokers:** 24 days a year for a band 6 analyst to identify and send update to high-risk people at £55 an hour: £9,900 (55 × 7.5 × 24) (Burns & Jones, 2021). - **Responding to queries**: 0.2 FTE × NHS band 6 annual salary: 41.9 weeks (1,573 hours) per year, 37.5 hours per week: £17,303. - **Survey administration costs:** £5 per survey (5,408 × 5) = £27,040. - **Number of tests completed:** unit cost of spirometry test is assumed to be £72 (2,143 × 72) = £154,296. Total cost: £208,539 Per-person cost £208,539 / 2,143 = £97.31.
Benefit score (B)	95	Benefit score attributed to spirometry testing in the decision conferences.
Number treated: Number of people tested (Nt)	2,143	Assumes that of the 169,015 potentially at-risk people, 20% are contacted each year and 80% of those contacted are reached. Of those reached, 20% complete the survey.

		(169,015 × 0.8 × 0.2) × 0.2 = 5,408.48 Then 70% of those people come forward for testing, the same response rate as a recent breast screening programme and that 56.6% of participants score about 16.5 on the CDQ. (NHS Digital, 2019). 5,408.48 × 0.7 × 0.566 = 2,142.84
Number who benefit: **Number of people diagnosed with COPD** **(N)**	594	Assume 27.7% diagnosis rate. 2,143 × 0.277 = 593.61
Additional population health benefit	56,430	Number of people diagnosed with COPD × benefit score. 95 × 594
Additional costs of pathway improvement	£208,539	Cost of test × number of people tested. 2,143 × 97.31
Pathway effects		
Predicted reduction in COPD hospital admissions	137	Predicted reduction in COPD hospital admissions: 593/4.34 = 136.64 per year. A hospital admission has a unit cost of £2,855.05.
Predicted reduction in AECOPDs managed in primary care	308	Predicted reduction in AECOPDs managed in primary care = 594/1.93 = 307.77. The unit cost for a primary care-managed AECOPD is £45.19.

Cost savings	£405,060.37	Number of avoided hospital admissions × cost of a hospital admission + number of avoided primary care-managed AECOPDs × cost of primary care-managed AECOPD. (137 × 2,855.05) + (308 × 45.19)

Conducting patients' yearly reviews through group consultations

Metric	Value	Description
Pathway improvement		
Cost of improvement **(C)**	£19.62	The estimate for the cost of a GP appointment used in the efficiency frontier above is £39.23 and, according to a GP working in Northamptonshire, the average time for a yearly review would be 15 minutes. Assuming a group consultation lasts 90 minutes, the cost would be £235.38; if 12 patients were seen in the appointment, the cost would be £19.62 per patient (39.23 × 6)/12.

Benefit score **(B)**	85	The score given in the decision conferences to primary care yearly reviews was 75. It is assumed that group consultations will improve the relative health gain by 10 points.
Number treated **(Nt)**	10%: 2,430 25%: 6,074 50%: 12,148	In 2021/22 there were 12,148 yearly reviews for patients. If each one takes 15 minutes, that is a total of 182,220 minutes spent on yearly reviews. If 10% of all this time were spent on group consultations, that would be 18,222 minutes allocated to group consultations. At 90 minutes per consultation, that would be 202 consultations. With 12 people in each one, that would be 2,430 people per year reviewed in group consultations.

		((12,148 × 15 × 0.1) / 90) × 12
Number who benefit **(N)**	10%: 2,430 25%: 6,074 50%: 12,148	Assumed everyone benefits.
Additional population health gain	10%: 206,040 25%: 516,290 50%: 1,032,580	Number of people in group consultation × benefit score. 10%: 2,424 × 85 25%: 6,074 × 85 50%: 12,148 × 85
Additional costs of pathway improvement	10%: £47,676.60 25%: £119,171.88 50%: £238,343.76	Number of people in group consultations × cost per person. 10%: 2,430 × 19.62 25%: 6,074 × 19.62 50%: 12,148 × 19.62
Pathway improvement effects		
Reduction in one-to-one GP yearly reviews due to group consultations	10%: 1,215 25%: 3,037 50%: 6,074	Assuming the times taken for both individual and group consultations remain the same, the group consultations would mean less time available for

		individual appointments. There were 12,148 yearly reviews in 2021/22. 10% of time spent on group consultations would mean 1,215 fewer individual appointments. The unit cost of a GP review is £39.23 according to the PSSRU (Burns & Jones, 2021).
Cost savings	10%: £47,644.45 25%: £119,141.51 50%: £238,283.02	Reduction in one-to-one GP yearly reviews × cost of GP review. 10%: 1,215 × 39.23 25%: 3,037 × 39.23 50%: 6,074 × 39.23

Expanding affordable warmth services

Doubling the number of people with COPD given energy efficiency improvements

Metric	Value	Description
Cost of improvement	£2,370.97	Average cost of warm home schemes used in the original efficiency frontier.

(C)		
Benefit **(B)**	65	Benefit score assigned to warm home schemes in the decision conferences.
Number additional treated **(Nt)**	39	39 people were given support in 2021/22. Doubling would mean an additional 39 treated.
Number additional who benefit **(N)**	39	Assumed everyone benefits.
Additional population health gain	2,535	Benefit score × number additional treated. 65 × 39
Additional costs of pathway improvement	£92,467.83	Cost of improvement × number additional who benefit. 2,370.97 × 39

Quadrupling the number of people with COPD given energy efficiency improvements

Metric	Value	Description
Cost of improvement (C)	£2,370.97	Average cost of warm home schemes used in the original efficiency frontier.
Benefit (B)	65	Benefit score assigned to warm home schemes in the decision conferences.
Number additional treated (Nt)	117	39 people were given support in 2021/22. Doubling would mean an additional 117 treated (39 × 3).
Number additional who benefit (N)	117	Assumed everyone benefits.
Additional population health gain	7,605	Number additional treated × benefit score. 117 × 65
Additional costs of pathway improvement	£277,403.49	Number additional treated × cost of improvement. 117 × 2370.97

Expanding access to pulmonary rehabilitation services

Referring all people with MRC score of 3+ to PR services

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£346	Cost used in the creation of the original efficiency frontier.

Benefit score **(B)**	90	Benefit score assigned to PR in the decision conference.
Number treated: **Number of accepted referrals** **(Nt)**	10,181	There were 2,249 accepted referrals for PR services in 2021/22. According to data provided by the System Analytics and Intelligence Unit (SAIU), there are 12,430 people with an MRC score of 3 and above. Therefore, there are an estimated 10,181 people remaining to be referred to PR services.
Number who benefit: **Number of people completing the course** **(N)**	4,072	Current completion rate is 40%, used in the original **efficiency frontier**.
Additional population health gain	366,480	Number who benefit × benefit score. 4,072 × 90
Additional costs of pathway improvement	£3,522,626	Number treated × cost of improvement. 10181 × 346
Pathway effects		

Reduction in hospitalisations	105	NNT = (1 – (PEER × (1 – OR))) / ((1 –PEER) × (PEER) × (1 – OR)) In 2021/22 there were 725 hospital admissions for COPD among 15,328 people. Therefore, the patient expected event rate is 4.7 per 100 people (725/15,328). NNT = (1 – (0.047 × (1 – 0.44))) / ((1 – 0.047) × (0.047) × (1 – 0.44)) = 38.82. Number of hospital admissions avoided = 4072/38.82 = 104.89. The unit cost for a hospital admission is £2,855.05.
Cost savings	£299,780.25	Reduction in hospital admissions × cost of a hospital admission. 105 × 2,855.05

Expanding referral criteria to include people with MRC score of 2+

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£346	Cost used in the creation of the original **efficiency frontier**.
Benefit score (B)	90	Benefit score assigned to PR in the decision conference.
Number treated: Number of additional people undertaking the course	2,541	According to data provided by the SAIU, there are 12,865 people with COPD and an MRC score of 1 or 2. Here we assume that half of those people have an MRC score of 2 and that 39.5% have a referral accepted. 39.5% is the number of people with an MRC score of 3 and above who were

(Nt)		referred to PR services in the county in 2021/22. (Office for Health Improvement & Disparities, 2022).
Number who benefit: **Number of additional people completing the course** **(N)**	1,016	Current completion rate is 40% used in the **baseline year**.
Additional population health gain	91,440	Number who benefit × benefit score. 1,016 × 90
Additional costs of pathway improvement	£879,186	Number treated × cost of improvement. 346 × 2,541
Pathway effects		
Reduction in hospitalisations	26	Number of hospital admissions avoided = 1016/38.82 = 26.17. The unit cost for a hospital admission is £2,855.05.
Cost savings	£72,231.30	Reduction in hospitalisations × cost of hospital admission. 26 × 2,855.05

Offering a post-PR exercise course

10% of people who undertake PR attend the post-PR exercise groups

Metric	Value	Description
Pathway improvement		
Cost of improvement	£220	According to Breathe Easy representatives in the decision

(C)		conference, the post-PR exercise group they run costs £5/6 per session. Here we have used the mid estimate of £5.50 and assumed that people would attend one course a week for 40 weeks of the year. We assume that the cost to the person covers the costs of providing the course.
Benefit score **(B)**	90	In the decision conferences, PR was given a score of 90. Here we assume that the post-PR exercise course, through maintaining the benefits of PR, would have the same score.
Number treated: **Number of people attending post-PR exercise sessions** **(Nt)**	90	According to data provided by the SAIU, 901 people completed PR in the **baseline year**. Assuming this number stays the same, 10% of people would be 90 people.
Number who benefit: **Number of people attending post-PR exercise sessions** **(N)**	90	Assumed that everyone benefits.
Additional population health benefit	8,100	Number who benefit × benefit score. 90 × 90
Additional costs of pathway improvement	£19,800	Number treated × cost of pathway improvement. 90 × 220

25% of people who undertake PR attend the post-PR exercise groups

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£220	According to Breathe Easy representatives in the decision conference, the post-PR exercise group they run costs £5/6 per session. Here we have used the mid estimate of £5.50 and assumed that people would attend one course a week for 40 weeks of the year. We assume that the cost to the person covers the costs of providing the course.
Benefit score (B)	90	In the decision conferences, PR was given a score of 90. Here we assume that the post-PR exercise course, through maintaining the benefits of PR, would have the same score.
Number treated: Number of people attending post-PR exercise sessions (Nt)	225	According to data provided by the SAIU, 901 people completed PR in the baseline year. Assuming this number stays the same, 25% of people would be 225 people.
Number who benefit: Number of people attending post-PR exercise sessions (N)	225	Assumed that everyone benefits.
Additional population health benefit	20,250	Benefit score × number who benefit. 90 × 225
Additional costs of pathway improvement	£49,500	Cost of improvement × number treated. 220 × 225

50% of people who undertake PR attend the post-PR exercise groups

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£220	According to Breathe Easy representatives in the decision conference, the post-PR exercise group they run costs £5/6 per session. Here we have used the mid estimate of £5.50 and assumed that people would attend one course a week for 40 weeks of the year. We assume that the cost to the person covers the costs of providing the course.
Benefit score (B)	90	In the decision conferences, PR was given a score of 90. Here we assume that the post-PR exercise course, through maintaining the benefits of PR, would have the same score.
Number treated: Number of people attending post-PR exercise sessions (Nt)	451	According to data provided by the SAIU, 901 completed PR in the **baseline year**. Assuming this number stays the same, 50% of people would be 451 people.
Number who benefit: Number of people attending post-PR exercise sessions (N)	451	Assumed that everyone benefits.
Additional population health benefit	40,590	Benefit score × number who benefit. 90 × 451
Additional costs of pathway improvement	£99,220	Cost of improvement × number treated. 220 × 451

Introducing a referral pathway to Breathe Easy groups

10% increase in uptake

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£31.03	Cost per person used in the original efficiency frontier.
Benefit score (B)	62	Score used in the original **efficiency frontier**.
Number treated: Number of people tested (Nt)	18	175 people attended the Breathe Easy course in the baseline year. A 10% increase would see an additional 18 people treated.
Number who benefit: Number of people diagnosed with COPD (N)	18	Assumed everyone benefits.
Additional population health benefit	1,116	Number who benefit × benefit score. 18 × 62
Additional costs of pathway improvement	£558.54	Number treated × cost of improvement. 18 × 31.03

25% increase in uptake

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£31.03	Cost per person used in the original **efficiency frontier**.

Benefit score (B)	62	Score used in the original **efficiency frontier**.
Number treated: Number of people tested (Nt)	44	175 people attended the Breathe Easy course in the baseline year. A 25% increase would see an additional 44 people treated.
Number who benefit – people diagnosed with COPD (N)	44	Assumed everyone benefits.
Additional population health benefit	2,728	Number who benefit × benefit score. 44 × 62
Additional costs of pathway improvement	£1,365.32	Cost of improvement × number treated. 31.03 × 44

50% increase in uptake

Metric	Value	Description
Pathway improvement		
Cost of improvement (C)	£31.03	Cost per person used in the original **efficiency frontier**.
Benefit score (B)	62	Score used in the original **efficiency frontier**.
Number treated: Number of people tested (Nt)	88	175 people attended the Breathe Easy course in the baseline year. A 50% increase would see an additional 88 people treated.
Number who benefit: Number of people diagnosed with COPD	88	Assumed everyone benefits.

(N)		
Additional population health benefit	5,456	Benefit score × number treated. 62 × 88
Additional costs of pathway improvement	£2,730.64	Cost × number who benefit. 31.03 × 88

6. References

Aboumatar, H., Garcia Morales, E. E., Jager, L. R., Naqibuddin, M., Kim, S., Saunders, J., Bone, L., Linnell, J., McBurney, M., Neiman, J., Riley, M., Robinson, N., Rand, C., & Wise, R. (2022). Comparing self-management programs with and without peer support among patients with chronic obstructive pulmonary disease: a clinical trial. *Annals of the American Thoracic Society*, 19(10), 1687–1696. https://doi.org/10.1513/AnnalsATS.202108-932OC

Airoldi, M., Morton, A., Smith, J. A. E., & Bevan, G. (2014). STAR – People-powered prioritization: a 21st-century solution to allocation headaches. *Medical Decision Making*, 34(8), 965–975. https://doi.org/10.1177/0272989X14546376

Au, D. H., Bryson, C. L., Chien, J. W., Sun, H., Udris, E. M., Evans, L. E., & Bradley, K. A. (2009). The effects of smoking cessation on the risk of chronic obstructive pulmonary disease exacerbations. *Journal of General Internal Medicine*, 24(4), 457–463. https://doi.org/10.1007/s11606-009-0907-y

Bolton, C. E., Bevan-Smith, E. F., Blakey, J. D., Crowe, P., Elkin, S. L., Garrod, R., Greening, N. J., Heslop, K., Hull, J. H., Man, W. D.-C., Morgan, M. D., Proud, D., Roberts, C. M., Sewell, L., Singh, S. J., Walker, P. P., & Walmsley, S. (2013). British Thoracic Society guideline on pulmonary rehabilitation in adults: accredited by NICE. *Thorax*, 68(Suppl 2), ii1–ii30. https://doi.org/10.1136/thoraxjnl-2013-203808

Bowers, N., Smith, C., & Wilkins, T. (2022). Energy efficiency of housing in England and Wales: 2022. Office for National Statistics. https://www.ons.gov.uk/peoplepopulationandcommunity/housing/articles/energyefficiencyofhousinginenglandandwales/2022

Burns, A., & Jones, K. (2021). Unit Costs of Health and Social Care 2021: 1. Services. https://www.pssru.ac.uk/pub/uc/uc2021/services.pdf

Burns, D. K., Wilson, E. C. F., Browne, P., Olive, S., Clark, A., Galey, P., Dix, E., Woodhouse, H., Robinson, S., & Wilson, A. (2016). The cost effectiveness of maintenance schedules following pulmonary rehabilitation in patients with chronic obstructive pulmonary disease: an economic evaluation alongside a randomised controlled trial. *Applied Health Economics and Health Policy*, 14(1), 105–115. https://doi.org/10.1007/s40258-015-0199-9

Centre for Evidence-Based Medicine. (n.d.). *Number Needed to Treat (NNT).* https://www.cebm.ox.ac.uk/resources/ebm-tools/number-needed-to-treat-nnt

Conner, M., Grogan, S., West, R., Simms-Ellis, R., Scholtens, K., Sykes-Muskett, B., Cowap, L., Lawton, R., Armitage, C. J., Meads, D., Schmitt, L., Torgerson, C., & Siddiqi, K. (2019). Effectiveness and cost-effectiveness of repeated implementation intention formation on adolescent smoking initiation: a cluster randomized controlled trial. *Journal of Consulting and Clinical Psychology*, 87(5), 422–432. https://doi.org/10.1037/ccp0000387

da Costa, B. R., Rutjes, A. W., Johnston, B. C., Reichenbach, S., Nüesch, E., Tonia, T., Gemperli, A., Guyatt, G. H., & Jüni, P. (2012). Methods to convert continuous outcomes into odds ratios of treatment response and numbers needed to treat: meta-epidemiological study. *International Journal of Epidemiology*, 41(5), 1445–1459. https://doi.org/10.1093/ije/dys124

Decramer, M., Miravitlles, M., Price, D., Román-Rodríguez, M., Llor, C., Welte, T., Buhl, R., Dusser, D., Samara, K., & Siafakas, N. (2011). New horizons in early stage COPD – improving knowledge, detection and treatment. *Respiratory Medicine*, 105(11), 1576–1587. https://doi.org/10.1016/j.rmed.2010.12.015

Drummond, M., Sculpher, M., Claxton, K., Torrance, G., & Stoddart, G. (2015). *Methods for the Economic Evaluation of Health Care Programmes* (4th ed.). Oxford, UK: Oxford University Press.

Edelman, D., McDuffie, J. R., Oddone, E., Gierisch, J. M., Nagi, A., & Williams, J. W. (2012, July). Shared medical appointments for chronic medical conditions : a systematic review. *VA Evidence-Based Synthesis Program Reports*. US Department of Veterans' Affairs, Washington, D.C. https://www.ncbi.nlm.nih.gov/books/NBK99785/

Fan, V. S., & Coultas, D. B. (2022). Peer support and chronic obstructive pulmonary disease self-management: a promising approach? *Annals of the American Thoracic Society*, 19(10), 1640–1641. https://doi.org/10.1513/AnnalsATS.202207-591ED

Godtfredsen, N. S. (2002). Risk of hospital admission for COPD following smoking cessation and reduction: a Danish population study. *Thorax*, 57(11), 967–972. https://doi.org/10.1136/thorax.57.11.967

Hayhoe, B., Verma, A., & Kumar, S. (2017). Shared medical appointments. *BMJ*, 358, j4034. https://doi.org/10.1136/bmj.j4034

Johnson, K. M., Sadatsafavi, M., Adibi, A., Lynd, L., Harrison, M., Tavakoli, H., Sin, D. D., & Bryan, S. (2021). Cost effectiveness of case detection strategies for the early detection of COPD. *Applied Health Economics and Health Policy,* 19(2), 203–215. https://doi.org/10.1007/s40258-020-00616-2

Kopsaftis, Z., Wood-Baker, R., & Poole, P. (2018). Influenza vaccine for chronic obstructive pulmonary disease (COPD). *Cochrane Database of Systematic Reviews*, 2018(6). https://doi.org/10.1002/14651858.CD002733.pub3

Kostikas, K., Price, D., Gutzwiller, F. S., Jones, B., Loefroth, E., Clemens, A., Fogel, R., Jones, R., & Cao, H. (2020). Clinical impact and healthcare resource utilization associated with early versus late COPD diagnosis in patients from UK CPRD database. *International Journal of Chronic Obstructive Pulmonary Disease*, 15, 1729–1738. https://doi.org/10.2147/COPD.S255414

Milner, J., & Wilkinson, P. (2017). Effects of home energy efficiency and heating interventions on cold-related health. *Epidemiology*, 28(1), 86–89. https://doi.org/10.1097/EDE.0000000000000570

Nacul, L. C., Soljak, M., & Meade, T. (2007). Model for estimating the population prevalence of chronic obstructive pulmonary disease: cross sectional data from the health survey for England. *Population Health Metrics*, 5, 8. https://doi.org/10.1186/1478-7954-5-8

NHS Digital. (2019, February 28). *Proportion of women taking up breast screening invitations falls*. https://digital.nhs.uk/news/2019/proportion-of-women-taking-up-breast-screening-invitations-falls

NHS Digital. (2022, September 6). *Decrease in smoking and drug use among school children but increase in vaping, new report shows*. https://digital.nhs.uk/news/2022/decrease-in-smoking-and-drug-use-among-school-children-but-increase-in-vaping-new-report-shows

NICE. (n.d.). Chronic obstructive pulmonary disease: what are the risk factors? https://cks.nice.org.uk/topics/chronic-obstructive-pulmonary-disease/background-information/risk-factors/

NICE. (2021, November 30). Tobacco: preventing uptake, promoting quitting and treating dependence. Updated 16 January 2023. https://www.nice.org.uk/guidance/ng209/chapter/recommendations-on-treating-tobacco-dependence

Office for Health Improvement & Disparities. (2022). Fingertips: Public Health Profiles. https://fingertips.phe.org.uk/search/COPD#page/1/gid/1/pat/15/ati/167/are/E38000243/iid/253/age/1/sex/4/cat/-1/ctp/-1/yrr/1/cid/4/tbm/1

Osman, L. M., Ayres, J. G., Garden, C., Reglitz, K., Lyon, J., & Douglas, J. G. (2010). A randomised trial of home energy efficiency improvement in the homes of elderly COPD patients. *European Respiratory Journal*, 35(2), 303–309. https://doi.org/10.1183/09031936.00187708

Parkin, D., & Devlin, N. (2006). Is there a case for using visual analogue scale valuations in cost-utility analysis? *Health Economics*, 15(7), 653–654. https://doi.org/10.1002/hec.1086

Phillips, L. D. (2007). Decision conferencing. In W. Edwards, R. F. Miles, & D. von Winterfeldt (Eds.), *Advances in Decision Analysis: From Foundations to Applications*. Cambridge University Press.

Puhan, M. A., Gimeno-Santos, E., Cates, C. J., & Troosters, T. (2016). Pulmonary rehabilitation following exacerbations of chronic obstructive pulmonary disease. *Cochrane Database of Systematic Reviews*, 12(12), CD005305. https://doi.org/10.1002/14651858.CD005305.pub4

Safiri, S., Carson-Chahhoud, K., Noori, M., Nejadghaderi, S. A., Sullman, M. J. M., Ahmadian Heris, J., Ansarin, K., Mansournia, M. A., Collins, G. S., Kolahi, A-A., & Kaufman, J. S. (2022). Burden of chronic obstructive pulmonary disease and its attributable risk factors in 204 countries and territories, 1990–2019: results from the Global Burden of Disease Study 2019. *BMJ*, 378, e069679. https://doi.org/10.1136/bmj-2021-069679

Stead, L. F., Bergson, G., & Lancaster, T. (2008). Physician advice for smoking cessation. *Cochrane Database of Systematic Reviews*, 2008(2), CD000165. https://doi.org/10.1002/14651858.CD000165.pub3

Terzikhan, N., Verhamme, K. M. C., Hofman, A., Stricker, B. H., Brusselle, G. G., & Lahousse, L. (2016). Prevalence and incidence of COPD in smokers and non-smokers: the Rotterdam Study. *European Journal of Epidemiology*, 31(8), 785–792. https://doi.org/10.1007/s10654-016-0132-z

The Health Foundation. (n.d.). STAR: a tool for commissioners. https://health.org.uk/funding-and-partnerships/programmes/star-a-tool-for-commissioners

The Health Foundation. (2012). Learning Report: Looking for value in hard times. https://www.health.org.uk/sites/default/files/LookingForValueInHardTimes.pdf

Tindle, H. A., Stevenson Duncan, M., Greevy, R. A., Vasan, R. S., Kundu, S., Massion, P. P., & Freiberg, M. S. (2018). Lifetime smoking history and risk of lung cancer: results from the Framingham Heart Study. *Journal of the National Cancer Institute*, 110(11), 1201–1207. https://doi.org/10.1093/jnci/djy041

University of Leeds. (2020). INTENT smoking prevention programme. https://intent.evidencetoimpact.com/

Walters, J. A., Tang, J. N. Q., Poole, P., & Wood-Baker, R. (2017). Pneumococcal vaccines for preventing pneumonia in chronic obstructive pulmonary disease. *Cochrane Database of Systematic Reviews*, 2017(1). https://doi.org/10.1002/14651858.CD001390.pub4

Wright, D., Twigg, M., & Thornley, T. (2015). Chronic obstructive pulmonary disease case finding by community pharmacists: a potential cost-effective public health intervention. *International Journal of Pharmacy Practice*, 23(1), 83–85. https://doi.org/10.1111/ijpp.12161

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